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The S-A Page

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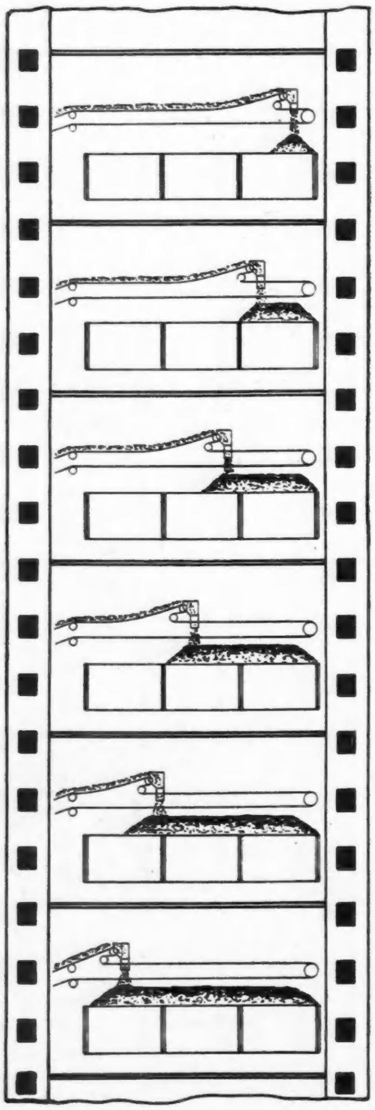
Two Methods of Distributing Ore to Bins



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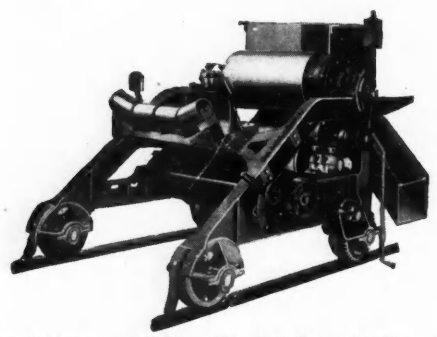

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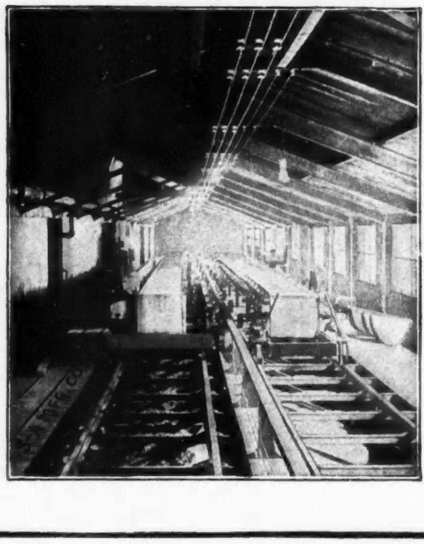

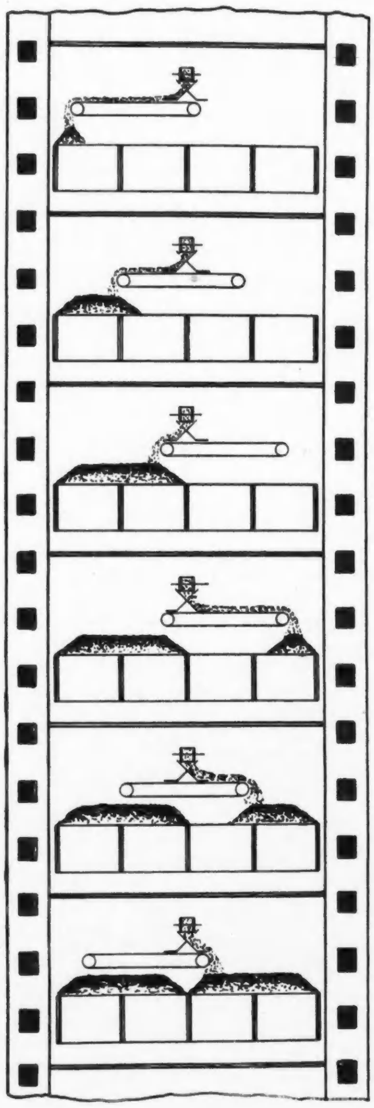

"S-A" Self-Propelling Tripper

The belt is unloaded at a uniform rate, the tripper being advanced over the entire length of the bins.

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The material is discharged from both sides, as shown.

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Engineering and Mining Journal

VOLUME 104 OCTOBER 20, 1917 NUMBER 16

Development of Copper Converting

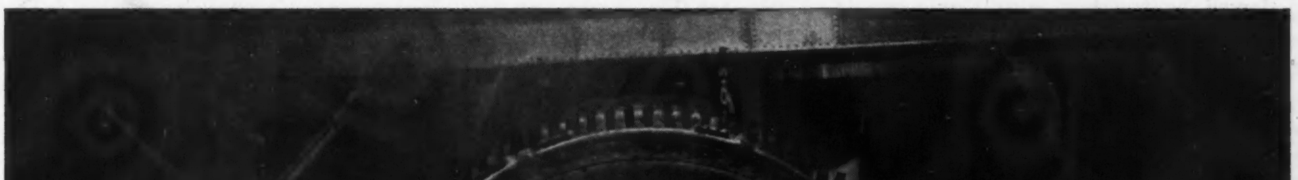
By MILO W. KREJCI*

The gradual development of copper converting is discussed from its experimental stages at the Parrot works in Butte, through the period of acid converting, to the renaissance of the basic lining and the subsequent application of magnetite coating to increase the life of the lining.

THE converting of copper matte is accomplished by forcing air through small openings called tuyeres, into molten matte contained in a steel vessel lined with refractory material. The converting temperature is about 1200° C. The small streams of air, passing through the liquid matte, oxidize the iron to iron oxide and the sulphur to sulphur dioxide. The iron oxide combines with silica, forming slag, while the sulphur dioxide passes off as gas. The process is entirely pyritic, the heat being furnished by the oxidation of the iron and sulphur and by the formation of the iron-silicate slag. The copper is reduced to the metallic state and settles to the bottom of the vessel, from which it is cast, either directly or through the medium of refining furnaces, into shapes suitable for further treatment.

The steel converter first used by Sir Henry Bessemer in 1856 paved the way for the conversion of copper mattes in a similar apparatus. Although several attempts along this line had been made by Raht, Semenikow and Hollway, it was not until 1880 that Manhès and David produced copper successfully in a converter. Their first radical departure from the steel practicc

*Assistant superintendent, Boston & Montana Reduction Works, Anaconda Copper Mining Co., Great Falls, Mont.



THE 20-FT. UPRIGHT CONVERTER DEVELOPED AT GREAT FALLS, MONT.

was to change the situation of the tuyeres from the bottom and to place them on the side, a short distance above the bottom. Not that the bottom-blast converter cannot be used for copper mattes, but that the operating conditions are so much more simple with the side-blast tuyeres of today.

The proper operating conditions for converting copper were so little understood when the Manhès converter was first introduced at the Parrot smelting works at Butte, in 1883-4, that for a while there was a doubt whether or not it would be adopted commercially. It was a common occurrence to have the charge become so cold that the tuyeres would "freeze," as well as the entire charge, and again so hot that the charge would foam violently and discharge the entire contents of the vessel on the converter floor. The converters were lined with quartz and clay, their capacity varying from one to 4½ tons of matte.

On account of the troubles experienced, it was found advisable to divide the converting into two separate operations: (1) Blowing matte from 35% up to 80% copper, and then casting the resultant white metal. (2) Blowing the remelted white metal to copper. This was abandoned in a few years as it was found unnecessary. The operators, having become sufficiently skilled in the work, were able to skim their charge at the right time, and blowing to finished copper without the remelting of the white metal was carried out as it is in the present-day practice.

Battle of the Upright and Horizontal Converter

The upright or Parrot type of converter, which was followed by the horizontal, or Leghorn, type, was installed at Bisbee and Anaconda in the early 90's and continued to be the prevailing type of converter, with the exception of the plants at Great Falls, Mont., and Aguascalientes, Mexico. The horizontal form of converter consisted of a horizontal, cylindrical vessel, with lateral tuyeres, resting on cast-iron rollers, and revolving in a horizontal plane by means of a rack and pinion operated by hydraulic power. There were no radical departures in the horizontal type of converter until the advent of the Peirce-Smith apparatus in 1910, with the possible exception of the change from hydraulic to electric power for tilting the converter.

The vertical or Great Falls type of converter went through a number of radical changes as to the shape of the converter bowl, as well as other features, and finally resulted in the present 12-ft. vertical-type converter. The converters at Great Falls have always been of the vertical type. The Great Falls converter plant was started in 1892, using a converter which closely followed the design used in the steel practice. They were circular in cross-section, 7 ft. 1.5 in. in diameter, and 14 ft. 9.5 in. high, over all, were arranged for acid lining and had eight side-blast tuyeres. The converter revolved on trunnions, through one of which the air blast entered, while the other was fitted with a pinion which engaged a horizontal rack attached to the piston rod of a hydraulic cylinder. The control of the air and the tilting was from a central pulpit on the opposite side of the building from the converters, and in full view of them. This was taken from the steel practice, which practice, I believe, is still followed at all steel converter plants.

The first linings were tamped by hand, and it was not until 1896 that this work was done with a tamping machine. This resulted in a more substantial lining, an increase of the output of the same by 25%, and a much lower cost. The 7-ft. type, or Class I as it was known at Great Falls, was supplanted in 1904 by a converter elliptical in cross-section, 9 ft. 8 in. by 8 ft. 8 in., with the long diameter at right angles to the trunnions. This was known as Class II. In the 7-ft. converter it had been observed that the linings always wore away more rapidly at the tuyeres than anywhere else. The next most rapid wear seemed to be opposite the tuyeres, while the least wear appeared to be at the sides. This new type allowed a heavier lining on the tuyere side to be used.

Advent of Electrically Tilted Converters

The advent of this converter resulted in doubling the output per lining, larger charges and an increased speed of working of about 40%. It differed from the Class I in that it had twelve 1½-in. tuyeres instead of eight ⅞-in. tuyeres. It was larger in size and was operated electrically instead of by hydraulic power.

This was the first application of electric power for converter operation, and was so successful that it has almost entirely supplanted the use of hydraulic power for this work.

Although the results obtained from the Class II converter were encouraging, it was felt that further improvements could be made which would give a still larger capacity and faster working. It was found that the Class II converter lining first wore out at points on the sides under the trunnions; also that the converter would work faster if it had more tuyeres. This led to the design and installation of the Class III type. It was an elliptical converter with the long diameter on the line of the trunnions instead of at right angles to them, as in the Class II. The long diameter was 12 ft. and the short diameter 10 ft.; the height was 1 ft. less than Class II and there were 15 instead of 12 tuyeres. It was put into operation during 1907. The work of this converter was a great improvement over the Class II, and resulted in a greater output per lining, and more rapid working.

A study of the linings and operation of the Class III converter showed that it wore out at the tuyeres, as in Class I. In order to retain the thickness of the Class III lining, and make it thicker at the tuyeres, a new converter was designed and called Class IV. It was circular in horizontal section, was 12 ft. in diameter, had the same height and also the same number and size of tuyeres as the Class III. The Class IV converter was put into operation in February, 1910, and was found to be satisfactory and resulted in the abandonment of all of the other previous types except the Class III converter.

Other Developments of Acid-Converting Practice

During the 25 years of acid-converter operation many other improvements took place in the method of handling matte, casting copper and slag, namely:

1. The casting of matte and the remelting of the same in cupolas which poured directly into the converters were replaced by the installation of forehearths or settlers following the blast furnaces. From these,

or from large reverberatory furnaces, the matte was tapped into ladles and poured into the converter directly by means of overhead cranes, or by way of a launder from a car equipped with a tilting arrangement.

2. The disposal of the liquid converter slag was changed from the old method of casting the same in beds of sand or flue dust, and then breaking up the chilled cake and smelting in blast furnaces to one of the following: (a) Pouring the liquid converter slag into reverberatory furnaces or into blast-furnace settlers. (b) Casting the slag in casting machines of the circular or straight-line type and resmelting in blast furnaces. (c) Agglomeration of the slag with fine ore, concentrates and flue dust into nodules and smelting the product in blast or reverberatory furnaces.

3. The casting of the copper was changed from the method of pouring directly into molds, set on trucks placed underneath the converter, to the present method of pouring from the converter into a large ladle, which is carried by an overhead crane to a casting machine, either of the circular or straight-line type, or to a refining or heating furnace, from which it is cast.

4. The old "latch" tuyere valve was replaced by the Dyblie ball tuyere valve. Though the original has been changed somewhat in detail, the same main features prevail today.

5. The use of barren quartz and clay for converter linings was replaced by ore with an admixture of other copper-bearing material, such as slime, copper precipitate, etc.

6. The life of the acid linings was materially lengthened by the addition of ore to the converter charge, which method of charging ore is the present practice in basic converters.

7. The first small converters were operated by means of a lever, later by a wormwheel, but as the size increased hydraulic power was used, followed later by electrical control. The last two survive, though the electrical control predominates.

Basic Converting

A radical departure from the acid-lining practice took place in 1910, by the adoption of the converter lined with magnesite brick, following the experiments of Peirce and Smith at Baltimore and Salt Lake City on lead-copper mattes. It is generally known as basic converting to distinguish it from acid converting. Unlike the basic-converting steel practice, the lining is inert and does not enter into the chemical reactions in the converter.

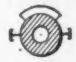
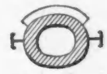
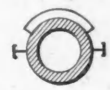
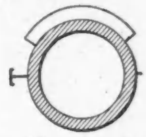
Many early attempts had been made to use a converter lined with chrome or magnesite brick along these lines by Keller, Knudsen, Baggaley and by experimenters at Anaconda and Great Falls. The best results, previous to those of Peirce and Smith, were probably obtained by Baggaley at Butte.

The Peirce-Smith Horizontal Converter

The converter of Peirce and Smith consists[1] of a horizontal, cylindrical shell of steel plate 10 ft. to 13 ft. in diameter and from 26 to 37 ft. 2 in. long, and holds from 30 to 60 tons of copper. It is bound with three cast-steel I-beams revolving on three pairs of carrying rollers. The heads of the cylinder are also of steel and are made adjustable in order to take care of the longitudinal expansion. The heads telescope into the shell and are held in place by I-beams.

The converter is equipped with 32 to 41 tuyeres 1¼ to 1¾ in. in diameter, placed in a horizontal run. The shell contains removable plates along the tuyere line to allow for repairing the tuyere zone without cooling down the converter, and it is provided with an opening near the end for charging the ore and

DEVELOPMENT OF THE VERTICAL CONVERTER AT GREAT FALLS

Class No.		Diameter of Shell	Kind of Lining	Tuyeres No.	Tuyeres Diam.	Tons per Lining	Minutes Blowing per Ton of Copper
		Circular 7 ft. 1.5 in.	Acid	8	⅞ in.	17	43
	II	Elliptical 8 ft. 8 in. x 9 ft. 8 in.	Acid	12	1¼ in.	40	30
	III	Elliptical 12 x 10 ft.	Acid	15	1¼ in.	54	26.3
	IV	Circular 12 ft.	Basic	26	1¼ in.	..	30*
	V	Circular 20 ft.	Basic	26	2 in.	..	12.6

* Lower grade matte (38% Cu) treated. Matte treated under acid practice 45 to 52% copper.

a vent for the gases, but in some installations this has been placed in the center. An opening with a spout is provided on the pouring side of the shell for the removal of slag and copper. The converter is lined with magnesite brick. Hydraulic or electric power is used for tilting by means of two wire ropes, one end of each being attached to the converter and the other to a block connected with the operating mechanism. In the main it is the ordinary, horizontal converter with the ends extended to allow for larger capacity.

Magnesite Lining Generally Adopted Following Peirce and Smith's Successful Work

Shortly after the Peirce-Smith converter proved to be commercially successful, the horizontal converters at Anaconda were lined with magnesite and proved that the success was not confined to the details of the Peirce-Smith converter. At Great Falls the first magnesite-lined converter for regular basic practice was put into operation early in 1911, and in a few months the change was made throughout the entire plant. All of the Class IV converters were lined, as well as one of the Class III as a spare.

The first converter was fitted with 15 tuyeres of 1¼-in. extra-strong tubing. After the second and third converters had been lined, using the same number of tuyeres, a fourth converter was lined, which was an exact duplicate of the others, but was fitted with 26 tuyeres of the same diameter. The spare converter was fitted with 24 tuyeres. All of these converters were operated successfully from the start. The converters with the greater number of tuyeres naturally worked their charges more rapidly, due to the increased volume of air used.

[1]The latest standard type of Peirce-Smith converter is described on page 674.

It was then decided to go to a much larger unit; a 20-ft. converter was decided upon, still adhering to the upright type. The first converter of this type was fitted with 62 tuyeres of 2-in. boiler tube, having an internal opening of 1¾ in. These were finally replaced with 26 tuyeres having an opening of 2 in. This large type of converter has been adopted both at Great Falls and Anaconda and is doing good work. Wherever the vertical type of converter has been installed in plants other than those mentioned, the 12-ft. circular vessels have been used.

Protecting the Basic Lining

As the magnesite lining of a converter is expensive and requires considerable time to put in place, it is naturally of the utmost importance to prolong the life of the same as much as possible.

The principle of the basic lining is simple. A basic (or neutral) material is used in order to avoid chemical action between the lining and the products of the process, which are also basic. The necessary silica to form slag is supplied by introducing siliceous ores into the converter, either through the mouth or the tuyeres. The usual practice is to use a magnesite-brick lining in the converter shell, varying from 9 to 30 in. in thickness, the heaviest lining being at the tuyeres.

Unless the temperature is too high, there should be no chemical action on the lining. However, the temperature in the converter is continually varying as the process is an intermittent one. The lining is hot during the blowing period and cools down during the period of pouring and before recharging. These variations of temperature cause the lining to crack and spall off. With an exposed lining of brick there is a mechanical wear by the charge, which is greater when the temperature is high, as the brick is soft. Thus the chemically indestructible lining is not really so.

In order to guard against this wear and protect the brick, it was the early practice to heat up the newly lined converter and blow a few charges of white metal that had been worked up from another converter. Keeping the temperature down resulted in binding the brick and coating it with a thin layer of white metal and copper. The converter was then used in blowing matte. This offered some protection but was not satisfactory as the protection was soon gone and the brick again exposed.

Development of Protective Magnetite Coating

To avoid the transfer of white metal, the practice of blowing matte in the heated new converter was adopted and an attempt made to coat the brick with it. This was done by blowing the charge for a few minutes and then allowing the converter to cool for 15 or 20 min. This process was continued until the brick had been coated with matte. This gave better results than the white-metal treatment.

This soon led to the development of coating the lining with a layer of magnetite. While blowing matte without silica to form the initial protective coating of the newly lined converter, it was observed that the material was highly magnetic. An analysis showed that it was principally magnetite. Further investigation of the subject showed that magnetite formed readily when the temperature was too low for the formation of the iron slag by union of FeO and SiO_2 and the proportion of silica was low. Any excess of iron over what was needed to combine with the silica present was oxidized to magnetite.

The melting point of magnetite was found to be given by various authorities between 1527° and 1538° C. As the ordinary working temperature of the copper converter is about 1200° C., any magnetite present would be in a mushy condition and would readily attach itself to the lining of the converter. It was evident that here was a basic coating that satisfied all conditions. It could be put on at will without any cost, from the material that was being treated. It was so simple that one wondered why it had not been thought of before. It was almost automatic. Had Keller and other early experimenters with basic linings understood this, acid linings would not have survived as long as they did. The use of this protective coating soon manifested itself in a tremendous tonnage per lining. Early in 1912 these linings were producing over three times the output of the large Peirce-Smith apparatus. It was apparent that the principle evolved by A. E. Wheeler and myself was not understood by other users of basic converters at that time.

Lining Troubles Greatly Reduced Since the Magnetite Coating Has Been Adopted

Before the method of applying this protective coating to the magnesite brick became known to the outside world, operating troubles with basic lining were many. The life of linings in some plants was from five to 20 days. In one plant it required the services of three successive shifts of bricklayers to keep the converters lined in order to keep them in operation. When the simple trick was learned, the entire force of bricklayers was dispensed with.

With proper operation and care, once a converter is lined, it should never be relined. This would be the case if 100% efficiency were possible. The full details of applying this coating were described[2] in 1913 at the time of the Butte meeting of the American Institute of Mining Engineers.

There have been few changes in the practice of converting copper matte during the last few years. These have been principally confined to the various mechanical features and details of the converting machine, such as tuyere design, change in the materials of construction, operating mechanism, thickness of lining, etc.

Although some copper is still being produced in acid-lined converters, it is, I believe, wholly confined to foreign countries, namely, Japan and possibly Russia and Australia. The tonnage, however, is so small that it may be said that practically all copper converting is done in basic-lined converters. Even Japan is in the process of transition, as some of the larger copper companies in that country are installing converters lined with magnesite brick.

The converters in general use today are principally confined to one of the two following types: (1) Peirce-Smith or horizontal type. (2) Great Falls or vertical type. This is entirely so in new installations. A few plants still have the old Bisbee type converters that were formerly used with acid lining. In the main

[2]Trans., A. I. M. E., 1913, Vol. 46, pp. 562-5.

THE CONVERTER AISLE AT THE WASHOE REDUCTION WORKS AT ANACONDA, MONT.

STARTING THE BLOW

SKIMMING THE 20-FT. CONVERTER

the Peirce-Smith converter has been confined to the plants of the American Smelting and Refining Co., which company encouraged the development of this type.

Use of Vertical Converters Greatly Extended

Up to the early part of 1912, with the possible exception of Aguascalientes, Mexico, the only vertical type converters were at Great Falls. Within the next two years, following the excellent results obtained, over a dozen plants throughout this country and other parts of the world adopted the Great Falls type of converter in their new installations.

It might be of interest to cite an instance of how the application of the magnetite coating aided materially in saving an entire relining. During the reconstruction of the Great Falls converter plant, in the latter part of 1913, when the Anaconda company was installing the 20-ft. vessels and the converter roof was open, a storm of snow and sleet resulted in soaking the brick of a newly lined converter. On drying out the brickwork preparatory to putting it into service, it was found that the lining was to all appearances about ruined as the bricks were badly spalled and disintegrating. This was particularly true in the center of the bottom. It was nevertheless decided to put it into operation and get what service could be obtained from the lining. The converter was thoroughly coated with magnetite and started. In order to protect the bottom, a charge of magnetite slag was prepared in another converter and poured into it. The converter was placed in the vertical position and the magnetite slag allowed to set for about 18 hours. Sufficient silica had been added so that the magnetite slag contained about 6% SiO_2. This had the effect of slightly lowering the melting point of the slag so that the magnetite would not freeze in making the transfer. This converter has continued to be in service, it being found necessary to patch the bottom in this manner about every six months. It demonstrated the effectiveness of the protective coating, as well as the importance of laying the brick dry.

Although magnesite brick is apparently unaffected by water at ordinary temperatures, it disintegrates rapidly from the steam generated. In order to demonstrate this, the experiment of placing a magnesite brick in a pan of water, and then covering it, was made. Steam was then turned into it. At the end of 24 hours it was found that the brick had entirely disintegrated.

The advent of basic converting has made it possible to convert low grades of matte at a profit. Under acid linings the conversion of these mattes, on account of the heavy relining expense, was prohibitive.

Some Operating Precautions

1. The converter should not be overloaded; too great a burden of matte or slag offers too much resistance to the air blast. As converting is primarily an oxidation process, the speed of working depends on the rapidity with which the air can be furnished to the molten matte. The slag should be removed as soon as it is liquid.

2. The temperature of the converter should be regulated by the addition of cold matte, ore, etc., or by the throttling of the air blast in case there is a shortage of cooling material.

3. The tuyeres should be thoroughly punched out at the end of each charge, and kept uniformly open during the blow, in order to prevent a concentration of air at any one point.

4. The addition of a small amount of hot matte about 10 min. before the charge is finished will insure hot copper and eliminate any necessity of additional heating to prevent freezing of copper in the pouring ladle while casting.

It is evident from the preceding discussion that the function of magnesite brick as the first lining is to protect the shell of the converter until such time as the magnetite lining has been properly formed and that magnetite is the true lining on which converting is carried out. If any other cheap form of initial lining could be installed that would stand the temperatures and chemical action during the formation of the magnetite, the expensive magnesite brick could be dispensed with, thus decidedly lessening the cost of a lining. Some experiments along this line have been conducted at Great Falls, but in every case the lining material has contained so much silica that it united with the iron as this was oxidized and was destroyed before the magnetite lining could be formed. It is possible that some cheap foundation may be developed so that the full benefit of the magnetite lining can be obtained. Possible materials for such a lining are, of course, the present magnesite, either as bricks or ground magnesite; chrome, either as bricks or in ground condition; alumina in some form, or perhaps the magnetite itself.

Latest Type Peirce-Smith Converter

The present type of 13 x 30-ft. Peirce-Smith converter consists of a horizontal cylindrical shell of steel plate, supported by two cast-steel riding rings, 8 ft. from each end, revolving on four sets of carrying rollers, each set comprising two rollers, with faces bearing on the riding ring and a cradle support in a cast-steel foundation plate. The heads of the cylinder are made of steel plate, flanged to telescope into the shell and are held in place by I beams. The converter has forty-one 1¾-in. tuyeres placed at 6½-in. centers, and is built with or without removable tuyere plates.

The converter is tilted by electric motor turning a shaft and pinion meshed in a girth gear riveted to the converter shell, allowing the converter to turn 360°. The converter stack is at a point halfway between the riding rings. It is an opening with axes 6 ft. x 6 ft., having curved front and back, but straight sides; the stack is made of cast steel.

Converter flux—at the rate of two tons in 5 min.—may be charged into the converter, while blowing, from a storage hopper through a "silica gun" using converter blast. Matte and cold "dope" are charged, and slag and blister copper are poured, through the stack opening. The daily capacity of the converter usually varies from 110 to 125 tons of blister copper, while converting a 40% matte.

Converters of this size are at present operating at Tacoma, Garfield and El Paso; they are being installed at Hayden, Ariz., at the Braden Copper Co. in Chile and also at the new plant of the British America Nickel Corporation at Sudbury, Ontario.

Zinc Oxide Furnaces

By JOHN F. CREGAN*

Two general types of zinc-oxide furnaces have been developed in the United States as a result of diverse conditions in ore and fuel supply. Eastern works use a series of separately controlled grates, the zinc fumes passing to a common collecting flue. Western metallurgists prefer self-contained unit; individual charges controlled by the balance of the whole furnace. The author considers that the Western practice is best adapted to varied ores and fuels.

IN THE burning of zinc ores for the production of zinc oxide there are two distinct types of furnaces in general use. Each has been subject to variations in structural details in different installations, but the basic lines of operation have been followed in every case and the distinguishing features of each type always remain well defined.

Up to a few years ago the process of zinc-oxide manufacture, on perforated grates, was carried on in two widely separated sections of the United States, namely, along the Atlantic seaboard and in the territory west of the Mississippi River. The metallurgists of these districts had different ideas and therefore developed the two types of furnaces above mentioned, which have become known as the Eastern and Western types of zinc-oxide furnaces. The two types of furnaces are shown in the accompanying drawings.

The Eastern furnace consists of a series of individual furnaces, each separately controlled with regard to blast pressure and exhaust and arranged so that the zinc fumes leave each separate furnace and pass into a common collecting flue or header.[1] This header is generally made of light, sheet steel and is separate from the furnace except for sheet-steel pipe connections which convey the zinc fumes from each furnace to this header. There are means of adjustment and control on each of these pipe connections so that each furnace may be shut off from the main header whenever desired. A settling tower or chamber of some sort is built separately from the furnace and connected thereto by the sheet-steel pipes which form the fume-collecting system.

The Western furnace is a self-contained unit with furnaces and dust flue under one common arch. There are secondary arches and side walls which separate the several charges, but the exhaust pressure on the individual charges cannot be controlled beyond the balance which controls the whole furnace. A settling chamber is built in with the furnace, of which it forms a continuation. The air blast and other features are practically identical in principle with practice.

The Eastern type of furnace is used principally at Palmerton, Penn.; the Western type is installed at numerous works in the West. These two distinct types of furnaces were originally developed through the use of the different ores and fuels that characterized the operation in the different sections in which the furnaces were operated. In

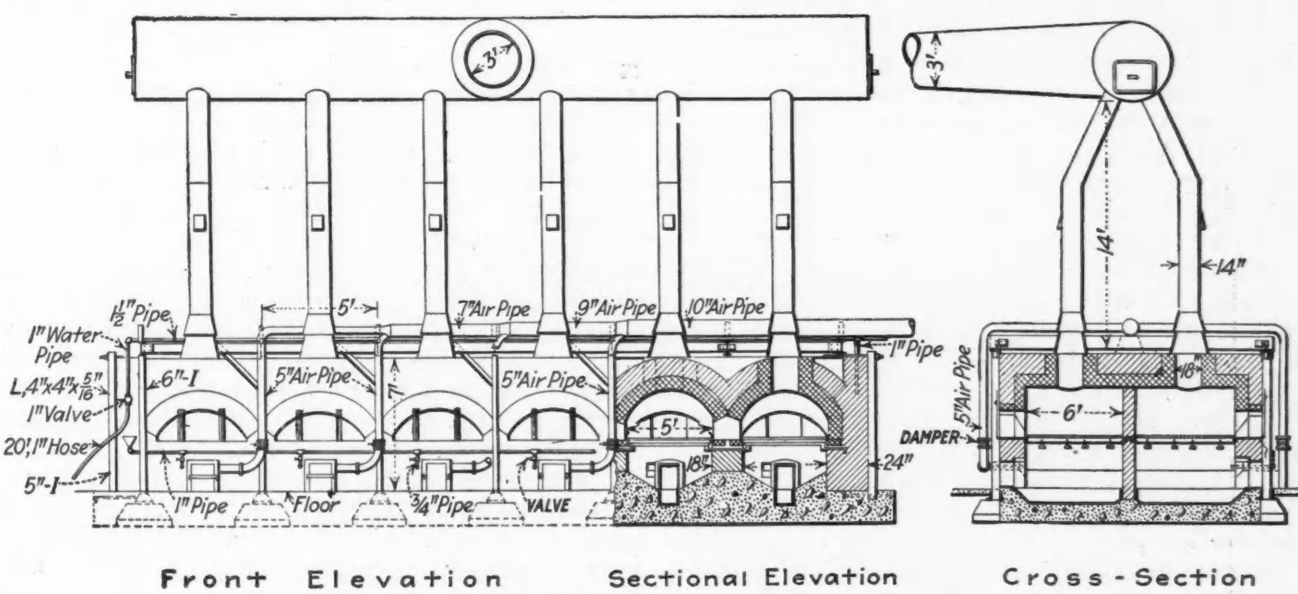


FIG. 1. STANDARD TYPE OF EASTERN FURNACE

the East the ore generally used was a pure silicate or carbonate and required no treatment other than crushing and sizing. The fuel was anthracite of good quality. Both ore and fuel came to the smelter in quantities sufficient to operate the furnaces uniformly for long periods of time. This regularity of operation and furnace charge tended toward development along certain lines and was in keeping with conditions imposed by the materials in use.

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[1]In speaking of furnaces in this article, and in this industry, there is the same confusion that exists with respect to spelter-distillation furnaces. Thus, in this paragraph Mr. Cregan has used the word "furnace" in two senses, viz., (1) describing the whole structure, and (2) describing one of its constituent portions. Europeans obviate this confusion, partially, by referring to the whole furnace as a "massive," which term has not found employment in American literature, but we use the expression "block" which is equivalent. It will be noted that Mr. Cregan, later in his article, refers to the "block." It would be better if we should confine the word "furnace" to the whole, and in the case of oxide furnaces describe the constituent parts as "grates."—W. R. I.

The Western territory presented different and more complicated conditions. Ore was obtained in the open market whenever and wherever it was offered. This resulted in a varied supply, consisting of silicates, carbonates and sulphides, and the diversity of the supply usually resulted in a variable tonnage which would not permit the operation of the furnaces on any one kind of ore for any considerable period. The fuel problem presented the same conditions as the ore supply. Diverse sources of fuel supply meant a fuel of uncertain and irregular quality, when compared with conditions in the East, and produced conditions which were never met with in the Eastern territory. A furnace was accordingly developed to meet all the varied conditions as they were presented.

In the operation of both types of furnaces the primary object is to treat the largest quantity of ore per furnace consistent with a burden which will permit the smallest metal content remaining in the cinder. In order to accomplish this end there have been numerous experiments with grate areas. While the burden per square foot of grate surface per furnace depends entirely on the character of the ore used, there are certain physical limitations that govern the amount of grate area per furnace which will produce the best results. A discussion of all of these governing conditions would be too lengthy for the scope of this article.

Governing Conditions of Furnace Design

A furnace may be only as wide or as long as the degree of structural stability of the arch whose span is the length or width of the furnace desired. The furnace should be of such width that inaccessible corners may be reduced to a minimum. It should be of such length that an ordinary unskilled workman may operate it with tools within his ability to handle. It should have a tonnage capacity so that each charge may be of such size that the operator will work at his greatest efficiency with the least effort. Finally, the grate area of each furnace should be so proportioned to the total grate area in the furnace block that the drawing and charging of the individual furnaces in their regular order will have the minimum cooling effect on the block itself. Experience has shown that individual furnaces, 6 x 6 ft., meet the above conditions in general, and certain combinations, such as making double furnaces of the above dimensions, work satisfactorily.

With the grate area of an individual furnace as stated above, the question of the number of furnaces per block may be discussed. The Eastern practice has settled the number at present to six, although there are furnaces in this district so modified that the actual number of furnaces is only four per block. In the West the number varies from eight to 16 double furnaces per block. In this matter the radical difference in the theory and practice between the Eastern and Western types is strongly marked, and at first glance seems irreconcilable, but the elements governing both are the same although the working conditions are the exact opposites of each other. The maximum number of furnaces that can be built into a block would be the number which in ordinary operation would generate as much heat as the structural materials and baghouse equipment could withstand. In other words, it would be the number of furnaces which would produce heat enough to keep the plant right at the danger point all the time unless methods were employed to reduce the heat, and those methods would at the same time reduce the efficiency of the furnace. The minimum number of grates per block is the number which in ordinary operation will hold the heat of the block at a degree that will not retard the working of any grate in the block when one or more grates in the block is drawn or charged. This should be accomplished without the aid of devices for the equalizing of the operating conditions of the block during the charging periods.

When all other conditions have been considered, it is well to have the size of the furnace block accord with the arrangement for the necessary labor to operate the furnaces. Success in operation depends largely on continual watchfulness, and this may be aided by having as few operators on the furnace block as possible, so that responsibility for the condition of the furnaces may be restricted. This is important, owing to the strong tendency in the industry toward 8-hour shifts which increase the number of men per block and, in so doing, divide the responsibility. A combination that would meet all the foregoing requirements most satisfactorily would be blocks of 16 single furnaces in the Eastern type and blocks of 12 double furnaces in the Western type. This arrangement would so place the men that the minimum number would be employed per block and each man's work would show its maximum worth.

Mechanical Equipment

The zinc-oxide process has been the subject of experimentation for many years and, while numerous changes have been made in the furnace detail, the only radical changes worth mentioning are the semi-automatic disposal of slag which was introduced in 1898 and was followed later (in 1904) by the automatic charge mixer and the mechanical charger. These developments have been practically confined to the Eastern territory and have been the salvation of the industry in that section. One Western furnace is equipped with the mechanical charge mixer and furnace charger and one other plant in that section has the mechanical charge mixer. While the Eastern furnaces are particularly adapted to these mechanical features, there is no reason why their installation should be limited to that section, inasmuch as the Western-type furnace represents a greater field for a further combination, with this equipment, of a mechanical slag puller which has yet to be developed. The introduction of these mechanical features not only increased the efficiency of the furnaces but abolished the most arduous duties in connection with the process. They greatly reduced the number of men required for operation under the old process, and, through the abolishing of the "man-killing" duties which existed under that process, permit a much simplified operation to continue during the labor scarcity of the last few years. The furnaces gained in efficiency by receiving a uniformly mixed charge of correct weight and by reducing the time required for charging.

The particularly heavy character of the work required in the operation of a zinc-oxide furnace imposes the necessity of giving careful thought in constructing the furnaces, so that advantage may be taken of every feature which will render the operation less difficult. The many variations that are noted in the size and arrangement of furnaces are traceable to this effort to reduce the work. The mechanical charger eliminated the heavy work involved in the old hand-charging method, and the removal of the slag is now the element that presents the most difficulty. A characteristic of the slag in a zinc-oxide furnace is that it sticks to the brickwork on the side walls and back of the furnace. This sticking of the slag makes the cleaning of the furnace difficult and it is important that the clinker be entirely removed from a furnace before a new charge is introduced. The method of operation in the Eastern territory brings this condition more into prominence than in the West. Experiments to overcome this condition resulted in the doubling of the furnaces in various combinations. This doubling of furnaces was designed to reduce the brick area in which the clinker could stick. Eastern operators have decided that the greatest difficulty in removing the slag is presented in cleaning the side walls and have combined three single furnaces into one, thus removing two side walls. Western operators consider that their arrangement of combining two furnaces into one by removing the back wall satisfactorily meets the same condition.

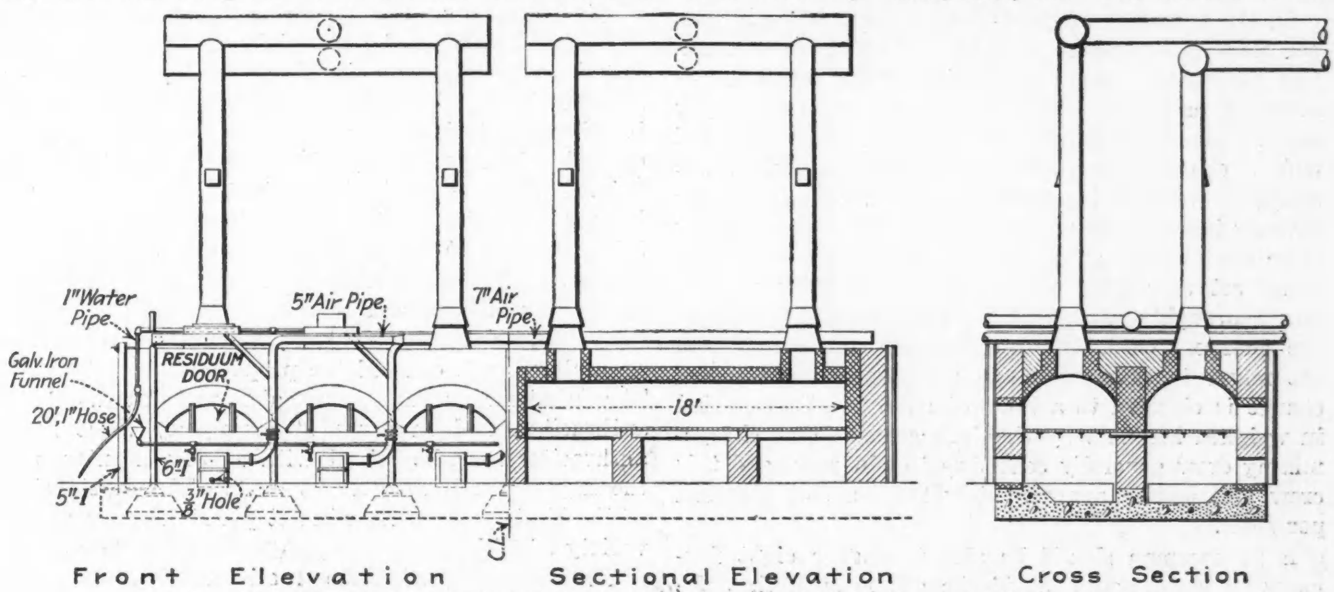


FIG. 2. EASTERN FURNACE WITH THREE GRATES THROWN LONGITUDINALLY INTO ONE

Another labor saver is introduced by placing the grates at the proper height above the operating floor. A few inches in this dimension may mean that the work on the furnace will be reduced or increased, as the case may be. The point involved is the placing of the grates at the exact elevation that will permit the average man to do the work in as easy and as natural ways as possible. The height of 2 ft. 10 in. from the floor line to the top of the dead plate has met with general approval from furnace operators.

The successful operation of a zinc-oxide furnace depends largely upon the flexibility of the air control, both in regard to the air blast and the air exhaust. There is no way in which the size of this apparatus may be figured entirely from a theoretical standpoint because the governing conditions are variables and usually beyond ordinary control. Experience in the process has determined the size and the type of this equipment that are best suited to the work, and the general practice is to have an excess of both pressure and exhaust and to control them by means of blast gates and dampers. Each furnace block should have its own air system with interchangeable connections on the blast, so that in case of trouble two blocks may be served with one blast system. The size of the equipment depends upon the number of furnaces per block. The blower should be capable of delivering a pressure of at least 6-in. water gage under the grates. The air-blast flues should always be carried above ground and introduced into the chamber under the grates by conveniently arranged conductors. This permits a definite control of the air blast at all times. It was the practice several years ago to build furnaces with underground air flues, but that system proved to be generally unsatisfactory owing to the blocking of the flues by water, dust, etc. The amount of air required per furnace is determined by experience and is regulated by a blast gate conveniently located.

Great care should be exercised in constructing a block of zinc-oxide furnaces, both in the selection of material and in workmanship. The firebrick should be chosen for its ability to resist abrasion under high heat. Liberal allowance should be made for expansion and the entire block of furnaces securely ironed in the regulation way. The firebrick in the side walls and back of furnaces should be laid in header courses with the brick dipped in a thin slurry of fireclay. For the red brick a cement mortar, strongly tempered with lime, will permit a reasonable expansion without developing cracks. Buck staves should be of structural steel and so placed as to be independent of tie-rods through the furnace structure. All tie-rods should be placed outside the furnace structure and be readily accessible in case of the necessity of repair or renewal. During the period preceding the present era of high prices a block of Eastern furnaces could be built for $5000, while a block of Western furnaces, consisting of 12 double furnaces, would cost approximately double that amount.

The heating of a furnace for the first time is an operation that requires patience and it is important that the work be both wisely and well done. A small wood fire should be started at each end of the block and maintained for several days. Other fires may be added gradually until at the end of one week each individual furnace in the block has its own wood fire. These fires may then be increased so that at the end of the tenth day from the starting of the first fire the fuel may be changed to coal under a slight air blast. The coal fire may then be increased gradually so that at the end of the third week the furnace is ready for its initial charge. This period is not too long for this preliminary heating because the furnace should be at its working heat when the first charge is introduced, and a failure to have the furnace at the required heat results in a wastage of ore and a considerable repair bill in patching the furnace and replacing broken tie-rods and buck staves.

Distribution of Labor

In the operation of the furnaces the number of men per block is dependent upon the extent of the mechanical labor-saving equipment with which the block is provided, as well as upon the number of furnaces per block. Zinc-oxide plants are now generally equipped with a charge-mixer, and this equipment divides the operation between two crews of men whose duties are entirely independent of each other. The charge mixer is an electrically driven, geared, rotating cylinder with vanes set at angles on its interior to pick up and mix thoroughly the several materials that constitute the charge. Coal, ore and flux are introduced into the mixer in proportionate quantities and the mixed charge is elevated to a bin to be drawn off as needed in weighed amounts by the furnacemen. The charge-mixing crew generally consists of eight men, and this crew will handle approximately 200 tons of material per shift.

A furnaceman should be able to charge eight furnaces in eight hours or, if the ore is such that the burden per square foot of grate area can be doubled, he should charge four 6 x 6-ft. furnaces in eight hours with each furnace working on a burden of 120 lb. of ore per square foot of grate area. The labor arrangement on all zinc-oxide furnaces is based on this general proportion and the number of men distributed per block accordingly. In plants where there is no mechanical equipment other than the charge mixer the furnaceman gets his required number of charges from the bin and arranges these charges in neat heaps on the floor before each furnace. His firing coal is provided for him. When a charge is worked off, the furnaceman breaks up the clinker and pulls it from the furnace. A wheelbarrow is conveniently arranged so as to receive this clinker as it drops from the furnace. There are generally two large barrow loads to the charge and as they are filled the barrows are wheeled to the dump. When the furnaceman has the furnace thoroughly clean he covers the grates with a thin layer of what is called bed coal. About 4 lb. of coal per square foot of grate surface will make a good bed fire if the coal is of good quality. When this bed fire reaches a state of incandescence it is carefully smoothed over with a rabble and the new charge is then spread over the grates, care being taken to have the charge layer of as uniform density as possible. A strong air blast is maintained during the entire charging period, and when the charge has been leveled off and all corners have been packed, the air blast is reduced until a film of burning gas is noted just above the top of the charge. The furnace door is then closed, water is turned into the ashpit until the overflow point is reached, and the charge requires no further attention for six hours except to watch for and eliminate any blow-holes that may appear. At the end of six hours the charge is rabbled over and the blast increased. One hour later the charge is again rabbled and the blast increased if the condition of the charge warrants it. This operation is repeated at half-hour intervals until the charge is ready to come out, which is usually at the end of eight hours. The clinker is then removed from the furnace, and the furnaceman proceeds with a new charge as before.

The charge generally consists of a certain weight of ore which varies in amount from 80 to 120 lb. per sq.ft. of grate surface. Coal is added in amounts varying from 80 to 100% of the weight of the ore. When flux is necessary, this is added in amounts varying from 10 to 90% of the ore used. The entire tonnage is mixed as intimately as possible and, when spread over the furnace grates, will form a layer from 6 to 8 in. in depth. The best fuel is anthracite coal sized to pass over ¼-in. and through $\frac{5}{16}$-in. mesh. At present this size of coal is too expensive for use in the smelting of zinc oxide, and operators have to be content with almost anything available above the quality of dirt coal. Where anthracite is not procurable except at a prohibitive cost, coke of the proper size may be used. The Western furnaces may also use various semi-anthracites, and in cases of emergency these semi-anthracites may be mixed with small percentages of the higher grade bituminous coals. The construction of the Eastern furnaces will not permit the use of this variety of fuel.

The tools used in furnace practice are few and simple in character. The furnaceman's equipment consists of an all-steel wheelbarrow, one No. 2 scoop, a rabble and a clinker bar. The rabble is simply a steel rod, ⅝ in. in diameter and about 10 ft. long, with a loop handle at one end. On the other end is welded a 10-in. piece of ½ x 2-in. iron which acts as a pusher, leveler and hook. The clinker bar is a 1-in. steel bar, 10 ft. long, with a looped handle on one end. This loop should be opened about 8 in. to give the operator a leverage on the bar. The other end is spread out in a shape to act as a slicer in Western practice and in the East this bar is provided with a chisel-pointed wedge.

Eastern Methods

The foregoing is a description of the operation as it is practiced in the Western territory. In the East the general principles are the same although the introduction of mechanical equipment divides the work differently among the men. In the East the ore and coal are delivered in bag bins. An electrically propelled scale car operates under these bins and draws off fixed amounts of ore, coal and flux. The scale car is then run to the mixer and delivers its load by gravity and goes off for another charge. When the charge has been mixed it is discharged by gravity to a skip and elevated to a bin in the furnace room. This bin discharges to electrically operated cranes on both sides of the furnace room, and these cranes are equipped with three or more weighing hoppers. These cranes take their capacity of weighed charges and distribute them to hoppers placed above each furnace. There is a chute which conveys the charges from these hoppers to the center of the furnace. The furnaces and the furnace room are elevated about 10 ft. above ground level, and on both sides of the furnaces, under the furnace building, is a system of railroad tracks for cars to receive the clinker from the floor hoppers. There are individual hoppers in the floor opposite each furnace and these hoppers are equipped with doors in the floor to receive the clinker from the furnaces and with discharge gates to permit the deposit of clinker into the cars.

After the furnaceman has broken up the clinker in any furnace he pulls it out of the furnace with his rabble. The clinker drops by gravity into the floor hopper, and trains come along immediately and empty these hoppers and convey the clinkers to the dump. The furnaceman then proceeds with his bed fire and when this has reached the right stage of incandescence, he levels it and then opens the charge-hopper discharge gate and the charge falls by gravity into the furnace. It is then leveled and the blast regulated.

The efficiency of a zinc-oxide furnace is determined by an analysis of the clinker. A number of factors can contribute to a low efficiency but these may be eliminated through knowing its performance by the zinc content of its clinker. A furnace showing 1% of zinc in its clinker is doing excellent work and this figure may be taken as a standard because of consistent attainment at certain plants. The general practice, however, results in a much higher zinc content in the clinker, but that is due largely to giving the clinker analysis less prominence than baghouse recoveries. The latter are misleading because of the general conditions of operation. The clinker analysis determines the amount of zinc oxide that has left the ore and leaves no doubt as to the work of the furnace.

THE DIFFERENT THEORIES

As previously stated, the conditions that were presented in the two sections of the country in which the zinc-oxide industry was established led to different theories of operation, and this variation in theory led to different types of construction. These differences continue to exist and the continued construction of new furnaces along the same lines in each section seems to indicate that these different theories are still deep-seated.

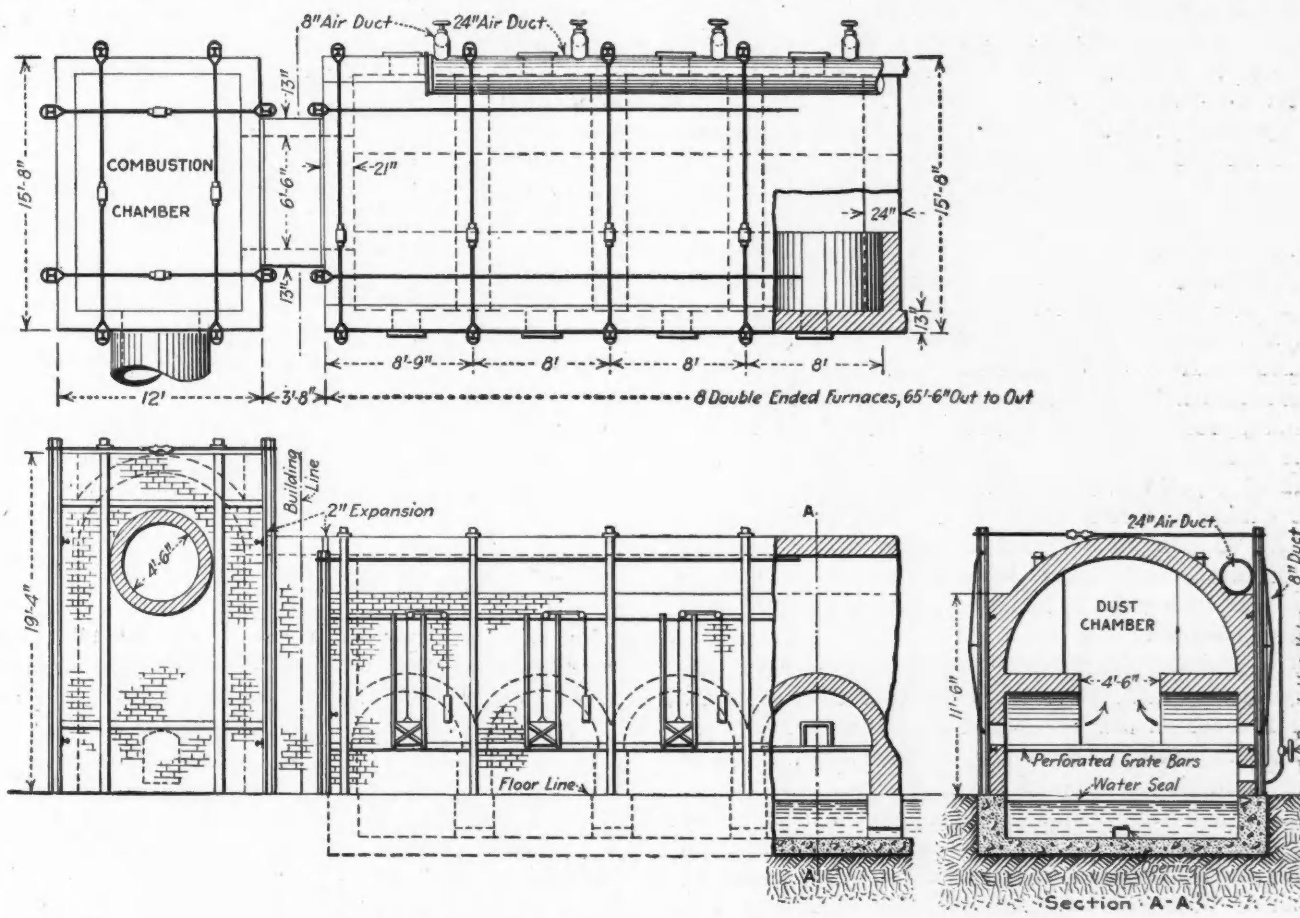


FIG. 3. WESTERN TYPE OF FURNACE AS BUILT AT LEADVILLE, COLO.

The Eastern practice is based on the assumption that zinc oxide is perfect at the immediate instant of its volatilization from the ore. The subjection of the zinc oxide to continued heat after its formation is held to be detrimental to the pigment, giving it a pink or brownish tint. In fact, the rapid removal of the zinc fumes from the heat zone produces the bluish-white tint that is commercially so desirable. To meet the conditions of this theory, the furnaces are built in individual units so that each charge will work independently of every other charge. Each furnace is a distinct unit by itself, and the only relation that one furnace bears to the other is that by their assembly sufficient heat will be held in the block to permit the operation to continue. The zinc fumes are drawn from each furnace as rapidly as possible and subjected to no heat other than that with which the zinc oxide was volatilized.

Clinker Should Be at a Bright Red Heat When Drawn from Furnace

The conditions imposed by the above theory result in working conditions of an intensive character. It is necessary to be ever on the alert and take advantage of every minute while the furnace is in operation. It is of prime necessity that each furnace be charged as rapidly as possible and that working conditions begin within the furnace without delay. The furnace must be gradually brought up to its working maximum with the idea in mind that the clinker will be at a bright red heat when drawn and, to accomplish this end, the clinker is drawn when it ceases to give off zinc fumes. This state is reached about the end of the seventh hour after the charging of the furnace. The entire process is operated virtually on a time schedule and in case of circumstances which would delay the operation of charging to any degree the method requires the forcing of the furnaces to bring them up to schedule.

The working conditions for the furnacemen under this method are particularly severe. When the clinker is at the bright red heat that is necessary, it is at its maximum of toughness and is extremely difficult to remove from the furnace. The severity of the work, coupled with the heat radiating from the furnace and clinker, produces working conditions of a drastic order. The element of time requires that the work be performed rapidly and the entire operation of drawing the clinker and recharging the furnace involves practically 45 min. of so much intensive and exhausting labor that usually no duties are imposed on the furnaceman during the 1¼ hours intervening until the next charge becomes due.

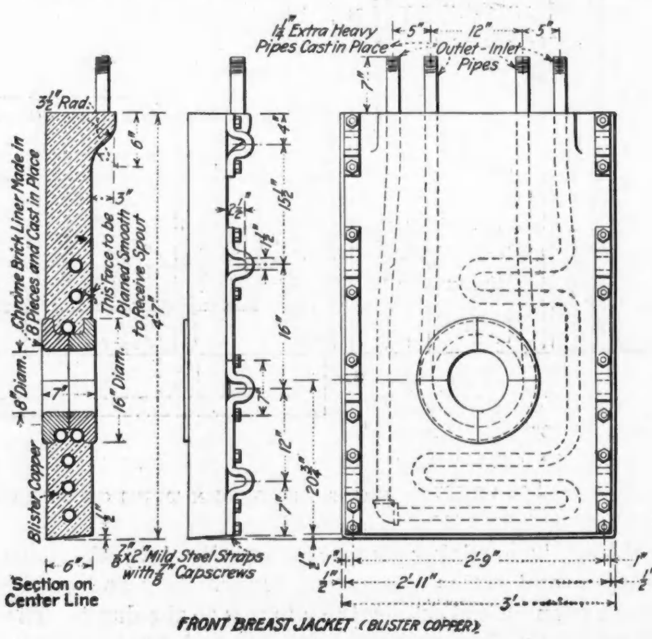
The Western operation is based on a plan of conservation of heat. The theory is that the heat from one furnace should be utilized in a direct manner in aiding the operation of the other furnaces which will thus maintain the heat of the entire block at its unit working temperature. It is held that the passage of the zinc fumes through a series of furnaces of equal temperature produces no ill effects on the resulting product. It is also held that this method of operation will maintain the equilibrium of the block and obviate the necessity of regulating the heat in the entire block through variation in the heat of individual furnaces. The working of the furnaces under this plan permits of a comparatively leisurely operation and increases the working efficiency of the furnacemen at least 100%. As the heat of one furnace is directly communicated to the next furnace, and so on, no furnace is dependent upon itself for working conditions. There is no necessity of forcing the charge by means of the air blast, and the charge burns out completely before it is removed from the furnace. The zinc content of the clinker is reduced to the last possible degree and the clinker itself, being comparatively cold at this stage of the operation, is easily removed from the furnace.

There is no good reason for the existence of the two radically distinct types of zinc-oxide furnaces. The Eastern type is fundamentally an anthracite burner and cannot produce commercial zinc oxide without the use of a smokeless fuel. Its operation is difficult because of the trouble in holding a constant degree of heat. Its method of operation is defined by its structure and the resulting conditions for labor are most severe, tending to increase cost.

The Western type may be styled a universal furnace. It can be operated on various grades of fuel and can produce commercial zinc oxide not only from anthracite and other smokeless fuels but also from semi-bituminous coal. It will produce a clinker lower in zinc than the Eastern furnace and the finished product of zinc oxide will be of equal quality. There is no trouble in conserving the heat, and the labor conditions are such that except in extremely hot weather no trouble is experienced in training men for the work. Its range of operation is greater and more flexible and permits a wider field of successful operation than can be accomplished under the limited conditions imposed by the Eastern type of furnace.

Chrome-Brick Bushing for Water-Cooled Copper Breast Jackets

The front breast jacket used in a 54 x 360-in. copper blast furnace, operated by the Granby Consolidated Mining, Smelting and Power Co. at Anyox, B. C., required frequent replacing and was a continual source of annoyance. The jackets used were made of converter copper cast around 1¼-in. extra-heavy cooling pipes. As

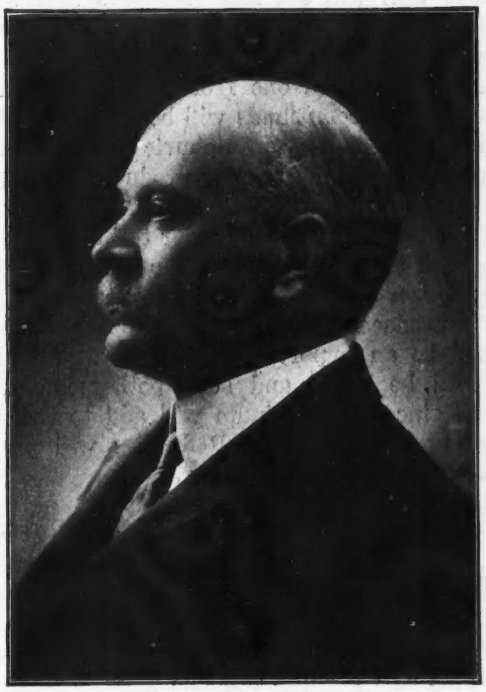


CHROME BRICK BUSHING IN GRANBY BREAST JACKET

a large amount of low-grade corrosive matte had to be handled, the life of such breast jackets was of short duration at the Granby works.

To obviate this, chrome-brick liners were inserted around the connection hole as shown in the accompanying sketch. This chrome-brick bushing protected the jacket from the cutting effect of the matte and gives an almost unlimited life to the breast jacket if the chrome brick be renewed whenever the furnace is down for general repairs.

A Group of Distinguished Metallurgists



ROBERT C. STICHT

WILLIAM WRAITH

JAMES HEGGIE

FOREST RUTHERFORD

Copper Metallurgy of the Next Generation, a Forecast

By EDWARD P. MATHEWSON*

A prophetic suggestion of conditions that will confront the future metallurgist. He will be replaced by the industrial chemist who will simplify processes and increase recoveries. "Labor problem" of today to be solved by more democratic management with "Brains, Capital and Labor" as partners.

WITHIN a very few years, unless all signs fail, the copper metallurgist will be replaced by the industrial chemist or the chemical engineer. A great advance has been recorded in copper metallurgy during the last 30 years, but still greater achievements will soon be chronicled.

The first great change that will take place will be the substitution of electricity for all other forms of power and also for carbonaceous fuel in the smelting of the ore except in those cases where carbon reduction is necessary. The electricity will be generated either at hydro-electric plants or at the coal mines.

The electrification of the Butte, Anaconda & Pacific Ry. and the Chicago, Milwaukee & St. Paul Ry., in Montana, has been accompanied by such a great financial saving that as soon as the great war is over the attention of the whole world will be called to the electrification of its railroads. In the East there are several examples of electrified railway terminals. Coal mines even now could be used as generating stations for electrical power. Electricity is transmitted 300 miles in any direction without great line loss, so that generating stations at mines 600 miles apart would solve the problem. It is not too much to expect that electricity will be transmitted 1000 miles without serious loss. Today there are known coal deposits at sufficiently frequent intervals across the American continent to permit the above scheme to be carried out.

Another important discovery will doubtless be made, namely, a method of converting heat directly into electricity. Then electricity will be by far the cheapest source of power and will be applied in all branches of copper metallurgy.

The advocates of conservation will soon put a stop to the present wasteful system of hauling coal to haul coal. All railroads will be electrified. The next step will be to discover the method of really harnessing the lightning. The apparatus required will be simple and the amount of power available tremendous.

In metallurgy proper the complication of processes now in use will be discarded and the model smeltery of today will soon be regarded as a crude and wasteful affair. One simple operation will extract the metal from the ore and put it in the form of matte which will then be treated chemically for the extraction of all its constituents. Of course, in many localities even the smelting operation will be omitted and the ore treated chemically from the start. In very favored instances the ore will be treated in place.

The wire-rope tramway will disappear and ore will be transferred from mountain side to smeltery by giant aëroplanes that will act like enormous hawks seizing their prey and carrying it away in their talons. In those plants where smelting is practised all gases will be purified, separated one from the other and saved. Nitrogen and its compounds will be most important by-products of the smeltery. Sulphuric acid and condensed sulphur dioxide will be regular products of every large plant. The farmer will welcome the smeltery to his locality for two reasons: In order to bring him a good market close to the farm for his product and to make cheap fertilizer available, for the smeltery will soon be the chief producer of complete fertilizer, of which arsenic will be an important constituent. All the rare metals will be saved and such bothersome, common metals as zinc and aluminum will add to the revenue of every up-to-date plant. Refineries will preferably be built near the source of power.

The labor question will be largely solved. Capital will be considered as "cold-storage labor." It will not regard labor as the hired servant, neither will labor regard capital as its slave. There are three important factors in each industrial enterprise: "Brains, labor and capital." Some one is said to have asked Andrew Carnegie which of the three was the most important, and the canny Scot replied by asking, "Which is the most important leg of a three-legged stool?"

These three elements will be regarded as partners As an indication of what is coming, numerous profit-sharing schemes may be cited today and in some cases labor is even represented in the local management of industries. Labor is surely going to have just as much to say as capital on the board of directors. The brains (technical, managerial and financial) will probably hold the balance of power.

Boards of directors will be such in reality and not only in name. Dummies will be absent from them. The true state of affairs will be known to every one on the board and thus to every one connected with the establishment. With perfect frankness in these matters a real democratic management and set of employees will result. In this way the labor agitator will be dethroned. The company's interest is the interest of every employee, and the millenium is at hand. Joking aside, there is no doubt that the labor problem will be solved along some such lines as above. Capital will have to be content with smaller returns.

Taxation will have to be regulated in such a manner as to keep capital employed. It may be necessary that a provision be made whereby excess labor can be used in Government enterprises, public works, etc. With this provision or safety valve for the labor of the country, prosperity will reign and we shall truly have a "government of the people, by the people and for the people." If we are not happy then it will be our own fault.

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Metallurgy of Antimony*

By K. C. Li†

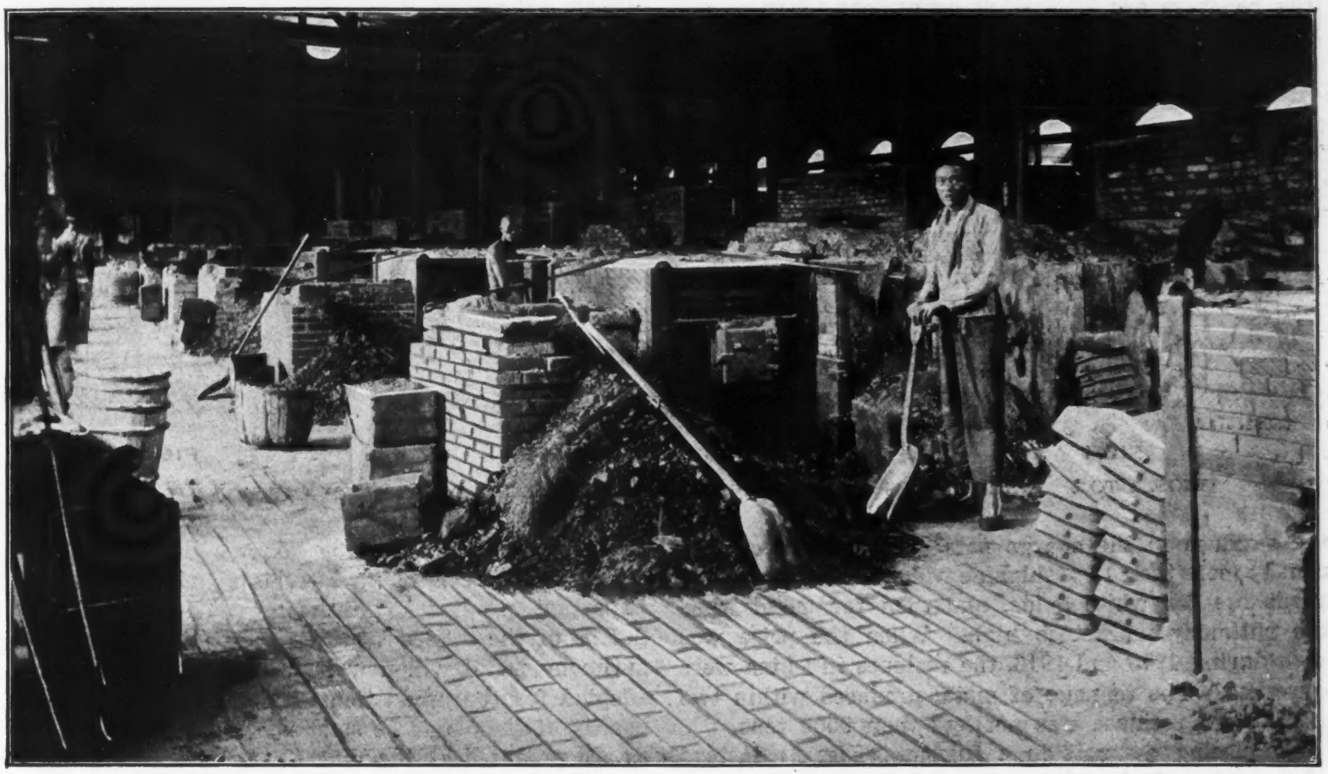
Production of "antimony crude," antimony oxide and regulus is described together with the developments of the Herrenschmidt process as used in China. The principal types of furnaces are illustrated.

STIBNITE, Sb_2S_3, antimony sulphide or antimony glance, is the chief ore from which antimony is extracted. The other ores, such as cervantite, kermesite, etc., occur only in small quantities in nature and are generally mixed with the stibnite before smelting. Up to the present, dry methods of extraction have proved most successful and are generally adopted. The more or less pure sulphide of antimony is called antimony needle or antimony "crudum" while the refined metal is called "antimony regulus."

One of the first and simplest steps in the smelting of antimony is the process called "liquation" of crude antimony. Ores containing over 90% sulphide are considered crude and receive no further treatment. Ores containing less than 90% and more than 40% sulphide are converted into crude antimony by means of the liquation process. Ores to be treated by this process should not be crushed too small, walnut size being the most convenient. If the ore is too large the heat will not penetrate effectively, and the same thing results if the ore is finely powdered and packs closely together. Ores containing less than 40% sulphide are used for producing regulus direct.

In the liquation process it is important to maintain the proper temperature, which is a red heat. Any increase of temperature leads to volatilization of the sulphide, whereas any decrease results in too much sulphide being left in the residue. Liquation may be carried out either by (a) intermittent working in pots, or (b) continuous working in tube furnaces or in reverberatory furnaces.

In China the former is the usual practice although it is generally supposed to be less efficient than continuous liquation. In the first method the smelting is done in pots which may be heated by actual contact with the fuel in the furnace or by the flame only. Pot liquation is simple and can be carried out easily at the mine. With rich ores and cheap fuel it is a satisfactory method. In China the liquation is carried out in a narrow furnace built of ordinary brick, each furnace containing two pairs of pots or crucibles. One pot sits above the other and the ore is charged into the upper pot. The heat liquates out the sulphide, which trickles through one or two ½-in. holes in the bottom of the upper pot into the lower or collecting pot. When sufficient of the molten sulphide has accumulated in the lower pot, it is ladled out into molds. Each pair



REVERBERATORY FURNACES OF WAH CHANG MINING AND SMELTING CO., CHANGSHA, CHINA

Sixteen of these furnaces are used to reduce the antimony oxide produced by the modified Herrenschmidt process. In the foreground on either side of the firebox are the first and second slag skimmings. The first slag skimmed is discarded; the second slag—at the right—is saved and retreated. On top of the furnaces are piled for drying the oxides saved from the scrubbing towers

*Excerpt from a paper entitled "Antimony, Its Metallurgy and Uses," read before the American Institute of Metals and reprinted from its "Journal," Vol. 11, No. 1, with additional illustrations and descriptions, supplied by the author.

†Mining engineer and metallurgist, Woolworth Bldg.; representative in New York of the Wah Chang Mining and Smelting Co., Ltd., Changsha, China.

of crucibles is fired independently, being separated from its neighbor by a partition wall. The lower pot is embedded in the ashes so as to avoid the full temperature of the furnace. The pots used are manufactured locally and last from 300 to 360 hours according to the labor conditions. The Chinese evidently consider that the advantages possessed by this method more than outweigh the disadvantages and inefficiency of intermittent working. The furnace (Fig. 1) is cheap and easy to build; the operation requires but little skill or experience.

At different places in Germany, Hungary, and France the liquation process is conducted in a still more primitive fashion. The pots are heated by being placed on the fuel in an open fire. The upper or charging pots are made of fireclay and are of varying sizes which hold from 10 to about 40 lb. The lower pots or receivers are made of burnt clay and are deeply embedded in the ashes of the fire. The pots are arranged in rows, each row being separated from the next by means of a brick wall. The space around the pots is packed with fuel. The receivers are emptied at convenient intervals and top, tapering to about 7¾ in. at the bottom. The tube walls are approximately ¾ in. thick. In the side of each tube is a small hole through which the residue can be removed. During working, these holes are closed with a clay plug. Underneath the tubes are little chambers containing the receiving pots which may rest on the floor of the chamber or may be placed on a carriage provided with wheels. The charge for each tube is about 5 cwt., a charge requiring about three hours for complete liquation. If coal is used, the fuel consumption is about 65% of the sulphide production; that is, 65 cwt. of coal is burnt in securing 100 cwt. of crude antimony.

Continuous liquation is sometimes carried out in ordinary reverberatory furnaces with a taphole placed at the lowest point in the bed for tapping the molten sulphide. The advantages are: (1) Less expense for fuel; (2) less labor required; (3) furnaces require fewer repairs; (4) large quantities of sulphide can be produced in a short time. The disadvantages are: (1) Cost is heavy; (2) there are heavy losses, due to volatilization during the operation. The volatilization

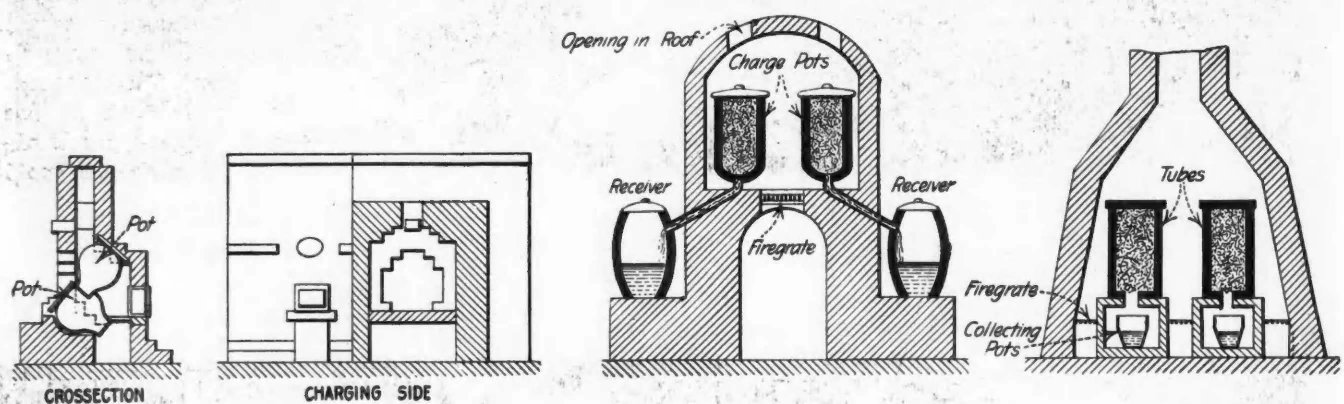


FIG. 1 FIG. 2 FIG. 3

FIGS. 1 TO 3. EARLY TYPES OF LIQUATION FURNACES FOR PRODUCTION OF ANTIMONY CRUDE

the residues in the charge pots are found to contain usually more than 12% sulphide which is treated as low-grade ore for white oxide, and then for metal when the antimony market is high. When the price was high during 1915 and 1916, the residues in China were reworked. The tonnage of metal produced within two years from residues was not less than 9000 tons.

By placing the pots in a furnace (Fig. 2) instead of in an open fire, heat is conserved, fuel is economized, and it is possible to work with lower-grade ores. The pots containing the charges are placed alongside the fire grate and the receivers are placed either directly below the bed of the furnace and surrounded by sand, or, better still, they are placed outside the furnace altogether and connected by clay pipes to the bottom of the charge pots. The advantage of the latter method is that the receivers can be emptied whenever necessary without interrupting the working of the furnace.

It has already been stated that intermittent working is expensive in fuel and uneconomical in results. Better results are obtained by the adoption of continuous working in tube or reverberatory furnaces. The tube furnace (Fig. 3) is built of brickwork, the inside being firebrick. There are three fire grates completely surrounding the tubes which are arranged in groups of four, the tubes are over 3 ft. high and are 10 in. in diameter at the

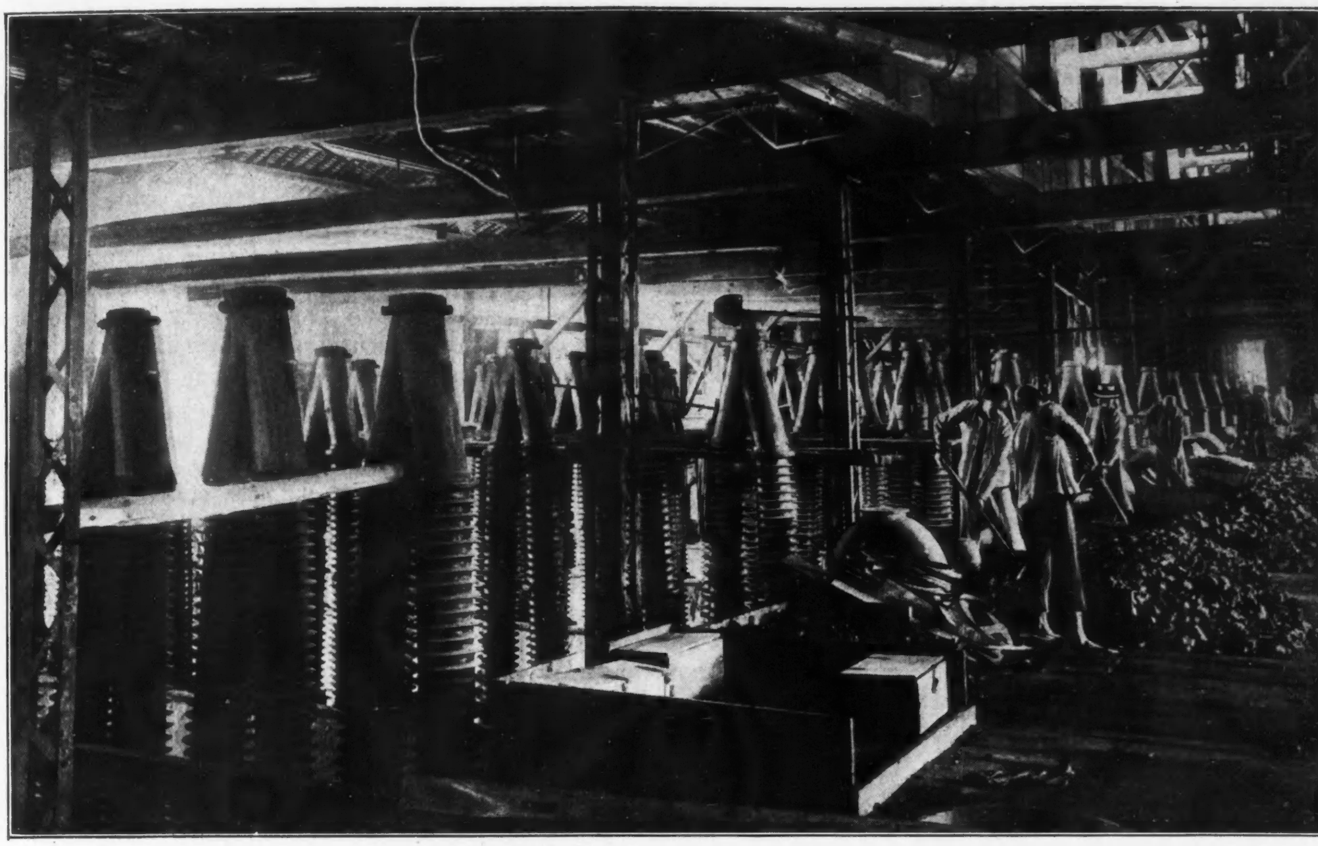
can be offset by using the Herrenschmidt condenser.

In commerce, antimony regulus or metal is the most important product of antimony smelting, and some details of the different processes in use for producing antimony metal will now be considered. The method adopted for the production of metal depends upon the quality of the ore to be smelted. Low-grade ores, such as are produced by the Wah Chang Mining and Smelting Co., of Changsha, China, cannot profitably be smelted directly into metal. Such ores must first be converted into oxides and then reduced in reverberatory furnaces. On the other hand, rich ores may be converted into metal by direct methods although in China it is a more common practice to convert the richer ores into a crude form, oxidize it into oxide in reverberatory furnaces and then reduce into metallic antimony.

As low-grade ores are more plentiful than rich ores, the process of oxidizing the ore and then reducing the oxide is the more important and should be considered first. When antimony ore undergoes an oxidizing roast, the product is either the stable tetroxide or the volatile trioxide. If the latter is obtained, the roast is called a volatilizing roast.

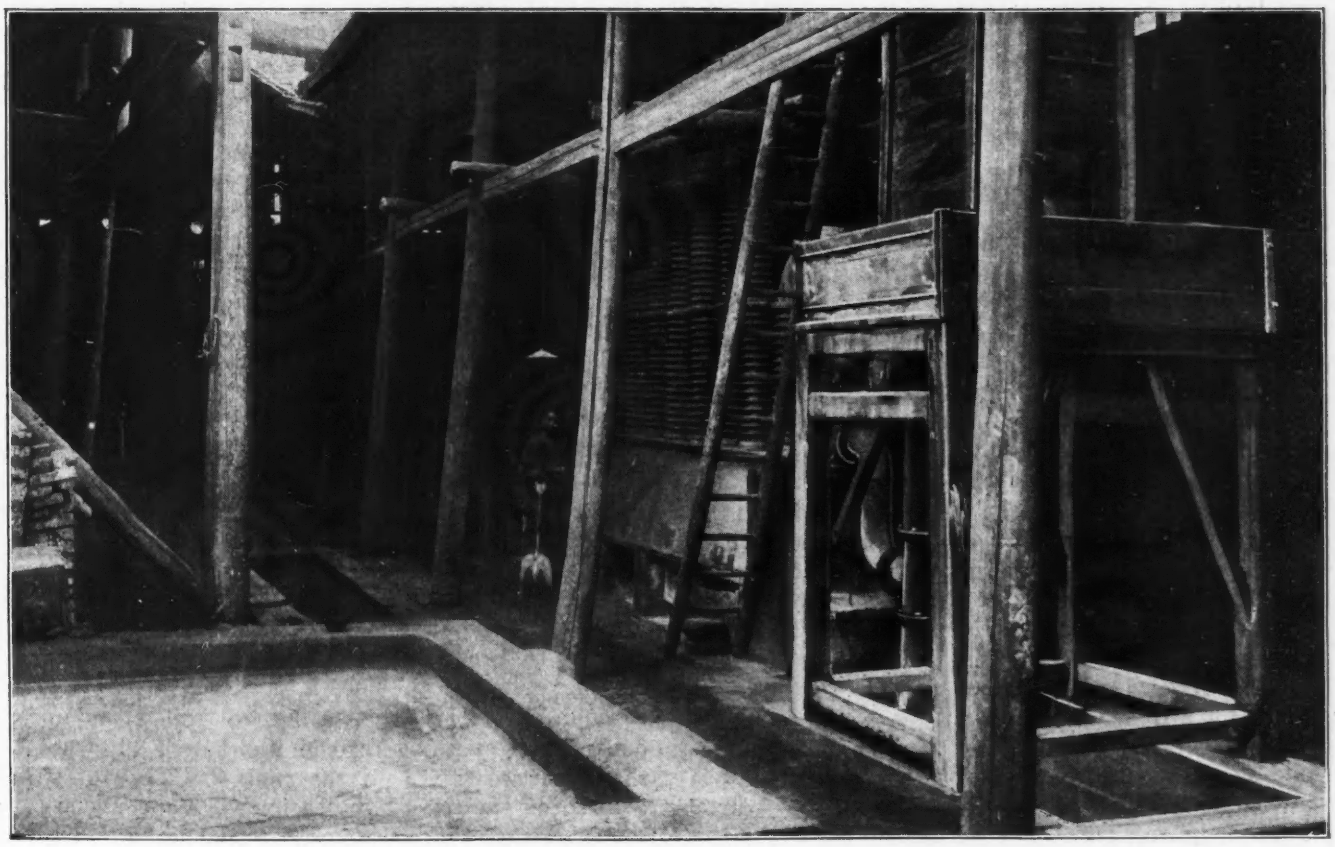
When antimony glance is heated a little over 350° C., the trioxide is formed and sulphur dioxide is given off.

$$Sb_2S_3 + 9O = Sb_2O_3 + 3SO_2$$



FEED FLOOR IN THE HERRENSCHMIDT DEPARTMENT OF THE WAH CHANG ANTIMONY WORKS

After considerable experimentation the Wah Chang Mining and Smelting Co. succeeded in placing the Herrenschmidt furnaces on a satisfactory operating basis. The furnaces are shaft furnaces, of which four are used, producing antimony trioxide, which is in turn reduced in reverberatory furnaces producing a high-grade antimony. The condensing pipes which form a prominent feature of this view are shown from a slightly different angle in the lower illustration. The ores are fed by hand, with two men to each furnace. This plant is at Changsha in the Province of Hunan



CONDENSING PIPES AND DUST BINS OF THE HERRENSCHMIDT FURNACES AT CHANGSHA, CHINA

The antimony trioxide from the Herrenschmidt furnaces is condensed in the pipes and falls into the bin beside which the man is standing. The oxide is removed at intervals through the handholes, dropped into trays, then dumped into cars and taken to the reverberatory-furnace department. The gases and any uncondensed fume are passed through the scrubbing towers at the right

A part of the trioxide is further oxidized to the pentoxide, Sb_2O_5, which, combining with some of the trioxide, forms the tetroxide Sb_2O_4. The roasted material should consist chiefly of tetroxide but under ordinary conditions the product may contain antimony glass, undecomposed sulphide, etc. The proper temperature (about 350° C.) should be maintained and the charge must be prevented from fritting by constant and regular rabbling. The richer ores cause more trouble through fritting, and the presence of gangue is found to help in preventing fritting. The temperature should be raised toward the end of the roast, so as further to roast any remaining unoxidized sulphide. An ore properly roasted has an ashy gray color on cooling and should not frit in the furnace. Excess of air is, of course, necessary to produce the tetroxide, otherwise the volatile trioxide would be the product.

The roasting of stibnite for the production of tetroxide of antimony is now generally carried out in reverberatory furnaces provided with condensing apparatus. The furnaces are of two kinds: (1) Egg-shaped intermittent hand-rabbled furnaces; (2) long-hearth reverberatory furnaces also rabbled by hand, the charge being moved progressively from the cool or feed end as in the old hand reverberatory furnaces formerly used for roasting lead ores.

In the egg-shaped furnace (Fig. 4) from 5 to 6 cwt. of ore can be roasted in about six hours. The door

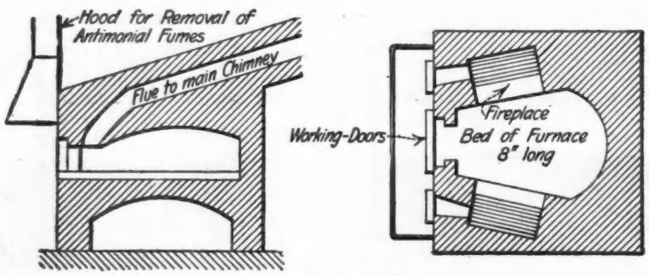


FIG. 4. FURNACE FOR ROASTING STIBNITE TO TETROXIDE

must be closed during the first two hours, but should be opened toward the end so that air is admitted freely and the workmen can rabble the charge well to prevent fritting. There is about 4–8% loss of antimony, depending upon the skill of the laborers.

In the German type of hand furnace there is a long bed of over 40 ft., having a width of 7 ft. 6 in. The furnace is capable of holding about 30 cwt. and there are working doors along each side. Five or 6 cwt. is charged in at one time and there are three charges in 24 hours. Each charge remains in the furnace about 40 hours. The charges are gradually worked from the cooler to the hotter parts of the furnace, and during the last two hours the heat is strong and the charges are rabbled almost continuously. Generally speaking, rich ores require a longer time to roast and freer admission of air.

Volatilizing Roasting

When it is desired to produce the volatile trioxide of antimony, recourse is had to the process of volatilizing roasting. In this method the admission of air is restricted and higher temperatures are required; the trioxide is readily formed by admitting steam at a high temperature, and at the same time the hydrogen combines with the sulphur in the stibnite to form hydrogen sulphide. The many advantages derived from adopting this method have brought it into general favor, and it is extensively used in one form or another both in France and China.

Its advantages are: (1) Arsenic oxide is more volatile than antimony trioxide and can be separated therefrom. (2) When the ores contain precious metals, these are generally found in the residues after volatilization. (3) It is the only method really suited to low-grade ores. (4) Condensation is more efficient and loss is almost eliminated. (5) Less fuel is required, as the sulphur in the ore can be utilized as fuel. (6) The condensed trioxide can be reduced to metallic antimony or it can be marketed as white oxide, without further treatment, to make paint, enamels, etc.

Important Developments of Herrenschmidt

Although Mr. Herrenschmidt was not the originator of the volatilization method it is not too much to say that his work in this direction was the most successful and resulted in great improvements in the method. I therefore feel justified in devoting most attention to describing the Herrenschmidt process and only glancing at others.

The method of producing trioxide of antimony by volatilization was first applied in 1844 and between that year and 1881 gradual improvements were effected. In 1881 Mr. Herrenschmidt patented a process which was the forerunner of his later and greatly improved processes.

A low-grade ore, say 20 to 25% antimony, was placed in a blast furnace or cupola with about 10% of coal. For an oxide ore larger percentages of coal were needed. In this furnace the ore was smelted to produce the volatile trioxide, which passed from the furnace into a condensing chamber directly connected to the furnace. Any trioxide not being condensed in the condenser passed along to a reservoir containing water and was there condensed. The air necessary for oxidation was drawn in by a fan seated at the far end of the water reservoir. Part of the oxygen drawn in combined with the sulphur in sulphide ores to form sulphuric acid.

The chief fault in this process was that the condensation was not as efficient as it might have been, and some years later, in 1903, the inventor took out another patent which was a decided improvement on his first one. He saw that the condenser must possess a large cooling surface, have great facilities for deposition of the oxide and also be able to subdivide the current of volatile oxide. All these were provided for in his 1903 patent. The arrangement of the apparatus is shown in Fig. 5.

The ore is charged into the furnace A where it is roasted to produce the oxide. A fan H draws the volatile oxide into the flues B as shown by arrows, then through a series of condensing tubes D. Any uncondensed oxide passing through the fan is absorbed by the water contained in the tank J. The tubes are covered on the top by the casings C while underneath the tubes are other casings E. It should be noted that the oxide has to traverse a tortuous path, and in so doing it comes in contact with a large cooling surface. The lower cases E are provided with inclined walls F which greatly facilitate the removal of the condensed oxide. The transverse section on the right of the main sketch gives a better idea of the tubing and the manner of removing the condensed oxide.

In 1908 Herrenschmidt again improved on his previous patents. The furnace was improved and the flues between the furnace and the condensing pipes were eliminated, so that the oxide passed directly from the furnace to the condensers. The casings over the tops of the pipes were discarded, and the pipes were joined together at their tops to form a series of inverted V's, as shown in the views of the Wah Chang plant at Changsha; in addition to these improvements two ventilators were introduced, and any volatile trioxide passing through the fans was condensed by coming in contact with water sprayed down at intervals through a coke tower. In 1909 the Wah Chang Mining and Smelting Co., Ltd., of Changsha, China, bought the patents of Herrenschmidt to convert low-grade stibnite ores and the residues from the liquation process into antimony oxide. The tonnage of antimony residues in Hunan Province, China, was large, but since this process was adopted the residues have been nearly smelted out, and may account for the recent great increase in production.

The oxide produced by the Herrenschmidt process is smelted with some fluxing materials in a reverberatory furnace to produce antimony regulus. The yield of

In Italy in 1907 a process was invented of which the chief features were the following: (1) Cold water runs continually along the roof of the condensing chambers. (2) Sacks are suspended in the chambers to catch the condensed oxide. (3) The smoke is passed through a chamber containing a number of filter bags and is there robbed of any volatile oxide which it may contain.

The last phase in the metallurgy of antimony is the production and refining of metallic antimony. Unrefined antimony metal is sometimes called crude antimony, but as such metal is never marketed, the name is unnecessary and might be confused with the liquated sulphide which is also commonly called crude antimony or more correctly antimony crudum.

Antimony metal may be obtained from the oxides (trioxide or tetroxide), antimony crudum, or by direct smelting of antimony ores. The first two sources are generally used. Reduction of the oxides is carried out either in reverberatory furnaces, water-jacketed furnaces, or blast furnaces. In reducing the oxide, care must be taken to guard against volatilization and also to prevent any unaltered sulphide remaining in the mass. A fusible slag composed of substances such as potash, soda, Glauber salt, etc., is provided, and being lighter than the metal, forms a cover which prevents volatilization, and at the same time dissolves any sul-

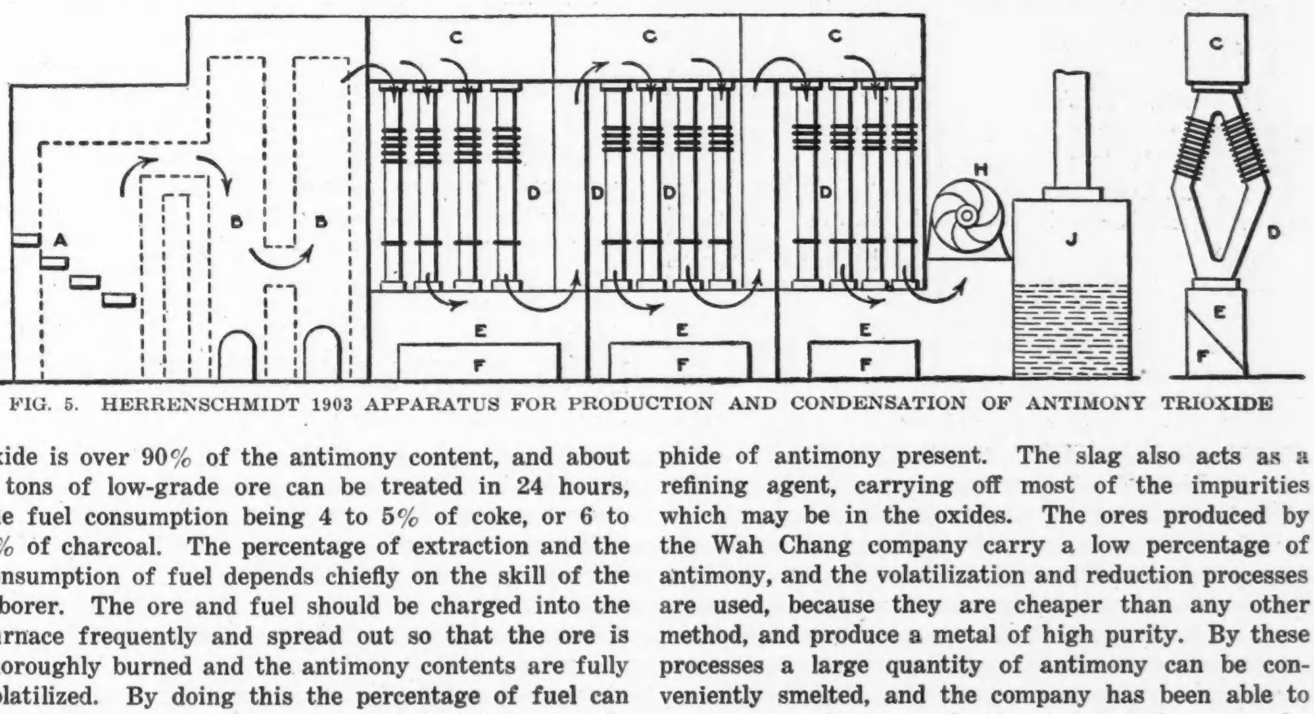


FIG. 5. HERRENSCHMIDT 1903 APPARATUS FOR PRODUCTION AND CONDENSATION OF ANTIMONY TRIOXIDE

oxide is over 90% of the antimony content, and about 6 tons of low-grade ore can be treated in 24 hours, the fuel consumption being 4 to 5% of coke, or 6 to 7% of charcoal. The percentage of extraction and the consumption of fuel depends chiefly on the skill of the laborer. The ore and fuel should be charged into the furnace frequently and spread out so that the ore is thoroughly burned and the antimony contents are fully volatilized. By doing this the percentage of fuel can be cut down to about 2 to 3% and the yield of oxide can be increased to 95 per cent.

In 1902 M. Plews patented a process for the production of antimony oxide. In his process the sulphide ore is crushed into small pieces and charged into an ordinary type, rotary furnace, which has been previously heated to a dark red. An oxidizing flame is then produced in the furnace, and the temperature increased to a light red. This temperature is maintained until all the volatile trioxide is given off. The oxide is drawn off into condensers by means of a fan in the usual way and the last traces of uncondensed oxide are absorbed by coming in contact with water. The oxidizing flame is obtained from coal or producer oil-gas.

phide of antimony present. The slag also acts as a refining agent, carrying off most of the impurities which may be in the oxides. The ores produced by the Wah Chang company carry a low percentage of antimony, and the volatilization and reduction processes are used, because they are cheaper than any other method, and produce a metal of high purity. By these processes a large quantity of antimony can be conveniently smelted, and the company has been able to increase greatly its production to meet the extra demands for antimony created by the present war.

Reduction with Reverberatory Furnaces

The reduction of ores in reverberatory furnaces is simple and easy to control but is attended by heavy loss of antimony and is seldom used except for rich ores and cheap fuel. The loss of metal is generally about 20% and may be even 30 to 40% with careless working.

Oxides mixed with oxide ores, liquation residues, antimonial flue dust, etc., are charged into reverberatory furnaces having an egg-shaped bed. The dimensions of the furnace (Fig. 6) are: Length about 8 ft.; width in center, 5 ft. 3 in.; width at bridge, 3 ft. 4 in.; height of bridge, 1 ft. 4 in. At the deepest part of the bed is a hole through which the metal is tapped. An 8-in. flue leads into condensing chambers about 400 ft. long. The antimonial vapor passes into these chambers and is there deposited. The condensate obtained from the chambers may contain as much as 50% of antimony.

The furnace charge consists of about 500 lb. of roasted ore, oxidized ores, flue dust, etc., together with about 100 lb. of flux, composed of salt, soda, about 70 lb. of ground charcoal and sometimes a small quantity of Glauber salt. It is also found to be good practice to re-melt about 300 lb. of slag from previous charges. The flux is charged into the furnace first, and when it is melted down and all boiling or agitation of its surface has ceased, the other materials are charged into the furnace, about 40 lb. every 15 or 20 min. The charge is then well stirred, and the scum produced is drawn off. After the last charge has been put in, the temperature of the furnace is raised and kept up until the process is completed.

During the smelting the charcoal acts as a reducing agent, robbing the antimony of its oxygen, while part of the soda combines with the sulphur and the remainder helps to form a slag with the gangue. Any other metals present are carried into the slag, as sulphides, by the action of the sulphide of soda which is produced through the reduction of the Glauber salt by the charcoal. Common salt serves the same purpose by carrying foreign metals into the slag as chlorides. The fuel consumption is somewhere between 5 and 6 cwt. per charge and the loss is about 14 to 15%. When considerable antimony sulphide is present, a little iron or iron slag may be added to assist in reducing the sulphide.

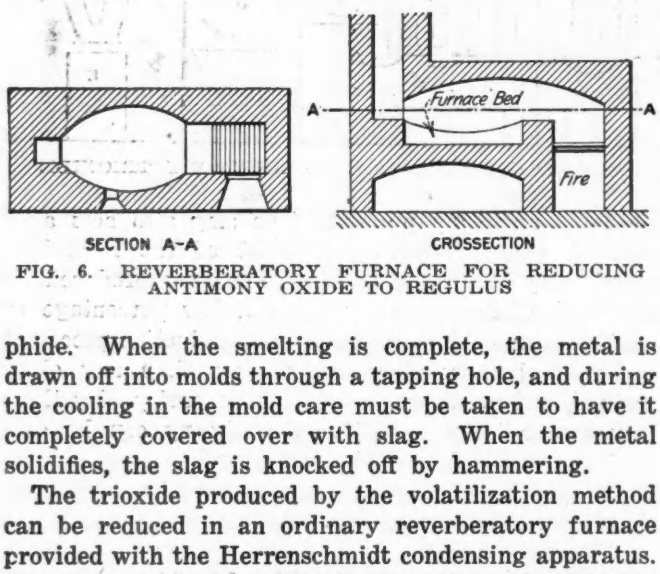


FIG. 6. REVERBERATORY FURNACE FOR REDUCING ANTIMONY OXIDE TO REGULUS

When the smelting is complete, the metal is drawn off into molds through a tapping hole, and during the cooling in the mold care must be taken to have it completely covered over with slag. When the metal solidifies, the slag is knocked off by hammering.

The trioxide produced by the volatilization method can be reduced in an ordinary reverberatory furnace provided with the Herrenschmidt condensing apparatus. The furnace is first heated, then charged with the following: Ten parts of the trioxide; 6 parts of the sulphide (crude); 1 part of carbon (charcoal or anthracite). The charge is thoroughly rabbled after about six hours in the furnace and the metal separates out from the slag and is soon ready for tapping into molds. The "starring" of the regulus is done in the mold. A purifying mixture, composed of 6 parts of carbonate of soda and 4 parts of antimony trioxide, is melted down in a small chamber at one end of the reverberatory furnace. When the metal is ready to be tapped some of this molten mixture is poured into the molds to be used. The regulus is then run into these molds, and the purifying mixture, being lighter, immediately comes on top, forming a cover over the regulus. When the metal solidifies, any of the mixture remaining on top is removed by hammering.

Reduction of roasted ores may also be carried out in water-jacket blast furnaces. The ores, having been first roasted in a reverberatory furnace, are charged into a shaft furnace with three tuyeres. A fluxing charge is added, and after reduction is complete the metal is drawn off. The metal obtained is by no means pure and requires to be further refined.

Herrenschmidt suggests that the trioxide could be reduced in a water-jacketed furnace in the following manner. Balls, about the size of an egg, are made up of 82% trioxide of antimony, 12% carbon and 6 to 7% carbonate of soda. These balls, mixed with 5 to 20% coke, are charged into the furnace and there reduced.

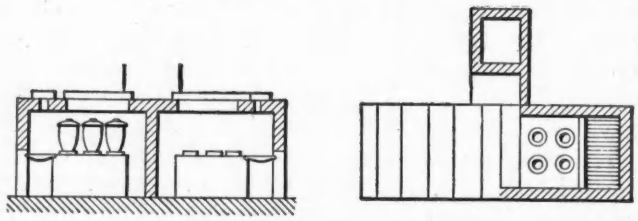


FIG. 7. FURNACE USED FOR REDUCTION IN CRUCIBLES

The loss of oxide due to volatilization is considerable but may be recovered by using the Herrenschmidt condensers. The metal obtained is impure and must be re-melted, either in a crucible or a reverberatory furnace, in order to refine it.

Reduction in crucibles is a method sometimes adopted when the ores are rich, or when antimony crude or volatile oxide is used to produce the metal. Large quantities cannot be treated and the cost is high. Herrenschmidt claims to have a process of reduction in crucibles, in which it is possible to smelt and refine or "star" the metal in one operation. Balls consisting of antimony oxide, powdered anthracite, carbonate of soda and water are charged into crucibles contained in a furnace (Fig. 7) and reduced to regulus.

Antimony crude or antimony "needle" is frequently marketed and used for various purposes, such as vulcanizing rubber, match making and the manufacture of ammunition. As the market for crude is limited, it is necessary to convert the greater part of it into antimony regulus. This may be done in one or two different ways: (1) Converting the sulphide into antimony oxides and then reducing the oxides in reverberatory furnaces. (2) Direct smelting of the sulphide to metal, iron being added as the reducing agent.

The Wah Chang Mining and Smelting Co., having a monopoly of antimony smelting in Hunan Province in China, is in a position to obtain large quantities of crude from other companies that have no facilities for producing regulus. The Wah Chang company tried the direct method of reducing the antimony sluphide, but owing to its inconvenience and cost, this method was abandoned in favor of the first-mentioned method. The antimony crude is powdered and charged into a furnace where it is oxidized. The oxides produced are either the stable tetroxide or the volatile trioxide.

These oxides are reduced with the oxides obtained by the roasting of low-grade ores. In this connection it might be noted that the Wah Chang company has recently adopted a method for volatilizing roasting, which is claimed to be as good as the Herrenschmidt process. Instead of using the elaborate Herrenschmidt condensers two long, simply constructed condensing chambers are used. At first these chambers were not fitted with any baffle plates, and it was believed that the introduction of baffle plates would greatly increase the condensing efficiency.

Production by the Crucible Process

In the direct process of reducing the antimony crude the crushed sulphide or perhaps rich ore is charged into crucibles which are put in a crucible furnace. Iron is added and the sulphur, having a greater affinity for iron, combines with it to form iron sulphide, and antimony metal is left. The high specific gravity of the iron sulphide makes it difficult to separate the metal from the iron sulphide. This difficulty is overcome by adding sodium sulphate and carbon, which combines with the iron sulphide to form a fusible slag of low specific gravity. The iron is generally in the form of shavings, or turnings, and common salt may be used instead of sodium sulphate and carbon. In this process the chief losses are due to volatilization and to loss of metal carried away in the slag, and may amount to 35% or more. The metal produced is impure and must be remelted to refine and "star" it.

The extraction of antimony by wet methods is still a matter of academic discussion rather than practical application, and I shall therefore pass over these methods in the present discussion and conclude the metallurgy of antimony with a few words on the methods employed for refining the metal.

Refining of Antimony

The impurities generally found in antimony are sulphur, iron, arsenic, copper and lead. The latter occurs frequently as it is a common thing to find antimony and lead together in ore. Arsenic can be separated out during oxidizing, while the other impurities must be carried off in the slag. Copper and iron can be removed by the addition of antimony sulphide, together with soda or potash, or Glauber salt and charcoal. The addition of soda or potash also helps to remove sulphur by fusion, and converts arsenic into arsenate of soda or potash. It is somewhat difficult to remove the lead, and when antimony ores are found to contain a considerable percentage of lead, they may with advantage be smelted together with lead ores to produce hard lead.

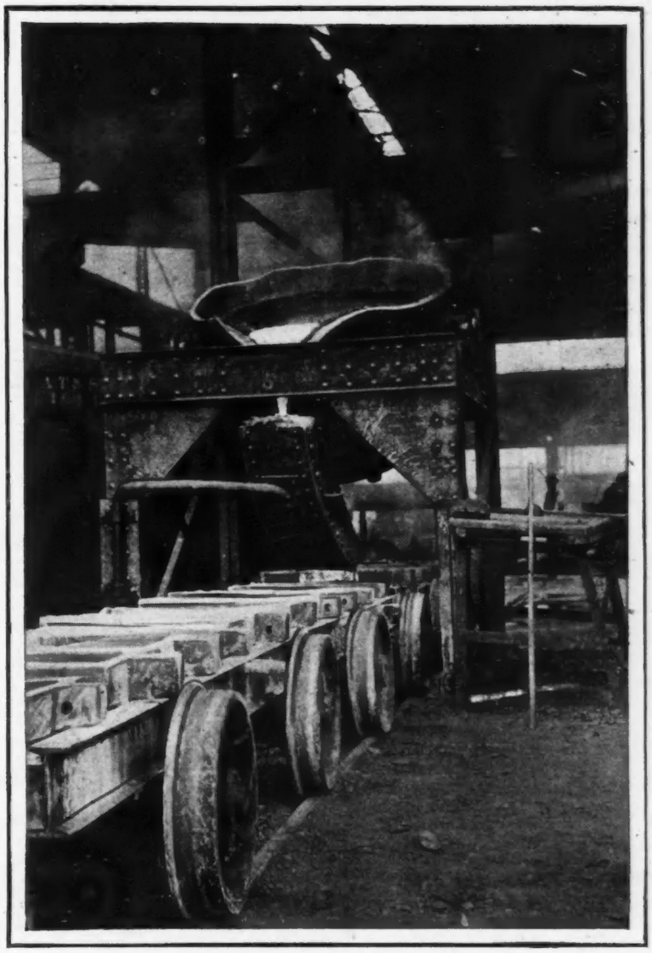
In the trade the purity of antimony is generally judged by the "starring." The "star" either does not appear or it is poorly defined if the antimony is impure, if the pure metal is exposed during solidification or if the slag covering sets before the metal does.

In the Herrenschmidt method, as used by Wah Chang company, the refining is practically done in the furnace, while additional refining and "starring" are accomplished by means of the starring mixture poured into the molds ready to receive the molten metal.

The metal obtained by the smelting processes adopted in Mexico, England, Hungary and other countries is so impure that refining must be carried out as a separate process. In England the impure metal is broken up small and charged into pots or crucibles which are placed close to the fireplace in a crucible furnace. Whenever the metal commences to melt, the purifying or "starring" charge is added and the flux must cover the metal completely. When fusion appears to be complete the mixture is stirred once with an iron rod and the charge is poured. The success of the operation is judged by the appearance of the slag which should be smooth and of a deep-black color.

Copper-Casting Apparatus

Like everyone else, the Consolidated Arizona Smelting Co., of Humboldt, Ariz., finds it almost impossible to get quick shipments on new machinery and, in order to handle the increased production, it built in 20 days the copper-casting machine shown in the accompanying illustration. The old copper trucks, which were originally used for handling the bullion direct from the converters, have been utilized in the new installation.



COPPER-CASTING APPARATUS BUILT IN 20 DAYS AT CONSOLIDATED ARIZONA SMELTERY

The principal points of interest are the pouring of the molds underneath the casting ladle—which keeps the bottom of the ladle hot and prevents heavy skulls from forming—and the loading of each charge direct into the car for shipping. The men operating the machine trim the bars. A chain block is used for tilting the ladle, and a winch for moving the trucks carrying the molds. The ladle is lined with hot slag once every 24 hours, and easily handles 100 tons of bullion per day.

Tennessee Copper Co.'s New Settlers

By T. W. Cavers*

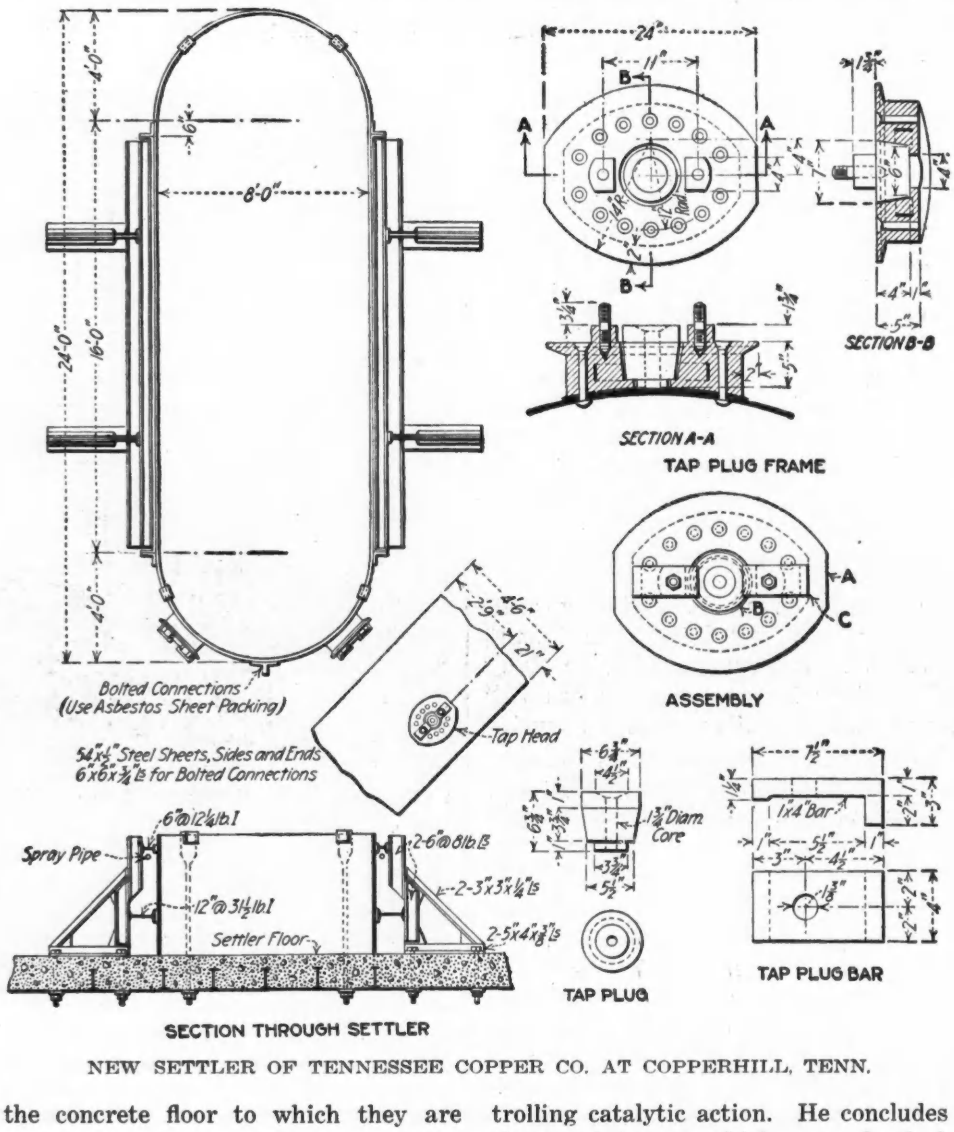
At the smeltery of the Tennessee Copper Co., Copperhill, Tenn., the round settlers formerly used have been replaced by narrow ones, 8 ft. wide and 24 ft. long, in the shape of a rectangle, 8 ft. by 16 ft., to which is added semicircular ends of 4-ft. radius. The straight part on the sides of the settler is a single sheet, stiffened by two I-beams and supported by knee-braces. The semicircular end next to the furnace is made in one piece; the other end is in two pieces, each having a tap head for removing matte.

All the pieces are joined together by heavy bolts through cast-steel angles which are riveted to the sheets. Sheet asbestos is used to make the joint tight. Half-inch steel plate is used throughout. The sheets rest on their edges on the concrete floor to which they are anchored.

A spray line runs completely around the settler and the water is caught in a concrete ditch in the floor. There are two slag spouts, each connected with a launder. The slag stream is cut off by a piece of clay on the end of a "dolly bar." The settlers are lined with a refractory brick, preferrably chromite. The bottom is about 16 in. thick and consists of four courses of standard-size brick, laid on the concrete floor, one on edge, one flat and then two on edge. The sides are built of 9-in. brick with the end of the brick tight against the steel. For the circular ends, No. 2 keys and 9-in. straights are used.

Tap heads and plugs are made of cast iron. The plug fits the round hole in the tap head; it is luted with retort cement and held in place by lugs and set screws. The tap head is cast around a wrought-iron or steel hoop to prevent cracking vertically when in use.

*Smelter superintendent, Tennessee Copper Co., Copperhill, Tenn.



NEW SETTLER OF TENNESSEE COPPER CO. AT COPPERHILL, TENN.

Theory of Contact Catalysis

Theory of contact catalysis was discussed by Prof. Wilder D. Bancroft, in a paper before the American Electrochemical Society, from the standpoint of adsorption upon the catalyst as the determining factor controlling catalytic action. He concludes that: (1) Only those substances which are adsorbed by a solid are catalyzed by it; (2) while the catalytic action of solids may be solely the result of the increased surface concentration in some cases, this is not always the only factor; (3) a solid catalytic agent may be considered as equivalent to a solvent and may therefore displace the equilibrium; (4) as a result of selective adsorption different reaction products may be obtained with different catalytic agents; (5) a catalytic agent tends to produce the system which it adsorbs the more strongly.

Raritan Copper Works at Perth Amboy, N. J.

The Raritan Copper Works is one of the world's greatest copper refineries. After preliminary furnace refining, the copper is refined electrolytically and finally cast into commercial shapes known as wire bars, slabs, wedge bars, cakes, ingots and ingot bars. Silver, gold, platinum, palladium, selenium and tellurium are obtained from the anode slimes; other byproducts are copper sulphate and nickel sulphate.

THE plant of the Raritan Copper Works is situated 23 miles from New York in Perth Amboy, N. J., at the mouth of the Raritan River. In addition to lighterage service to New York and the foreign steamship lines, the works has direct rail connection with the Pennsylvania, Central of New Jersey and Lehigh Valley railroads. Shipping facilities for incoming and outgoing material are thus unexcelled.

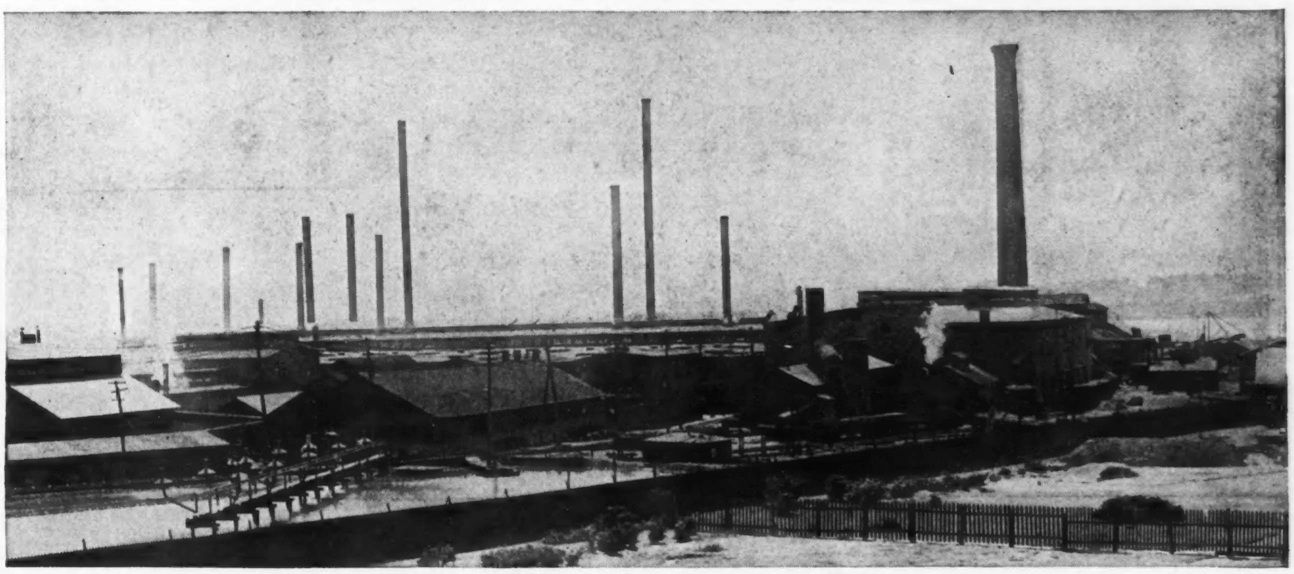
The plant covers an area of 40 acres and has a refining capacity of 40,000,000 lb. of copper per month. The materials received from the copper smelteries are all in the form of crude bullion, no ores being handled. Most of the copper received comes from Western smelteries. The greater part of the copper products of the Anaconda Copper Mining Co. of Montana and all of those of the International Smelting Co. of Tooele, Utah, the Inspiration Consolidated Copper Co. of Arizona, the Miami Copper Co. of Arizona, the Greene-Cananea Copper Co. of Cananea, Mexico, and the Pennsylvania Salt Manufacturing Co. of Natrona, Penn., is refined at this plant. In addition, copper is regularly received from the Rio Tinto, British Columbia, Copper Queen, and Arizona Copper companies and also from Japanese and other companies.

*Excerpts from a description of the Raritan Copper Works, published in connection with an exhibit of its products at the third "Exposition of Chemical Industries," Sept. 24-29, Grand Central Palace, New York.

The regular products of the plant include all commercial forms of refined copper, such as wire bars, ingots, ingot bars, square and round cakes, wedge bars, slabs and billets. The byproducts produced are refined silver and gold, platinum, palladium, selenium, tellurium, copper sulphate, and nickel salts.

Two grades of copper are produced. The highest, or "N. E. C." brand of copper, is probably as pure a commercial grade as any on the market. It has a high electrical conductivity and meets all requirements where copper of exceptional purity is desired. The second grade, "M. A." and "A. B. S." brands, is a pure ingot copper, and, while of too low conductivity for electrical uses, is exceptionally satisfactory for casting purposes.

Silver, gold, platinum, palladium, selenium and tellurium are obtained from the anode slimes resulting from the electrolytic treatment of the copper anodes. Silver and gold are ordinarily disposed of in the usual bar form; platinum and palladium as sponge. Selenium is produced in several different forms; namely, the red amorphous form, in powder; the vitreous form, in powder, sticks and half-pound cakes. Tellurium is made up into sticks and 1-lb. and 5-lb. cakes. A small proportion of nickel is found in most crude copper. In the process of electrolytic refining this accumulates in the electrolyte and is separated out and crystallized, at this plant, as pure nickel sulphate ($NiSO_4.7H_2O$).



VIEW OF THE RARITAN COPPER WORKS, LOOKING EAST

The furnace department, in which crude copper and electrolytic cathodes are melted and refined, contains six refining furnaces with an aggregate capacity of about 2,300,000 lb. of copper per day and five anode furnaces with a total capacity of about 2,000,000 lb. per day. Waste-heat boilers used on the furnaces generate a large part of the steam used in the plant.

Electrolytic refining of the anodes, received from the smelteries and produced in the anode furnaces, is carried on in two tank houses. No. 1 tank house contains 1800 lead-lined tanks and is capable of turning out

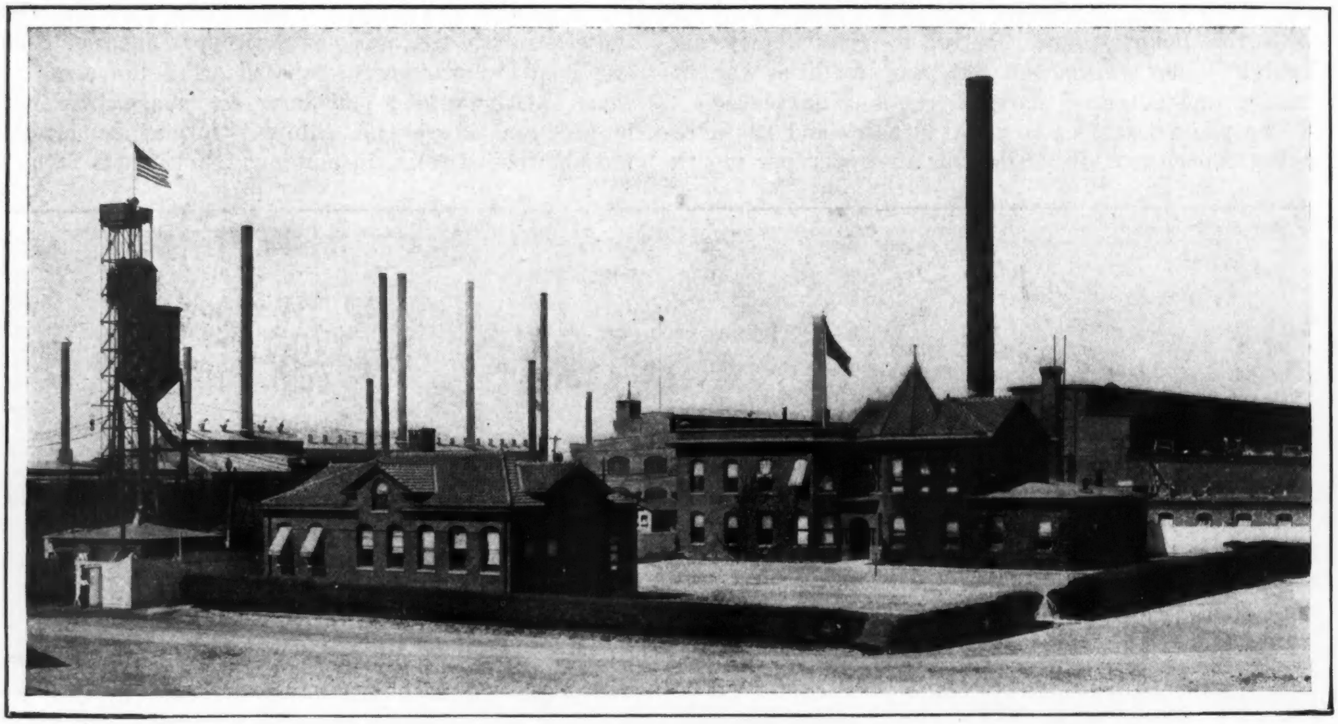
21,000,000 lb. of cathodes per month. No. 2 tank house, containing 1656 tanks, will produce 19,000,000 lb. per month. The electrolytic slimes resulting from electrolysis of the copper are worked up by fire and electrolytic methods. The silver and gold are parted electrolytically by the Thum and Mœbius systems. Facilities are also provided for recovering the other byproducts already mentioned. Power for refining and general uses is supplied from two power houses. The aggregate capacity of the steam- and electric-generating units is about 14,000 kw.

Electrolytic Refining of Copper

The electrical industry, which uses most of the copper output, requires a very pure grade which the fire-refining process cannot furnish; moreover, most copper ores carry traces of silver and gold which concentrate in the "blister copper" and are not recovered by fire refining. For these reasons practically all blister copper is refined by the electrolytic method. With two or three exceptions, all the copper refineries of the United States are situated on the Atlantic coast to facilitate shipping the finished material to Europe, for even in normal times the amount of refined copper sent thither far exceeds that consumed at home. Refining at this works may be divided into three stages: Melting the blister copper and casting into anodes; electrolysis and deposition of cathode copper of 99.98% purity; melting cathodes and casting into commercial shapes, such as wire bars for wire mills, cakes for rolling mills, ingots for the brass and alloy manufacturers.

The blister copper is delivered to the refinery in the form of slabs weighing about 300 lb. These are melted in reverberatory furnaces known as blister furnaces of 500,000 lb. capacity, the details of the operation being practically the same as in the refining furnaces to be described later. In this melting but little refining is attempted although some of the impurities are removed with the slag and the sulphur is practically eliminated. The copper is cast into anodes 37 x 28 x 1⅝ in., weighing about 500 lb. A typical assay of anodes follows: Cu 99.25%, Ag 70 oz., Au 0.25 oz., As 0.060%, Sb 0.052%, Ni 0.050%, Pb 0.053%, Fe 0.058%, Bi 0.003%, S 0.004%, Se, 0.008%, Te 0.038%, O 0.100%. Complete analysis would disclose traces of other elements.

The anodes are then electrolyzed in tanks in an acid solution of copper sulphate, usually 16% bluestone with 12% free sulphuric acid. The voltage is about 0.25 volt per tank. One ampere of current per hour deposits 1.186 grams of copper according to Faraday's law copper being divalent. The products of electrolysis are: Cathode copper, 99.98% pure; anode residues and slimes, and impure electrolyte. Of the usual impurities found in blister copper, the nickel, cobalt, iron, zinc and arsenic dissolve and foul the electrolyte, while the silver and gold, along with the rest, remain in the slimes and drop to the bottom of the tanks.



ADMINISTRATIVE BUILDINGS AND MAIN LABORATORY OF THE RARITAN COPPER WORKS
Small brick building in left foreground was used as the Anaconda laboratory before acquisition of the refinery by the Anaconda Copper Mining Co. Circular tank used for storage of ashes. In the background are shown the tank houses to the right and the furnace building to the left

At the Raritan works the multiple system of refining is employed. In this the anodes and cathodes in the tanks are connected in multiple, the tanks themselves being connected in series. The electrolytic tanks are of wood, 118 x 34 x 44 in., and are lead-lined. They are carefully insulated on glass and are so placed that any leakage of electrolyte may easily be detected. There are two tank houses, one of 1800 tanks and the other of 1656 tanks. Four circuits of 7000 amp. in each tank house give a current density of 18 amp. per sq.ft. of cathode surface. The tanks are arranged in nests of 11 cells each, the nests being so placed together so as to circulate the electrolyte in cascade through two tanks. The circulation of the electrolyte is maintained at the rate of 4 gal. of solution per minute per tank.

After leaving the lower tank in the cascade the solution drops to hot wells where it is reheated by means of steam coils to 60° C. and thence pumped to the top of the cascade. Tests have shown that the best conditions for the electrolysis is a circulating solution at 55° Centigrade.

Each tank contains 28 anodes and 29 cathodes. The anodes, each weighing 500 lb., properly spaced, are lowered together by means of a crane into the tanks. Between the anodes are then placed the cathodes, thin starting sheets of copper, 30 in. wide and 37 in. long, weighing about 8 lb. each. At the end of 10 days, with a current of 7000 amp., the cathodes have increased in weight to an average of 125 lb. each. They are then taken out of the tanks, carefully washed to remove adhering electrolyte and sent to the refining furnace for melting. A second set and later a third set of starting sheets follow the same procedure. At the third lifting of cathodes, 30 days from the time they were put into the tanks, the anodes of crude copper have so dissolved that only skeletons of the originals remain. These are known as scrap anodes.

Making Cathode Starting Sheets

The cathode starting sheets are made from blanks, called starting blanks, of hard-rolled, polished copper $\frac{1}{8}$-in. thick. These blanks become cathodes in regular electrolytic tanks, and in 24 hours so much copper has deposited on them that it can easily be stripped off in thin sheets, which, after being looped, become starting sheets. The copper deposits on both sides of the blank so that one starting blank makes two starting sheets. To prevent the deposited copper from adhering fast to the blanks they are covered with a thin film of grease or oil before electrolysis. They are grooved $\frac{1}{2}$ in. from the edges, the deposited copper parting readily along the groove, giving standard size starting sheets without trimming. After stripping the copper on the edges of the blanks the latter are oiled and again put in the electrolytic tanks, being thus in continuous use.

After the third lifting of cathodes, the solution is siphoned from the tanks. The scrap anodes are washed to remove adhering slimes and are sent to the blister furnaces to be recast into 500 lb. anodes. The slimes are then pumped to the silver department where the gold and silver are recovered in pure condition. The semi-rare metals, selenium and tellurium, are also extracted to an extent corresponding to the limited commercial demand for them. Small quantities of platinum and palladium concentrate in the slimes and are recovered here. The lead, bismuth and antimony are shipped as crude metal to lead smelteries for further purification.

The electrolyte is an acidulated solution of copper sulphate containing 4% Cu and 12% free H_2SO_4. The total impurities, such as Ni, As, etc., are kept below 2%. This is accomplished by purifying a certain percentage of the electrolyte each day. At the Raritan works this is done by a series of crystallizations, whereby the copper in the solution is recovered as "commercial bluestone" and sold as such. The nickel is recovered as high-grade nickel sulphate (single salts). The acid after the removal of the arsenic is used over again in the electrolyte.

The operation of a tank house requires constant vigilance. The power house delivers to the tank house a given quantity of current for which the tank house is supposed to furnish an equivalent weight of cathode copper. Theoretical figures are all based on Faraday's law, but short circuits, bad contacts and leakage of current all tend to lower the efficiency and are carefully watched. Most refineries obtain an efficiency of 90% based on power consumption.

The cathode copper, containing 99.98% Cu, absorbs, when molten, reducible gases, more particularly sulphur, to such an extent that the melting becomes a refining process, refining from the gases absorbed during the melting period. The presence of oxygen, or rather copper sub-oxide, greatly increases the solubility of these gases in cast copper and it is for this reason that from 0.03 to 0.08% of oxygen will always be found in commercial copper.

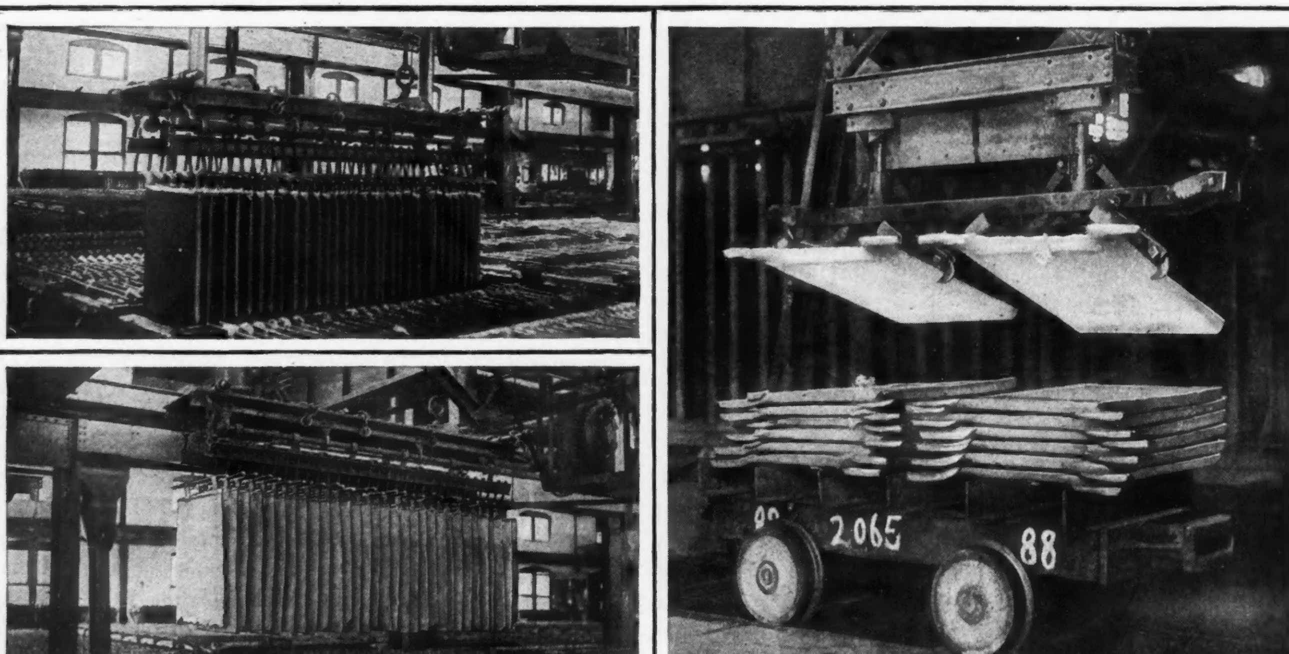
The copper is melted in large reverberatory furnaces of 225 to 250 tons' capacity. The furnaces in normal times are usually lined with magnesite bricks up to above the metal line, with silica-brick for roof and sides. The fuel is bituminous coal and the gases on leaving the furnaces are conducted through waste-heat boilers. The melting or refining operation may be divided as follows: Charging, melting, oxidizing, poling and casting. All operations are so conducted that it takes about 24 hours to work the complete cycle of a charge.

Charging was formerly done by hand, a laborious operation, but now all furnaces are charged with a charging machine. This picks up 40 cathode sheets, weighing about 5000 lb., at a time and puts them in the furnace much more compactly than could be done by hand, thus materially increasing the capacity. Charging usually takes two hours. The side doors are then closed, luted, and the fire increased to hasten the fusion of the copper.

In 10 to 12 hours so much copper is melted that the oxidation period can begin. In this period the molten copper is nearly saturated with cuprous oxide and brought to what is known as "set copper," containing from 4 to 5% of suboxide of copper. In this process all impurities are oxidized and all hydrogen, carbon monoxide and sulphur compounds removed. This is accomplished by blowing compressed air through iron pipes under the molten bath, also by "flapping" the charge. Flapping consists in striking the surface of the metal with the edge of the head of a rabble, in order to uncover the surface of the copper. The furnaceman watches the operation by taking button samples and observing the fracture, which is characteristic and well-defined in all stages.

After the charge is oxidized the slag formed is skimmed off, the bath covered with coke or charcoal, and the "poling" process begins. This consists of forcing the butt ends of green poles underneath the surface of the metal. This causes a violent action in the metal bath, and the carbon from the wood and coke quickly reduces the dissolved cuprous oxide. This operation takes two or three hours. When the suboxide of copper has been reduced to 0.3-0.6%, which can readily be told by the fracture of the button sample, the copper has reached the "tough-pitch" stage and is ready for casting.

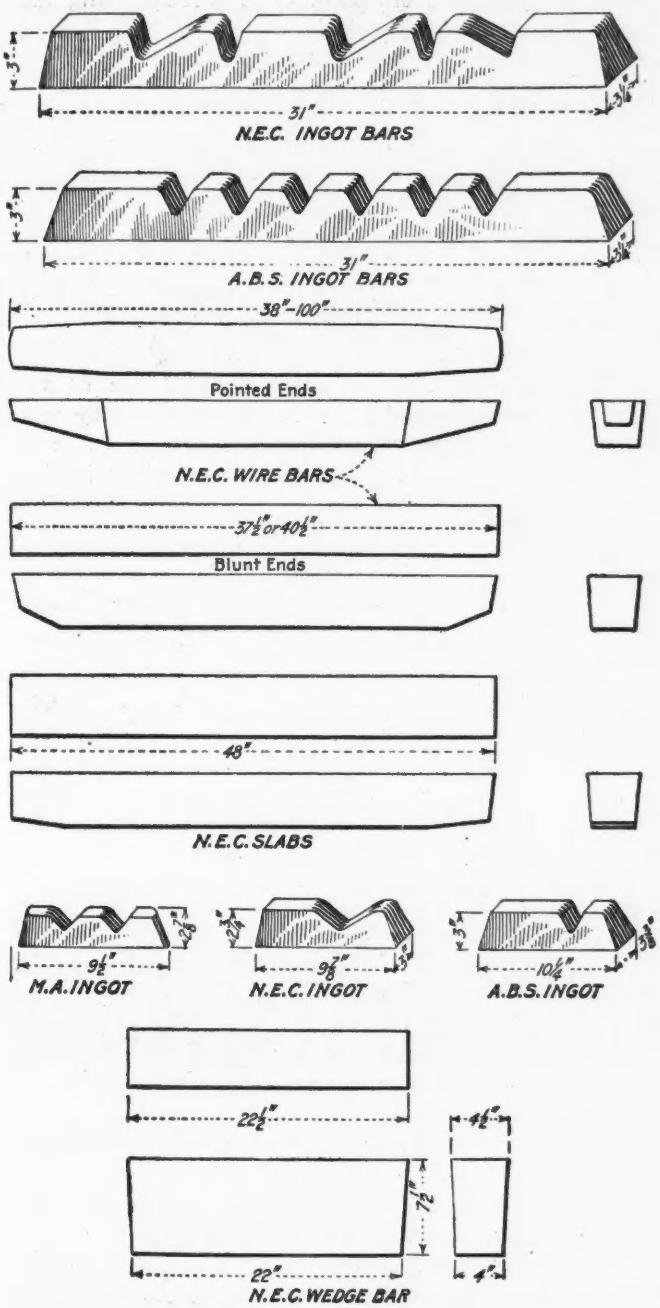
VIEW SHOWING THE INTERIOR OF EXTENSION TO NO. 2 TANK HOUSE



MECHANICAL HANDLING OF ANODES AND CATHODES AT RARITAN COPPER WORKS

Views on left show anodes (above) and cathodes (below) being conveyed by electric traveling crane, which raises and lowers entire anode or cathode contents of a tank in one operation. View on the right shows a mechanical device for loading anodes at the blister furnace

This operation consists of casting the molten copper into commercial shapes, wire bars, slabs, wedge bars, cakes, ingots and ingot bars. The molds, which are made of copper and sprayed with a bone-ash emulsion, are placed radially on a circular casting machine, known as the Clark casting machine. As the wheel turns around, the molds are filled with copper from the furnace. After the copper has set, the molds automatically tip, dropping the copper bars into a



COMMERCIAL SHAPES OF COPPER

water bosh which pickles the copper and gives it the characteristic red color. The bars come up from the bosh on an endless belt and, after weighing, are ready for shipment. A representative analysis of refined electrolytic copper would be as follows: Cu, 99.92-99.97%; O, 0.02-0.07%; Ag, 0.001%; Au, 0.00001%; S, 0.003%; Fe, 0.0035%; Ni, 0.0015%; As, 0.0015%; Sb, 0.0015%.

Through all furnace operations much slag is made, mainly an oxide slag containing 40-50% Cu. This is smelted in a blast furnace. The slag from the latter containing less than 1% Cu is granulated and used for filling purposes.

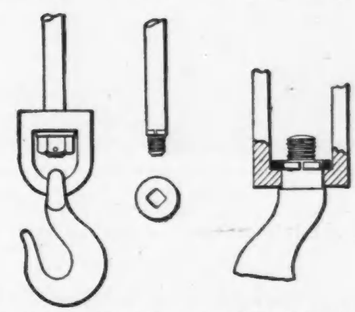
A variety of shapes suitable for different industrial purposes is made, and the illustration shows the general details. N. E. C. wire bars with pointed ends are made in 13 sizes and different weights vary from 135 to 770 lb.; minimum length of 38 in. up to a maximum of 100⅛ in.; widths of 3$\frac{21}{32}$ to 5⅜ in., tapering to widths at other end of 3$\frac{3}{16}$ to 4⅝ in.; depths vary from 3¾ to 5¼ in. The blunt-end type is made in two sizes, with weights of 135 and 175 lb.; lengths of 37½ and 40½ in.; widths, 3⅝ and 3$\frac{15}{16}$ in., tapering to 3⅛ and 3$\frac{7}{16}$ in.; depths of 3⅝ and 3$\frac{15}{16}$ inches.

N. E. C. slabs are made in eight sizes. The only length is 48 in., except in three special sizes, and the width varies from 3½ to 5½ in. The weight varies from 190 lb. for a 2½ in. thick slab of 5 in. width to 420 lb. for a 5 in. thick slab, of 5½ in. width. N. E. C. circular cake is made 20 in. in diameter with weights varying from 200 to 500 lb. N. E. C. wedge bars weigh 225 lb. and have a length of 22½ in., tapering to 22 in., a width of 4½ in. tapering to 4 in. and a depth of 7½ in. N. E. C. ingot bars of 70-lb. size and A. B. S. ingot bars of 76-lb. size both have a length of 31 in. N. E. C. ingots of 20-lb. size are 9⅞ x 2¾ x 3 in. A. B. S. 22-lb. ingots are 10¼ x 3 x 3⅜ in. and M. A. ingots, 16-lb. size are 9½ x 2⅞ inches.

N. E. C. billets are made in diameters of 4 in. to 8 in., nine sizes, with a length of 15 in. to 50 in. The weight varies from 93 to 583 lb. N. E. C. square cakes are made in 11 sizes, the minimum being 14 x 17 in., weighing 151 lb. for 2 in. thick slabs, up to size 45 x 45 in., 6 in. thick, weighing 3864 pounds.

Fastening Crane Hooks

To fasten light crane hooks securely is a necessity and the nuisance and danger in smelting or other operations of having the nuts unscrew and come off entirely may be overcome in the following manner.



FASTENING LIGHT CRANE HOOK

A washer of annealed tool steel, faced true on both sides and with a square hole that fits snugly on the squared end of the hook stem, can be placed under the nut. The nut is secured by a small pin which prevents loosening.

North Butte Mining Co., during 1916, produced 560,673 wet tons of ore and 120 wet tons of precipitates and smelted 544,365 dry tons of ore and 89 dry tons of precipitates which yielded 24,498,181 lb. Cu, 1,047,063.56 oz. Ag, and 1,712,004 oz. Au. There was also mined 1625 tons of zinc ore which yielded 412,953 lb. Zn and 2510 oz. of silver. Copper was sold at the average price of 23.295c. per lb., silver at 66.-371c. per oz., gold at $20 per oz. and zinc at 10.674c. per lb. Four dividends, amounting to $1,075,000 were paid during the year.

Smelting at Old Dominion Works, Globe, Ariz.

Improved smelting conditions were established at the Old Dominion reduction works this year, when it was decided to ship its concentrates and flue dust to Miami and smelt in the blast furnaces at Globe only the oxide ores from the company's mines and such custom ores as could be secured in the district. The necessary sulphide ore is brought from Bisbee.

SMELTING conditions at the Old Dominion works at Globe, Ariz., were much improved when, in May, 1917, the company began shipping all its concentrates and flue dust to the reverberatory-smelting plant of the International Smelting Co. at Miami, Ariz. In its blast furnaces at Globe the Old Dominion Co. smelts the oxide ores of the company's mine and such custom ores as are obtainable in the district, a supply of sulphide being shipped from the Calumet & Arizona mines at Bisbee. This plan has eliminated all fines from the blast-furnace charge and made conditions much better for blast-furnace operations, with the result that the furnaces can be driven faster, two furnaces smelting approximately the same tonnage that three did when the jig and table concentrates were smelted at Globe.

The smelting ore as hoisted from the mine is dumped from the skips into a receiving pocket, conveyed thence by belt conveyor to the crushing plant, and passed through a gyratory crusher, where it is broken to 3½-in. size, elevated and passed through the sampling mill; the custom ores are unloaded into bins and delivered by belt conveyor into the same system as the mine ores.

The sampling mill consists of a five-cutter Vezin system with the necessary crusher and rolls between the sample cutters; the ore is cut by the various cutters as it descends through the mill by gravity. The ratios of ore cut out for the sample are as follows: Cutter No. 1, 1: 10; cutters 2, 3, 4 and 5, 1: 5 each, the resultant sample being 32 lb. for every 100 tons of ore sampled. For two tests, made recently, to prove the accuracy of this mechanical sampling, two high-grade spotted ores were chosen, one an oxide and the other a sulphide. The rejects from each cutter were held, and in turn carefully sampled, original and duplicate samples being made from each. The accompanying tables give the results of the tests.

CHECK TEST ON MECHANICAL SAMPLING

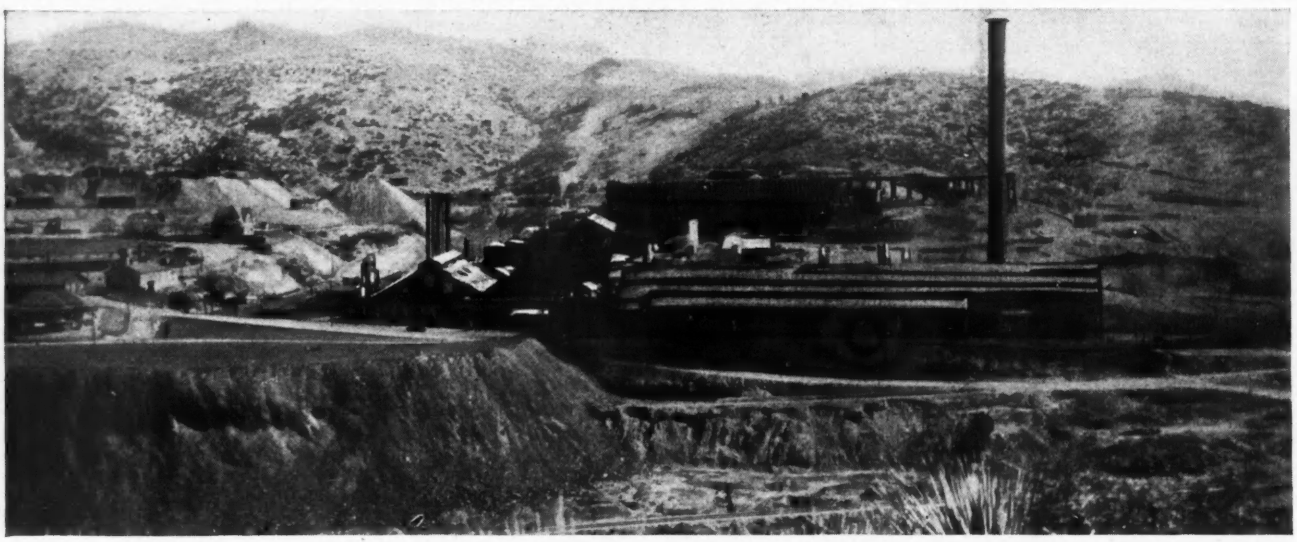
Test No. 1, Sulphide Ore				Test No. 2, Oxide Ore			
Reject of Cutter No.		Ag	Cu	Reject of Cutter No.		Ag	Cu
1	Original	0.50	17.69	1	Original	2.70	11.46
	Duplicate	0.50	17.77		Duplicate	2.70	11.49
2	Original	0.65	17.58	2	Original	2.85	11.38
	Duplicate	0.65	17.65		Duplicate	2.85	11.46
3	Original	0.55	17.66	3	Original	2.75	11.37
	Duplicate	0.55	17.66		Duplicate	2.75	11.42
4	Original	0.60	17.79	4	Original	2.80	11.46
	Duplicate	0.60	17.83		Duplicate	2.80	11.40
5	Original	0.55	17.57	5	Original	2.80	11.45
	Duplicate	0.55	17.62		Duplicate	2.80	11.40
Average Original		0.57	17.66	Average Original		2.78	11.42
Average Duplicate		0.57	17.70	Average Duplicate		2.78	11.43
Sample Original		0.60	17.69	Sample Original		2.80	11.40
Sample Duplicate		0.60	17.67	Sample Duplicate		2.80	11.45

The rejects from the sampling mill are delivered into storage bins and taken from these bins by steam-locomotive haulage to smeltery bins. There is no mixing other than that which the ore receives by being loaded from storage bins into cars and emptied from cars into smeltery bins.

At the smeltery the coke, limerock, sulphide and oxide ores are placed in separate bins. The blast-furnace charges weigh about 2000 lb. each and consist of varying amounts of oxide ores, sulphide and limerock, according to the grade of the matte and the silica and alumina in the charge. In turn this charge is dropped from scale hoppers into side-dump cars and taken direct to furnaces. The relative amounts of the various elements in the charge are given in the accompanying table.

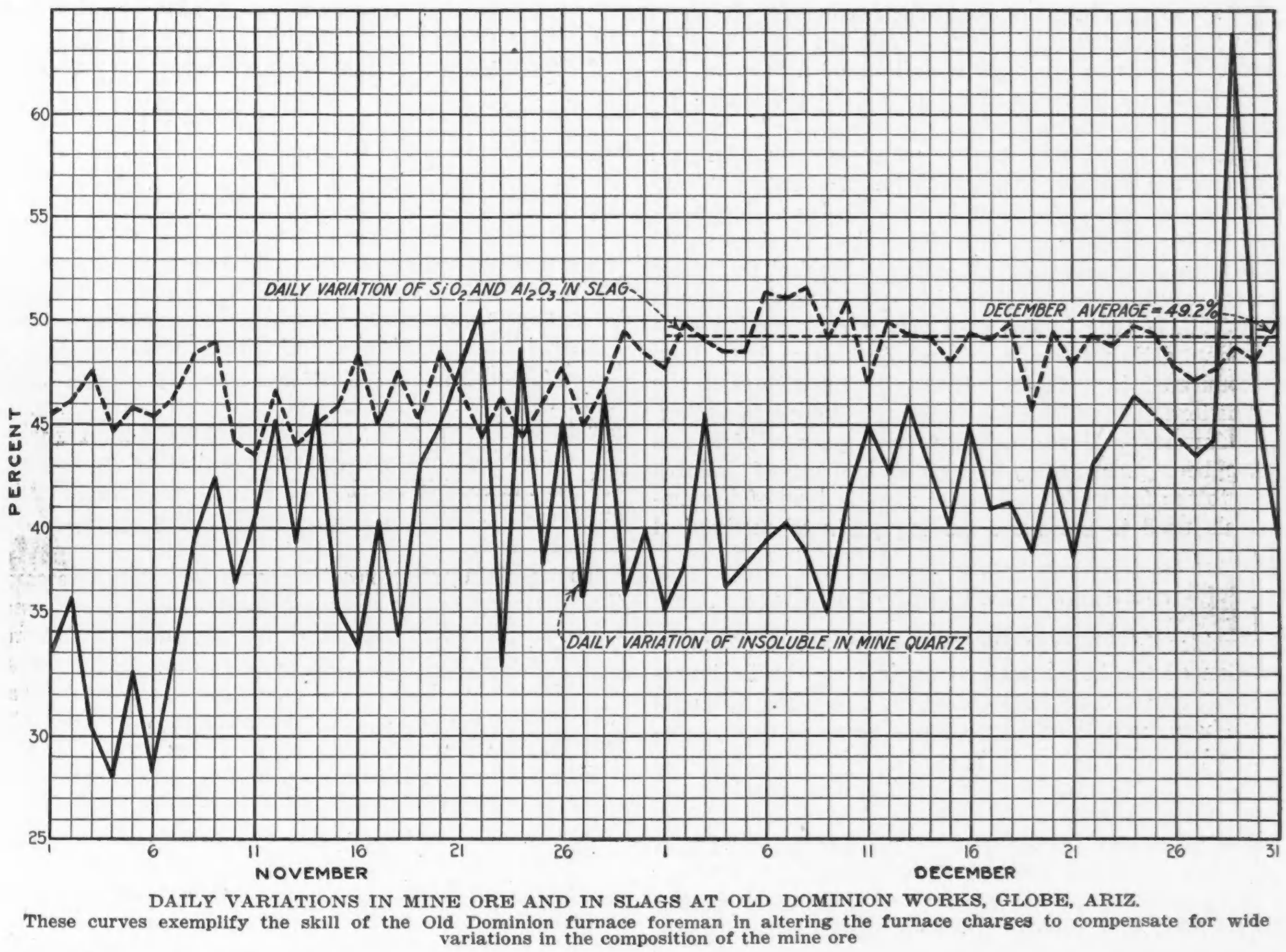
CONSTITUENTS OF THE BLAST-FURNACE CHARGE

	SiO_2	Fe	CaO	Al_2O_3	S	Cu
Mine ore	32.4	23.3	2.6	7.3	1.0	7.03
Lease ore	30.5	25.0	5.4	6.7	....	5.35
Custom ore	36.2	20.2	1.7	5.2	16.5	11.11
Sulphide ore	6.3	40.2	1.4	1.9	44.5	2.21



SMELTING WORKS OF THE OLD DOMINION CO. AT GLOBE, ARIZ.
The power plant is in the left center and the stock bins in the background. The concentrating and sampling mills do not show in this view, being farther to the left

The method of feeding is to dump three coke charges and also three ore mixtures directly on top, so that the coke is underneath the charge mixture. In the accompanying table are given furnace data for two furnaces in operation from May 1 until June 30, 1917, under the new conditions mentioned above. The analysis of coke follows: H_2O, 0.14%; volatile matter, 2.1; fixed carbon, 78.64; ash, 19.12%. Limerock analysis is: Insoluble matter, 4.4%; Fe, 2.0; CaO, 46.9%. The composition of a typical slag is: Cu, 0.46%; SiO_2, 37.4; FeO, 34.1; CaO, 12.7; Al_2O_3, 8.5%. It is interesting to note how expert the foremen have become in changing their charge before too late to cause serious trouble. No analyses of the ores are available until long after the ore is smelted, and yet with a wide variation in the silica and alumina contained, necessitating a range sometimes from 5 to 20% limerock on the



DAILY VARIATIONS IN MINE ORE AND IN SLAGS AT OLD DOMINION WORKS, GLOBE, ARIZ.

These curves exemplify the skill of the Old Dominion furnace foreman in altering the furnace charges to compensate for wide variations in the composition of the mine ore

charge in the same 24 hours, the running of the furnaces and the silica and alumina in the slags is remarkably uniform, considering the conditions. The two curves given in the accompanying chart show the variation in the silica and alumina in the ores smelted and also the slag made over a period of two months.

BLAST-FURNACE DATA AT OLD DOMINION

Width at tuyères, both furnaces	44 in.
Length No. 1	231 in.
Length No. 2	198 in.
Height of column	11 ft. 6 in.
Diameter of tuyères	4 in.
Number of tuyères, No. 1	44
Number of tuyères, No. 2	36
Air pressure	25 oz.
Cu.ft. of air per min	17,660
Tons smelted per 24 hours per furnace	360
Tons per sq.ft. of hearth area	5.0
Cu.ft. of air per ton charge smelted	72,474
Indicated horsepower-hours per ton charge	13.37
Coke to charge	12.5%
Fixed carbon	9.8%

The converting plant at the Old Dominion works consists of one stand of the Great Falls, 12-ft., upright type and one 10½ x 8-ft., horizontal type. The latter is seldom used. It is on this 12-ft. stand that L. O. Howard, formerly superintendent of this smeltery, made a record of over 75,000,000 lb. from one lining. Since then the linings have been averaging 24,000,000 lb. before patching becomes necessary. The converter slag is poured into the blast-furnace settlers. The bullion from the converter is transferred to an old matte ladle, lined with mud and placed on a truck; copper is poured directly from this ladle into molds, the molds being placed on trucks drawn by a motor; the tilting of the bullion ladle is done by steel cable attached to a small engine operated by compressed air.

CONVERTING DATA AT OLD DOMINION

	Cu	SiO_2	Fe	CaO	Al_2O_3	S
Analysis of ore fed	3.12	76.9	4.8	1.7	5.8	0.4
Analysis of slag	2.00	22.0	53.7	1.4	2.0	....
Analysis of matte made	44.16	....	27.4	...	...	23.2
Air pressure				14.4 lb.		
Cu.ft. of air per min. per converter						7,083
Cu.ft. of air per ton matte						78,844
Cu.ft. of air per ton bullion						182,728
Cu.ft. of air per ton Fe slagged						289,762
Oxygen efficiency						55.93%

Caucasus Copper Co., closed for almost two years, resumed work toward the end of 1916. It is understood that the company's smelting works were producing copper at Christmas and that good progress has been made since that time in the work of restoration at the mines and smelting works. The total output of copper in the Caucasus in 1916 is reported by a British consul as 4700 tons.

Choice of a Blende-Roasting Furnace

BY MARCH F. CHASE*

The blende roasting furnace must be selected to suit particular conditions, and it is therefore impossible to say that one furnace is better than another. However, the use of continuously rabbled muffled furnaces is increasing, owing to improvements in the design and construction of this type, and future development may be expected along the lines of the Ridge, Wedge, Huntington-Heberlein and similar furnaces.

PROBABLY more than 100 different types of furnaces have been tried for roasting blende. Of these not more than 15 distinct kinds are being used at present. In many cases the failure of a furnace has been due to a lack of understanding, on the designer's part, of the problem involved; in others, to the use of unsuitable materials. In designing any metallurgical furnace the engineer is apt to be handicapped in obtaining suitable material to use in the structure. Frequently this is caused by the excessive cost of what he would like to use, but more often it is due to the fact that there is not any ideal material for his special work. This is particularly true in the case of the construction of a blende-roasting furnace. Great difficulties have been encountered in getting refractories to withstand the conditions under which it is necessary to operate a roasting furnace, and undoubtedly some types of furnaces have been prematurely discarded because of failures due to the firebrick used. The same is true of the materials used to build the moving parts of mechanical furnaces.

Conserving the Heat of Roasting

Besides this there seems to have been a lack of appreciation of the importance of conserving the heat produced from the roasting reaction, and when attempts have been made to accomplish this, many of them, especially in muffled furnaces, have been without a thorough analysis of the problem. In some muffled roasters the fuel gases actually take heat away from the sulphur gases. However, the greatest trouble generally has been with the draft and air-intake regulation.

To roast blende it is necessary to bring each particle of ore to a temperature sufficiently high to ignite and burn it, and also to bring it in contact with sufficient oxygen to oxidize completely the metals and the sulphur. The temperature necessary is between 700° and 800° C., and the heat is supplied by fuel and the combustion of the sulphur. The oxygen contact with the ore is obtained by rabbling or stirring.

Theoretically, sufficient heat can be obtained by the oxidation of the sulphur, provided the sulphur gases are removed from the furnace at a concentration of 5% SO_2 or better. So far no furnace has been constructed to utilize fully this heat, and it has been necessary to apply external heat. This, while not being difficult in reverberatory furnaces of all kinds, has given a great deal of trouble in the mechanically raked muffles. The fuel requirements figured to bituminous coal vary anywhere from 8 to 35% of the ore charged. Under proper conditions a complete roast of an average blende can be had without the temperature of the ore ever being above 800° C. If the temperature during any period of the roasting is allowed to go much over this, many ores have a tendency to fuse and the roast cannot be completed. From many furnaces the fused concentrate has been taken, which showed an entirely unaltered core of blende. If the temperature is lower than 700° C. and the ore is still in contact with sulphur gases, sulphates are formed which are hard to break up. The ore should be kept at a temperature between 700° and 800° C. until it is completely desulphurized. This means that the air for burning the sulphur should be preheated before it is admitted in the final stages of the roasting process. Part of the heat for heating this air can be supplied from the hot roasted ore.

Rapid Heating of Ore Increases Capacity

In order to get the greatest capacity out of the roasting furnace per square foot of hearth area, the ore should be heated as rapidly as possible to the proper roasting temperature. In some of the old, hand-rabbled, muffled furnaces this result is obtained with a low coal consumption by taking the fire gases over the top hearth. The main objection to this has always been the high temperature of the sulphur gases as they leave the furnace. It is doubtful, however, if this objection is important, as the cooling can be so readily done afterward in an apparatus that is much cheaper than the roasting furnace itself.

To maintain proper roasting conditions it is necessary that the ore be completely and continuously stirred and rabbled. This has been the first big problem to confront the designer of mechanical furnaces of both reverberatory and muffled types. The natural material from which to make the rabbles or stirrers was iron. It was found, when ordinary cast iron was used, that the stirring rabbles burned out rapidly. This was overcome by cooling the rabbles either by removing them from the furnace periodically, thus causing intermittent rabbling in muffled furnaces—though the removal could be accomplished successfully in reverberatory furnaces—or by cooling by circulating air, water or steam through them, thus causing considerable reduction in the furnace temperature and an appreciable heat loss, especially when water was the cooling medium. Only recently has this latter method proved to be satisfactory when used in a muffled furnace. The problem was approached in two other ways. One was to make the rabbles of firebrick, as in the Spirlet, and the other to use a special iron mixture as in the Merton.

In addition to the material of construction, much depends on the shape of the stirrer and the way in which the stirring is done. Improper rabbling will cause high dust losses and also excessive hearth accretions. A certain amount of these cannot be avoided, but no doubt they can be materially reduced by certain interior flue constructions and by a good system of rabbling.

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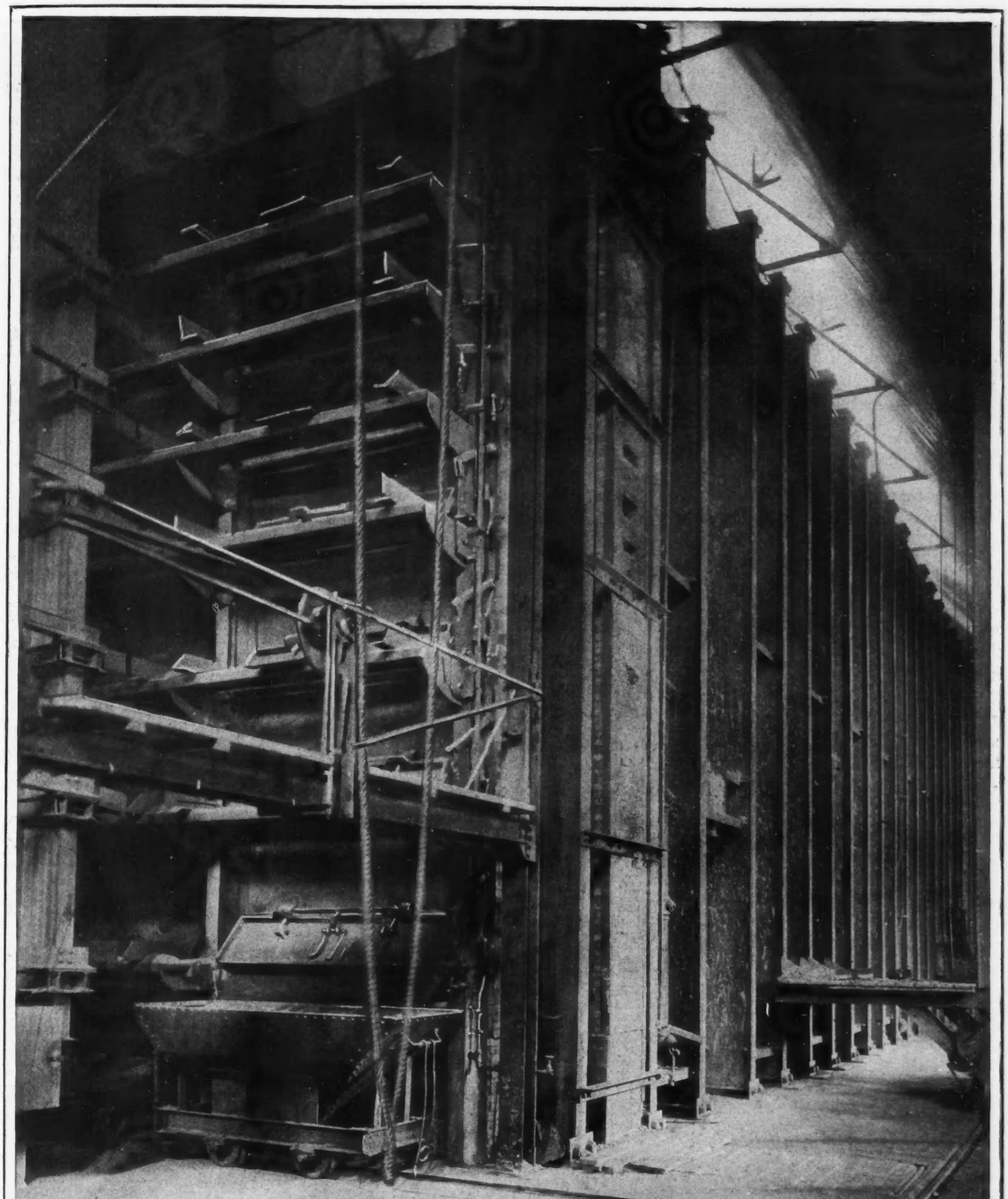


HEGELER ROASTING FURNACE, END AND SIDE VIEW

END VIEW OF HEGELER ROASTING FURNACE

In most furnaces the design of the movable parts has been such as to require the roof to be raised to a considerable height above the hearth. This is one of the chief sources of loss of heat in the Ropp reverberatory furnace. Here we have a roof arch spanning the firebox and the roasting hearths, and this, plus the rake mechanism, tends to bring the top of the arch so far from the ore as to rob the combustion gases of a part of their effectiveness. Hence the conditions in this furnace are such as to lead to a high fuel cost, although the labor cost is extremely low, only one man being required for 12 hours per furnace.

The Zellweger, Cappeau and Brown furnaces are more or less similar to the Ropp and have this same objection. All of these types of furnace have been modified more or less by different builders. The builders, however, have devoted themselves principally to working out the mechanical equipment of the furnace rather than to trying to conserve the heat. In this respect only slight changes have been made, such as the different methods employed to supply air for the combustion of the fuel gases and for the burning of the sulphur. In some cases considerable gain has been made in the capacity of the furnaces by these modifications. It may be said of all the furnaces of this general type that they have been extremely well worked out mechanically and can be operated economically with cheap fuel, preferably with natural gas. They are not expensive to construct, and under the conditions above stated, where the sulphur gases are to be wasted, a modified Ropp, such as those built in the Southwest, is probably the best reverberatory furnace. If fuel is expensive, then a type similar to the Merton, Ridge or Wedge should be used. The Merton or Ridge reverberatory furnaces take considerably less fuel than does the Ropp and the repairs are somewhat higher. The former furnaces are more expensive to build. They probably are more satisfactory, from the standpoint of fuel economy, than the straight-line furnaces as used in this country and have been used in Australia and Russia. One of the last big installations of reverberatory roasters was that recently completed in Siberia, where the Merton furnaces were used. The Merton, as first installed, had to be redesigned and strengthened mechanically, but the present furnace apparently is doing fair work. Any one of these furnaces, as now designed, if built of the proper materials, should be economical where fuel is high.

There is no record of any Wedge furnace being used for roasting blende where the fuel gases are directly in contact with the ore. However, there is no reason why it should not be as good a furnace for roasting blende, under these conditions, as either the Ridge or the Merton; both of these furnaces have been successfully used in this way.

Delplace vs. Hegeler Furnaces

There are a limited number of mechanical, muffled furnaces in commercial use at present, and fewer types of the hand-raked muffles. These latter are being gradually replaced by mechanical furnaces. The Delplace is an exceptionally good hand-raked furnace and is often considered superior to some of the mechanical roasters. In fact, De Lummen has figured that the Delplace furnace would roast for 50c. per ton less than the Hegeler. Unfortunately, in making this comparison De Lummen could not have had accurate data on the Hegeler furnace as prior to the war the working cost of a number of Hegeler furnaces was considerably under $2 per ton, but the fact probably remains that the Delplace furnaces are being operated more cheaply in some plants than the Hegeler or other mechanical furnaces are being operated in others, due consideration being given to the different labor and fuel conditions under which the operations are conducted.

In most cases, unless conditions are exceptional, the proper type of muffled roasting furnace to install would be a mechanical one. Of the mechanical furnaces the general kinds to choose from are: The Hegeler, Spirlet, Ridge, Wedge and Huntington-Heberlein. Of these five, the Hegeler, the Spirlet and the Ridge are being used to roast blende for spelter manufacture. The Wedge, as used at present, is a combination of the muffled and reverberatory types of furnaces, but there is no reason why it cannot be modified, in order to do away with the reverberatory feature, and become similar in type to the Huntington-Heberlein, which, although more or less in the formative stage, still has possibilities of success, in view of the operation of the Ridge rabble-cooling system.

If one were required to build a furnace free from any experimental features, the choice would be limited to the Hegeler, Spirlet and Ridge, regardless of the fact that other types appear to have the possibility of being developed into commercial furnaces.

No Standard Model of Hegeler Furnace

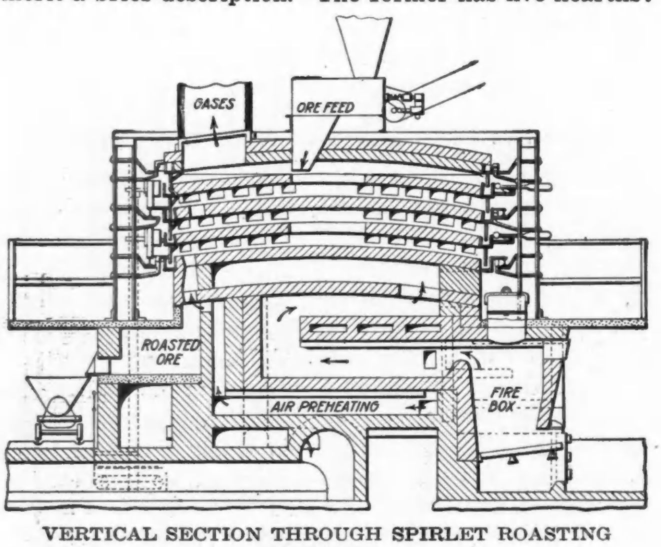
The Hegeler furnace is too well known in principle to require any detailed description. It has been used extensively—I might say almost exclusively—in this country and somewhat in Germany and Australia. It is a large-tonnage furnace, cannot be economically used on less than 30 tons per day and may be used up to 50 tons per day. The original Hegeler patent (U. S. No. 303,571) was applied for in 1882; since that time the furnace has been changed in many respects, and in hardly any two installations is it exactly alike. The name Hegeler, when applied to a roasting furnace, does not mean a certain definite structure; it refers only to a very general type. Almost every Hegeler furnace is different, not only in the minor points but also in many important features. For instance, there are used at the present time three totally different systems of firing and three systems of operating machinery, while there are almost as many air-regulating methods as there are furnaces. Besides these, many details, such as the design of the doors, location and size of drop holes, construction of arches and shape of rakes are different.

Every possible objection has been urged against the Hegeler furnace, among which may be mentioned these: It is difficult to regulate and expensive to build; it takes a comparatively large amount of room and is awkward in shape; it is difficult to arrange for easy and cheap handling of ore; it gives a fluctuating SO_2 gas and its fuel consumption is high. Regardless of all of these faults, if it is properly built, in the hands of trained men this furnace can be operated to produce a well-roasted product at a low operating and maintenance cost. Its size is such that it is not easy to control and, once it gets out of order, time is required to get it straightened out. It does take considerable space, and the SO_2 gas varies to such an extent as to affect the acid system, and on fixed draft it is almost impossible to get an average gas of much over 4%.

In chamber-acid system, if operating with fans, it is possible to get 5% or over as an average gas. There is often trouble with the air regulation, and at times a considerable portion of green ore is drawn, which has to be recharged. The hearth accretions are heavy, and the hearths must be kept continually chiseled. Much depends on the details of design and the specifications of materials, and neglect in many things, which might be easily considered minor, will lead to endless trouble in operation and high expense of maintenance. The efficient operation of a Hegeler furnace is largely a matter of skilled operators, of whom it takes eight when working eight-hour shifts. In the hands of inexperienced men the roasting results and cost will be extremely disappointing.

Ridge Water-Cooled Rabbles and Spirlet Fireclay Rabbles

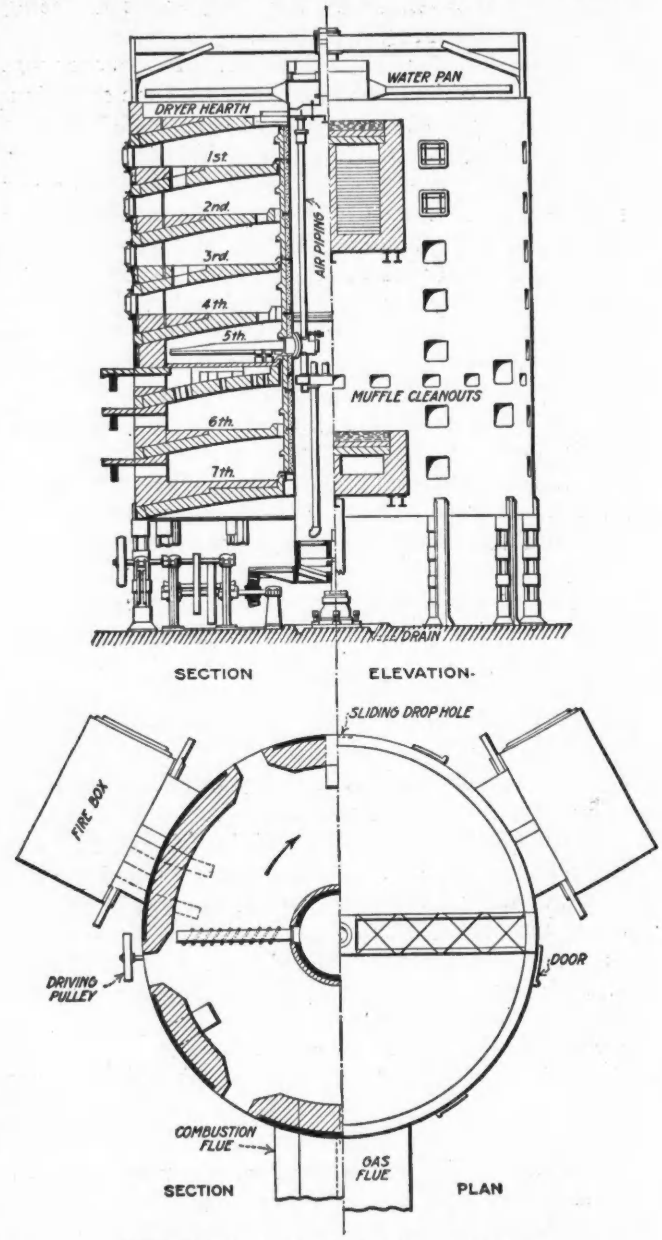
The Ridge and the Spirlet furnaces were previously mentioned with the Hegeler as types of mechanical furnaces to use in roasting blende for spelter, and they merit a brief description. The former has five hearths:



VERTICAL SECTION THROUGH SPIRLET ROASTING FURNACE

One for drying and heating the ore, three for roasting (the fourth being a muffled hearth) and one for cooling the ore and preheating the air. The ore is moved from hearth to hearth by rabbles hung on arms fastened to hollow, water-cooled columns, which require about 15,000 gal. of cooling water for every 24 hours of operation. There are four of these shafts to each furnace and each shaft is driven from the bottom by bevel gears. There are four arms to each hearth except the cooling hearth, where only three are used. The ore is fed continuously to the top or preheating hearth, traveling from the feed hopper to the opening of the first hearth, back along that hearth, and so on to the cooling hearth, where it is finally discharged. The discharge opening is to one side of the longitudinal center line and behind a brick wall which protects the gearing from the dust and the heat. The roasted product, when Broken Hill concentrates were used, reached a tenor of total sulphur as low as 0.75% on a 10% consumption of coal in the producers. The SO_2 content in the sulphur gases averages 6½ to 8½%. About 10 hp. is required to operate one of these furnaces.

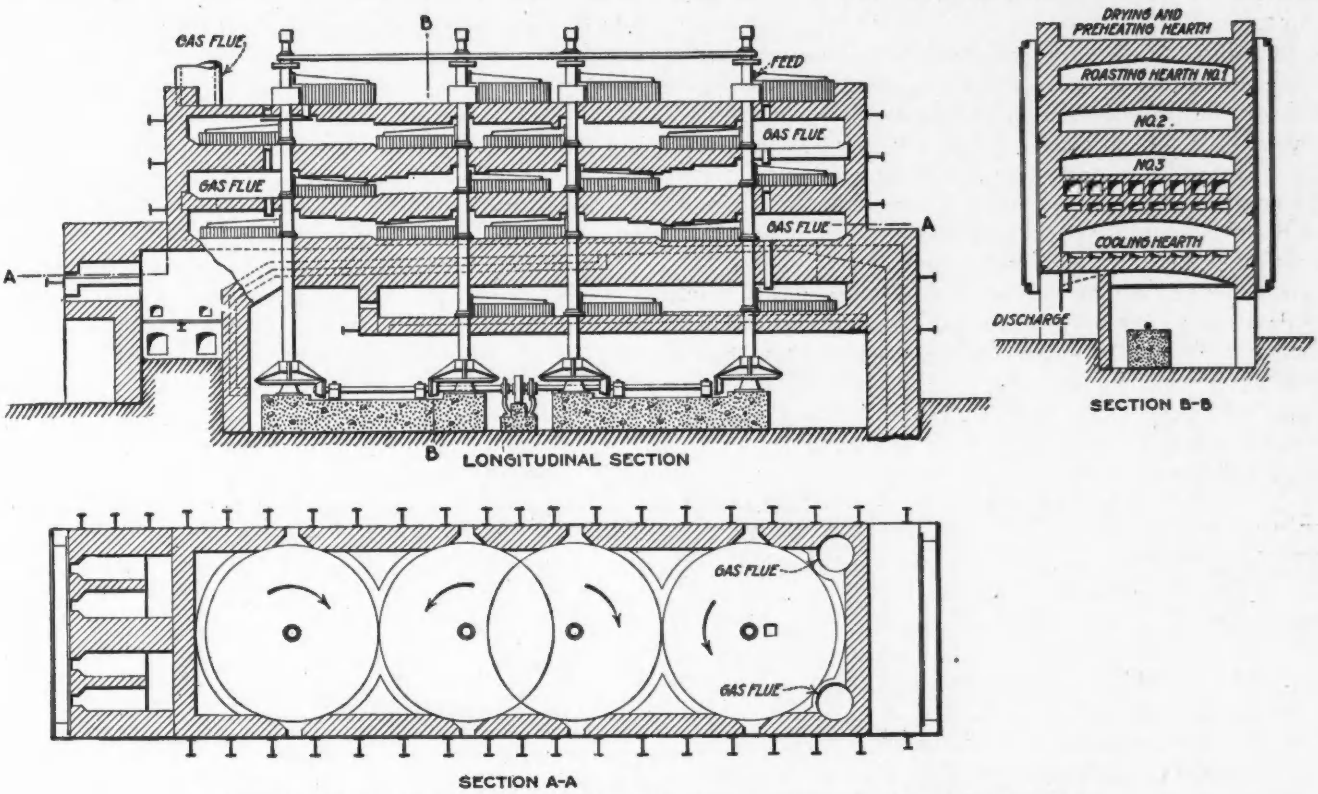
The Spirlet roasting furnace has several rotating hearths, projections from one making the rabbles for the hearth beneath. There are not any metal parts exposed to the hot gases, as the rabbles are made of special fireclay shapes which can be removed only by closing down the furnace and cooling it off. The working period for one of these furnaces is usually about three



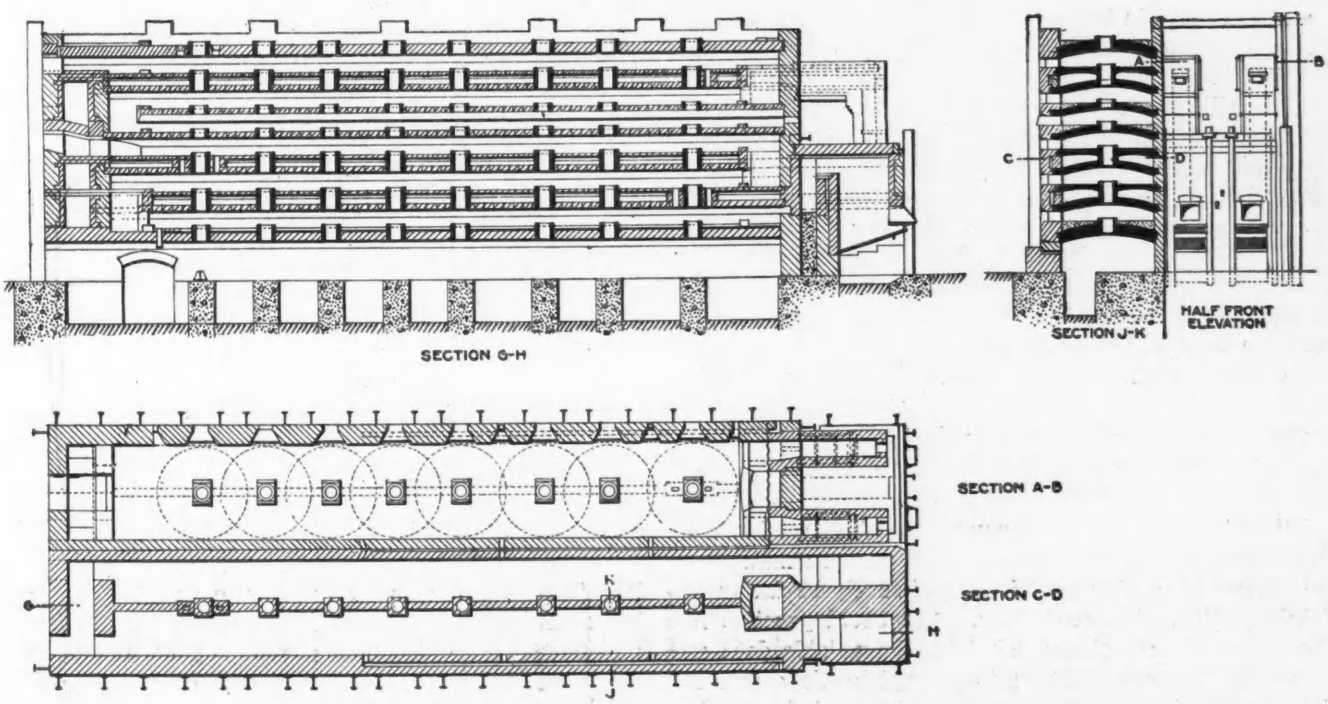
THE WEDGE MECHANICAL FURNACE

months, and then, because of wear and breakage in the rabbles, the furnace has to be closed down and cooled off before the rabbles can be removed. The last hearth is muffled and has the roasted ore discharging from the periphery into a hopper where part of the heat is extracted to preheat the air, the remainder of the heat in the air being obtained from the firebox. This furnace consumes about 10% of coal as fuel, requiring about 2 hp. to operate a five-ton furnace, and gives a gas high in SO_2 with a loss of 1 to 2% of zinc in the dust. The furnace is limited as to size, and there is considerable difficulty in changing the form of the rabble in case of changing the kind of ore charged to the furnace.

The Wedge furnace for roasting blende for sulphuric acid is, as stated, a combination of the muffled and the reverberatory, similar in principle to the Repath patent (U. S. No. 785,437). This idea was first used by the combustion gases come in direct contact with the ore. Up to the present time there have been a number of these furnaces built, but in every case except one the roasted blende has been used in a leaching process. There is no available data as to the amount of sulphur as sulphate remaining in the roasted ore. This is so



SECTIONAL PLAN AND ELEVATIONS OF RIDGE BLENDE-ROASTING FURNACE



MERTON MUFFLED SIX-DECK DUPLEX ROASTING FURNACE

Vieille Montagne a great many years ago but was soon abandoned. While it has been suggested time and again, so far as my knowledge goes, the Wedge Mechanical Furnace Co. was the first to operate successfully a furnace on this principle. On the lower hearths the important in the subsequent spelter-furnace work that until it is found that it can be kept below the allowable limit there will always be some doubt as to the usefulness of the furnace for roasting for spelter purposes. Fortunately there are two installations in this country that will soon be operating on spelter ores, and before long the data will be available.

The Huntington-Heberlein furnace, which is a straight-muffled type of turret furnace, is now being tried in England. Its special features are the methods of air admission and certain mechanical details in the construction of the rabble holders and operating machinery.

In both of these furnaces attempts are made to conserve the excess heat generated in the upper hearths. One of the difficulties with furnaces of this type has always been the regulation of the air supply. In roasting, the air or gas must be continually removed from the surface of the ore. This is accomplished by having as high a velocity of the gas as consistent with minimum dusting and high percentage of SO_2. This requires that the muffles be low. In furnaces of this character a low muffle is difficult to obtain, and in addition there is always danger of unequal distribution of the gas current over the bed of the ore. In the Spirlet furnace this diffiuclty has been overcome by making a roof of each hearth to carry the rabble blades.

To determine the best type of kiln to use under any given set of conditions one must consider (1) the proper roasting of the ore and (2) the suitability of the gas for making acid. The first cost and the working cost are of less importance. Well-roasted ore is of the utmost importance to the smelter, as a high sulphur content directly affects the metal recovery, and a loss here could not be offset by any gain made in the acid systems by using a better gas.

From the standpoint of working efficiency a furnace should produce a high, uniform SO_2 gas, free from dust, and a low-sulphur roasted product free from lumps and fritted masses of ore. From the standpoint of economy the excess heat in the first stage of the roasting should be transferred to the final stages. In order to get these results a kiln must be constructed so that the following conditions are complied with: (1) The ore must be rabbled continuously; (2) the arches must be low, so that the gas traveling over the ore continually sweeps away the SO_2 in contact with it; (3) the ore must not fall through the ascending current of gas; (4) the air must be introduced hot; (5) the temperature of the different hearths must be readily controlled by regulating the air supply; (6) the ore should be cooled by air later used for roasting, and (7) the rabbles should be easily accessible and capable of being quickly changed.

The structure must take only a small amount of floor space to permit cheaply handling the ore to a battery of furnaces.

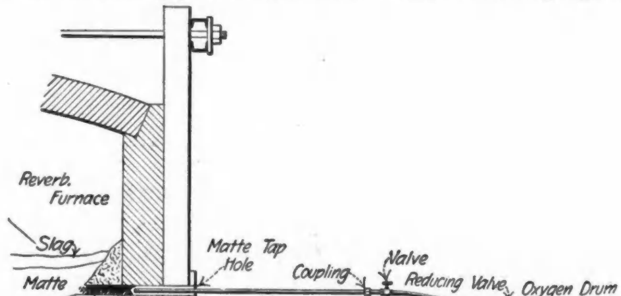
When judged in this manner we find that no furnace fully fills the required conditions, and the furnace that we choose, no matter what it is, will surely be far from fulfilling all of the conditions. The usual practice in choosing is to collect and tabulate all available data of operating furnaces, and then to attempt to allow for different operating conditions. There is great danger in doing this, as often the data are very incomplete and incorrect. This information is, of course, of value, but too much weight should not be given it.

Recently it was necessary to decide on a kind of furnace to be used in a large zinc-roasting plant; after careful consideration of all sorts and kinds of furnaces it was decided to erect three distinct types; one of these was a hand furnace and two were mechanical ones. The results of these tests were that the hand furnace was finally adopted temporarily. It was figured that the latter could be built quickly, and while the mechanical furnaces showed great promise of finally successful development, they also were far from being perfectly worked out, and the saving due to continuous operation at present would more than offset the total cost of the hand furnaces even if discarded within two years.

This illustrates the point which I wish to emphasize, namely, that the conditions under which the installations must be made have much to do with determining which furnace to use, and that it is impossible to say that one furnace is better than another. From recent reports of continuously-rabbled muffled furnaces it is quite safe to say that this type will be much more generally used in the future than it has been in the past. The great difficulty of maintaining the rabble arms has been overcome, and the past objection of the inability to cool the arms and maintain the heat of the furnace can no longer be urged against the types of roasters using this system. The advantages are so great over intermittent rabbling, as in the Hegeler, or the firebrick rabble of the Spirlet, that one can confidently expect the development to be along the lines of the Ridge, Wedge, Huntington-Heberlein or similar furnaces.

Opening a Frozen Taphole with Oxygen and Red-Hot Pipe

At the Steptoe plant of the Nevada Consolidated Copper Co. at McGill, Nev., a novel method is employed for opening a taphole. In the course of ordinary operations in the reverberatory plant the taphole in a furnace occasionally becomes frozen and the bar drawn without obtaining a flow of matte. The process of opening a frozen taphole with a star bit or diamond-point drill is an exceedingly laborious and time-consuming operation.

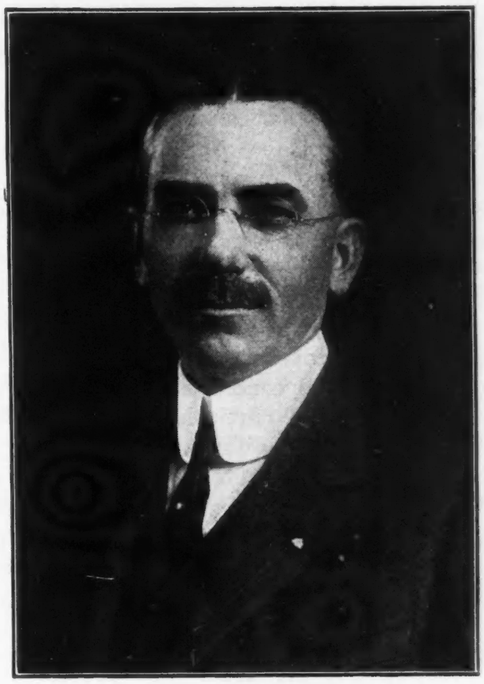


OPENING FROZEN TAPHOLE WITH OXYGEN

The method shown in the accompanying illustration is a substitute for the hammer and drill and is quick and effective. The small ¼-in. pipe is first heated to a bright red heat and the oxygen turned on to maintain a pressure of about 60 lb. An active combustion of the hot iron pipe-end is immediately set up. The heat developed by this burning iron is utilized to melt its way through the frozen matte or slag in the taphole and the 60-lb. pressure is sufficient to blow back all melted material, thus cleaning the hole in a few minutes, instead of hours as formerly.

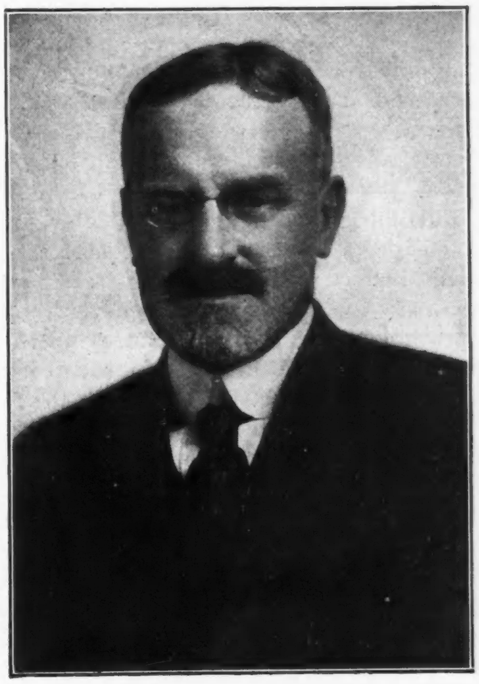
A Group of Distinguished Metallurgists

HERMAN GARLICHS



W. E. NEWNAM

H. R. HANLEY



JULIUS W. HEGELER

The Use of Reinforced Concrete in Metallurgical Work

By Frank R. Corwin*

During the last few years I have been studying the effect of heat and furnace gases on reinforced concrete to try and find a suitable structure to replace brick in roasting furnaces, which are always a source of trouble and expense. A number of articles have appeared from time to time in metallurgical publications with varying opinions as to its adaptability for this purpose, but my experience has been entirely satisfactory.

To give some idea of what can be expected of furnace hearths properly constructed of reinforced concrete, I wish to call attention to an article[1] written by Selden S. Rodgers and myself, in which mention is made of some concrete hearths that were built at the Great Falls plant in 1912. The roasters in which these hearths were built have been operated continuously since that time, except during the last year, when they have been operated intermittently because of curtailed production. The hearths are still in good condition and show no signs of wear. One furnace in particular was operated under severe temperature conditions, while making tests on air-cooled arms, but, with the exception of two small cracks, the hearths were not affected. Even though cracks appear, the operation of the furnace is not affected in any way, as the reinforcing rods are so arranged that the hearth is still held in shape, and the loose pieces of concrete cannot fall out. One of the advantages of this type of hearth over the brick is the monolithic structure, which does away with the breaking of arms and the shutting down of the furnace for repairs made necessary by the falling of the arches.

Another place where I have found reinforced concrete preferable to brick is around the center drums carrying the arms. In one of the new plants in the Southwest, considerable trouble was experienced by brick falling out around the drums, causing the breakage of many arms and a great deal of lost time. After the brick had been replaced a number of times, reinforced concrete was substituted and found to be so satisfactory that the new furnaces are being built of concrete. Fuel oil is used in these particular furnaces, and the flame plays directly on the concrete without any detrimental effect.

It has been my experience that whenever reinforced concrete does not withstand temperatures up to 1500° F., the trouble has been either in poor construction or lack of care in seasoning the structure when the furnace was first started. Special care must be given to the mixing and the concrete should be handled as quickly as possible when it is poured into the forms. It must then be allowed to set thoroughly before the forms are removed and, after removing the forms, dried out with a slow fire before starting the furnace. Extra time and care spent in the construction and subsequent seasoning will be well paid for in the life of the structure. I have tried a number of different mixtures but have obtained the best results with this one, originally used at Great Falls: Portland cement, 1 part; tailing sand, 2 parts; crushed slag, 4 parts. The crushed slag used was screened through a ½-in. screen.

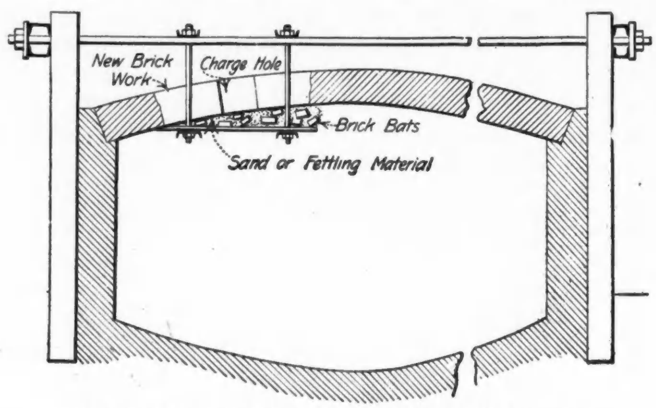
My experience in replacing brick with reinforced concrete in roasting furnaces has been so satisfactory that I have felt justified in recommending that a furnace be built throughout with reinforced concrete. The walls will be braced with circular steel bands to take the thrust of the arches, only a light steel shell being used. The shell will be constructed of No. 16 boiler plate, and put in place after the concrete walls have been constructed, a space of 4 in. being left between the steel shell and the concrete that will be packed either with slag or mineral wool for insulation. A great deal of heat will be retained in the furnace, which is usually lost through the walls, and should make it possible to roast low sulphur charges with less fuel. Aside from the many advantages that reinforced concrete has over brick in the actual operation of roasting furnaces, the actual cost of concrete hearths is one-half that of brick, and a furnace built along the lines suggested above would show a big saving in the original cost of construction, to say nothing of the low repair costs after the furnaces were operating.

*Superintendent, Consolidated Arizona Smelting Co., Humboldt, Arizona.

[1] "Increasing the Efficiency of MacDougall Roasters at the Great Falls Smelter of the Anaconda Copper Mining Co.," presented at the August, 1913, meeting of the American Institute of Mining Engineers.

Replacing a Reverberatory-Furnace Charge Hole

A steel-and-sand support is employed at the Steptoe plant of the Nevada Consolidated Copper Co., at McGill, Nev., in replacing burned-out charge holes in the roof of a reverberatory furnace. The brick work around the charge hole is always the first to be destroyed in the course of the furnace campaign. After cutting back the burned brick far enough to obtain a suitable bearing, the use of the method shown in the accompanying sketch makes it possible to replace the brickwork around the charge hole in an interval of three or four hours, while with the older method of building a wooden "center" supported on the furnace hearth it was necessary to allow the furnace to cool off for several days. The hanging steel-and-sand "center" is dropped on the hearth of the furnace after the brickwork has been keyed up and the several parts are pulled out through the side doors before firing up the furnace again.



REPAIRING FURNACE ROOF AT McGILL, NEV.

Delivery of Roasting Furnace, necessary for carrying on large-scale tests at the Tucson station of the United States Bureau of Mines, has been delayed by strikes at San Francisco.

Granby Smelting Works at Anyox, B. C.*

BY WAKELY A. WILLIAMS†

Metallurgical problems in connection with the smelting of the Granby ores at Anyox are discussed, as well as the selection of equipment. Plunger feeding of blast furnaces overcame early difficulties in this operation. Concentration of first matte by resmelting in the blast furnace is to be eliminated by extension of converting capacity, a 20-ft. Great Falls type converter having been recently ordered.

THE smelting works at Anyox, B. C., of the Granby Consolidated Mining, Smelting and Power Co., was built primarily to treat the ores from its Hidden Creek mines, but also with a view to handling other Granby and custom ores. Anyox is on the western shore of Observatory Inlet, in northwestern British Columbia; the mines and the smelting and power plants are all within a comparatively short radius of the town. There are five distinct orebodies developed by the Granby company, known as Nos. 1, 2, 3, 4 and 5; they are irregular copper-sulphide orebodies in metamorphosed sedimentaries—schists, slates and limestones—cut by dikes. Oxidation has been only slight and sulphides are found where the orebodies come to the surface.

When selecting the site for the plant, the three main considerations were: (1) Plenty of slag-dump room for future years; (2) sufficient ground for future enlargement of plant; and (3) availability of water power. Since the mines, smeltery and wharves had to be connected by railroad, minimum up-grades were provided from wharves to smeltery and practically level grade from the mines to the smeltery. It is estimated that there is room at the site selected for 12,000,000 to 20,000,000 tons of granulated slag. On account of the steep, glaciated hillsides, all natural benches are narrow and the one selected for the site was as wide and long as could be found in this vicinity. Falls Creek at the north end of the site presented the only near-by water supply available. An economical power arrangement was obtained by installing a high-pressure, water-pipe line from the dam to the power house which is at the foot of the hill near the mouth of Falls Creek. All timber and underbrush, and a layer of muskeg covering the surface of the ground to a depth varying from 2 to 8 ft., were removed, and all footings placed on rock or on a glacial-gravel foundation.

From the plans it will be noted that the ore bins are not directly back of the furnaces but are situated to one side, making an angle of about 80° with the line of the furnaces. The charge trains enter the feed floor between the furnaces and converters, and the sampler is at the end of the bins next to the furnace building. The arrangement is not exactly ideal, but, because of the length and narrowness of the bench, it was the best that could be designed under the circumstances, and in practice it has worked satisfactorily.

GENERAL VIEW OF SMELTING WORKS OF THE GRANBY COMPANY AT ANYOX, B. C.

The furnaces and converters are in one building. The building is a steel structure with wooden roof, having an asbestos covering. It is 80 ft. wide and 390 ft. long, having concrete retaining walls both in front of and back of the furnaces. The furnace-floor elevation is 119 ft. and converter-floor elevation 110 ft. above sea level. A common crane runway 40 ft. wide serves both departments upon which operate two Niles, direct-current, 500-volt, 40-ton, quick-acting cranes with main and auxiliary hooks of the same size. In the

*The second of a series of three articles dealing with the copper operations of the Granby Consolidated Mining, Smelting and Power Co., at Anyox, B. C. The first article describing the Granby company's Hidden Creek mine appeared in the "Engineering and Mining Journal" of Oct. 13, 1917.

†Superintendent of smelters, Granby Consolidated Mining, Smelting and Power Co., Ltd., Anyox, B. C.

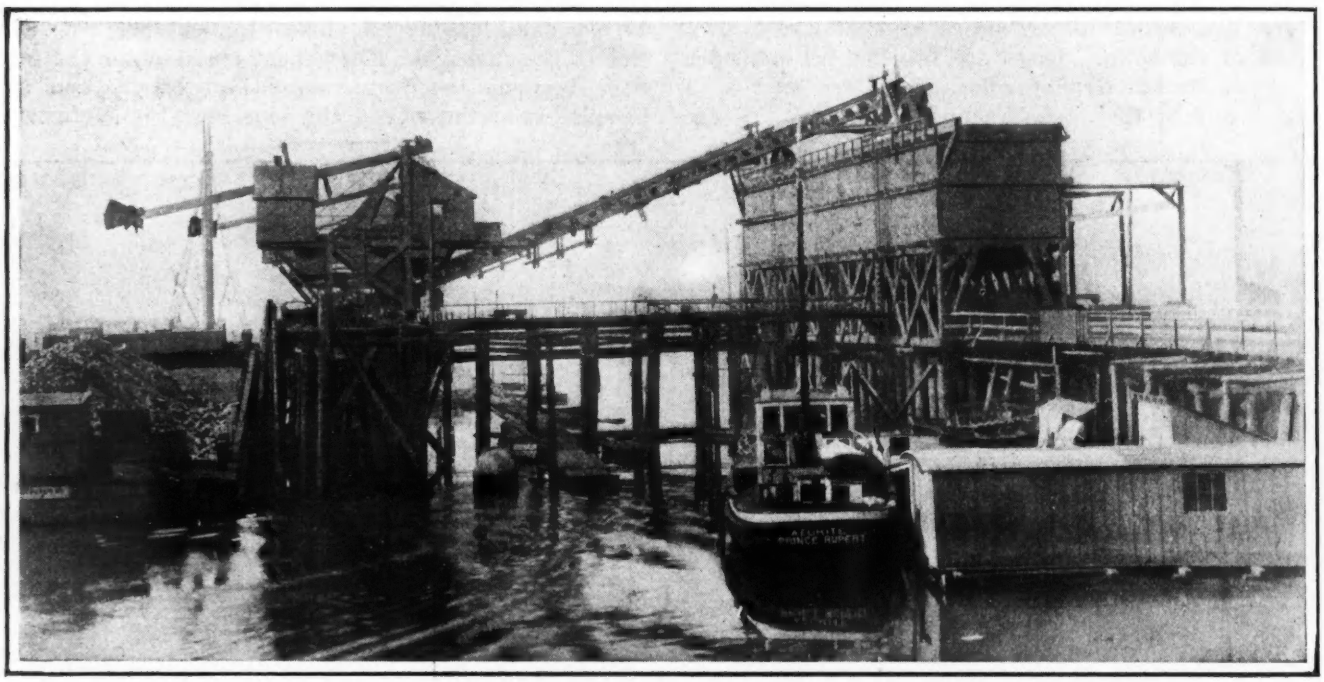
southern end of the building there were originally three furnaces. Later a fourth was added.

The long axes of the furnaces are in line and parallel to the long axis of the building. The furnaces are of the rectangular straight-bosh type. The original three furnaces are 50 x 360 in. at the tuyeres, which are of 4-in. diameter and spaced 10.8 in. from center to center. There are two tiers of jackets. The lower jackets are 10 ft. 6 in. high and 4 ft. 6 in. wide and rest on heavy, water-jacketed base plates; the upper jackets are 6 ft. 8 in. high and 5 ft. wide. The furnace is supported by heavy-steel H columns and 20-in. box-type mantel beams. These are exceptionally well braced with heavy I-beams and girders. Jackets and tuyeres are of the welded type. The latter are of the Anaconda type with ball-and-socket joint. Furnaces Nos. 1, 2 and 3 measure 13 ft. 2 in. from the tuyeres to the top of the upper jackets, while on No. 4 furnace, which has a third tier of jackets, this distance is 18 ft. 2 in., the extra 5 ft. of height having been gained by lowering the settler floor. With this exception No. 4 furnace has the same measurements. Steel water-jacketed spouts, having a trap of 15½ in., discharge over a bronze-nose jacket and give excellent service. Cooling water which is ice cold the year round insures the permanence of a thick, protective crust which is never "hulled" through a campaign. The furnaces work under a 45- to 50-oz. blast and use 900 cu.ft. of air per min. per ft. of furnace length.

Each furnace is served by one 16-ft. and one 8-ft. settler having a 9-in. chrome-brick lining. The brick stands 9 in. away from the shell, the intervening space being filled with lightly tamped backing, consisting of common bats crushed to ½ in., from which the fines have been removed by screening. At the tap holes, of which there are two, 18 in. of chrome brick is used without backing. The tapping block is a magnesite brick having a 1-in. hole, embedded in a plate of converter copper. Due to the frequency with which matte is tapped, a tapping bar is rarely needed. Aside from renewing brick at the tap holes, which is necessary about once a month, very little repairing of lining is necessary. The cooling spray has been abandoned. Slag flows from the 16-ft. settler to the 8-ft. settler, thence to the granulating launders. An appreciable amount of matte is recovered from the second settler. Granulated slag is deposited on the dump through launders lined with slag plates and having a fall of ½ in. to the foot.

The feed floor is at an elevation of 145 ft. The furnace tops are constructed of heavy, cast-iron lintels and columns, all well bound and braced. The side walls and ends are bricked with 18 in. of red brick, and the semicircular, steel hood is lined with firebrick. A steel down-take, 9 ft. in diameter, leads the gases from the furnace to the dust chamber.

Charge tracks, of 3-ft. gage and 56-lb. rails, run on either side of the furnace and continue out of the building to the converter-slag bins and sintering-plant bins. The Anaconda type of steel charge cars of five-ton capacity is used. Trains of 12 cars each are hauled by a 12-ton, Baldwin-Westinghouse, electric locomotive. There are two of these trains in service. Cars are dumped by overhead, horizontal, compressed-air cylinders running on trolleys, two to a furnace, one on each side.



RECEIVING BINS AT ANYOX AND MEANS FOR UNLOADING OUTSIDE ORES AND FLUXES

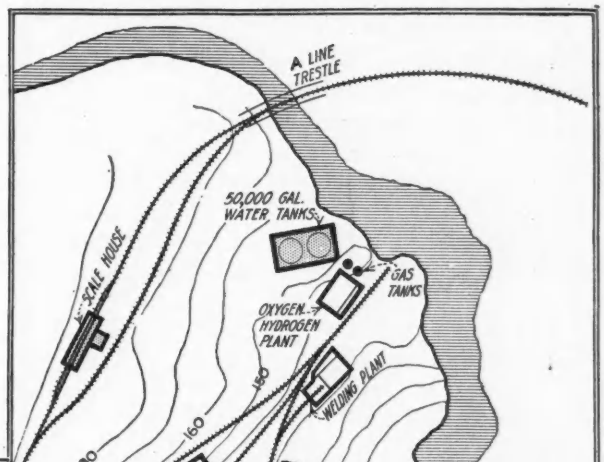
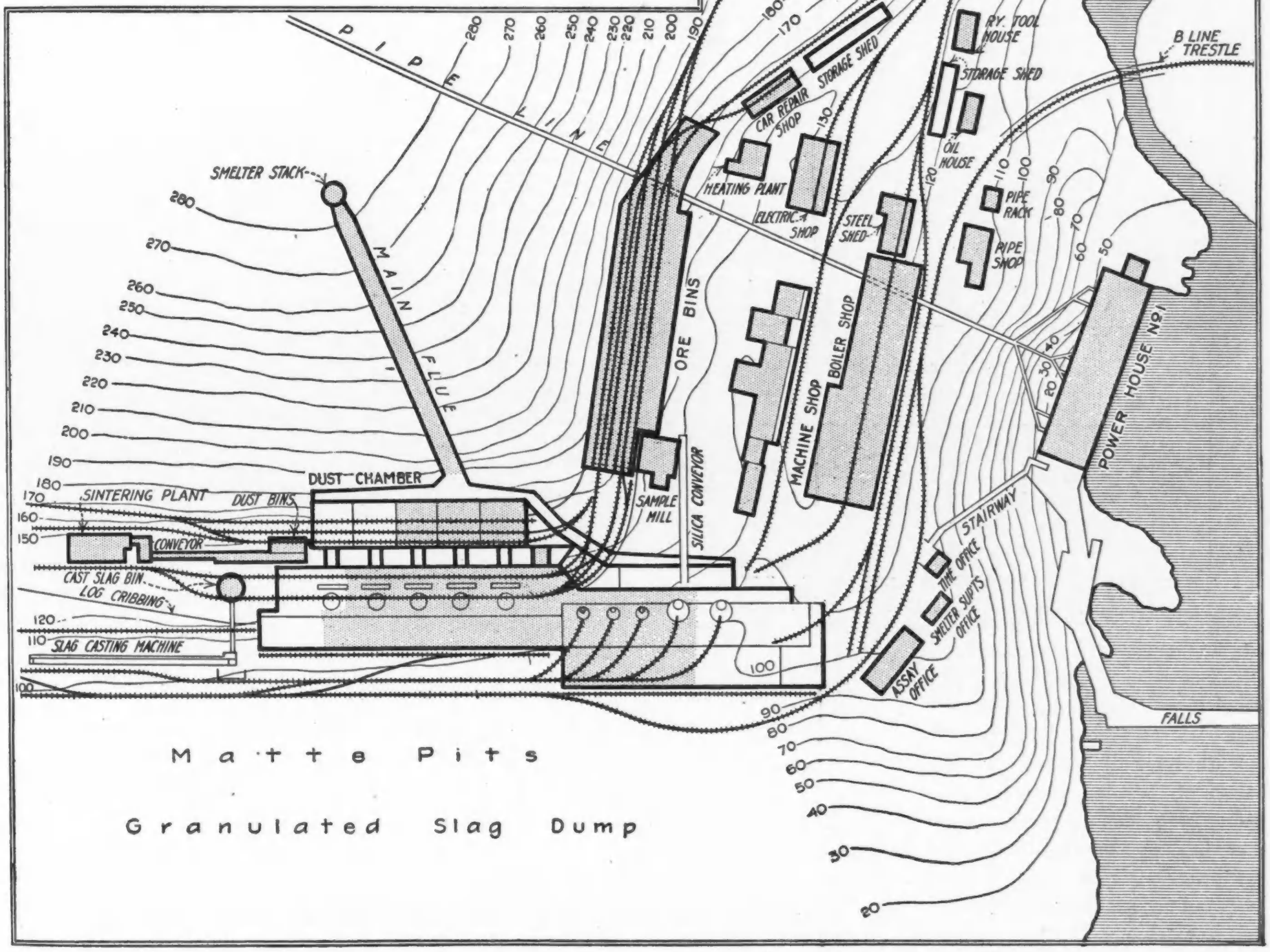
The manner of charging[1] the furnaces is their most striking feature. The charging space is divided into three sections by the columns supporting the lintels. The original bevel plates were removed and in their place were built hoppers with horizontal bottoms and cast-plate sides. They are 2 ft. 6 in. deep and the bottom plate overhangs the top of the jackets 9 in. At the back of the hoppers, held under the charge floor, are heavy cast-iron plows operated by compressed-air pistons in cylinders working under 100-lb. pressure. The

[1]"Eng. and Min. Journ.," Oct. 7, 1916, p. 661.

capacity of each hopper is 5000 lb. of charge and each section has two, making 12 in all per furnace.

When a charge is needed in the furnace, air is turned on and the plow pushes the charge from the hoppers into the furnace. Any hopper can be operated independently and the amount charged at any one time can be controlled. This arrangement permits charge trains to be dumped and released without having to wait for the charging of the furnace. In this system of feeding the proper overhang with the proper drop of the ore have to be determined to get the right distribution of coarse and fines, so that the furnace may run properly. The amount of drop and overhang depend upon the character of the ore and whether or not it is desired to feed to the middle or to the jackets. It is possible to place the charge in any desired place and to favor any particular section of the furnace. The main idea was not original with the Granby company but was taken from Sticht's description of the smelting practice at Mount Lyell. The Granby company worked out the mechanical details to suit its own construction only. The idea was first tried out on No. 4 furnace, and as the experiment showed a tendency toward smoother running of the furnace and kept it in better shape than any of the others, it was decided to adopt this feed system on the three remaining furnaces.

In the northern end of the building there are three 12-ft., Great Falls type, electrically operated converters, each having 12 tuyeres of 1$\frac{5}{16}$ in. diameter. Punch rods are upset to 1½ in. and tuyeres reamed with 1⅝-in. bar. Blast pressure is 13 lb. and air consumption from 6000 to 7000 cu.ft. per min. per converter. Ladles of 85 cu.ft. capacity are used but are being replaced by ladles of 120 cu.ft. capacity. Converter slag at present is poured into the settlers of furnaces smelting the ore charge. Charges of copper weigh about eight tons and are cast into flat, bevel-edged bars measuring 30 x 18 x 3 in. A straight-line casting machine is used which dumps the bars into a cooling tank, after which they are conveyed to the casting floor. The blister copper averages 99.25% Cu.

LAYOUT OF GRANBY SMELTING WORKS AT ANYOX, B. C.

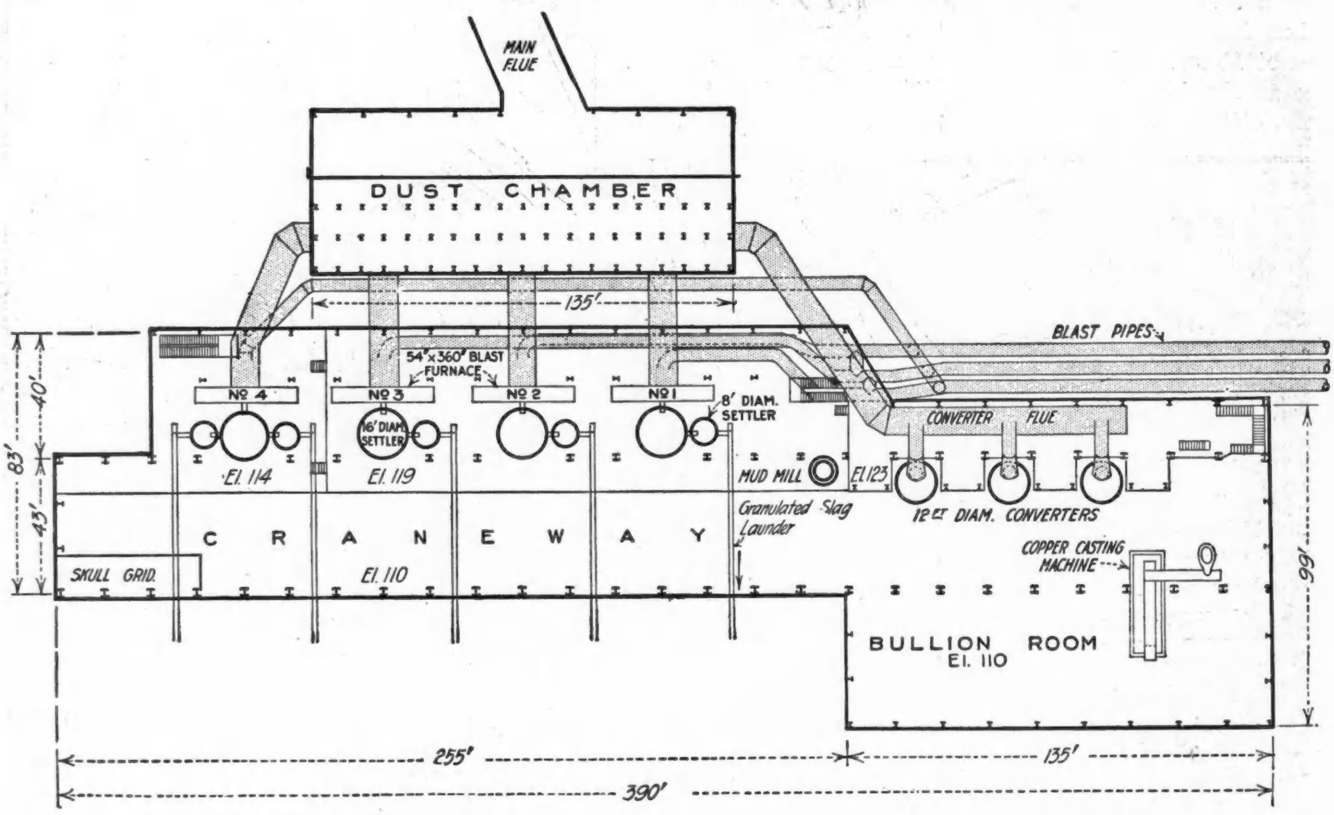
The slag-skull grid is at the top of a steel bin having a sloping bottom and chutes for discharging the contents into railroad cars. The top of the bin measures 12 x 45 ft. and is laid with 12-in. I-beams running lengthwise and supporting 12-ft. lengths of 90-lb. rail laid crosswise and spaced 7 in. apart. Skulls are dumped on this grid and pieces not sufficiently broken by the fall are further reduced by hand. Part of one man's time is required for this work.

CHARACTER OF HIDDEN CREEK ORES

About 75,000 tons of ore are smelted per month, of which the Hidden Creek mine at Anyox furnishes roughly 65,000 tons, the remainder of the ore comes from outside sources. Nearly all the Hidden Creek ores smelted to date have come from No. 1 and No. 2 orebodies.

Orebody No. 1, as developed to date, appears to be nearly neutral as regards Fe and SiO_2 requirements for from different parts of the same stope. There is a steady fluctuation of ore composition but the degree of variation is fortunately becoming less. In the accompanying table A and B each represent the average of a month's run and illustrate the extremes in SiO_2 contents by months; C and D represent two extreme analyses by lots of 1000 tons.

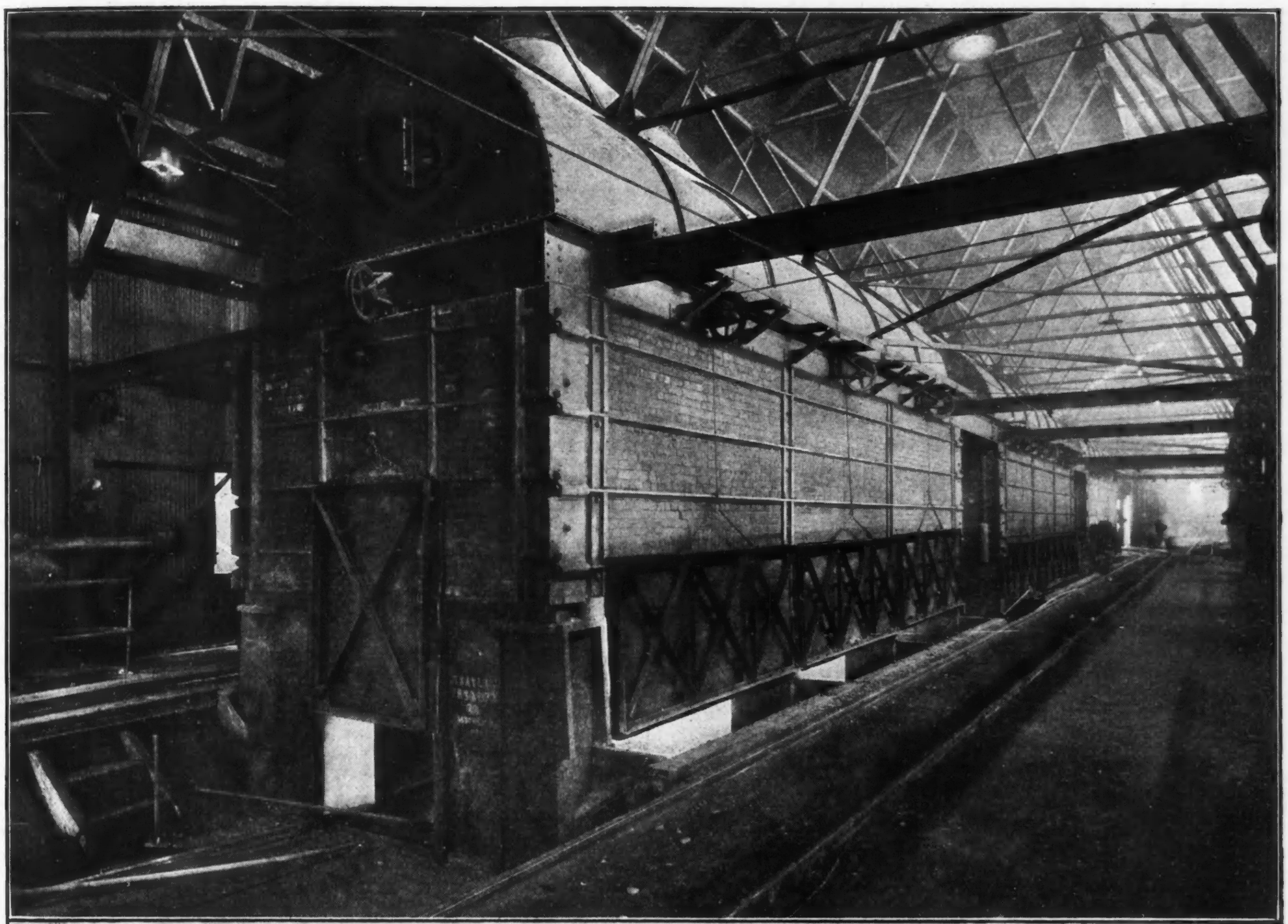
Ore from the No. 2 orebody is more siliceous and aluminous than that from orebody No. 1. The average analysis of No. 2 ore for the last year is given in the accompanying table. The sulphide portion of the ore consists of chalcopyrite, pyrite and pyrrhotite; CaO seems to be present with the silicates rather than as calcite. Unlike No. 1 ore, it can be mined with the introduction of little waste rock, which is fortunate in view of the already high amount of combined SiO_2, as implied by the high Al_2O_3 and MgO content. Physically No. 2

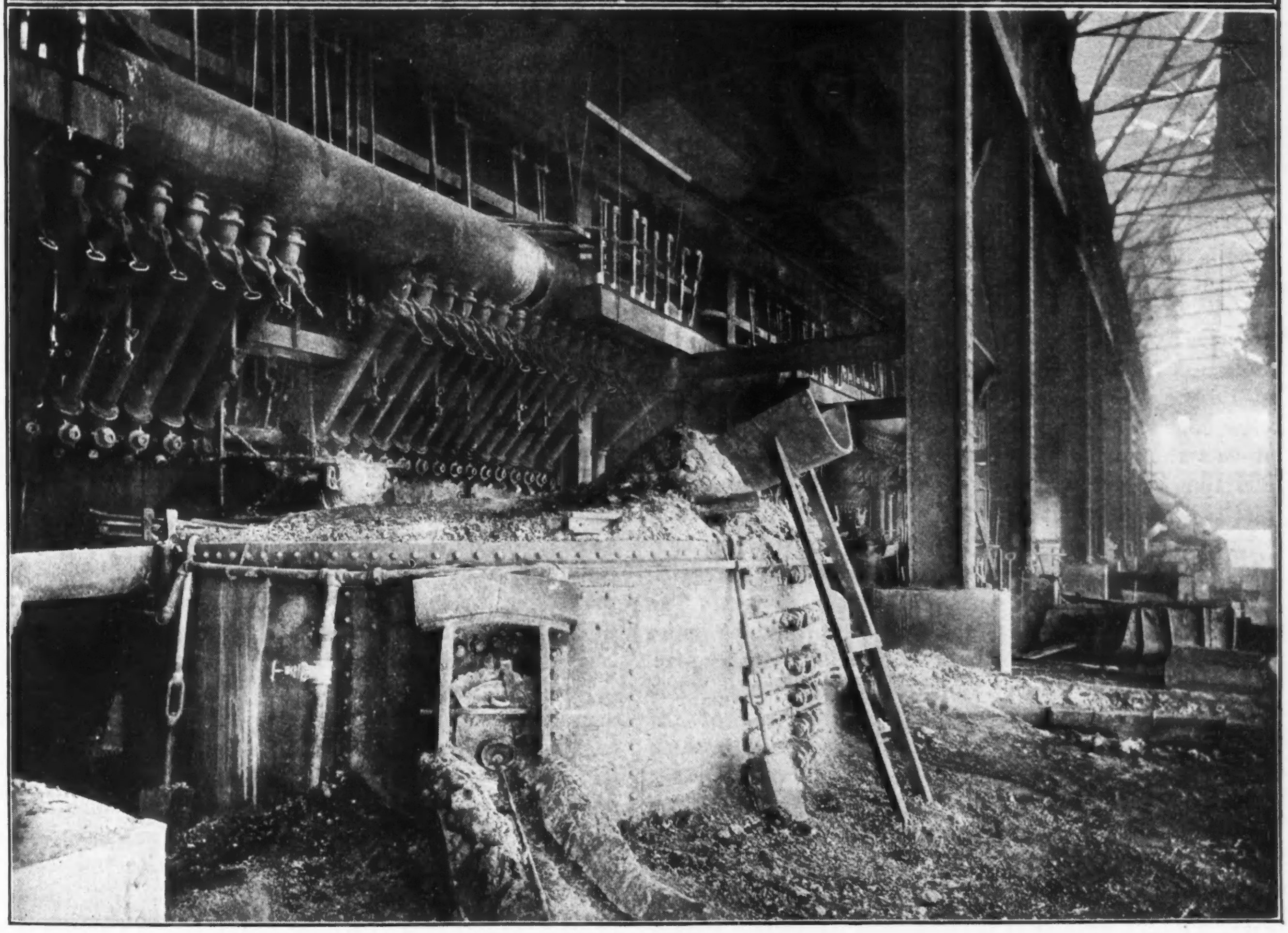


PLAN SHOWING ARRANGEMENT OF BLAST FURNACES AND CONVERTERS AT GRANBY SMELTERY

smelting, though the output to date has been less siliceous than the average of the orebody as sampled. An analysis of current production from orebody No. 1 is given in the table on page 712. The Fe occurs principally as pyrite, most of the SiO_2 as free quartz, and CaO is present mainly as calcite. Some of the combined SiO_2 is present on account of the admixture of waste rock which cannot be avoided without hand sorting. No. 1 ore carries a considerable proportion of fines; screening tests show over 25% passing a ½-in. screen. An intimate mixture of gangue and sulphides is typical, the particles of each being often granular and loosely cemented together, though this condition is not universal as both sulphides and gangue also occur in larger masses. Analyses show a tendency to variation in the composition of the ore shipped to the smeltery. This is caused by a variation of the character of the ore, not only from different stopes but also ore is well adapted for the blast furnace, containing only about 8% fines, being hard and not given to crumbling. It is by comparison fairly uniform in character, fluctuating in analysis much less than the No. 1 ore. The table gives the average of analyses, E and F, for two different months and illustrates the extremes of the range of variation. There is another classification of Hidden Creek ores, a low-grade quartz schist, of which several thousand tons per month is used in the concentration of matte. A typical analysis is shown in the accompanying table.

Outside ores consist of custom ores and ores from the Granby company's Alaskan mines. The Midas mine, a Granby property at Valdez, Alaska, is shipping about 3000 tons a month of siliceous, aluminous sulphide ore. From the Mamie mine on Prince of Wales Island and from several custom shippers, a heavy magnetite ore to the amount of about 5000 tons a month is





FEED AND TAPPING FLOORS OF THE 54 x 360-IN. COPPER-MATTING FURNACES AT THE GRANBY WORKS, ANYOX, B. C.

received. Shipments of a copper-bearing, specular hematite from the White Horse district have been received; also miscellaneous siliceous ores from a number of different shippers amount to about 2000 tons a month. In most of these ores the gangue consists principally of natural silicates of CaO, Al_2O_3 and MgO. "Clean ores," those wherein the SiO_2 is predominantly quartz, or the CaO is calcite, are sparingly offered. An analysis of outside ores is given in the accompanying table.

Fluxes Mined by the Granby Company

Limerock of good quality obtained from the company's quarry at Swamp Point on the Portland Canal, analyzes: SiO_2, 5.0%; CaO, 50.0%; MgO, 2.0%. The Granby company operates several small quartz mines in the immediate vicinity of Anyox. One ledge carries about \$8 in gold and silver. The quartz is full of cracks and fractures, is very friable and shatters so readily that by the time it reaches the smelter bins fully 60% will pass through a 1-in. mesh.

Coke comes from several sources. It contains from 18 to 26% ash, averaging 23%, and physically it will grade from fair to inferior. Clay suitable for smeltery use is found in abundance near the works.

Shipments of outside ores arrive on steamers or barges in amounts ranging from a few tons to 2500 tons. The amount taken for a sample and the method of procedure are varied to meet requirements. Hidden Creek ores are lotted in 40-car lots weighing approximately 1000 tons. An automatic sampler at the mine cuts out $\frac{1}{25}$ of the crushed ore which is then sent to the sampling mill at the smeltery. As the ore is usually smelted before its analysis can be obtained, a close examination is made, as it is dumped into the bins, for the purpose of estimating approximate percentages of SiO_2 and the general character of the silica, whether "clean" or "dirty," and if dirty, whether due to gangue or included waste. This inspection applies particularly to No. 1 ore and is extremely useful in detecting radical changes which might otherwise manifest themselves in a disarranged furnace.

Analyses of Furnace Charges and Products

No. 1 and No. 2 ores are treated in equal proportions and ordinarily such a half-and-half mixture requires flux of a basic nature. The basic ingredients used consist of matte, limerock or oxidized iron ores. It was the former practice, while smelting about 45,000 tons of ore a month, to convert the first fall of matte. The amount of matte thus made in excess of what the converters could handle was poured out, sent to the bins and resmelted on the regular ore charge in amounts ranging from 5 to 15% of this charge. The addition of resmelted matte usually called for more SiO_2 in the charge which was supplied with quartz, thereby increasing the proportion of free SiO_2. The accompanying table gives a typical analysis of the charge, slag and matte; the proportions used in such a charge are: No. 1 ore, 43.6%; No. 2 ore, 43.6%; matte, 8.7%; quartz, 4.1%. The Fe oxidized is, 69%; coke to charge, 3.8%; matte fall, 23.4%. This characteristically pyritic charge ran well as long as the ores remained fairly clean and not too unsteady in composition. By hard driving the three converter stands were just about able to produce the required amount of copper from an average 16% Cu matte when smelting about 45,000 tons of ore a month. Later, however, increased ore tonnage made it necessary to supply converter matte of a higher grade. This was accomplished by devoting one furnace to matte concentration, and part time only is necessary when three furnaces are in operation; but with four furnaces in operation it takes one furnace full time to regrade matte from the other three.

Under present practice the half-and-half mixture of No. 1 and No. 2 ores is smelted with limerock or oxidized iron ores or both. The addition of these basic materials to the charge is subject to frequent changes in much the same way as quartz is raised and lowered in ideal pyritic smelting of heavy sulphides. The analysis of a charge typical of the present practice is given in the accompanying table, the components of which are: No. 1 ore, 44.4%; No. 2 ore, 44.4%; magnetite ore, 5.6%; limerock, 5.6%. The Fe oxidized is, 63.0%; coke to charge, 5.6%; matte fall, 21.1 per cent.

The use of "ready" bases such as CaO and oxidized Fe for flux, instead of matte wherein the Fe must be oxidized to become available, is dictated by the increase in proportion of silicates in the ores and the disturbing degree to which they fluctuate in analysis. This is especially the case where Al_2O_3 is one of the variables and too close an adherence to pyritic conditions is bound to cause trouble. Slags commonly carry about 10% Al_2O_3 but occasionally go to 12% or beyond, the effect of the higher Al_2O_3 content is to increase coke consumption, decrease oxidation and render the furnace more susceptible to irregularities of an unfavorable nature. Limerock is nearly always in the charge, because, aside from its beneficial effect on diluting and increasing the fluidity of the slag, it reduces resistance to the blast and seems to keep the crusts undercut, thereby mitigating the evils of incrustation.

ANALYSES OF ORES, FURNACE CHARGES AND PRODUCTS

Analysis of	Cu %	Insol. %	SiO_2 %	Fe %	FeO %	CaO %	S %	Al_2O_3 %	MgO %
Ore No. 1 (current)	2.00	23.9	20.8	30.8	....	5.4	30.7	4.0	1.9
Ore No. 1 A	2.80	17.3	14.7	33.3	....	5.2	34.2	2.5	0.6
Ore No. 1 B	2.19	27.4	23.4	29.5	....	5.5	29.1	3.9	1.6
Ore No. 1 C	2.40	12.0	10.4	34.9	....	5.0	38.8	1.3	...
Ore No. 1 D	1.64	31.0	27.3	28.2	....	3.4	28.9	5.7	..
Ore No. 2 (current)	2.13	....	29.2	27.8	....	3.5	21.0	8.0	4.4
Ore No. 2 E	2.32	34.6	26.9	27.5	....	3.7	20.7	6.8	4.1
Ore No. 2 F	2.13	40.2	32.4	25.4	....	3.0	17.3	8.7	4.0
Quartz-Schist Ore	0.79	52.9	46.2	19.8	....	4.0	16.1	5.7	2.7
Outside Ores:									
Midas	4.3	47.6	37.3	19.4	....	1.5	17.6	8.5	6.1
Magnetite	1.8	21.4	14.0	47.0	....	5.0	3.5	5.0	5.5
Hematite	3.6	14.6	11.7	50.0	....	1.7	0.9	4.0	2.1
Custom siliceous	5.0	59.3	36.4	10.9	....	2.2	3.8	5.8	7.8
Swamp Point Limestone	....	....	5.0	....	....	50.0	....	....	2.0
Smelting Results with 8.7% of Matte on Charge:									
Charge	3.14	....	22.5	30.3	....	3.8	26.2	4.0	2.1
Slag	0.28	....	37.0	....	44.4	6.3	....	6.6	3.4
Matte	16.0	....	....	....	....	....	....	....	....
Present Practice with no Matte on Ore Charge:									
Charge	2.05	....	23.0	28.9	....	6.3	24.6	6.1	3.3
Slag	0.18	....	35.6	....	38.1	9.8	....	9.4	5.1
Matte	11.0	....	....	....	....	....	....	....	....

Magnetite ore in amounts ranging from 5% to 15%, usually forms part of the sulphide-ore charge. There is no trouble in effecting the proper reduction of Fe_3O_4 in spite of presumably unfavorable furnace conditions, namely, rapid running and oxidizing atmosphere in the focus. Furnaces have run steadily on a charge consisting of sulphide ores 87½%, magnetite ore 12½%, and 5% of good-grade coke, with satisfactory results. Some Fe_3O_4 escapes reduction and finds its way into the matte, but rarely causes tap hole troubles in the settlers.

Various outside ores of a siliceous-aluminous nature are sometimes smelted in small quantities in the regular charges. Usually, however, a special charge is made up for their disposal and smelted in one furnace only.

Local Quartz Used in Concentrating Matte

In concentrating first matte to converter grade, local quartz is the main source of silica. As before stated it seems to run to fines and greatly increases incrustation troubles, but fortunately, in this regard, the ratio of concentration is not required to be high. Hidden Creek siliceous ores frequently replace part of the quartz and help to coarsen the charge. Limerock also forms part of the charge. Converter matte averages between 20 and 25% Cu, and slag from matte concentration will average: Cu, 0.30%; SiO_2, 37.0%; FeO, 45.0%; and CaO, 8.0 per cent.

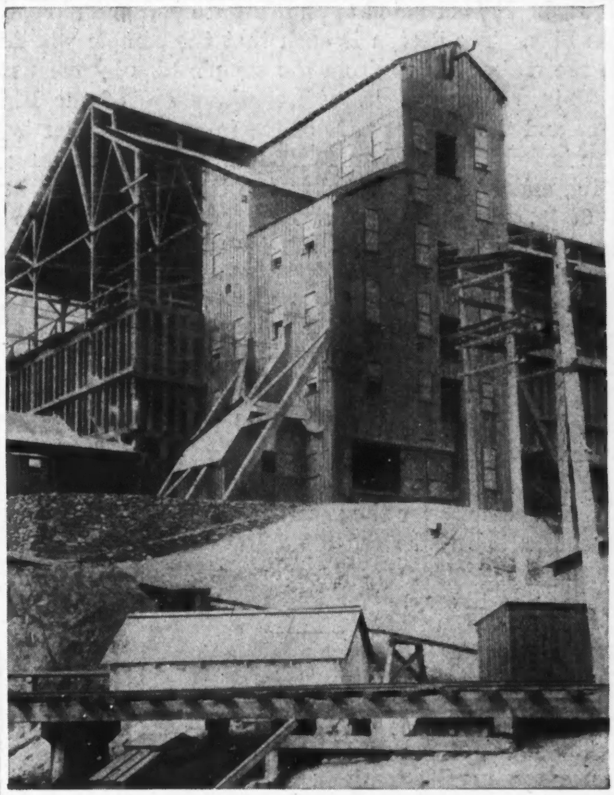
In furnaces Nos. 1, 2 and 3 the charge column is carried about 12 ft. above the tuyeres; in furnace No. 4, which is 5 ft. deeper, a 15-ft. charge column is carried. Less incrustation, smoother running and longer campaigns seem to be the rule with this furnace—attributed partly to the greater fall and consequent better spreading of the charge.

Under average conditions of ore charge, a furnace will take about 900 cu.ft. of air per min. per ft. of furnace length at 48 oz. pressure. A matte-concentrating furnace runs more openly and receives sufficient blast at lower pressures. Numerous analyses of gas issuing from the 12-ft. ore column as well as from the 15-ft. ore column show little if any free oxygen. The volume of blast going to the different furnaces is ascertained by means of Pitot tubes. Each blast pipe has one of these tubes inserted at a suitable point between the common main and the bustle pipe and is connected to a meter reading the number of cubic feet of air per minute.

An ore furnace smelts on an average about 850 tons ore per day but sometimes exceeds 1000 tons. The amount of matte produced is greater and its disposal at times a serious factor, especially when rapid running and low oxidation combine to cause a prolific fall. Furnace crucibles are lined on the bottom and sides with chrome brick. The breast jacket, which is made of converter copper, cast around pipe coils, did not give much life until the practice of bushing the outlet with 2 in. of chrome brick was introduced. This protects the metal against the cutting effect of the matte and, by renewing the brick whenever the furnace is down, an unlimited life of the breast jacket appears possible.

Low-grade matte from the ore furnaces goes to beds situated on the slag dump in front of the building. On furnaces Nos. 1, 2 and 3 a system of brick-lined launders spanning the crane aisle permits the matte to run directly from settler to bed. The maximum distance thus traversed by molten matte is about 200 ft. The No. 4 furnace being at a lower level, has insufficient fall to dispose of matte in this fashion and requires the use of ladle and crane to get it into a launder leading out of doors. There are four matte beds holding several thousand tons each, separated by walls of flue dust. After cooling off a bed with water, it is broken up to some extent with a few shots and reclaimed with a back-haul, drag-line scraper-digger, as already described in the *Journal*.[2]

The grade of matte converted over a period of 12 months averaged 21% copper. Converter-slag analyses



GRANBY SAMPLING MILL

SINTERING PLANT AT ANYOX, B. C.

[2] "Eng. and Min. Journ.," Dec. 25, 1915, p. 1050.

were: Cu, 2.0%; silica, 25.0%; FeO, 64.8%. The blister copper averaged 99.25% Cu. Siliceous flux is mostly quartz, while cooling material, of which a considerable amount is used, is derived from furnace cleanings, sweepings, converter flue dust and siliceous mine ore. The converting department is being enlarged by the addition of 135 ft. of building to house two 20-ft. Great Falls type converters. The copper-casting machine will be enlarged, and a straight-line machine for casting converter slag is also to be installed. Converter slag will be skimmed into slag-pot cars instead of ladles and will be taken to the slag-casting department, cast into slabs and returned to the blast furnaces. It is intended to send to the converting department the first smelting matte irrespective of grade, using the large converters for concentration and finishing in the 12-ft. converters, thus allowing all four furnaces to operate on ore.

There is a large tonnage of concentrating ores in the various mines of the company, and a great deal of experimental work has been done with these ores during the last two years. There is being installed at present a 100-ton experimental flotation unit to obtain further data with respect to the handling of these ores.

Flue Dust, Settling and Sintering

The 9-ft. downtakes of the blast furnaces lead into a settling chamber, 225 ft. long, 50 ft. wide and 30 ft. high; this is a steel structure with brick walls, having three rows of hopper bottoms each served with tracks for dust removal. This chamber has deflecting baffles at each downtake for the purpose of reducing air currents and distributing the gases; and it will also have suspended wires to give a better settling of flue dust. The back wall will have holes leading to a breeching, after the manner of steam plants, thence to a 20 x 20-ft. flue 400 ft. long running up the hill to a reinforced-concrete stack 22 ft. in diameter by 153 ft. high. The elevation at the base of the stack is 280 ft. and the elevation at the top of the stack is 433 ft. above mean tide. The top of the stack, measured above the feed floor, is 288 feet.

The converter stacks will lead directly to a brick-and-steel chamber, 25 x 20 ft., having two rows of hoppers with tracks below for dust collection. Baffles and breeching are the same as in the big chamber, and the flue leads to the main flue and thence to stack.

Flue dust is made amounting to about 4% of the ore smelted and a sintering machine of the Greenawalt type has been installed for handling this material. The dust is brought in cars drawn by an electric locomotive, dumped into concrete bins feeding to a 24-in. conveyor belt which leads to a bin directly over the mechanical mixer—in this case an ordinary cement mixer. The flue dust is moistened to the proper degree and elevated to bins over a specially constructed charge car. There is one bin for crushed limerock and one for the material to be sintered—either flue dust or concentrates. The limerock is laid on the grates first and flue dust over this until the pan is full. The sintering charge is then ignited, down draft being used. When the material is sintered, the pan is turned over on its trunnions, the product falls on breaker cars, and thence into bins from which charge cars take it to the furnaces. The fines are returned to mixer. The pan is 8 ft. wide, 12 ft. 6 in. long and 9 in. deep, and has a capacity of 100 tons per 24 hours.

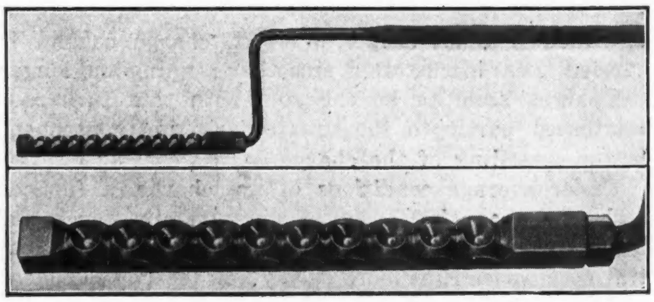
Ore Storage and Sampling

The furnace-charge bins are of heavy wood construction, with two ore alleys underneath and chutes on both sides of the alley to deliver into the charge cars. On the outside of the regular charge bins there is a row of sample bins. The charge-bin structure is 72 ft. wide by 320 ft. long and is suitably divided into pockets. There is storage for 525 tons of coke, 2575 tons of secondaries, 2340 tons of flux and 8600 tons of ore. The bins are served on top by five lines of track all leading to the main high line and everything coming to the bins is weighed over 80-ton track scales. Weighing hoppers for coke and limerock, and track scales for ore comprise the weighing system for furnace charges.

The sampling mill is a heavy, wooden structure having five floors served by man elevators and is well lighted. It is situated at the furnace end and alongside the bins. The design is such that the sample will feed to the main crusher from the sample bins by means of a 30-in. conveyor belt. All crushers are of the Blake type and the samplers are of the improved Snyder type. Ore is fed by belt to an 18 x 36-in. breaker, crushing to 3 in., and is then elevated to the top of the mill where a 60-in. sampler takes a 10% cut. This sample is crushed to pass through a 1-in. ring by a 10 x 16-in. crusher. Another 10% cut is then taken which goes to 14 x 40-in. rolls and is crushed to ½-in. size. A 10% sample is again taken and goes to 10 x 18-in. rolls, where it is crushed to ¼-in. size. From this product a final 10% cut is taken for samples to pipe sampler or to sampling floors. The large elevator has 8 x 14-in. buckets and the reject elevators 7 x 9-in. buckets. The mill is designed so that all rejects go to a conveyor belt and thence out over the receiving bins, and by a system of chutes to any desired bin. The final sample is taken to the assay office and is dried and bucked down for analysis and assay.

Dip Mold for Bullion Samples

At the smeltery of the Ohio & Colorado Smelting and Refining Co., at Salida, Colo., the dip mold shown in the accompanying illustration is employed for taking samples of bullion. The mold, developed and successfully used at this plant, will take 10 clean gum-drop samples from a kettle of bullion at one dip, each weighing approximately one-half assay ton. The buttons are weighed up by the assayer without trimming.



DIP MOLD FOR BULLION SAMPLES

Quality of Iron for Anode Molds

The life of anode molds made from cast iron is greatly dependent upon the percentages of sulphur and phosphorus contained in the iron. The proportion of these elements is directly controlled by the grade of pig iron selected. In casting molds a charge is usually made up as follows: Equal quantities of pig iron and old molds are used, and the coke amounts to from 8 to 12% of the charge; in wheeling in the charge the men figure one-quarter of the entire bulk to be the correct amount of coke.

A mold's unfitness for further use is usually due to one of two causes: (1) The iron is "soft" and the grains of carbon large, and the mold becomes burned out at a point where the molten copper first strikes the iron, forming a groove so deep that final shape of casting is unsuitable; (2) a much larger number of molds are lost through breaking, due to the iron being in a condition known as "hot short" or "cold short," or by the expansion and contraction strains produced by sudden heating or cooling. Phosphorus causes iron to be hot short, and sulphur, cold short.

Mold Service in Tons Cast

In figuring the life of a mold in tons of copper metal cast, the number of new molds put into use each month is considered as the number used up. The records of the service of molds in use in an Eastern refinery, were kept on a basis of the entire production of anode copper in the plant and the replacement of broken molds. A comparison of two periods will show the wide variation. In one month 138 molds were used for a production of 9745 tons, or an average of 70.5 tons per mold. Another month's average showed far more favorable results, being 5988 tons cast with 13 molds put out of commission, or an average of 460.6 tons per mold. These represent the extremes. An average of eight months reported shows that 576 molds were used in producing 60,604 tons of anodes, or an average of 105.2 tons per mold. Still further figures representing the rapid change in duration of service are shown by the mold costs per ton of copper produced, for three consecutive months, which were as follows: $0.119, $0.196 and $0.205, showing how these charges nearly doubled on account of corresponding increase in breakage.

Variation of Pig Iron Analyses

The same brand of pig iron was used during the period in which the above records were made, but analyses of five different shipments showed considerable variation which undoubtedly corresponded with the variation in life of the molds; silicon varied from 3.82 to 4.44%, averaging 4.06%; manganese varied from 0.35 to 0.42%, averaging 0.385%; sulphur from 0.035 to 0.065%, averaging 0.0472%; phosphorus 0.608 to 0.96%, averaging 0.814%. In a single instance where a mold broke after being used for only two charges, or casting about 10 tons of anode copper, the parts of the mold were drilled for a sample and the drillings analyzed, showing: Sulphur, 0.097%; phosphorus, 1.01%; silicon, 2.82%; manganese, 0.23%, which amply illustrates the influence of high sulphur and phosphorus. In this case the quantities of these elements were even higher than the pig iron used. This may be accounted for by a possible irregular bad batch of iron going through the cupola, or high sulphur and phosphorus scrap being used, or, as far as sulphur is concerned, possible absorption from the coke.

Specifications for Pig Iron for Copper Molds

It was, therefore, evident that it was necessary to use iron of certain specifications, and after several trial shipments the following, regarding quantities of sulphur and phosphorus, were decided upon: Quantity of phosphorus present not to exceed 0.25%, and sulphur not to exceed 0.025%. Amount of silicon was specified to be not less than a minimum of 2.25%, and not more than 2.75%, although the silicon does not seem to be as important an element as either of the others, but controls the hardness of the iron and fluidity in pouring. It is undesirable in large quantities and a certain minimum amount is necessary to produce fluidity. Manganese is not so important in the life of molds but acts as a deoxidizer and reduces the amount of sulphur.

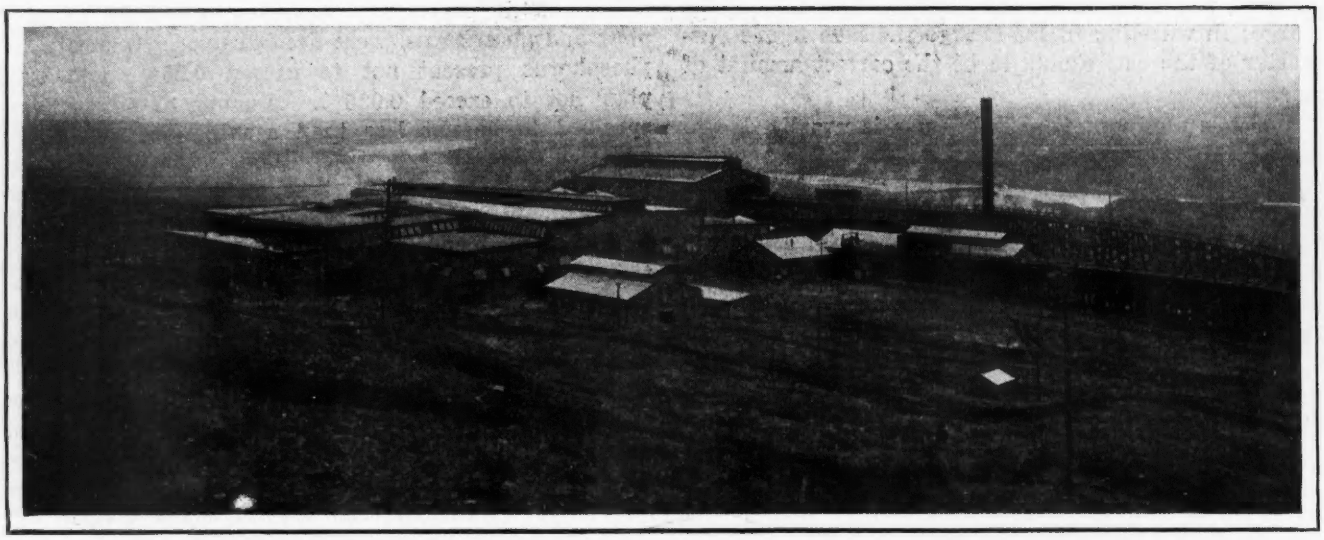
Results from using iron of the above specifications showed a distinct increase in the life of the molds, amounting to more than a hundred per cent. Records for one month after introduction of the above pig iron showed an average of 208 tons of anode copper per mold, which, in comparison with the previous average of 105 tons for an eight-month period, is decidedly favorable. It was further provided that any iron which, in the purchaser's opinion, seriously fails to meet the above specifications may be rejected at seller's expense or, if accepted, may be paid for at a price proportional to the service of the iron.

Smelting a Copper-Nickel Ore in an Electric Furnace

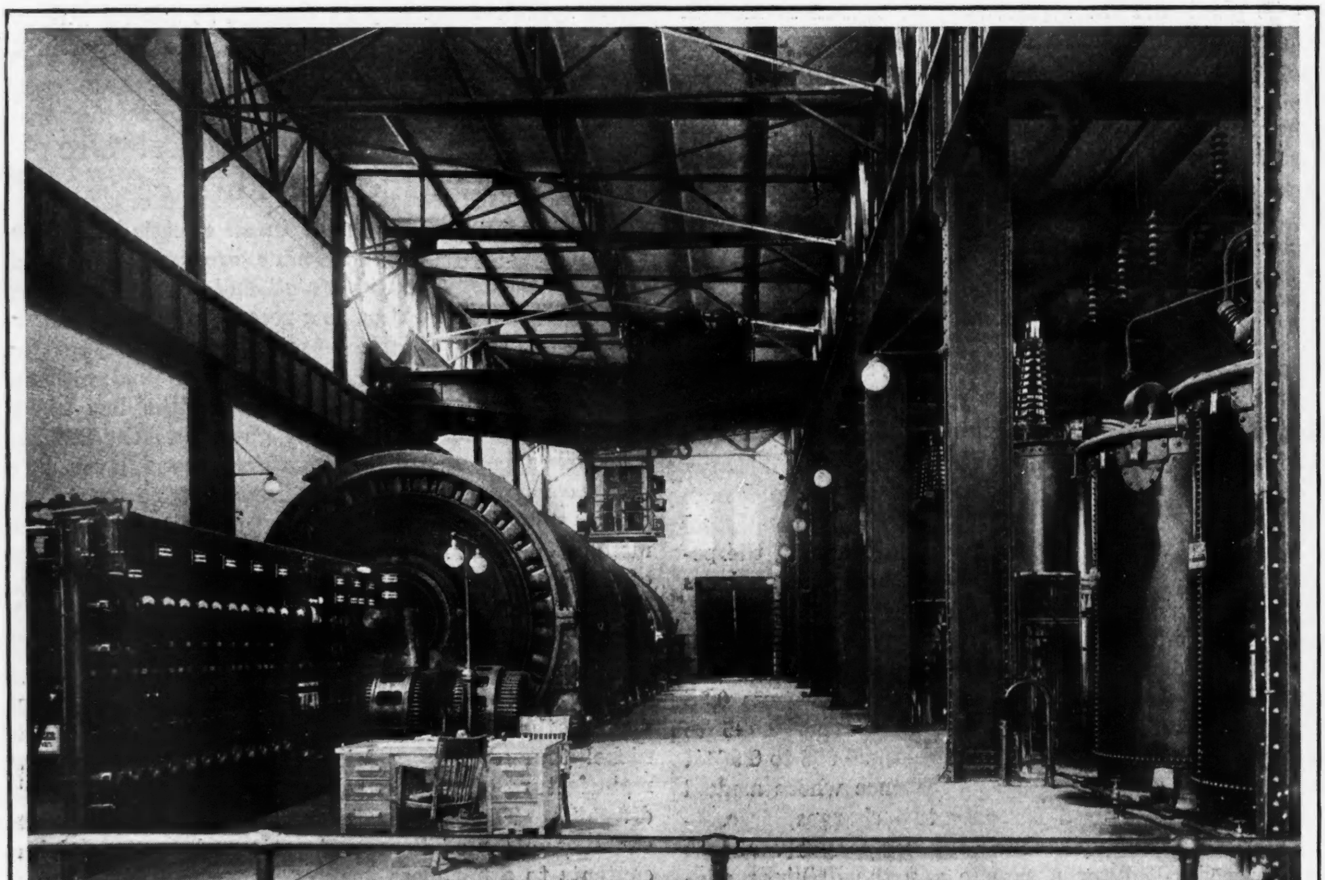
Smelting experiments made in an electric shaft furnace on a copper-nickel sulphide ore from the Black Forest were described in *Metall und Erz, 1916*, by A. von Zeerleder. According to a recent issue of the *Journ. Soc. Chem. Ind.*, the ore contained 1.3% Ni, 44% Cu, 14.7% Fe, 4.5% S, and 45% SiO_2, and had hitherto been neglected mainly on account of the low nickel content. The furnace product gave, on solidification, a nickel-copper matte, below which was a layer of a heavy compound of iron, nickel, and silicon, containing only a small quantity of sulphur and copper. Experiments made on a larger scale in a Girod electric furnace of 300-kg. capacity gave a matte with 4.9% Ni, 4.1% Cu, 30.5% S, and 60% Fe, and a ferro nickel with 13.8% Ni, 0.72% Cu, 8.37% Si, 1.32% S, and 75% Fe. A recovery of 91.3% of the total nickel and 77.4% of the total copper in the original ore smelted was made in these combined products. Refining of the ferro-nickel to a degree sufficient to allow its use in the manufacture of nickel-steel can be carried out without difficulty. The addition of 5% of iron scale and an equal quantity of lime suffices to reduce the sulphur contents to a harmless amount.

Nitrate of Soda Production in Chile for the half-year ended June 30 is estimated at 1,463,900 gross tons. There were 122 oficinas in operation and 52 idle. Exports for the half-year were 679,000 tons to the United States and 526,000 to Europe or 1,205,000 tons, against 1,330,000 tons last year.

Photographs from the Field

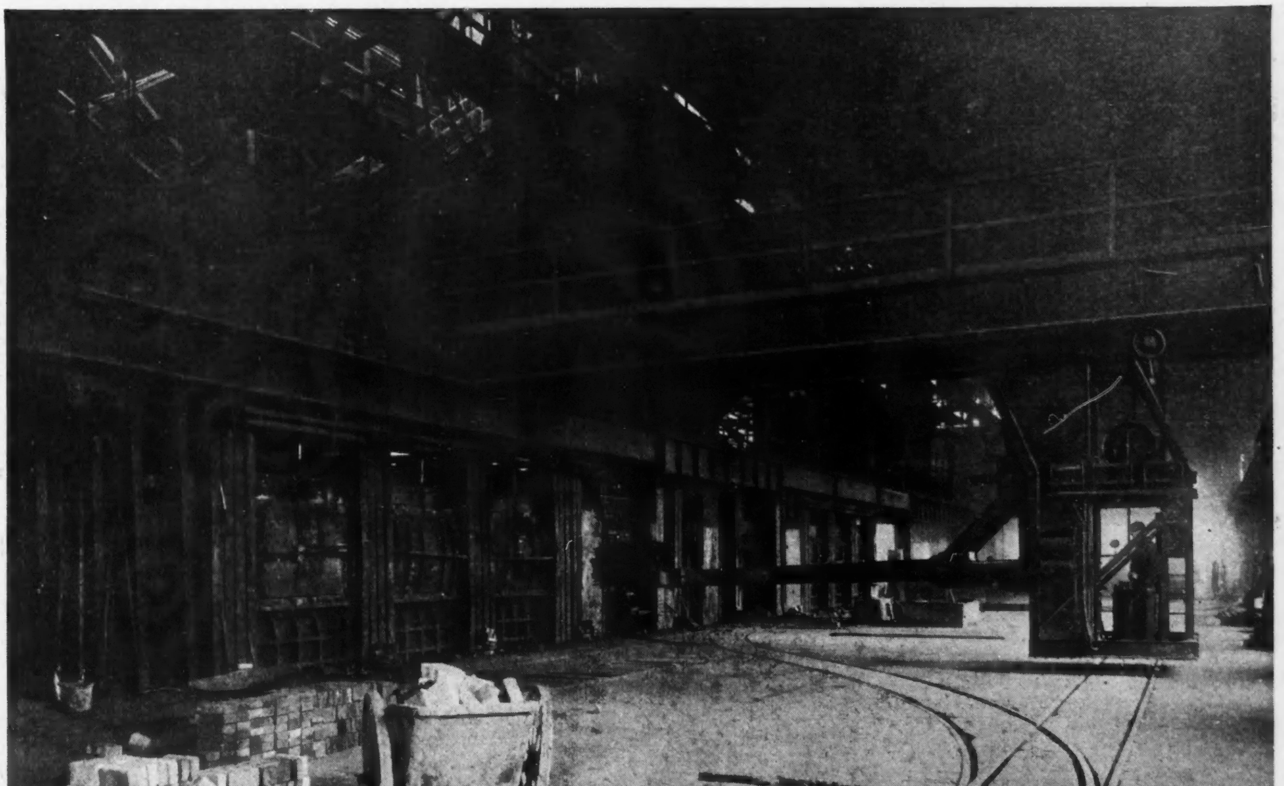


ELECTROLYTIC ZINC REFINERY OF THE ANACONDA COPPER MINING CO. AT GREAT FALLS, MONT.—CAPACITY OF 6,000,000 LB. MONTHLY BEING INCREASED TO 10,000,000 LB. PER MONTH

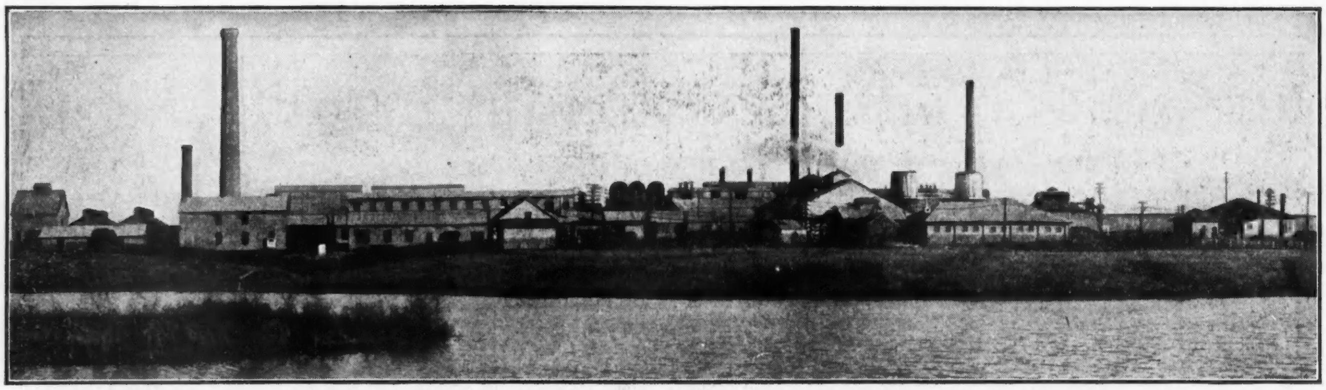


ELECTRIC-POWER SUBSTATION FOR ZINC PLANT AT GREAT FALLS, MONT.

GENERAL VIEW OF ELECTROLYTIC COPPER REFINERY OF THE ANACONDA COMPANY AT GREAT FALLS, MONT.—CAPACITY, 20,000,000 LB. PER MONTH

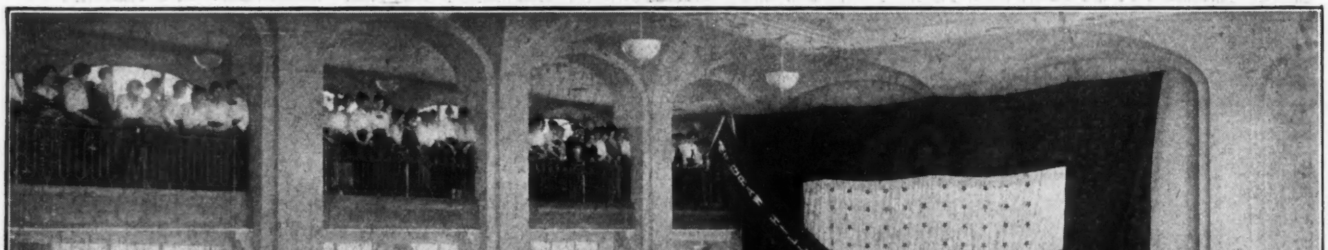


REFINING FURNACES AND CHARGING MACHINE IN THE ANACONDA REFINERY AT GREAT FALLS, MONT.



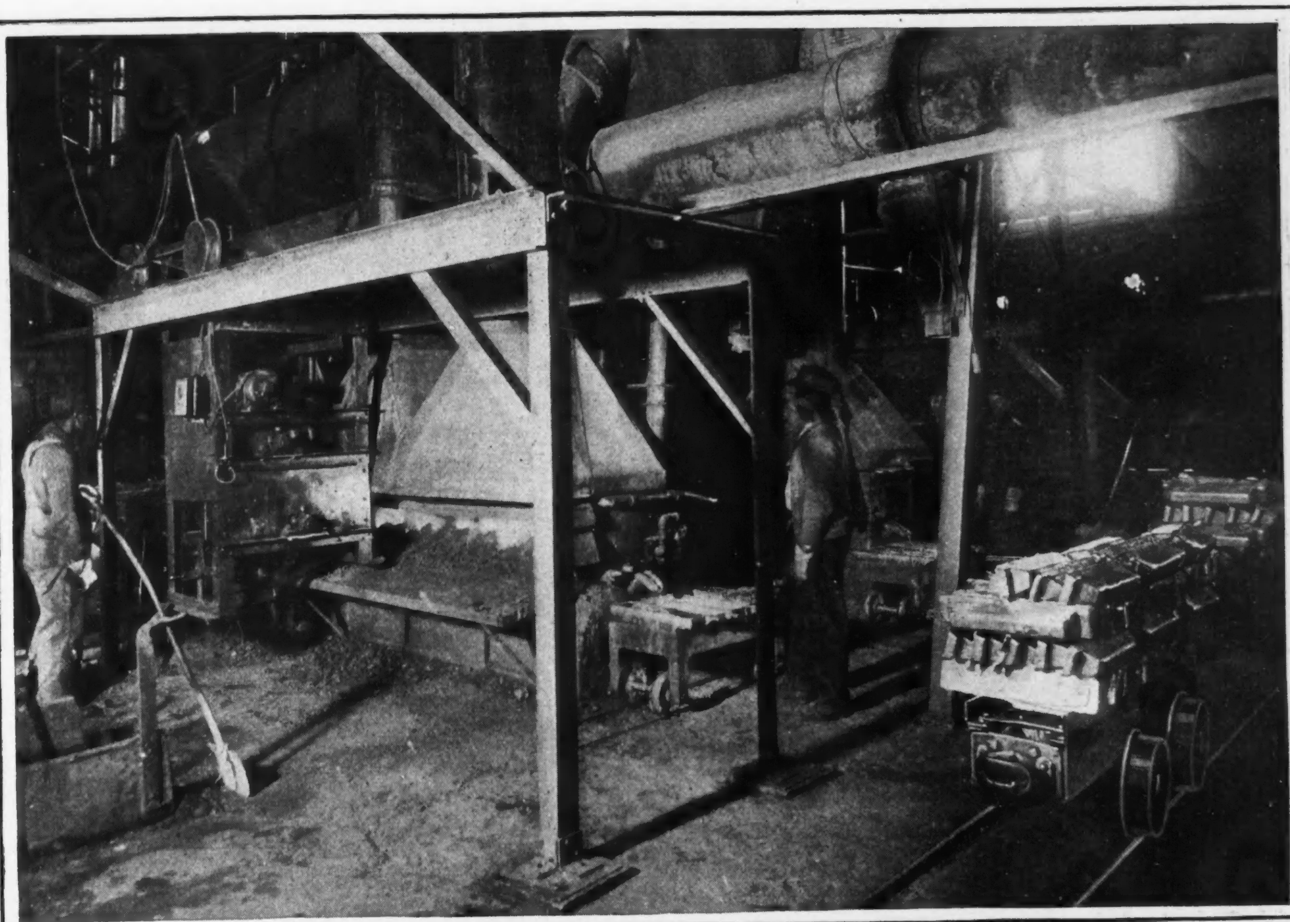
LEAD SMELTING WORKS OF THE ST. LOUIS SMELTING AND REFINING CO., COLLINSVILLE, ILL.

Formerly the lead in the Mississippi Valley was treated as nonargentiferous, but in recent years several companies have put in desilvering plants. The Collinsville plant desilverizes about 1 to 2 oz. of silver per ton, and produces an especially pure lead for the manufacture of white lead. Galena concentrates of over 68% lead are treated by the Newnam hearth process, which overcomes the disadvantages of the old-style Scotch hearth. The great drawback of the open hearth is the extremely severe working conditions owing to the intense heat and exposure to fumes. The leading advantages cited for the mechanical hearth used at this plant, and shown on the opposite page, over the old hand hearth are the following: Cool and sanitary hoods, mechanical rabblers and lead-well attachments that mold clean lead direct from the hearth basin with little attention on the part of the furnacemen. Other advantages of the Newman mechanical hearth for higher grade concentrates are: No flux required for treatment; expulsion of 95% of the sulphur; retreatment of all dust and fume produced, leaving gray slag as the only product to be sent to the blast furnace; large reduction in slag and matte produced; total extraction of 82 to 84% of lead contents of 70% concentrates, the extraction increasing with the lead tenor, practically eliminating any retreatment of mattes. Dwight-Lloyd machines are used as auxiliaries when concentrates lower than 68% are treated

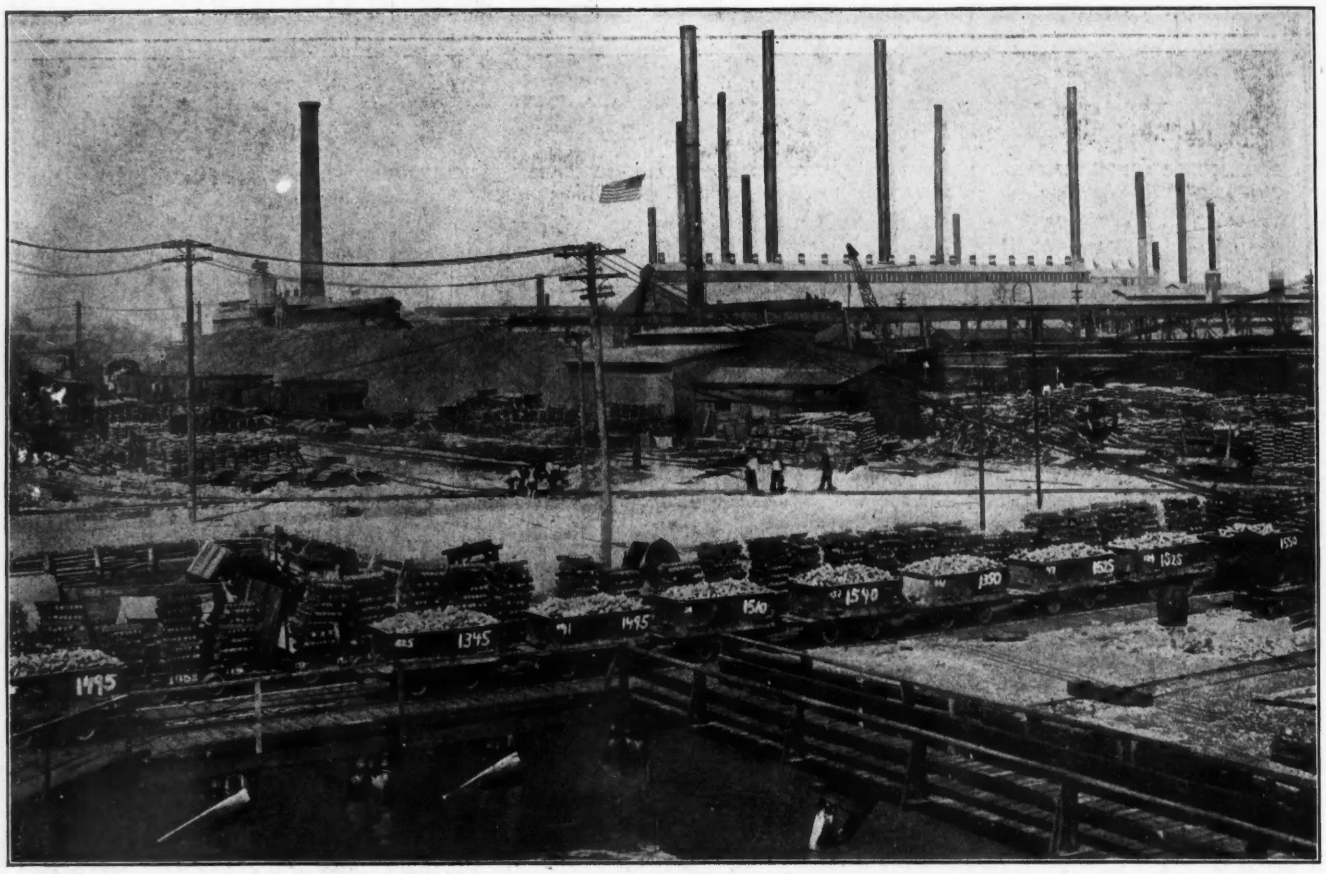


LIBERTY LOAN MEETING OF EMPLOYEES OF McGRAW-HILL PUBLISHING CO., INC.

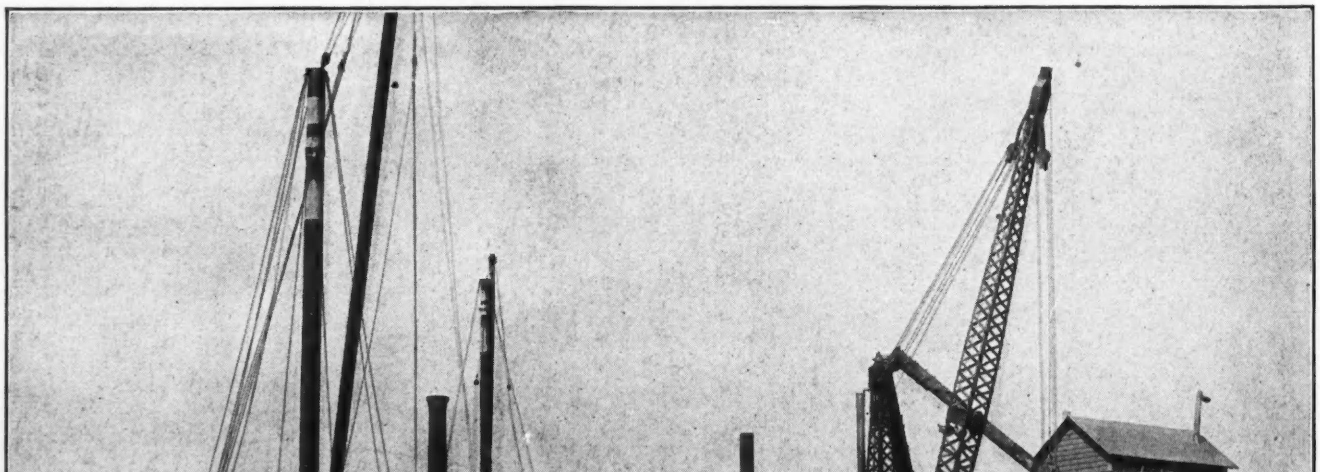
At this meeting there was unfurled a service flag with 42 stars, showing that 42 members of the company have entered military service. Since the meeting four stars have been added



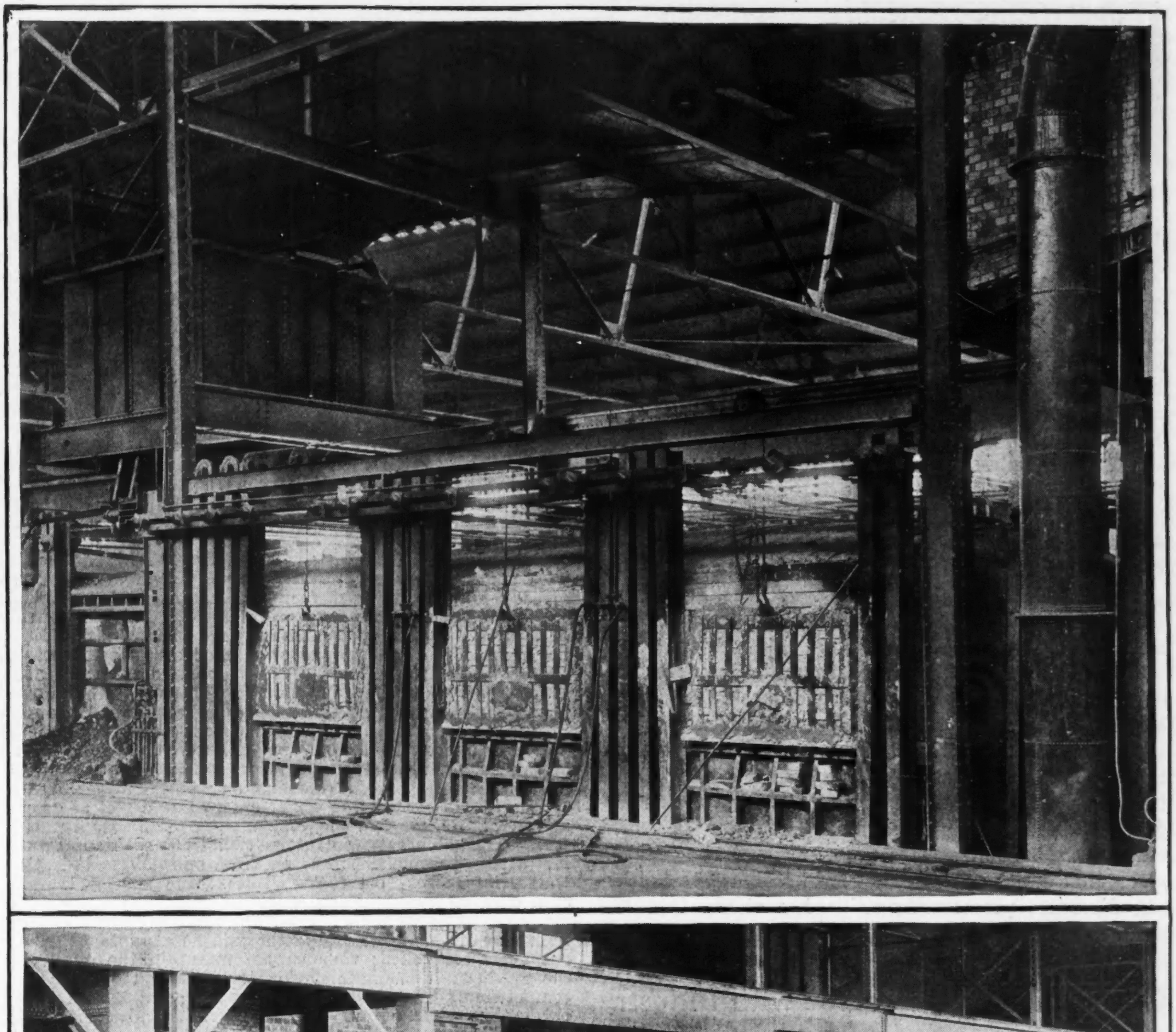
TWO VIEWS OF THE NEWNAM MECHANICAL HEARTH USED AT COLLINSVILLE, ILL.



VIEW OF RARITAN COPPER WORKS AT PERTH AMBOY, N. J.
Carloads of ingots and bars ready to be lightered to New York and thence shipped to Europe



LIGHTER, "ANACONDA NO. 2," LOADED WITH 800 TONS OF REFINED COPPER AT THE RARITAN WORKS FOR TRANSFER TO ATLANTIC LINERS



CHARGING AND CASTING SIDES OF REFINING FURNACE AT THE RARITAN COPPER WORKS

Events and Economics of the War

The systematic disclosure of German duplicity at Washington is continued by Lansing; Bernstorff now stands revealed as the head of numerous plots against American munitions plants and Canadian public works. The coal situation is far from satisfactory; a shortage is reported from many districts; the Fuel Administration maintains that this is only apparent, as more coal has been shipped this year than last. Dealing in 20 staple foods by all save small dealers will be licensed by Hoover beginning Nov. 1; sugar licenses are in prospect, says Hoover, unless Americans exercise greater economy. Government supervision of the foreign-language press has begun. The President has set Oct. 24 as Liberty Loan day by proclamation. The powers of the trading-with-the-enemy act are vested in various agencies of the Government. Railroads in the East are seeking higher freight rates from the Interstate Commerce Commission. Work is to be rushed on 787 ships for the Navy.

In Belgium the British continue their methodical drive, advancing materially at each shock. In Russia Kerensky has appointed a coalition cabinet and the Russian Congress has agreed to act as an advisory body to the provisional government. The Germans have landed troops on Oesel and Dagö islands in Riga Gulf, preparing it is said to move against Petrograd; a recent mutiny in the German navy is reported to have taken place; von Capelle, navy chief, is to resign; the Reichstag discusses peace. Argentina has stated that she will not break with Germany if her flag is respected.

Government Interference with Industry

The United States is not the only country wherein the government has interfered with the regular operation of the wheels of commerce and industry under the guise of regulating things for the most efficient conduct of the war. Complaints and criticisms come from Great Britain that are very similar to those that are being voiced here, while the course of things in Germany is manifestly very much troubled. The following interesting communication appeared in *The Evening Post* of New York under caption of "Special Correspondence from Zurich, Switzerland," dated Sept. 10, 1917:

A question which is nowadays being asked in business circles here is whether Germany is committing economic suicide. This question is forcibly suggested by developments in the "militarizing" of shops and factories in order to save workmen, credit, coal and raw materials.

The industrial production in each branch begins to be concentrated in certain factories. Germany is divided into dozens of military-commander districts called "Armee Corps Bezirke." The military authorities appoint those factories in each branch which they consider best fitted to take over the production of other factories which they decide to close.

They create in such military commander districts, in one branch after the other, so-called Zwangs-Syndikate, compulsory unions of manufacturers. One fine day the owner of a factory receives a military order to send his workmen, raw materials, and often also part of his machinery to some competitor and to cease production.

He receives from the military authorities a guarantee that this competitor who takes over his business in this manner will pay him the lost profit. The manufacturer can be glad if his former competitor appoints him as sales agent of the "Zwangs-Syndikate." Otherwise he himself is without work, and the military authority may send him anywhere to dig trenches or peel potatoes in a hospital kitchen. The "Armee Corps Kommandant" has full liberty to declare which factory is best fitted for being the concentrated producer of a district and which factory must be closed. There is no appeal from his decision.

The Berlin Chamber of Commerce complains that in hundreds of cases of such compulsory industrial concentration, the advice of this competent body was not once sought by the Armee Corps Kommandant. But the compulsory syndicates not only concentrate production and shut down factories; they also distribute the produce to the retail consumers. In the moment when, for example, the soap factories are concentrated they sell directly to the retail trade, and the chiefs as well as the staff of wholesale soap dealers are sent to munition factories, to field work or other military slavery.

It appears that military commanders are highly pleased with the results of this system, and in many cases it has already been stated that factories manufacturing valuable export articles for neutrals were closed. One consequence of this is the damage to Germany's exchange market. In the instructions sent to the owners of compulsorily closed shops and factories it is expressly declared that also after the war the reopening of the businesses will not be allowed without military permission. Much of the national resources in the way of industrial organization, adaptation of the individuals to local markets, special knowledge of the wishes of customers, special qualification for doing better work, are thereby destroyed from one day to the other.

Small towns, where the workmen, owning a plot of ground and living in their own houses, can work more cheaply and so form a valuable asset in international competition through low prices, become depopulated from one day to the other. Industrial secrets become worthless; the special training of a staff of workmen and employees, perhaps the work of many years, is destroyed. Even the factories which enjoyed the favor of this military system gain no advantages. Their output is controlled; they cannot maintain the quality of the product; it is diminished automatically by the lack of competition. The trademarks, made so well known to the public through heavy expenses in advertising, become worthless, for all products sold by the compulsory state syndicates are sent out without trademarks and without any individual sign of the manufacturer.

Perhaps these military commanders believe that they are acting in the national interests of Germany. They have the militaristic mentality, and believe that the destruction, or, better said, the suicide of German wealth, is a small sacrifice compared with the value of a military victory. But it is certain that the majority of German manufacturers and German merchants think otherwise. Here in Switzerland it is observed that German manufacturers with branches in neutral countries concentrate their production in the neutral countries, and gradually liquidate their German business. Their attitude is a silent criticism of the system of the military authorities. In the time of peace this economic suicide will have the worst consequences.

Trading With the Enemy

The Trading-with-the-Enemy Act, recently signed by the President, was framed on the broad, legal ground that in time of war all commerce between territories of belligerents is contrary to public policy, save as specifically permitted by the Government. The provisions of the Act apply to all persons in Germany or in territory occupied by her forces; to persons in countries allied with Germany; to persons outside of Germany but doing business therein; natives or subjects of Germany, residing outside of it and doing no business there, are not affected except as the President may proclaim.

Among the things specifically prohibited are the following: Dealing in property and extending credit on it as security; making new contracts or completing those existing on Apr. 6, 1917; drawing, accepting, paying, presenting for acceptance or payment, and indorsing evidences of dept; paying, satisfying, compromising or securing debts. A subject of Germany cannot with knowledge or reasonable cause for knowledge be carried into the United States, or out of it; or between ports of other countries on American vessels. Communication with Germany by mail, wireless or otherwise is forbidden.

The powers vested in the President by the act have been put into effect by proclamation. The President has created a board to censor all means of communication with foreign countries; censorship of the foreign langauge press is vested in the Postmaster General. The Exports Administrative Board is replaced by a new body, the War Trade Board, which will supervise exports and imports and consider licenses to trade with enemy firms. It will consist of Vance C. McCormick, chairman, representing the Secretary of State; Dr. Alonzo E. Taylor, representing the Secretary of Agriculture; Thomas D. Jones, representing the Secretary of Commerce; Beaver White, representing the Food Administrator; Frank C. Munson, representing the Shipping Board; and a representative of the Secretary of the Treasury; yet to be named. All but the Treasury representative are now members of the Exports Administrative Board, whose work hereafter will be done by the Bureau of Exports of the War Trade Board.

Foreign insurance companies in the United States are to be licensed by the Secretary of the Treasury. Patents, trademarks and copyrights are expressly excepted from the prohibitions declared and may be secured by Germans, as heretofore, provided Germany grants a reciprocal privilege to Americans. If conditions prevent Germans from filing applications therefor, a period of 14 months is allowed after the war in which such action may be taken. Licenses to use German-owned American patents may be issued. Supervision over enemy patents is assigned to the Federal Trade Commission.

The President's order defines the powers of the alien property custodian to act as trustee for all enemy property within the United States or to issue licenses exempting enemy companies from his supervision. An appointment for this position will be made soon. The custodian may require a transfer to himself of any property held for or debt owed to an enemy or enemy ally, and any person so holding any property or so owing any money may transfer the same to the custodian with his consent. Property or money so transferred to the custodian will be held until the end of the war and then dealt with as Congress shall direct. All funds or ready money may be invested in Liberty bonds and held in such form. The President has delegated to the Attorney-General the power to direct the payment of claims against enemy property in the hands of the custodian, upon the consent of all persons interested. All corporations, trustees, etc., issuing shares, etc., must, within 60 days after the Act became law, transmit to the custodian, sworn lists of shareholders, officials, directors, etc., with a statement of the extent of their interests in the corporation.

Navy To Purchase Own Supplies

The Navy will continue to maintain its own purchasing system instead of merging it with the War Industries Board, it has been decided. The question involved was whether or not the Board's plan of noncompetitive, secret bidding which applies to the Army and other branches would apply to the Navy. Representatives of the latter claim that this method as practiced by the Board is costing the country millions. The New York *Sun* cites the following cases:

The War Industries Board refused to give specifications or accept bids from a well-known manufacturer's agent here for a $3,000,000 order on the ground that he was a "middleman" and the board has a rule against dealing with "middlemen." A few days later an order was placed with the manufacturer direct for precisely the same material, at a difference in price of nearly $800,000 in favor of the manufacturer. The samples upon which the order was placed were precisely the same. The only difference was that the Government order was for $7,000,000 instead of $3,000,000.

A second case involves the direct purchase of $2,000,000 worth of shoes by the War Industries Board. The bulk of this supply has been purchased at prices ranging from $4.74½ a pair. Identically the same shoes from identically the same manufacturers would have been had, according to the navy representatives, for $4.65 a pair if the agents had been able to bid.

Railroading in France

Within 20 days after the War Department delivered designs for special locomotives and cars for the troops in France, the first of 680 engines and the first of 6000 cars were ready for shipment, according to a statement from Washington. The engines weigh 166,500 lb. and are of the eight-wheel-drive type, having great traction. They are lighter than the American standard as French roads cannot carry the latter. The cars are only 36 ft. long owing to the sharp curves of the French roads. They have French couplings so that they can be used in the same train with French cars. All equipment will be made inconspicuous with battleship-gray paint.

It is understood that five engineer regiments, composed largely of railway men, will handle the new equipment. Flanged wheel rims have been provided for many American motor trucks and trailers so that they can be used on the line. This scheme was tried by Pershing's forces in Mexico with good results. At the main American army base, among other equipment will be a complete railway-repair shop for all classes of rolling stock, fitted for work on both American and French engines and cars. Trained railway mechanics of long experience on American roads will do the work. Construction of the shops is said to be well advanced.

Electrical Engineers Wanted for Naval Reserve

The Secretary of the Navy has authorized the commissioning of 100 graduate electrical engineers as lieutenants, junior grade, in the Naval Reserve. In general, candidates must be citizens of the United States, between 25 and 35 years of age and graduate electrical engineers. They must have had not less than three years' employment in electrical work since graduation and must be of character and physique required for officers of the regular service. Pay and allowances are approximately: $2200 at sea; on shore, $2480. There is an additional allowance of $150 for uniforms in time of war. Eighty-five nominations are to be made by each of the following agencies: Naval Consulting Board, National Research Council, American Institute of Electrical Engineers. Upon receipt of the 255 nominations thus made certain forms will be sent each nominee to execute and upon receipt of the executed forms a Board of Naval Officers will select 100 for appointment. The officers so selected will be given a month's training and instructions on shore in naval methods, customs, regulations and instructions. Pay will begin on date of appointment. Upon completion of this training they will be ordered to the active fleet as electrical officers of ships for a period of at least six months. After this they will be assigned to duty as the exigencies of the service may demand, excepting such as may be unfitted for the Naval Service. The Provost Marshal General has stated that anyone subject to draft may be released from compliance to accept such an appointment.

Higher Interest Rate on Deposits Not Advised

The expediency of raising the rate of interest on deposits from 3% to 4% has been referred to the Comptroller of Currency by a number of national banks. The purpose is to reduce the inconvenience that might arise from large withdrawals of deposits for investment in Liberty Bonds. In reply the comptroller has stated that 4% is a decidedly high rate for national banks to allow on deposits under existing conditions, and has suggested that the banks take no step in this direction until they can determine exactly what will be the effect of the offering of Liberty Bonds upon their deposits. The banks have been further reminded that they can readily obtain funds for their legitimate needs at favorable rates from the Federal Reserve bank of their district, against which money they will not have to carry reserve as for deposits. National banks, furthermore, generally have the opportunity of being designated as temporary depositaries for the purchase money of Liberty Bonds sold through them.

Commandeering a Plant

An Eastern mill was recently commandeered and compelled to handle Navy work exclusively. It received the following notification:

> You are hereby ordered to postpone deliveries under any commercial contracts you may now have until all the material due the Navy has been delivered. If such action becomes necessary the department will direct the cancellation of such contracts.
>
> You will understand this to be a commandeering of your facilities for the Navy, thus relieving you from any claims on account of default in delivery under your commercial contracts.
>
> It is assumed that this order will be taken by you as sufficient authority, but you are advised that should such action become necessary, the department will be compelled to use such means as are necessary to secure compliance with these directions.

The company in question has no redress. Until all orders for the Navy are ready for delivery it cannot engage on any orders for its customers.

Lift Steel Embargo Against Japan

Japan is to be allowed sufficient steel to keep her shipyards at full capacity, it is reported from Washington. In return she will divert a number of vessels now building into the transatlantic trade with the stipulation, however, that they shall make alternate voyages to Japan. It is practically agreed that the boats shall be sent via Panama to Atlantic ports and thence with cargoes to Great Britain and France; after making the return voyage to this country, they shall go to Japan carrying ship steel. Japan has hitherto maintained that she could spare little tonnage without great inconvenience to herself. It is likewise announced from Amsterdam that the Nederland Steamship Co. has acquiesced in the American conditions for granting bunkering facilities. These provide that the company's vessels for every voyage between Java and the United States shall make a return voyage with cargoes exclusively American or partly Canadian.

Wages Raised in Central Coal Field

Bituminous coal miners of the central competitive field have won their fight for a general wage increase. An additional 10c. a ton will be paid for pick and machine mining, as against the miners' first demand for 15c.; day labor will be advanced $1.40 a day instead of $1.90 asked; pay for yardage and dead work will be increased 15% instead of 20% demanded. Trappers will get 75c. a day raise and other boys $1. The agreement is to last throughout the war. Operators consented to the new wages on the condition that they be absorbed in higher coal prices. The agreement presages a wage raise throughout the industry, as the central-field scale serves as the basis for all other districts.

Letter Postage Rates Increased

The Post Office Department has issued these instructions:

> Postmasters shall on and after Nov. 2 see that postage is paid at the rate of 3c. an oz. or fraction thereof on letters and other first-class matter, except drop letters and foreign mail.
>
> Postal cards are required to be prepaid 2c. and therefore the 1c. postal cards must have a 1c. postage stamp affixed to them in addition to the 1c. stamp impressed on such cards.
>
> Post cards (private mailing cards) bearing written messages must have 2c. postage prepaid on them.

These increases are in accordance with the provisions of the War Revenue Bill recently signed by the President.

May Penalize Car Diversion

As a means of keeping freight cars in active service, charges ranging from $2 to $5 a day on those diverted or re-consigned by shippers will be made by the railroads, if the Interstate Commerce Commission grants their appeal. Without a heavy charge, the railroad attorneys told the Commission, shippers hold loaded cars and change destinations and consignments at will, thus contributing to the congestion of the lines. One of the greatest factors in last winter's coal shortage, these attorneys contended, was the practice of shippers in using coal cars for storage.

Industrial News from Washington

By Paul Wooton, Special Correspondent

Globe-Miami Strikers Will Accept Labor Commission Award

The President's labor commission has concluded the hearing of the side of the striking miners in the Globe-Miami copper district of Arizona. The state leader of the strikers and President Moyer of the International Union of Mine, Mill and Smelter Workers have unreservedly placed the adjustment of the Arizona difficulties in the commission's hands with an unconditional agreement to abide by any decision the commission may make for maintaining peaceful labor relations in that state, at least during the period of the war.

The commission is now hearing the side of the operators and the views of other parties interested When this is completed it will formulate a plan of settlement through the coöperation of all persons concerned which it is hoped will satisfy all sides. The striking unions concluded the presentation of their case to the commission by making an unqualified offer to go back to work immediately upon the agreement of the operators to submit the dispute to arbitration by the commission, and to continue at work pending the arbitration. The strikers expressly stated that they were eager to do away with any delay which might be the cause of the slightest decrease in the normal production of copper for the use of the nation.

Circumstances Attending Passage of Explosives Bill

The Explosives Bill became a law under most unusual circumstances. It was signed by the Vice-President and the President after the Senate had adopted a resolution agreeing to reconsider the vote by which the conference report had been adopted. To understand the situation thoroughly, it is necessary to have in mind the history of the legislation. The bill was reported favorably by the House committee after brief consideration. It passed the House shortly afterward, but the Senate committee rewrote the entire bill, embodying in the law certain of the rules and regulations which had been drafted tentatively by the United States Bureau of Mines. This bill passed the Senate. In conference, the appropriation was reduced from $400,000 to $300,000. The price of the license was reduced from 50 to 25c. The conferees also eliminated the provision which authorized the investigation of any explosion which may have taken place since the beginning of the war. Numerous other minor changes were made, but it was this last change that met the determined opposition of Senator Walsh of Montana, the chairman of the Committee on Mines and Mining. He was anxious that the North Butte disaster be investigated under the authority of the Act.

The conferees had reached their agreement and their report had been accepted by each House during Senator Walsh's absence from Washington. On his return he introduced a resolution providing that the Senate reconsider its vote, so that disasters since the outbreak of the war might be investigated. The Senate adopted the resolution, but the House laid it on the table after Representative Foster, the chairman of the House Committee on Mines and Mining, had urged the House not to return the papers to the Senate as requested by Senator Walsh's resolution.

This action on the part of the House was called to the attention of the Senate by Mr. Walsh, who asked that action be taken to uphold the dignity of the Senate in view of the declination of the House either to comply with the Senate's request or to communicate reason for the refusal. Senator Walsh then introduced a resolution, which was agreed to, directing the secretary of the Senate to advise the President that the signature of the Vice-President was affixed to the bill inadvertently while there was pending before the Senate a motion to reconsider the vote by which the report of the Committee on Conference was adopted. This controversy not only threatened to prevent the passage of legislation deemed to be highly important but has given rise to friction between the two committees on mines and mining, which is likely to affect future legislation.

Gifford Urges Business Organization on Nation-Wide Basis

Creation of national organizations to cover all lines of industries was urged by Walter S. Gifford, director of the Council of National Defense and its advisory commission, at the war convention of the Chamber of Commerce of the United States, which was held at Atlantic City. Commenting on Sec. 3 of the Food Control Act, which has stripped so many of his committees of their membership and has left the Council of National Defense a mere skeleton, Mr. Gifford said:

> Any broad-minded man would have to admit that Sec. 3 of the Food Control Act is intended for the good of the people. It is really because the business men had failed to organize in time of peace and to be in a position to co-operate as organizations with the Government that we have Sec. 3. It is because the Government was forced to organize business as best it could that the situation demanded the passage of a law to prevent possible abuse in what was the only method of procedure that the circumstances permitted.

Mr. Gifford expresses his view of the need of national organization in the following language:

> Each industry would best serve the Government if it were organized on a nation-wide basis with complete representation of all members of the industry. Organization along state lines or by localities is admirable for chambers of commerce and local civic associations, but our industrial life is not so bounded. Industries are not largely affected by state lines. A national organization by industries is the form that will best serve the Government both in time of war and in time of peace.
>
> I hope that men of vision in industry will feel it their duty to assist in organizing the business of this country more completely than it has ever been done. The vision of organized business must be far-sighted and broad. Business

men should know more about business than the Government, no matter how able that Government may be. But remember that the day when business can move along feeling that its own interests are apart from and distinct from the interests of the people has gone by. The war has shown not only that public utilities are essential to the well-being of the people and therefore must be regulated to prevent abuses, but that coal, iron and copper mines and other lines of industry, in short, all vital business, must be carried on for the good of all the people.

Statistical Department Organized by War Industries Board

Arrangements have been completed whereby the United States Geological Survey will coöperate with the War Industries Board in furnishing statistics and other data concerning war minerals. The Survey will make further studies of the situation. The Board is building up a statistical department, which, besides being a clearing house for the statistical sections of various Government bureaus, is gathering data along many lines to be able to forecast future needs with accuracy and to have at hand correct information as to available resources. It will keep track of Government contracts in essential articles of primary importance and will thus be able to distribute orders more intelligently, it is thought. The statistical division also expects to be of decided help to the Priority Committee in giving it advance notice of impending shortages.

Prices Fixed for Steel Products Agreed Upon in Conference

Prices approved by the President last week on certain semi-finished and finished steel products were in line with those announced for plates, shapes, bars, pig iron, coke and iron ore in a statement dated Sept. 24. The new list of prices was issued after a two days' conference between the War Industries Board and committees and members of the American Iron and Steel Institute. The maximum prices of iron ore, iron and steel and their products, as announced to date, are given in the accompanying table. They became effective immediately upon announcement and are subject to revision Jan. 1, 1918.

PRICES FIXED FOR IRON ORE, IRON, STEEL AND THEIR PRODUCTS

Commodity	Price Agreed On	Base
Iron ore	$5.05 per long ton	Lower Lake ports
Pig iron	33.00 per long ton	Foundry and malleable valley furnaces
Steel bars	2.90 per 100 lb.	Pittsburgh and Chicago
Shapes	3.00 per 100 lb.	Pittsburgh and Chicago
Plates	3.25 per 100 lb.	Pittsburgh and Chicago
Blooms and billets, 4 x 4 in. and larger	47.50 per long ton	Pittsburgh and Youngstown
Billets under 4 x 4 in.	51.00 per long ton	Pittsburgh and Youngstown
Slabs	50.00 per long ton	Pittsburgh and Youngstown
Sheet bars	51.00 per long ton	Pittsburgh and Youngstown
Wire rods	57.00 per long ton	Pittsburgh
Shell bars, 3 to 5 in.	3.25 per 100 lb.	Pittsburgh
over 5 to 8 in.	3.50 per 100 lb.	Pittsburgh
over 8 to 10 in.	3.75 per 100 lb.	Pittsburgh
over 10 in.	4.00 per 100 lb.	Pittsburgh
Skelp, grooved	2.90 per 100 lb.	Pittsburgh
universal	3.15 per 100 lb.	Pittsburgh
sheared	3.25 per 100 lb.	Pittsburgh

The new list of prices was accompanied by the following comment by the War Industries Board:

The prices enumerated have been fixed by the President on the assurance of those representing the steel industry that these prices equitably adjust the relations of the steel interests to each other, and will assist them in fulfilling their obligations to give the counry 100% of production at prices not to exceed those heretofore announced. Measures will be taken by the War Industries Board for placing orders and supervising the output of the steel mills in such manner as to facilitate and expedite the requirements for war purposes of the Government and those nations associated with us, and to supply the needs of the public according to their public importance and in the best interest of all, as far as practicable. A spirit of coöperation was manifested by the steel men, and no doubt is entertained that every effort will be made to bring the production as nearly as possible up to the extraordinary demands resulting from the war.

The alloys and iron ore committees of the Iron and Steel Institute, who participated in the conference are constituted as follows: Alloys—J. A. Farrell, E. A. S. Clarke, A. A. Fowler, E. G. Grace, E. J. Lavino and E. H. Gary, the last-named being an ex-officio member. Iron Ore—H. G. Dalton, Frank B. Richards, Harry Coulby, C. D. Dyer, W. T. Shepard, G. H. Woodward, Leonard Peckitt, Frank Billings and Amasso S. Mather.

Lode Mining at Fairbanks, Alaska

Lode mining in the Fairbanks gold district of Alaska will remain practically at a standstill until the completion of the Government railroad to Fairbanks. Commenting on conditions in the Fairbanks district, J. B. Mertie, Jr., of the United States Geological Survey, says:

The cost of power and supplies has increased so greatly that most of the operators either have closed their mines or are operating on a scale little more extensive than prospecting. Most of the operators having high-grade gold ore do not care to continue work under present conditions, which allow them only small profits, and the owners of lower grade ore cannot afford to operate at all. The general policy of all concerned is to await the coming of the Government railroad to Fairbanks, the expectation being that this will effect a general decrease in operating costs. Cheaper power perhaps is the most urgent need of the lode mines and the railroad, by making available the coal resources of the Nenana and Matanuska coal fields, would help materially. A central power plant utilizing perhaps the low-grade Nenana coal may prove the ultimate solution of the difficulty.

With reference to pyrites, Mr. Mertie's investigation leads him to the conclusion that the only sulphide ores which have been found in lodes of commercial importance in Alaska are stibnite and galena.

More Data Sought from Geologists

As the returns on the census of geologists reach the United States Geological Survey, requests for additional information are being sent out to those indicating that they have specific knowledge of the following minerals: Chromite, platinum, potash, manganese, tin, iron pyrites, mica, graphite, arsenic, antimony and bismuth. In this way the Survey expects to collect valuable information with regard to developing greater domestic production of the minerals mentioned.

Experimenting with Phosphate in Northwest

While plans are being made for shipping high-grade superphosphates from the Pacific Northwest into the Middle West, A. E. Wells, superintendent of the Salt Lake City station of the United States Bureau of Mines, believes that none of the material has been manufactured on a commercial scale. The work thus far, he says, has been carried out only in an experimental way in preparation for future operations.

Editorials

This Special Smelting Number

WITH this issue we are repeating our venture, instituted last year, of issuing in the autumn a number of the *Journal* especially devoted to the interests of smelters. Our readers who are exclusively engaged in the mining and milling of ores will forgive us for this preëmption of an issue, for earlier in the year they had special issues devoted to their own subjects.

Smelters will find in this issue, just as they did a year ago, a collection of noteworthy, metallurgical papers. The present issue has a distinctive feature in its attention to branches of metallurgy that are not commonly discussed. Thus there has long been great interest in the subject of zinc-oxide manufacture, but there has been scarcely anything in technical literature about it. Mr. Cregan, in his article on "Zinc-Oxide Furnaces," which is a paper of eminently practical character, fills this gap in a highly satisfactory way.

With regard to blende roasting the same complaint respecting deficiency in the literature cannot be made, for, in fact, the literature on that important subject is extensive. However, it is not very satisfactory, barring the noteworthy article of Mr. de Lummen that we published not very long ago. Previous literature on this subject has been largely confined to descriptions of furnaces, without any analysis of their relative merits and the factors that should determine the choice of a furnace. March F. Chase, who was for many years in charge of the works of the Mineral Point Zinc Co., at Depue, Ill., and has later been engaged in metallurgical work in the vicinity of St. Louis, is a recognized expert on this subject. We asked Mr. Chase to contribute an article on "What Is the Best Blende-Roasting Furnace?" He did not think that he could write exactly under that caption, but has closely approximated to it under the caption of "The Choice of a Blende-Roasting Furnace." Our metallurgical readers will find this a thoroughly refreshing and valuable contribution upon this important subject. In introducing two new contributors, like Mr. Cregan and Mr. Chase, into the field of metallurgical literature, as we have done in this issue, we feel that we should have made good, even if we had done nothing else.

However, in presenting the paper by K. C. Li, on the "Metallurgy of Antimony," we have filled another gap in metallurgical literature. It is proper to say that Mr. Li's paper was presented originally to the Institute of Metals and was published in its proceedings, but for our present publication Mr. Li revised it and supplied new drawings and photographs, which greatly increase its value. Mr. Li is one of the leading officers of the Wah Chang Mining and Smelting Co., at the head of which is H. Y. Liang, who is well known to American metallurgists, as he was a visitor in this country a few years ago. Mr. Liang studied in the Royal School of Mines, in London, and then went to France and engaged in antimony smelting under Herrenschmidt, who had developed the modern metallurgy of antimony. That which is commonly described in the textbooks is as archaic as copper smelting in Orford blast furnaces. Having learned the business in France, Mr. Liang went to China and instituted smelting there on a scale which eventually made his company the chief producer of antimony in the world. Europe and America borrowed the germs of some of its other metallurgy from China, zinc smelting, for example. It is fitting, therefore, that China should have borrowed antimony smelting from Europe. And to complete the comparison, while China, to which the world owes the inception of zinc smelting, now comes to Europe and America to learn modern practice, we must go to China to get the best practice in antimony smelting which China learned from France.

The copper metallurgists get their share of this number in the excellent article by Mr. Krejci on "The Development of Copper-Converter Practice"; in the article by Mr. Williams describing the new Granby smelting works at Anyox, B. C.; in the article describing smelting at the Old Dominion Works in Arizona; and in the article describing electrolytic refining at the Raritan Works at Perth Amboy, N. J.

We regret that lead smelting does not receive its full share of attention, owing to disappointments at the last moment, but some excellent photographs show the working of the Newnam mechanical hearth at Collinsville, Ill., which is one of the most striking and perhaps pathfinding among recent developments in the metallurgy of lead.

We must not omit to call attention to the prophetic article by E. P. Mathewson, one of our past masters in metallurgy. In corresponding about this article, we asked Mr. Mathewson to let himself out, and he has done so, describing freely and frankly visions that no one except the big-minded metallurgist would have, and visions that no one except a metallurgist of assured position would tell about. We think it is the duty of metallurgists of that standing to unfold themselves, in order to afford inspiration for the coming generation, and it is gratifying that men like Ricketts and Mathewson are generous enough to do so. Mr. Mathewson will forgive us if we say that we do not indorse his ideas that involve the subjects of sociology and economics, but his expressions deserve thoughtful consideration, and perhaps we can all find that we can stand on some middle ground without sacrificing our traditions.

Congress Thinks Well of Perpetual Motion

THERE is a law known to scientists as the law of the conservation of energy, which is one of the fundamental laws of nature, like the law of gravitation and the law of supply and demand. There is no use in arguing about them. They are laws, immutable, inexorable, a part of nature itself. The law of the conservation of energy finds expression in thousands of ways. One of the ways is that nobody can get anything useful without spending something for it. There have been many thousands of inventors who have thought they could get power without spending anything for it, have thought that they could contrive motors that would run perpetually without any expense, but Nature with her troublesome old law forbade.

However, dreamers still dream (and fakers still fake) and now comes Garabed T. K. Giragossian, an Armenian inventor, of Boston, who believes he can extract from the air a mysterious power that will drive aeroplanes or battleships. Mr. Giragossian, without revealing his secret, made a decided impression upon members of the Senate and House of Representatives, and the two bodies, which together comprise Congress, adopted a resolution for an investigation of Mr. Giragossian's ideas by a committee of scientists approved by the Secretary of the Interior.

Congress is learning something at least. When, a few years ago, it was considering the discovery of the North Pole, it did not refer the matter to a committee of scientists, but (if our recollection be correct) simply voted that Doctor Cook did it. But the Giragossian matter shows progress. Some day it may even refer the drafting of revenue bills, and such things, to a committee of scientists.

Silver Production of the World

The silver production of the world in 1916, as nearly as can be ascertained from the available statistics, was 175,933,024 oz. fine, a slight decrease from 1915, but a considerable gain over 1914. The war conditions affected production in two ways: In one direction by increasing the demand and the prices, in the other by diminishing the supply of mine labor and by interfering with production in a few countries. Possibly a greater portion of the decrease from some previous years was caused by the internal troubles of Mexico, usually the second producer of the metal.

SILVER PRODUCTION OF THE WORLD

(In Troy Ounces, Fine Silver)

	1914	1915	1916
United States	72,455,100	74,961,075	74,414,802
Canada	28,406,711	26,625,960	25,669,172
Mexico	27,546,752	39,570,151	38,250,000
Central America	2,754,868	2,920,496	3,127,500
South America	10,448,557	13,687,464	14,650,000
Total America	141,611,988	157,765,146	156,111,474
British India	236,440	284,875	262,500
China	....	18,230	21,500
Japan	4,836,228	5,079,552	5,194,800
Chosen	16,864	21,876	33,900
Dutch East Indies, Indo-China, etc.	52,847	48,032	56,650
Total Asia and Oceanica	5,142,379	5,452,565	5,569,350
Transvaal	901,763	996,379	954,600
Rhodesia	150,794	185,233	171,200
Congo and other Africa	5,993	4,770	6,500
Total Africa	1,058,550	1,186,382	1,132,300
Europe	9,240,025	9,276,930	8,954,400
Australasia	3,573,077	4,295,757	4,165,500
Total forthe World	160,626,019	177,976,780	175,933,024
Value at av. N. Y. Price	$88,040,027	$88,425,983	$115,518,726

Figures for foreign countries are based largely on the statistics collected by the United States mint, where no direct official figures can be obtained. China is omitted in 1914, not because there was no production, but because no figures could be secured. Estimates for 1915 and 1916 are probably low.

The first table herewith gives the production by countries in troy ounces of fine silver. The figures are taken from official sources wherever possible, and in other cases are estimated as closely as possible and checked by export reports and other authorities.

The second table gives the silver production of the world for 10 years past, in ounces.

SILVER PRODUCTION FOR 10 YEARS

(In Troy Ounces of Fine Silver)

1907	183,446,268	1912	250,915,189
1908	212,585,573	1913	223,582,706
1909	227,289,440	1914	160,626,019
1910	240,213,965	1915	177,976,780
1911	254,201,239	1916	175,933,024

The total reported production in 1916 was less than that of 1915 by 2,043,756 oz., or 1.2%; but it exceeded that of 1914 by 15,307,005 oz., or 9.5%. It was less by 78,268,215 oz., or 30.7%, than that of 1911, which was the heaviest in recent years. The increase in output from 1907 to 1911 was steady and quite normal. There was a slight check in 1912 and a somewhat greater one in 1913, probably due to the low prices which prevailed in those years partly, and partly also to the interruption of mining in Mexico, which at one time was the largest producer. The sharp fall in 1914 was due to the outbreak of the great war, which for a time demoralized production of all kinds, and especially stopped the working of copper mines in this country which are large silver producers also. The output in Australia was also cut down by labor and other troubles at the Broken Hill mines. The year 1915 showed a very considerable recovery and though 1916 fell back again a little—chiefly owing again to the troubles in Mexico—the difference was not great.

The great demand for silver this year and the consequent extraordinary rise in prices, still high in spite of the recent decline from the maximum, is now stimulating production everywhere. The causes of this demand have been heretofore referred to and it is only necessary to say briefly that the demand for the East has kept up well, while that in Europe has very largely increased, owing to the coinage of great quantities of silver money, which is largely taking the place in ordinary circulation of the gold which has been absorbed by the governments for war purposes.

In fact, the coinage demand in 1916 was unprecedented and it is certain that a larger part of the metal was coined and went into circulation as money than ever before. A collateral to this is that the demand for silver for use in the arts, while good in the United States, was light in all European countries. There are reports that some of the heavy coinage is being hoarded, but these rumors cannot be verified.

Silver is peculiar among all the prominent metals in that a large part of its production is as a byproduct, in connection with other metals, as lead, copper, gold, etc. Comparatively few mines are worked solely or chiefly for the silver contents. Its production is consequently less affected by the direct demand for it, depending largely on that for the other metals, and there have been years when supply seemed to exceed the demand. In 1916, however, the conditions were reversed and the demand was—for a part of the year, at least—in excess of the supply. It was a year when the advantage was with the sellers rather than the buyers of silver.

The new tax bill, especially as it relates to mining companies, continues to be obscure and probably will so remain until we get some Treasury decisions.

What a serious thing to say is that! That Congress so bungles vital legislation that industries are thrown upon the mercy of bureaucrats, with no redress except the tedious course through the courts! In the meantime we get nothing but glimmerings as to the operation of the new law. What are capital and earned surplus employed in the business, remain unanswered questions. About the only thing we can surely see is that companies of large capitalization, like Anaconda, are better off than those of small, like Utah. The clause that permits a deduction from earnings to be made on account of depletion of the mine also affords some hope for the correction of inequities.

The liquidation in the stock market is ascribed to grave concern respecting the new tax law more than to any other one cause. It is not so much a dislike of the high taxation as it is of the inequitable and unscientific system that was evolved in star-chamber proceedings and enacted by Congress without adequate discussion. The President could take no more important step, as a war measure, at the present time than to appoint a committee of experts to redraft the tax law in a scientific way and have it ready for Congress to adopt as an amendment when it meets next December.

BY THE WAY

The young bride had just spent a week at her new home in one of the older Western mining camps. The ground had been located and relocated several times, and in every direction monuments could be seen The bride was heard to remark that until she had come to the West she "had no idea how sentimental mining people were," and thought it "perfectly fine that so many monuments had been put up in memory of the old prospectors and miners."

It sounds simple when you hear it, but some of the simplest solutions are seldom thought of in an emergency. At a mine in the tropics a heavy rain caused a river to rise so rapidly that two miners, neither of whom could swim, were marooned from camp. While the foreman was rigging up a device to rescue them with a wire rope, pulley and "bosun's chair," one of the men disappeared. Within 10 min. he strolled into camp in a semi-nude condition, carrying a queer-looking object. Upon being pressed for an explanation Manuel grinned and exhibited his "water wings," saying, "at the village of my birth in Andalusia, Spain, all the small boys do this whenever they get a chance." He had slipped off his shoes and overalls, tying up the legs of the latter with his shoestrings. Wetting the cloth and inflating his pontons, all he had to do was start far enough upstream and propel himself to the desired point.

Another South African venture is in prospect for American capital. Sir Abe Bailey, who recently formed the Anglo-American Rhodesian Exploration Co., with a capital of £250,000 to acquire all his Rhodesian assets, has started for New York with the intention of increasing its capital to £1,000,000. The new company's head office is at Salisbury, with branches at Bulawayo, Gatooma, Victoria, and Penhalonga. "Apparently," says the London *Fiancial Times*, "judging by the title of his new enterprise and the fact that he is visiting the United States before paying his promised early visit to England, Sir Abe is about to preach the gospel of Rhodesia's coming greatness to Yankee capitalists; that he will receive a friendly welcome by the latter is foreshadowed by the successful launching of the Rand-American Syndicate formed early last year by Isaac Lewis. The Syndicate's program has been delayed by the postponement of the Transvaal Mining Leases Bill to another session of the Cape Parliament, but the indications are that American finance is going to have a big finger in the South African pie after the war, if not before." With breathless anticipation—and hands on our pocketbooks—we await the arrival of Sir Abe.

Some extravagant person night-lettered that the following was overheard at the recent St. Louis A. I. M. E. convention: The engineer, "Yes, Blank lost all his money in a wildcat mine." His wife interrupted, "I didn't know you had to mine for wild cats." The wife of another engineer butted in with: "Oh, yes you do, but it never pays. When I was a little girl in southwestern Virginia I rambled upon Angel's Rest Mountain one day, looking for berries. Suddenly I saw the cutest little kitten ever. Instead of coming when I called, it ran into a hole in the ground. Determined to have that kitten, my sister and I commenced mining with a stick. Pretty soon we struck the mother lode almost at grass roots and collected some rich samples. We each promised faithfully, hope-to-die cross-our-hearts never to tell a soul, but it was not necessary. When we were about 100 yd. from home something informed mother what had happened and she ordered us to bury our clothes before coming to the house. You see, our kitten was a 'wood pussy,' which is another kind of a wild cat."

Recently in driving a heading in the Bonne Terre mine of the St. Joseph Lead Co., at Bonne Terre, Mo., an odor of gasoline was noticed. As the heading advanced, it became stronger until finally the emanations from a drillhole took fire from the open flame of a miner's cap-lamp. This fire was easily extinguished, but further drilling brought out so much more "gas," that another big fire occurred and was extinguished with difficulty. As this occurred in a porous dolomite with a heavy sandstone below and on an anticlinal structure, visions of a gas field were conjured, further heightened when a churn-drill hole sunk to this horizon produced about 100 gal. of gasoline—and then petered out—but it was clean, straight gasoline. A quiet investigation of the neighborhood developed the fact that a blacksmith shop had been run for years immediately over the "gasoline drift" and that it had been equipped with an old gasoline engine supplied from underground tanks. With gasoline at 10c. per gal., a slight but steady leakage was not noticeable and would never have been detected, but for the unique outbreak of a gasoline fire in a new rock drift in the mine directly under the old tank.

Saving for the Liberty Loan

The pledge of "ability and purpose to save money to win the war" is the sum and substance of the loyal citizen's duty in the matter of the Liberty Loan. Commenting on the advantage of saving the money to buy the bonds over the plan of some persons to raise the money by selling other securities, the *Sun* says:

"The sellers (of securities) may use the money received from the sale of their holdings in subscribing for the Liberty Loan; we wonder if they realize what a mistake they make to subscribe with money got in this way.

"It is better to borrow money with which to subscribe to the Liberty Loan than to disturb past savings already invested. The borrowing should in every case be done with the idea of repayment from current income in as short a time as is compatible with the personal circumstances of the borrower.

"The ideal way to subscribe to the Liberty Loan is not, as so many persons seem to think, to pay cash down for the full amount of the bonds. The ideal way to buy a Liberty bond is to pay a little cash down and save the rest from current income—if possible, before the next Liberty Loan offering; if not, as soon as may be. Those who pay cash down in full for Liberty bonds merely transfer money already accumulated to the credit of the Government, but they do not pledge their saving power, they do not enlist their willing and continuous effort in the task of saving, they do not set themselves any work to do in the work we all must do if we are to win the war.

"Those who borrow money with which to buy Liberty bonds, but with no idea of repaying the principal in a definite time, merely tie up some one else's money. They are excusable, perhaps, if they know that the other fellow would not have bought Liberty bonds with it. Even then they do not enlist their own saving power nor his. Those who borrow in anticipation of future savings are in the same excellent class with those who pay a little cash down and undertake to save the rest to meet instalments. The net result is the same; their saving power is brought into action.

"Those who sell what they have to get cash to buy Liberty bonds do a destructive thing. They are guilty of a kind of financial sabotage. There is not and cannot be defence for men who by their acts do their best to wreck existing investments. Their acts cannot be defended on the ground that the Government's colossal investment requires them. It does not. Proper saving by the American people combined with a judicious use of our credit facilities will foot the war bill with no difficulty whatever.

"The most critical point in relation to the Liberty Loan, and the one point which makes relevant recent occurrences in the stock market, is the method of subscription. Neither the total amount of the subscription nor the actual number of subscribers is of such moment at this time as that the American people as a whole shall understand in what way and by what means they ought to take the bonds.

"The test of the real usefulness of an individual's subscription is the engagement of his saving power. If, in buying Liberty bonds, he has not pledged his ability and purpose to save money to win the war, he has not done his full bit! This lesson must be driven home in the general consciousness. When it comes home, we shall have no trouble about the total subscriptions or the number of subscribers. Anyone can save. And anyone who can save can subscribe."

Suspension of Assessment Work

DENVER CORRESPONDENCE

In reporting adversely on the Shafroth resolution providing for the suspension of assessment work on unpatented mining claims during the war Secretary Lane stated that so far as he had been advised there was no general demand or necessity for relieving the owners of mining claims from performing the usual labor and improvements on their claims. He thought that to grant the exemptions proposed might inure to the benefit of claimants who are holding public lands under mining locations for speculative purposes. This statement was made despite the fact that there were on file with the Committee of Mines and Mining urgent appeals from nearly all portions of the mining regions of the West, asking for this legislation. The adverse report of the Interior Department would mean the defeat of the Shafroth resolution[1]. Therefore Congressman Taylor prepared a substitute wherein assessment work is waived for the present year only.

Secretary Lane has stated that he is inclined to favor the resolution as amended. Just why he is inclined to favor the suspension of assessment work this year and not next, should the war continue, is not clear, but in any event it is probably all that can be expected at this session. Any effort to extend the time will probably jeopardize any legislation in this direction. The justification for the Shafroth resolution should be clear to any mining man. Following the declaration of war a large number of miners, probably more than from any other industrial group in Colorado, enlisted or quit their jobs in the mills and shops and as skilled mechanics sought employment in the United States navy yards. When the conscription law passed, another large exodus took place, for miners volunteered in order to choose the various branches of the Army and Navy under which they preferred to serve. A still further loss came with the selective draft. The situation has been further aggravated by industrial disturbances where strikes were threatened or actually took place, and since employment in other lines of industry could readily be obtained a large number of men left the mines for fear of being involved in labor troubles. At Leadville and Cripple Creek and in the San Juan there are mines where a hundred more men could find employment, if they could be obtained, at a higher wage and under more favorable conditions than ever before.

In Colorado alone there are over 5000 unpatented claims, requiring annually half a million dollars' worth of labor as assessment work. This work is never classed as productive, is seldom even considered development work, and is frequently nothing more than surface exploration and practically valueless so far as production is concerned. With the acute labor shortage now pre-

[1]This account was written before the passage of the Shafroth bill reported in the issue of Oct. 6.

vailing, assessment work means just that much labor diverted from production of metals vitally essential to the successful prosecution of the war. For this reason not only in Colorado, but also throughout the metal-mining states mining organizations are practically unanimous in urging the passage of the Shafroth resolution or some other similar legislation, and the action of the Interior Department and the United States Bureau of Mines in reporting adversely on the measure after it had passed the Senate was a surprise as well as a disappointment.

Hollow Magnetite Electrodes

An invention relating to the manufacture of magnetite electrodes, and particularly of hollow magnetite electrodes, by a casting operation has been patented by Arthur P. Scott. The process, described in the specification of U. S. Pat. 1,226,121, May 15, 1917, involves the preparation of molten magnetite in a suitable type of electric furnace. The bottom of the furnace is provided with a protective conducting layer of magnetite, prepared from "purple ore" or leached Rio Tinto cinder. In order to prevent penetration of the magnetite conducting layer by the arc, broken anode scrap is added to the ore charge. This does not go into solution as readily as raw ore and settles to the bottom. The lining of the furnace itself is of some substance, such as magnesite, that is not attacked by the magnetite.

In melting the ore the graphite electrode is lowered into contact with the magnetite bottom and a charge of purple ore is thrown in around the electrode, which is raised as fast as the ore is melted and becomes conducting. When a clear fluid bath of sufficient quantity has accumulated, a little more ore is thrown on the surface as a temperature check and to limit the formation of ferrous oxide. When this is absorbed the bath is ready to pour. The whole operation takes from one to 1½ hours.

For casting the hollow electrodes a mold of gray cast iron is used, split diagonally along its major axis, and the two halves are drawn together during casting by pivoted bolts and keys. For convenience the mold is mounted on trunnions which permit its rotation in a vertical plane. Before casting, the mold is heated to about 350° C. At a lower temperature the chilling effect is great and the electrode is liable to crack during annealing. At a higher temperature there is a tendency to adhere to the mold, but it is safer to risk moderate sticking, with a danger of rupture in stripping, than to have the mold too cold. A coating of lime or bone ash, applied with an air brush after each casting, helps to prevent sticking in hot molds.

In casting, the molten magnetite at a temperature of about 1590° C. is poured directly into the preheated mold. The mold is allowed to stand undisturbed for one minute after filling and is then quickly inverted to discharge the molten interior, leaving a shell of solid magnetite on the interior of the mold. The mold is then laid on a horizontal stripping table, the keys are quickly knocked off, and the upper half of the mold is removed. An iron spatula is thrust into the anode, which is lifted out of the lower half of the mold and taken to an annealing shelf. The anode, at a temperature of about 1100° to 1200° C., is buried in a bed of pulverulent nonconducting material, such as infusorial earth, and allowed to remain for about four days, when it is cool enough to be removed and handled with safety.

Foreign Trade in Lead and Zinc

Imports of lead and zinc during June, July and the first seven months of 1917, are reported by the Department of Commerce as follows:

Articles and Countries	June Contents, Lb.	July Contents, Lb.	Jan.-July Contents, Lb.
Lead Ore:			
Canada	214,630	317,759	7,972,527
Salvador	155	1,700	3,117
Mexico	1,127,476	1,092,526	10,614,752
Chile	....	....	1,194,749
Peru	19,767	149,569	348,072
Italy	....	....	46,719
England	....	8,528,583	8,609,804
German Africa	2,657,945	....	4,405,145
France	....	55,410	120,102
Panama	....	6,084	6,084
Others	....	....	2,491
	4,019,973	10,151,631	33,323,562
Lead—Base Bullion and Bullion:			
Dutch East Indies	....	....	102,874
Peru	....	8,730	50,385
Canada	....	....	1,165,931
Mexico	7,610,683	6,214,098	39,418,182
	7,610,683	6,222,828	40,737,372
Lead—Pigs, Bars, etc.			
Panama	7,998	3,710	45,450
Barbados	247	....	2,814
Colombia	....	....	3,155
Haiti	450	1,000	38,502
Canada	....	10,024	327,782
Guatemala	....	....	52,400
England	....	....	80,188
Mexico	265,720	....	2,287,809
Peru	....	....	10,012
France	....	....	89,086
Chile	....	....	8,769
Jamaica	....	13,446	13,446
Others	772	3,832	7,086
	275,187	32,012	2,966,499

The gross weight of lead ore imported in June was 11,259 long tons, and in July, 10,260 long tons.

The actual tonnage of zinc ore imported in June and July amounted to 18,864 and 13,767 tons, respectively. The countries of origin and the metal contents were as follows:

Countries:	June Contents, Lb.	July Contents, Lb.	Jan.-July Contents, Lb.
Canada	520,000	878,962	4,753,962
Australia	6,228,646	....	23,427,162
Mexico	8,387,181	6,531,129	63,734,385
Spain	....	....	12,166,840
French Africa	....	....	1,245,000
Italy	....	2,822,400	2,822,400
	15,135,827	10,232,491	108.149,749
Zinc in Blocks, Pigs, etc.:			
Costa Rica	802	783	7,003
Panama	6,287	1,688	24,493
Cuba	16,791	31,913	233,935
Mexico	....	....	3,318
Ecuador	....	....	7,580
Canada	1,519	....	17,186
Brazil	1,168	....	5,513
Colombia	3,000	....	6,000
Jamaica	....	2,165	2,165
Others	....	274	1,762
	29,567	36,823	308,955

Imports of zinc dust amounted to 145,600 lb. in June, 92,796 lb. in July, 1917, and to 509,633 lb. during the first seven months. Of the July imports, 44,800 lb. came from Canada, 44,975 lb. from Japan and the remainder from Cuba.

Exports of lead and zinc were as follows (in pounds):

	June Contents	July Contents	Jan.-July Contents
Lead:			
Pigs, bars, etc., produced from domestic ore	13,241,999	6,270,671	64,753,454
Pigs, bars, etc., produced from foreign ore	1,483,825	179,369	12,064,658
Zinc:			
Pigs, etc., produced from domestic ore	23,847,236	15,289,279	189,748,276
Pigs, etc., produced from foreign ore	2,908,251	4,480,007	65,257,013
Sheets, etc	2,342,261	2,436,590	15,177,270

Personals

R. C. Canby has gone to Miami, Arizona.

G. H. Morgan was recently commissioned a lieutenant in the army and is now in Washington, D. C.

F. Julius Fohs, petroleum geologist, of Tulsa, Okla., has opened an office in New York at 60 Broadway.

A. C. Spencer, of the United States Geological Survey, is examining pyrite deposits in New England.

John T. Fuller returned recently to New York from seven months' examination work in northern Brazil.

C. M. Weld, of New York, has returned to Cuba to resume the professional work on which he was engaged last August.

Adolf Knopf has been put in immediate charge of the United States Geological Survey's investigations dealing with tin.

Waddill Catchings, president of the Sloss-Sheffield Steel and Iron Co., has been in Birmingham, Ala., on one of his regular visits.

P. S. Smith, administrative geologist of the United States Geological Survey, is examining sulphur deposits in Culberson County, Texas.

John C. Greenway, manager of the Calumet and Arizona Mining Co., has resigned in order to enter the Service. He sailed for France last week.

T. E. Rice, manager of the Pittsburg-Lorraine mine of South Lorraine, Ont., has been summoned for military service in the American army.

Harry F. Fay, of Boston, president of the Mayflower-Old Colony and Contact companies, has been making his annual inspection of these properties.

J. C. Metcalf, engineer at the Melba mine, on the Mesabi Range, has been appointed assistant engineer with Pickands, Mather and Co., at the Duluth office.

Frederic Royce, engineer for the Breitung interests at Negaunee, Mich., has joined the staff of the Johns-Manville asbestos properties at Asbestos, Quebec.

J. B. Umpleby, of the United States Geological Survey, has been given charge of the section of metalliferous deposits during the absence of **F. L. Ransome.**

A. F. Kuehn has been appointed consulting engineer for the Burma Corporation. The technical committee formerly in charge of the operations of this company has been dissolved.

Ambrose Monell, president of the International Nickel Co., has resigned to accept a commission as colonel on the staff of the commander of the American aviation forces abroad.

R. M. Draper, superintendent of the Chrome plant of the United States Metals Refining Co., has resigned. He is succeeded by **C. L. Colbert** from the company's smeltery at Midvale, Utah.

Robert C. Stanley, general superintendent of the Bayonne works of the International Nickel Co., has been elected a director of that company, taking the place of Mr. Monell, who lately resigned.

W. A. Bostwick, who has been assistant to the president of the International Nickel Co., has been elected president to succeed Ambrose Monell, who resigned in order to enter Governmental Service.

Lloyd M. Kniffin, assistant superintendent of the United States Metals Refining Co.'s plant at East Chicago, Ind., has been transferred to the Boston office. He is succeeded by **W. D. Kilbourne.**

Albert E. Hall, formerly at the Massey mine in Ontario, who has been with the Hampden Corundum Wheel Co., Chicopee, Mass., as superintendent of concentration, will shortly join the National Army.

H. W. Edmondson has resigned as manager of the Madison Mining Corporation, operating tungsten properties at Silvermine, Mo. He has been commissioned a captain in the Engineer Officers' Reserve Corps.

Myron L. Fuller, heading three parties from the Associated Geological Engineers, has completed a summer's fieldwork in West Virginia. **Clyde T. Griswold** was engaged during the summer on geological work in Wyoming fields.

Richard Roelofs, general n. ager of the Cresson Consolidated Gold Mining and Milling Co. at Cripple Creek, Colo., will retire soon. He will remain affiliated with other Carlton-MacNeill interests and will be succeeded at the Cresson by **A. L. Bloomfield,** of the Golden Cycle mill.

Noel J. Ogilvie has been appointed to succeed the late Dr. W. F. King as superintendent of the Geodetic Survey of Canada. Mr. Ogilvie has done important work in connection with international boundary surveys and was recently in charge of the geodetic survey of the British Columbia coast.

Stephen Royce, for five years chief engineer on the Gogebic Range for Pickands, Mather and Co., has resigned to take up general examination, exploration and geological work with **Dr. C. K. Leith** of Madison, Wis. He will continue to handle the exploration work of Pickands, Mather and Company.

C. W. Merrill, a distinguished metallurgical engineer of San Francisco, has joined the ranks of dollar-a-year men in Washington, being engaged with Hoover and Requa in the Food Administration. Mr. Merrill is giving his attention especially to chemical problems that have a bearing on the food question.

Obituary

Dr. E. F. Roeber, editor of "Metallurgical and Chemical Engineering," died of heart trouble in East Orange, N. J., on the morning of Oct. 17. He was taken ill about June 1, last, and was removed to Battle Creek, Mich. He failed rapidly, however, and was brought back to his home, where he died.

John McBride, federal mediator in the Globe-Miami copper strike and ex-president of the American Federation of Labor, died Oct. 9 in Globe, Ariz., from injuries received when a runaway horse kicked him through a plate glass window. He was at Globe in company with the Secretary of Labor and other members of the Federal labor commission investigating labor conditions in Arizona.

Theodore E. Schwarz died at Brookline, Mass., Sept. 30, aged 62 years. He was born in Boston, entered the Massachusetts Institute of Technology and was graduated as a mining engineer with the class of 1876. He went to Colorado immediately after graduation, taking charge of a tunnel at Georgetown. With increasing experience he was given more important positions, and had charge of many valuable mining properties. In 1890 Mr. Schwarz opened an office in Denver as consulting engineer, where he remained until 1908, when failing health obliged him to retire and he removed to Brookline to live. He was a member of the American Institute of Mining Engineers, Sons of the Revolution and the Colorado Scientific Society.

Societies

University of Manitoba—Classes in mineralogy, assaying and petrology for the benefit of prospectors and others interested in mining, which were held last year for the first time and proved highly successful, will be resumed this season under the direction of J. S. De Lury. Dr. Wallace, who was formerly associated with him in the work is now in command of the training school for officers.

Mining and Metallurgical Society of America, New York Section, held a meeting on Oct. 11 at the Columbia University Club. The speaker of the evening was W. F. Durand, chairman of the National Advisory Committee for Aeronautics, National Research Council, Washington, D. C. His topic was "The American Air Service," in discussing which he reviewed the development of the air fleet intended for military use in France. The meeting was preceded by a dinner at 7 p.m.

Industrial News

Walter A. Zelnicker Supply Co., St. Louis, has secured the services of J. C. Bryan, formerly with Manning, Maxwell & Moore, Inc. Mr. Bryan will be associated with the equipment department.

Asbestos Protected Metal Co., of Pittsburgh, announces the appointment of Ole K. Olsen, 822 Perdido St., New Orleans, as sales agent for Louisiana and the southern portion of Mississippi.

Morse Bros. Machinery and Supply Co. has dismantled the Junta mill at Telluride, Colo., and shipped the material to Denver, over 20 carloads being obtained. This plant was in operation only three weeks.

Trade Catalogs

Link-Belt Electric Hoists. Link-Belt Co., Chicago, Ill. Book No. 246. Pp. 44; 6 x 9 in.; illustrated.

Casings for Link-Belt Silent Chain Drives. Link-Belt Co., Chicago, Ill. Book No. 342. Pp. 6; 6 x 9 in.; illustrated.

Turbine Pumps for High Head Service. Worthington Pump and Machinery Corp., 115 Broadway, New York. Bulletin W-602. Pp. 32; 6x9 in.; illustrated.

"Turning Waste Into Profit." Prestolite Co., Inc., Indianapolis, Ind. Book No. 5. Pp. 20; 8½ x 11 in. Illustrated. Devoted exclusively to the possibilities of reclaiming broken machinery and metal parts by oxyacetylene welding.

Wire Rope, Armored Rope, Fibreclad Rope, Cordage. Waterbury Co., 63 Park Row, New York. General Catalog and Price List. Pp. 220; 3½ x 6 in.; illustrated. This is a neat cloth-bound catalog of pocket size, describing the products of this concern. Much valuable information is given as to the correct practice in the use of wire rope with particular attention to lubrication and splicing. Many useful tables are included as well as a dictionary of words and phrases relating to cordage.

Industrial Heating as a Central Station Load—Part Two—a 64-page book, 7 x 10-in., published by the Society for Electrical Development, Inc., of New York. It is issued with the purpose of pointing out and developing the field of general industrial heating. It takes up applications of electrical heat, such as arc welding and heat-treatment of steel. The book includes a list of classes of applications, their temperature range, lists of heating equipments furnished by various manufacturers and a bibliography of publications written on the subject.

New Patents

United States patent specifications listed below may be obtained from "The Engineering and Mining Journal" at 25c. each. British patents are supplied at 40c. each.

Catalysis—Process of Effecting Catalytic Reactions. Otto Christian Hagemann, Yonkers, and Charles Baskerville, New York, N. Y. (U. S. No. 1,238,137; Aug. 28, 1917.)

Concentrating Carnotite Ores. Herman Schlundt, Columbia, Mo. (U. S. No. 1,240,-607; Sept. 18, 1917.)

Copper-Nickel Pyrrhotite—Treatment of Copper-Nickel Pyrrhotite. Woolsey McAlpine Johnson, Hartford, Conn., assignor to the Continuous Zinc Furnace Co., Hartford, Conn. (U. S. No. 1,238,298; Aug. 28, 1917.)

Drying or Roasting—Improvements Relating to Drying or Roasting Apparatus of the Rotary Chamber Type. Oswald Elsworth, Newcastle-on-Tyne, England. (Brit. No. 104,939.)

Excavating-Machine. George Henry Dunlop, Auburn, Victoria, Australia. (U. S. No. 1,236,691; Aug. 14, 1917.)

Excavator. Cornelius G. Hastings, Glendale, Calif., assignor to Hastings Tunnel System Co. (U. S. No. 1,240,445; Sept. 18, 1917.

Flume—Albert C. Norton, Denver, Colo. (U. S. No. 1,237,544; Aug. 21, 1917.)

Furnaces—Improvements in and Connected with Crucible Furnaces. Frederick Samuel Wigley, Birmingham, England. (Brit. No. 105,146.)

Furnaces—Improvements in and Relating to Furnaces. Alfred Smallwood, London, N., England. (Brit. No. 105,818.)

Grinding and Tumbling Mill. Frank H. Ensign, Toledo, Ohio. (U. S. No. 1,238,652; Aug. 28, 1917.)

Hoisting-Engine Alarm. William J. Lilly, Butte, Mont. (U. S. No. 1,239,409; Sept. 4, 1917.)

Leaching Valve. Veunia Smith, Santa Monica, Calif. (U. S. No. 1,238,209; Aug. 28, 1917.)

Pump—Fritz W. Machlet, Elizabeth, N. J. (U. S. No. 1,237,668; Aug. 21, 1917.

Pump—William S. McFerren, Chambersburg, Penn. (U. S. No. 1,238,036; Aug. 21, 1917.)

Refractories, Production of. Paul R. Hershman, Chicago, Ill., assignor to the Mineral Products Co., New York, N. Y., a corporation of West Virginia. (U. S. No. 1,240,569; Sept. 18, 1917.)

Tunnel Shield. Cornelius G. Hastings, Glendale, Calif., assignor to Hastings Tunnel System Co., a corporation of New York. (U. S. No. 1,240,446; Sept. 18, 1917.)

Editorial Correspondence

SAN FRANCISCO—Oct. 13

Conditions on Comstock Lode continue to be favorable. Two companies, both situated at Virginia, Storey County, have been recently permitted by the California commissioner of corporations to raise funds through sales of stock. The Ophir Silver Mining Co. is allowed to sell 48,410 shares on the San Francisco stock exchange, and the Sierra Nevada company to sell 6650 shares purchased at a delinquent sale at a price not less than 15c. The Union Consolidated, reported previously to have struck good ore, has been delayed in extraction on account of an accident in the shaft. This also caused delay in the Ophir's production and hampered work. Repairs can readily be made.

BUTTE—Oct. 13

Dedication of Pioneer Monument commemorating the discovery of gold in Montana took place at Gold Creek in Powell County on Oct. 6. A number of pioneers and the Montana Geographical Society were present, and Granville Stuart, the only survivor of the group of pioneers who made the discovery, told the story of the journey made 60 years ago, resulting in the finding of gold. The monument erected on the spot of discovery consists of a plain marble shaft, 16 ft. high, designed by Edgar S. Paxson, who also was present at the unveiling. The monument is the gift of Mrs. Mary E. Morony and was erected in honor of her father, Capt. James H. Mills.

Boston & Montana Development Co. is doing considerable amount of work on its properties in the Elkhorn district in Beaverhead County. It has driven about 6500 ft. of openings for the development of two veins from a tunnel 950 ft. below the apex. A large fault was encountered about 2500 ft. from the portal of the tunnel and a lot of work has been done in an effort to find the faulted veins. One of them, known as the Idanah, has been recovered and a drift has been run on it a distance of 350 ft., for all of which distance the ore is in place. The other, a parallel vein, called the Park, has not yet been found, although the fault has also been gone through in that portion of the property and the engineers think it is but a matter of a short time when the Park vein will also be recovered. The ore in the Idanah vein is said to show good average contents in silver, lead, gold, zinc and copper. The company is also pushing construction work on 37 miles of railroad from a junction with the Union Pacific at Divide, Mont., to the mines in the Elkhorn district, and will be completed and equipped within a year. A large mill has also been contracted for and will be built early in the spring. The company owns about 1000 acres of mineral land in that district, and half as much more in another district, known as French Gulch. It also owns timber lands and water power sites. The railroad being built is only a small portion of the line that has been projected. The original plan was to build a main road from Divide, through the Big Hole river valley, famed for its agriculture and stock raising, and two branches, one to the Elkhorn and the other to the French Gulch mines, but the breaking out of the European war put an end to the financing which had been arranged for in London.

DENVER—Oct. 13

American Mining Congress is again active in Colorado and a campaign has been inaugurated to rejuvenate the Colorado chapter and increase the active membership to two hundred. The directors of the congress have appointed John T. Burns, an experienced organizer and a Westerner, as assistant to J. F. Callbreath, the National Secretary, with instructions to organize the West to the point of efficiency. Mr. Burns is now canvassing the mining camps of the state and is securing the coöperation of most of the substantial mining operators and engineers. These men believe that it is to the best interests of Colorado to have a live, well organized chapter, which can act in union with similar organizations, in adjoining states, in national matters. The Colorado chapter will coöperate with all other Colorado bodies engaged in furthering the interests of the mining industry, with a view to dealing with questions of national legislation favorable to mining. The congress is not completely satisfied with what it has accomplished in connection with the organization of the Bureau of Mines, but is now ambitious to take another important forward stride and secure a department of mining in the national Government.

SALT LAKE CITY—Oct. 13

Power Facilities for East Tintic district are being increased by the Utah Power and Light Co. This part of the camp of Tintic is to have a new drainage and development tunnel, to be driven over a distance of 5½ miles from Goshen Valley to a point near Silver City; and the Utah Power and Light power line is to be extended from the Tintic Standard, seven miles easterly, so as to afford power for the projected tunnel. Also a heavier line is to be laid between Knightsville and the Tintic Standard over a distance of 8000 ft., and the line to Homansville is to be improved. Since the coming into prominence of the Tintic Standard, the East Tintic district has been receiving more attention, and the question of better transportation is being agitated.

Car Shortage has caused the National Council of Defense to action in regard to Utah coal mines, and the mines have in prospect a temporary relief, with the hope of more permanent help. One thousand west-bound cars have been ordered by the National Council of Defense—in response to an appeal of Sept. 27 by the public utilities commission of the state—to stop in Utah for loading with coal on the Southern Pacific and Western Pacific railroads, and this number with 350 additional cars provided by the Southern Pacific, will afford for one week at least rolling stock commensurate with the capacity of Utah coal mines. The utilities commission has further requested of the National Council of Defense that a regular supply of cars be arranged for. In this matter, W. W. Armstrong, fuel administrator for the state, is to confer with the National Council as to the authority of the utilities commission to order empty cars within the state to the mines for loading. In connection with the question of the Utah coal supply, a statement by A. H. Cowie, vice president and general manager of the Utah Fuel Co. is of interest, giving the coal production of Utah for 1916 as 3,621,935 short tons, with the possibility—with adequate transportation—of raising this for the present year to 5,000,000 short tons and placing the increase by Utah coal mines immediately available at from 50,000 to 75,000 tons monthly.

WALLACE, IDAHO—Oct. 13

Report of Labor Conditions by W. J. A. McVety, state labor commissioner of Idaho, who was recently sent to the Cœur d'Alene district, has just been made public. Mr. McVety includes also with his findings the report of G. Y. Harry, commissioner of conciliation of the department of labor, who was here at the same time and for the same purpose. The mine managers met in conference in response to an invitation from Mr. Harry. The invitation requested that they meet himself, Mr. McVety, and C. O. Young, organizer of the American Federation of Labor. In his report to the secretary of labor, Mr. Harry states that the managers were willing to meet himself and Mr. McVety, but did not wish Mr. Young in the conference. He says that "in view of the fact that there has been no miners' union of any consequence in this district since the great riot and upheaval of 18 years ago and that the mines have been running on the open-shop basis, I found the managers adverse to having any dealings or doing any business with the unions," and he might have added that they were justified in that position, but he didn't. He then says that both he and Mr. McVety "placed before them the wishes of the Government, both national and state, with reference to labor conditions," but he does not outline those conditions. He does say, however, that they were "assured by the gentlemen present that they would meet at all times with their wage scale the rising cost of living, and see that fair and equitable conditions were maintained in the mines of the district regardless of any demands on the part of the local unions." He also found that there were four locals of the International Union of Mine, Mill and Smelter Workers, comprising a membership of 500 to 600, while there are about 6000 men working in the district. Immediately after this conference Mr. Harry says he conferred with men representing the district council of the miners' union and that "I recommended to them that so long as the existing standards were maintained that they make no demands at this time." Mr. Young, of the A. F. of L., and Mr. McVety "both participated in this conference and coincided in the recommendations which I made." Mr. Harry learned the next morning that the district council "decided to recommend to the unions that they let conditions rest as they are and make no efforts to change them until next spring." As the mining companies had given assurance that they would adjust the wage scale to the high cost of living and maintain fair and equitable conditions, the "change" here mentioned must refer to a demand to unionize the mines in the spring, a meaning that may be implied in the closing sentence of Mr. Harry's report, in which he says: "I believe that we can feel safe as to the continued operation of the mines in this district at least until next spring." In his report to the governor, after quoting in full with his approval Mr. Harry's report, Mr. McVety says: "I informed the mine operators at the conference that the Wallace field was virgin territory for organization work on the part of labor, and if the wrong organization succeeded in getting a footing, trouble was bound to follow. I asked what attitude the operators would assume if the present labor organizations put on an active campaign for membership, and E. R. Day, manager of the Hercules, answered they proposed to maintain the open shop and no discrimination." If we forget the official titles of the gentlemen making these reports, one would infer that they were prepared by union organizers rather than by representatives of the governments of the United States and the State of Idaho.

PHOENIX, ARIZ.—Oct. 11

Destruction of Two Plants producing munitions metal has caused the Arizona chapter of the American Mining Congress to petition the Federal Labor Commission now in the state to investigate the matter. The shaft and shaft-house of the Mammoth Molybdenum mine at Mammoth and the mills of the Union Basin Zinc mine at Golconda are the plants referred to. Both were destroyed by fire recently, entailing a combined loss of over $200,000. The local chapter has also requested from the Treasury Department, a broader secret service operation in the state for the protection of industrial plants.

DULUTH, MINN.—Oct. 12

Scarcity of Shipping Facilities, owing to boats failing to get back on their return trips as rapidly as they did last year, combined with the later opening of the season this year than last, makes the total ore shipments from the head of the lakes, so far during 1917, almost 2,000,000 tons less than they were at this time a year ago. September shows a falling off from the corresponding month last year, but September, 1916, was an extraordinarily good month for shipping conditions. The total tonnage, up to date, shipped from the head of the lakes is 33,000,000 tons, against 35,000,000 a year ago.

Report of County Mine Inspector, W. H. Harvey for the year ended September, 1917, shows there were 115 mines in operation out of a total of 138. Out of the 14,479 men employed, 6860 were underground miners, 3060 were openpit men, 2236 men were employed in stripping and 2323 were surface men. In 1916, a total of 19,916 men were employed. Although the number of men employed this year is less, the ore shipments from St. Louis County have been greater by 5000 tons than last year, with a total of 35,902,516 tons. The number of tons shipped from the underground mines was 11,347,693 and from the openpits, 24,554,823 tons. During this period there was 10,441,738 cu.yd. of stripping removed. The average pay per day in all the mines has been from $2.90 for common labor in the openpit to $4.42 for underground work, and steam shovel and locomotive men receiving from $3.71 to $7.34. The Pioneer mine, of the Oliver Iron Mining Co., at Ely, holds the record for the greatest shipments from an underground property for the year, which was 438,383 tons, and the Hull Rust of the same company, at Hibbing, holds the record for pits, having shipped 6,500,000 tons.

CALUMET, MICH.—Oct. 13

Annual Report of Mines Inspector of Houghton County for year ended Oct. 1, showed total number of men underground was 16,423. This compares with 16,520 in 1916, 16,005 in 1915 and 12,954 in 1914. In 1908 the figure was 17,224, in 1909 it was 17,974, and in 1910, 16,250. Under the circumstances and with all the hue and cry of shortage of men, the fact remains that while every mine needs more men underground, the working figure is better than the average. The percentage of casualities is 0.0029. Of the 48 men killed in the mines, Champion lost 7 and Calumet six.

JOPLIN, MO.—Oct. 13

Electric Power Was Crippled for many mines when a further break occurred in electric machinery, this time a turbine being reported out, in addition to the burnt out generator reported a week ago. The story of last autumn and winter threatens to be repeated, when one break followed another from midsummer until February this year. The company orders new equipment and adds enough new business to absorb the additional current to be generated before the equipment arrives. As last year, so this year. Fifty per cent. of electric power is off.

TORONTO—Oct. 11

Order Prohibiting Assessment Work in Rickard Township has been withdrawn by the government of Ontario owing to the timber rights granted along the Abitibi River. A considerable number of prospectors have gone into the district and many claims east and north of the original discovery have been staked.

Labor Conditions in Northern Ontario have been settled but situation in Porcupine remains bad, and with little hope of improvement. One of the unfortunate things is the fact that there are now three different scales of wages in the camp and unless this is adjusted, while there is no probability of a strike this fall or winter, there is every chance that there will be one in the spring. The Hollinger is paying a flat rate of $4 to everybody underground, the McIntyre recently raised the muckers to $3.50 a day, and the Dome and the rest of the camp are paying muckers $3.25 a day. The situation is further complicated by the system of bonuses being paid in Cobalt, where with silver over 90c. the men are receiving a bonus of $1 a day, drillers receiving $4.50 and muckers $3.50 to $3.75. Men are leaving Porcupine daily to go to Cobalt and also to the Sudbury camp where wages have again been raised. The McIntyre with a $5 cost and a $10 ore can stand these wages together with the high prices of supplies, and the Hollinger with an $8 ore and a large tonnage can also stand it, but the Dome is in a bad shape as a consequence of these conditions. The larger part of the mill tonnage is coming from the open pits and is running around $2.50 a ton with costs of $2.40. With the approach of winter, difficulties of keeping the pits open will be increased and it will not be economical to operate them. If all the tonnage were taken from underground, the tonnage would be cut to about 600 tons a day and the costs would be about $5. As the grade of the ore would be only a little over $6, the margin of profit would be small and the mine would be gutted by the time normal conditions returned. The mine to run at capacity should have 650 men and they have only about 200. This condition presages a shutdown of the mill, and the confining of operations to development only. In the case of a shutdown, which seems inevitable, milling will in all probability not be resumed for at least a year, but during that time the mine would be put in splendid shape, and a large amount of development caried on at greater depths.

The Mining News

ALABAMA

Clay County

LECROY GRAPHITE AND MINERAL CO. organized with an authorized capital of $250,000. Headquarters will be in Birmingham. The officers are H. W. Myers, president, and J. Frank Steel, vice-president. Mine is situated four miles from Holland and reported that capacity will be 300 tons per day.

Colbert County

NITRATE PLANT site at Sheffield has been approved of by President Wilson according to Washington report. Will be constructed by the Government with part of $20,000,000 appropriation.

ARIZONA

Cochise County

CALUMET & ARIZONA (Warren)—Production for September amounted to 5,020,000 lb. copper.

INSPIRATION (Miami)—Production for September amounted to 2,250,000 lb. copper.

SHATTUCK ARIZONA (Bisbee)—Production for September amounted to 1,566,446 lb. copper, 233,800 lb. lead, 26,028 oz. silver, 419 oz. gold.

Gila County

GILA COPPER SULPHIDE (Christmas) Issued notice of redemption of 6% convertible gold bonds dated April 1, 1913, and due April 1, 1918, to the amount of $80,000. Payment to be made at par after Oct. 1 unless bonds are sooner converted into shares of capital stock.

Greenlee County

ARIZONA COPPER CO. (Clifton)—Mines remain idle and company plans to operate smeltery as custom plant.

Mohave County

STEFFY CUSTOM MILL (Chloride)—Installing jigs and rolls. F. E. Steffy, superintendent.

MERRIMAC (Chloride)—Bonded to J. C. Rankin; will resume sinking with 50-hp. engine and compressor now being placed on foundations. J. P. Ryan, superintendent.

KEYSTONE (Chloride)—Remodeled mill being turned over to test machinery. Will commence running on dump ore, having several months' supply on hand. F. W. Sherman, superintendent.

EMERALD ISLE COPPER CO. (Mohave)—Orebodies of sedimentary gravel with silicate and carbonate of copper opened by pits and shallow shafts. Claims copper content, 2.75%. Experimental sulphuric-acid leaching plant of 10-ton capacity installed about a year ago showed 86% extraction using 70 lb. acid per ton, precipitating on scrap iron; cement copper, 77.6% Cu. Changed to electrolytic equipment on account cost of iron and chemicals; installing six-cell unit; power obtained from Desert Power and Water Co. Reports show 80 to 86% extraction; production 500 lb. cathode copper daily at 15c. a pound.

Pinal County

RAY SILVER LEAD (Ray)—At present shipping over 1000 tons monthly to Deming smeltery. Two new hoists installed and 80 men employed.

QUEEN CREEK COPPER (Superior)—Station cut on 300-ft. level. Sinking continued under contract to the 450-ft. level. On the 300-ft. level it is planned to crosscut to the footwall and drift on the vein.

PINAL CONSOLIDATED (Price)—Jack Davis and T. C. Wear, of Ray, sold option in Pinal Consolidated, situated about 14 miles southwest of Ray, to F. C. Armstrong, president of Arizona Hercules Copper Co. When wagon road to Price is repaired, shipments of silver-lead ore will begin.

BROKEN HILLS (Ray)—New York interests purchased 420,000 shares. At 120-ft. depth considerable exploratory tonnage of commercial ore opened. New hoist ordered to facilitate sinking. When wagon roads completed and mining equipment installed extensive development will be undertaken. W. R. Gordon, in charge.

Santa Cruz County

ARIZONA-EUROPEAN (Patagonia)—Commercial orebodies encountered and shipments being made. James Ritchie, manager.

HARSHAW (Harshaw)—This and several other old silver producers being overhauled to begin shipments again, owing to high price of silver.

RED FOX (Alto)—Shaft being sunk to 500 ft. Taken over on lease and bond by F. B. Kollberg. Mill will be installed when enough ore opened to secure working places for large production.

R. R. R. (Patagonia)—Now using water concentration; reported that expense of flotation, including royalties, not warranted by additional recovery. Producing at full capacity but handicapped by scarcity of Mexicans. Estimated that more than 10,000 Mexicans have gone north in last month or so.

Yavapai County

JEROME VERDE (Jerome) — Shipped two carloads ore to Humboldt smeltery. Raise in Maintop claim north of U. V. Extension line is 40 ft. Above 1200-ft. level and in ore.

BIG LEDGE (Mayer) — Construction work resumed on smeltery, second unit being erected with capacity of 500 tons. Reverberatory furnace and two converters being installed. Three shifts employed in Butternut and Henrietta mines. Construction of flotation plant and half-mile tramway to connect the mines with railway under consideration.

ARKANSAS

Marion County

NORTH STAR (Yellville)—Struck good ore in tunnel. Aerial tram contemplated from new orebody to mill.

ANNA MAY (Buffalo)—Drifted 60 ft. through zinc carbonate orebody on mountain side. Contemplate erecting mill this winter.

OHIO (Yellville)—Good blende ore opened. Hauling to mill at Reynolds mine, half mile distant, situated in Hall Mountain camp.

FOX DEN (Buffalo)—Situated in Cow Creek camp. Installing two 60-hp. crude-oil engines and enlarging capacity. Ore from Dry Bone mine will be milled here also.

CALIFORNIA

Calaveras County

SAFE DEPOSIT (Mokelumne Hill)—After being closed down three months, owing to scarcity of water, hydraulic operations resumed.

Eldorado County

BEEBE (Georgetown)—Reported that Bulkeley Wells interests surrendered lease. Shaft deepened to 264 ft. and crosscuts driven, but reported that results were unsatisfactory. J. H. Robinson and Martin Costello, owners of the property, will carry on development.

Kern County

CENTRAL CALIFORNIA GAS CO. (Bakersfield)—Railroad commission dismissed application for authority to construct transmission system for natural gas from fields to Corcoran, Hanford, Tulare and Porterville. on ground that company failed to show that natural gas is available in the quantity required.

Lassen County

PLINCO (Doyle)—Oscar Ridenour, mucker, killed Sept. 16 at 200-ft. level station of vertical shaft. Supposed to have been struck by truck after placing bucket on skids and signaling to hoist.

Nevada County

MOLYBDENUM reported discovered on railroad land between English Mountain mine and Lake Faucherie, above Graniteville.

ALLISON RANCH (Grass Valley)—Good ore reported disclosed in 700-ft. level. Reported property optioned by W. W. Bryne and associates, of Salt Lake. The

20-stamp mill is crushing about 90 tons a day. Ore is taken from four of the stopes, chiefly in 400-ft. level.

EMPIRE (Grass Valley)—New Ingersoll-Rand compressor, 2500-cu.ft. capacity, being installed, to be operated by 500-hp. motor connected to the main power line. New plant adjoins present compressor plant. Mine and mill in steady operation. George W. Starr, managing director.

ALLISON RANCH AND GOLDEN CENTER (Grass Valley)—Unverified report that C. A. Brockington tendered his resignation as manager. Recent development work at both properties and installation of mill and cyanide plant at Allison Ranch have been under Brockington's management.

Placer County

EXCELSIOR GOLD MINES (Forest Hill)—Fire at Cache Rock burned underpinning of powder magazine last August believed of incendiary origin. Fire in the nearby forest burned for several days near Fords Bar, Cache Rock and Todds Valley.

Plumas County

MANGANESE ORE of fair quality reported near summit of Mt. Hough, north of Quincy, being mined by W. S. Robinson and hauled to Quincy Junction for shipment over the Western Pacific. Manganese is also being mined in Dixon Canyon and Indian Creek.

MONITOR (Quincy) — Operations suspended for winter owing to necessary renewal of pumping apparatus. Developed to vertical depth of 130 ft., with several hundred feet of drifts. Reported body of gravel tapped but bottom of tunnel not reached. Believed deposit is part of famous Bellevue lead.

San Joaquin County

SAN JOAQUIN LIGHT & POWER (Stockton)—Authorized by Railroad Commission to use proceeds of $410,000 bonds for expenditures since Dec., 1916, and current debts. Furnishes power and light for southern end of Mother Lode mines and for towns and cities.

Shasta County

MAMMOTH (Kennett)—Estimated production for September is 1,280,000 lb. copper.

Siskiyou County

SODA DEPOSITS, near Dorris, belonging to H. A. Weed, C. U. Huff and W. E. Tibbe, of Weed, have been purchased by the Spreckles interests on a tonnage basis. Tonnage estimated at not over 2000 tons.

KNOW NOTHING (Yreka)—The 8-stamp mill overhauled and in commission. Compressor installed and machine drills will be used. Mill will be driven by water power. Worked under lease by W. R. Beall, after being idle about 20 years.

Sonoma County

GRAHAM (Ukiah) — Manganese claims on Red Mountain taken over by J. Chase of San Francisco. Contemplate installation of concentrating plant, capacity, 75 tons, and tramway.

Trinity County

PACIFIC GOLD DREDGING CO. (Oroville)—Dredge removal from Morrison gulch down Coffee Creek about five miles, completed. Reconstruction completed in a month. Buildings removed to new site. Pit for flotation, 190 ft. wide and 10 ft. deep.

Tuolumne County

IN CAYUSE GULCH, mining in Humbug district will be resumed by R. S. Ammen, of San Francisco, after suspension during warm months owing to lack of water.

SONORA WONDER (Sonora)—Reported sold to E. G. Blake, of Nevada. Clearing out 50-ft. shaft in progress. Owned by Knowles, Hough and Mrs. Bachman.

EAGLE-SHAWMUT (Shawmut)—Five stamps started, being the first reduction of ore for several months, owing to development work being done. Large amount of ore blocked out and probably mill will run at full capacity.

COLORADO

Boulder County

COMSTOCK (Caribou)—Being developed and operated under lease to Hankins & Co. On 200-ft. level, 3-ft. vein of silver-lead ore opened; producing 10 tons per day. Compressor and 30-hp. electric hoist installed.

BOULDER TUNGSTEN PRODUCTION CO. (Boulder)—Contract let to advance main tunnel 700 ft. Leases will be granted on some of veins already cut by tunnel, and some development will be done on company account. Refining plant operating.

CONSOLIDATED LEASING CO. (Eldora)—Developing properties of Swarthmore Consolidated Mining Co. under lease. Opened by 2000-ft. crosscut tunnel; 25-ton flotation mill, to be built soon and machinery ordered. C. E. Kahler, president and general manager.

Clear Creek County

PRIMOS (Empire)—Contracted with Silas Knowles for 2000-ft. crosscut tunnel to open property 600 ft. below present workings.

SILVER AGE (Idaho Springs)—C. Johnson and associates developing Ship Ahoy property under lease. Crosscut driven to vein and 6-in. streak high-grade silver-lead ore opened.

LAKE (Idaho Springs)—Bond and lease secured by W. T. Hireen. Opened by four levels driven from Virginia Canyon, and Big Five tunnel which cuts vein at 2300-ft. depth. Development will be performed on company account and operated on sub-leasing system. Pump installed on tunnel level to unwater east shaft. Intends to develop Mosher oreshoot above tunnel level and raise to surface. Robert Hasty, of Idaho Springs, superintendent.

Gilpin County

RIDGE and SARATOGA WEST (Central City)—Reported these properties at Russel Gulch will be reopened.

BRYAN TUNNEL (Black Hawk) — Shoot, good-grade lead-silver ore opened in winze; shipping to smeltery.

POWERS (Central City) — Lessees resumed shipping after unwatering shaft. Good-grade ore in lower levels.

BROOKLYN (Central City)—Will be reopened. Shaft is 500 ft. deep; crosscutting on 300-ft. level will be done. Contract to supply air to Homer mine made.

HOMER (Central City)—Shaft 200 ft. deep will be sunk 200 ft. more. Small force employed in development. Milling ore opened; 8-in. shoot smelting-grade ore assaying 1.5 oz. gold and 4% copper.

Ouray County

VERNON (Ironton)—Mill now making 12 to 14 tons concentrates daily. New orebody on 300-ft. level drifted on for 45 ft. Flotation unit in satisfactory operation and will add more units to increase capacity.

Summit County

EVANS DREDGE launched Sept. 17, near Breckenridge. Hull 130 ft. long and 40 ft. 8 in. bucket line will dig to 60 ft.; capacity of buckets, 8 cu.ft.

BUNKER HILL (Breckenridge) — Lessees breaking shipping-grade ore.

RARE METALS (Breckenridge)—Large shoot molybdenum ore assaying 1% opened in old tunnel workings.

CONGRESS (Breckenridge) — Milling plant being remodeled, and new machinery will be installed. Considerable ore developed. C. W. Warner, manager.

San Juan County

BELCHER (Silverton)—Reopened and developed by R. Ferguson and A. Marshall. Small vein of payable silver and copper ore opened and trial shipment made to Durango smeltery.

TELESCOPE (Red Mountain) — Upper workings being developed under lease by R. Sawyer and associates. Carload of high-grade lead ore from development work shipped to Durango.

CONGRESS (Silverton)—Being developed and operated under lease by Offerman, Hansen & Johnson. High-grade copper ore being shipped to Durango smeltery. Milling ore consigned to Silver Lake custom mill.

Teller County

PORTLAND (Cripple Creek) — Victor mill treating 600 tons and Independence 1400 tons daily; five units operating in latter.

SIGNAL HILL TUNNEL (Cripple Creek) —Experimental mill satisfactory. Signal Hill section southwest of Cripple Creek has been little developed.

KOMET MINING CO. (Cripple Creek)—Operating Victor mine under lease. Shaft retimbered to 900-ft. level; 1000-ft. level being unwatered, where development work will be done. Regular shipments made.

IDAHO

Blaine County

FEDERAL (Wallace) — Independence Mining Co.'s property in Wood River district optioned at $300,000 until Nov. 15; not purchased as previously reported. Owners are Mrs. H. J. Allen, of Hailey, Dr. Harper, of Chicago, C. F. C. Ruton, of New York, and others.

Bonner County

ARMSTEAD MINES, INC. (Sagle)—No. 3 tunnel advanced 366 ft. during September, which is a record for the district. Total length, 1748 ft. Cut two small galena stringers and expect to strike vein 1500 ft. further on early next year. Drift along vein on No. 1 tunnel level encountered copper ore. Will not construct concentrator until vein is cut; running tests on ore at present. Company pays bonus of $5 per ft. for distance of over 300 ft. per month in driving tunnel; $6 per ft. for over 400 ft. H. H. Armstead, president.

Shoshone County

ANTIMONY SHIPMENT was made by Coeur d'Alene Antimony Mining Co. from Pine Creek district to smeltery. Price of metal cause of developing several antimony properties in district.

REX (Wallace)—Value of lead and zinc concentrates shipped in September was $24,000, $8000 more than August. Value of shipments since Nov. 1 given at $190,000. Now shipping carload zinc concentrates per day and four or five of lead per month. Recently acquired zinc property near Miami, Okla. Capital stock increased from 2,000,000 to 5,000,000 shares.

IDAHO CARBONATE HILL (Mullan)—Organized by W. D. Greenough, formerly manager of Atlas mine near Whitehorse, Yukon. Has taken option on Carbonate Hill and Idaho Giant groups and also owns Boulder Creek group of claims, all adjoining. Plans for extensive development; work will begin within two weeks. Lead and zinc orebody developed on Carbonate Hill in tunnel, and 100-ft. shaft. Situated on south side of river in section heretofore not tested by deep workings.

MAINE

Washington County

U. S. MOLYBDENUM CO. (Cooper)—Property will be acquired by H. S. Predmore and A. S. Gunn, of New York, according to present arrangements. Reported that a 500-ton mill is planned to replace present 20-ton mill.

MICHIGAN

Copper

ADVENTURE (Greenland) — September output over 6000 tons.

WINONA (Winona)—Has arranged with R. R. Seeber, superintendent, to operate property on royalty basis, guaranteeing profits to company.

CENTENNIAL (Calumet) — September rock output was 10,000 tons, another falling off. Difficult to secure men and long tram hauls make costs high. Government price-fixing may necessitate closing.

WOLVERINE (Kearsarge) — Copper Range railway plans to take over rock haulage for Wolverine and Mohawk in two months. Production at Wolverine now down to 34 cars daily.

OSCEOLA CONSOLIDATED (Osceola) —No. 4 North Kearsarge getting into best grade of rock yet found. Tonnage at old Osceola branch maintained, but total for October will be about 100,000.

MASS CONSOLIDATED (Mass) — Should produce 19,000 tons of rock in October. Evergreen lode is furnishing some stamp rock, but Butler continues largest producer. Newer openings encouraging.

CALUMET & HECLA (Calumet)—Production in September by C. & H. and subsidiaries was: C. & H., 5,706,400 lb.; Allouez, 706,217; Ahmeek, 2,163,635; Centennial, 196,930; Isle Royale, 1,092,197; La Salle, 180,335; Osceola, 1,081,698; Superior, 136,023; White Pine, 293,003.

MINNESOTA

Mesabi Range

WEBB (Hibbing)—Owned by Shenango Furnace Co. has put shovel at work cutting approach for ore track into pit being stripped by Winston Dear.

BENNETT (Keewatin)—Operated by Pickands, Mather & Co., both by underground and open pit. Employing about 50 gangs of miners. Shaft work covers large area. R. L. Downing, superintendent.

NORTH EDDY (Hibbing) — Owned by Dean Iron Co. Contract with Peter Olson for ditch north of mine to divert water off caving ground and west along Great Northern railroad completed.

SHENANGO FURNACE CO. (Chisholm) —Shipments will run over million tons if Government does not remove boats. Plan an incline in Shenango openpit and change of method of mining. Improbable, delivery of machinery will permit work this year so will probably continue for another year along same lines.

Vermilion Range

LUCKY BAY AND ANDERSON mines leased to Ohio interests and will produce next season. Developed by E. C. Kennedy, of Duluth. McComber mine, at Robinson Lake, developed to 300-ft. level by Mutual Mining Co., of Duluth, under royalty lease. About 6000 tons in stockpile and equal amount available above 200-ft. level in No. 2 shaft. Iron ore in No. 1 shaft with about 2% sulphur as pyrites. Duluth and

Iron Range R.R. built to property and will ship this year, if boat tonnage available.

MISSOURI

Joplin District

COSDEN & AIKEN (Tulsa, Okla.)—Will move McDonald mill, at Prosperity, to lease at Tar River, Okla.

F. H. HARRINGTON (Joplin) — Sold first lease on 40-acre tract adjoining Picher-Whitebird at Picher, Okla., to George Beck, Miami, and associates. Consideration not made public.

HICKEL (Baxter Springs, Kan.)—Sold to J. M. Postelle, of Oklahoma City and associates, for $40,000. Situated three miles south of Baxter. Bought last June for $5000 by Mr. Hickel. Partly developed.

ST. JOE (Joplin)—New mill south of Picher, Okla., in operation. Julius Miller, Jr., of Joplin, promoted company and was manager of plant sold his one-fourth interest for $30,000 to J. W. Grounds and associates, of Kansas City.

MONTANA

Beaverhead County

ARGENTA AND BANNOCK districts showing activity and number of old silver mines may be reopened. Argenta, large producer in past, has high-grade slag on dump now being broken up and hauled by motor truck to railroad.

Lewis and Clark County

ROCK ROSE (Helena)—Taking out ore on 100-, 200- and 300-ft. levels.

CRUSE CONSOLIDATED (Helena)—Ore in north and south drifts at 150 ft.

PORPHYRY DIKE (Helena)—New 300-ton ball mill about ready. Electric power.

ECLIPSE-ARGO COPPER (Helena)—Four cars to smeltery monthly. One car concentrates; three of ore.

Missoula County

ROYAL MINING CO. will operate Charcoal mine near Missoula, having acquired title from Mrs. D. Harrington, of Butte, original owner. Recently encountered high-grade ore stringer. Formerly silver producer.

Silver Bow County

BIG DOME OIL AND GAS CO. (Butte)—Capital stock of $200,000; filed articles of incorporation on Oct. 4 with county recorder. Directors are John A. Plint, Charles E. Foye, Harry F. Bartels, Warren E. Coman and Louis B. Flagler.

NORTH BUTTE (Butte)—Is made defendant in another suit growing out of the fire in Granite Mountain shaft. Plaintiff is sister of Frank Scandula, who perished in the fire, it is alleged, due to the lack of water to extinguish the fire, and lack of another exit to safety but one blocked by fire. Damage asked for is $30,000.

Yellowstone County

OIL STRIKE made near Laurel in well 1000 ft. deep on Schauer ranch by B. F. Hoyt and associates. Considerable real estate activity has resulted.

NEVADA

Mineral County

WEDGE COPPER MINING CO. (Luning)—Property consists of nine claims in Santa Fe district, six miles from here, on Southern Pacific Ry. Development consists in number of tunnels showing copper ore carrying gold. Three leasers working in addition to company operations. Mark Walser, president. General office, Herz Building, Reno, Nev.

Nye County

TONOPAH ORE PRODUCTION for the week ended Oct. 6 was 8944 tons, valued at $156,520, comparing with 9519 tons, the previous week. Producers were: Tonopah Belmont, 2320 tons; Tonopah Mining, 2200 tons; Tonopah Extension, 2380 tons; Jim Butler, 700 tons; West End, 967 tons; Montana, 239 tons; Rescue, 133 tons.

MANHATTAN CONSOLIDATED MINES DEVELOPMENT (Manhattan) — Drifting east from fourth level, working two shifts. Face of drift 50 ft. from shaft. From third level, south crosscut extended 150 ft. Purpose is to strike two orebodies developed near surface; workings are gassy and raise will be made to second level for ventilation.

WHITE CAPS (Manhattan)—Maintaining average production of 100 tons per day. Development work on fifth level exposed east orebody for additional 32 ft., total being 65 ft. Drift still on foot wall so width between walls undetermined. A crosscut from footwall already shows 15 ft. of width.

NEW HAMPSHIRE

RUGGLE MICA MINE (Canaan)—Situated at Grafton, four miles distant, will be operated again after 25 years' shutdown. Has been in litigation.

NEW MEXICO

Grant County

BONNEY EXTENSION (Lordsburg)—Has been consolidated as Tyndale Copper Mining Co., W. T. McCaskey, president; T. Lester, vice president; J. P. Porteus, secretary and treasurer. Development work will begin this month under direction of J. B. Porteus.

BETHLEHEM COPPER CO. (Steins)—Employing 20 men sinking prospect holes. Veins traceable for 5000 ft. opened by number of holes show copper-silver ore. Trying to interest Los Angeles men. J. A. Sund, president.

UTAH

Juab County

PRODUCTION BY TINTIC MINES for first nine months of 1917 amounted to about 7300 cars which, estimated at 365,000 tons, in round numbers, represents a value of about $10,000,000. September showed 634 cars, as compared to August with 929 and 772 in July, the falling off being due to shortness of the month, smeltery embargo on some of the mines, shortage of railroad cars and difficulty in securing coal.

LEHI TINTIC MINING (Tintic)—Advanced 70 ft. in stope in right tunnel. Encountered vein matter for over 50 ft., showing mineralization; reported to be lead to main orebody. George Nicholes, president; H. J. Fitzgerald, secretary. Main office, 425 Atlas Block, Salt Lake City.

Salt Lake County

AMERICAN CONSOLIDATED (Salt Lake)—Compressor and drills to be installed soon to develop ore recently opened, carrying copper, silver and lead.

UTAH IRON AND STEEL (Midvale)—Will bring production up to about 50,000 tons of finished steel per year shortly, and have new open-hearth furnace ready for operation in about two weeks. Will make heavier bars and mine rails up to 30 lb. a yd. Stated to Public Utilities Commission fuel requirements are 3000 tons gas coal per month.

Summit County

PARK CITY PRODUCTION for September is given as 10,125 tons, valued at $400,000 to $500,000 from 12 shippers. August shipments amounted to 10,346 tons and July to 7500 tons. First six months of 1917 the tonnage was about 45,000, and for first nine months about 75,000, valued at about $3,500,000. Principal producers for September as follows: Judge Mining and Smelting, 2659 tons; Silver King Coalition, 2538 tons; Ontario, 1597 tons; Daly West, 1028 tons; California-Comstock, 366 tons.

JUDGE MINING AND SMELTING (Park City)—New electrolytic plant operating satisfactorily.

Tooele County

UTAH LIME AND STONE CO., near Timpie, plans to develop limestone quarries on Western Pacific R.R. Stated that railroad is to build extension to property, and number of lime kilns to be built. C. W. Nibley, of Salt Lake City, president; W. L. Ellerbeck, general manager.

WASHINGTON

Stevens County

AMERICAN MINERALS PRODUCTION CO. (Valley)—Has 20 teams, each hauling 10 tons magnesite ore from quarries. Standard-gage 16-mile railroad being built by General Construction Co., of Spokane, from here to quarries and connecting with Great Northern railroad.

VALLEY MAGNESITE CO. (Valley)—Operates plant with 25-ton capacity per day, producing calcined and dead-burned magnesite. Will enlarge to 125 tons capacity within 90 days. Standard-gage railway, 14 miles long, being constructed within ½ mile of quarries, will be in operation within three months. F. M. Handy, president and manager.

WYOMING

ROXANA OIL CO., subsidiary of Royal Dutch Shell property, six miles from Grass Creek, contracted for 5000-ft. well at $14 per ft., Roxana to pay for all material except fuel. Hole will be cased with 20-in. pipe probably for 2000 ft. Believed there are four strata bearing salt water before reaching 5000-ft. depth. No oil found within five miles of this drill hole.

CANADA

British Columbia

CANADA COPPER (Greenwood)—Production for September amounted to 537,229 lb. copper.

FLORENCE SILVER MINING (Ainsworth)—Shipped 500 tons concentrates and crude ore. Expect increase in October. F. R. Wolfe, president.

ENTERPRISE MINE in Slocan district sold by Finch & Campbell of Spokane for $375,000 to British Columbia Mines Co. of London, taken over on lease and option for $125,000 by Seattle-British Columbia Lead Silver Co., organized by H. F. Millard of Valdez, Alaska. Former owners worked property by handsorting, with profit.

Manitoba

MOLYBDENITE DEPOSITS reported discovered by W. Gordon, of Hawk Lake, within a few miles of Greater Winnipeg Water District railway line. Two main deposits have been staked out in Falcon Lake district by Gordon and G. B. Hall, 745 Somerset Block, Winnipeg. The first consists of three claims northwest of Finnel Lake, three hours' journey from Indian Bay at end of G. W. W. pipe line. The second consists of nine claims, four miles distant. Veins said to be 2 to 40 ft. wide of good ore.

New Foundland

HYDRO-ELECTRIC SMELTING CO. LTD. (Little Bay)—Making good recovery of cement copper from cuprous waters. Expect to produce 150 tons copper per year.

Ontario

ELLIOTT KIRKLAND (Kirkland Lake)—Made payment of $30,000 on property.

HOLLINGER (Porcupine)—Milling just enough ore to pay expenses. Company still short of men.

PITTSBURG LORRAIN (South Lorrain)—Leased Wettlaufer mill and producing silver concentrates.

BUFF MUNRO (Munro Township)—Two shafts down 50 ft. each. Roadway being cut to bring in small mining plant.

BEAVER CONSOLIDATED (Cobalt)—High grade vein encountered at 1600-ft. level stoped on for about 100 ft. Winze started on vein.

DAVIDSON (Porcupine)—Has obtained good results in diamond drilling. Crosscut will be run at 300-ft. level to prospect ground cut with drill.

TOUGH OAKES (Kirkland Lake) — In August treated 3400 tons. Short of ore due to faulting of main vein below 500-ft. level and expect decreased production.

LE HEUP (Gowganda)—Taken over by Toronto men. Adjoins Miller Lake O'Brien where silver discovery made some months ago permits production at 6c. per oz. mining cost.

KERR LAKE (Cobalt)—Recommended by directors that at stockholders' meeting on Nov. 12, company be dissolved and new Canadian corporation, known as Kerr Lake Mines, Ltd., be organized. Production of silver during September was 210,388 oz., compared with 200,855 oz. in August. Average monthly production for 12 months ended Sept. 30 was 216,102 oz.

DOME LAKE MINING AND MILLING (Porcupine)—Two new orebodies opened up and diamond drilling proved continuance to 600-ft. level. Not developing below 500-ft. level. Mill running on reduced tonnage; filtering equipment proved inefficient and discarded in July. Now using amalgamation only and on account large tailing loss milling only sufficient tonnage to cover operating and development charges. Will install Oliver filter. R. T. Reguell, manager.

MEXICO

EMBARGO ON GOLD exportation into the United States will now be modified in accordance with an arrangement arrived at between the United States and Mexican Governments. It is agreed that the United States will allow a certain amount of gold to be sent to Mexico and that Carranza will cancel the existing order prohibiting the removal of gold from the country.

SALVADOR

BUTTERS SALVADOR (San Sebastian) Tonnage crushed in August amounted to 3675 tons, averaging $11.66 per ton. Expenses amounted to $28,000; bullion for shipment, $36,000; profit, $8000.

BOLIVIA

FRANK & CO. (Oruro)—Shipped seven tons nickel and cobalt ore taken from surface to Liverpool, England, for test. Awaiting results before further development. Vein is about 24 in. wide on surface.

SOUTH AFRICA

ANGLO-AMERICAN CORPORATION (Johannesburg)—Registered with capital of $5,000,000, and increase of $10,000,000 provided for. Object is to negotiate for new Eastern Rand leases now being offered. Directors are: Ernest Oppenheimer, Chairman; W. L. Honnold, H. Crawford, H. C. Hull, C. H. Sabin and Boyce Thompson.

The Market Report

SILVER AND STERLING EXCHANGE

Oct.	Sterling Exchange	Silver New York, Cents	Silver London, Pence	Oct.	Sterling Exchange	Silver New York, Cents	Silver London, Pence
11	4.7525	88¼	44¾	15	4.7515	86¼	43¾
12	......	...	44¼	16	4.7515	85⅜	43⅝
13	4.7525	86¾	44	17	4.7515	84⅞	43⅛

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

DAILY PRICES OF METALS IN NEW YORK

Oct.	Copper Electrolytic	Tin Spot.	Lead N. Y.	Lead St. L.	Zinc St. L.
11	*23½	61	6⅞ @7⅜	6.90 @7.30	7.80 @8.00
12	....	...	....	......	......
13	*23½	61	6¾ @7	6.70 @6.90	7⅞ @8
15	*23½	61¼	6¾ @7	6.70 @6.80	7⅞ @8
16	*23½	61¼	6.70 @7.00	6.70 @6.80	7.80 @8.00
17	*23½	61¼	6.70 @6.80	6.70 @6.80	7.80 @8.00

* Price fixed by agreement between American copper producers and the U. S. Government, according to official statement for publication on Friday, September 21, 1917.

The above quotations (except as to copper, the price for which has been fixed by agreement between American copper producers and the U. S. Government, wherein there is no free market) are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for the deliveries constituting the major markets, reduced to basis of New York, cash, except where St. Louis is the normal basing point.

The quotations for electrolytic copper are for cakes, ingots and wirebars.

We quote electrolytic cathodes at 0.05 to 0.10c. below the price of wirebars, cakes and ingots.

Quotations for spelter are for ordinary Prime Western brands. We quote New York price at 17c. per 100 lb. above St. Louis.

Some current freight rates on metals per 100 lb. are: St. Louis-New York 17c.; St. Louis-Chicago, 6.3c.· St. Louis-Pittsburgh, 13.1 cents.

LONDON

Oct.	Copper Standard Spot	Copper Standard 3 Mos.	Copper Electrolytic	Tin Spot	Tin 3 Mos.	Lead Spot	Zinc Spot
11	110	110	125	245¾	243	30½	54
12	110	110	125	246½	243	30½	54
13	...	....	...	...	....	...	...
15	110	110	125	247	244	30½	54
16	110	110	125	247½	246	30½	54
17	110	110	125	247½	245	30½	54

The above table gives the closing quotations on London Metal Exchange. All prices are in pounds sterling per ton of 2,240 lb. For convenience in comparison of London prices, in pounds sterling per 2,240 lb., with American prices in cents per pound the following approximate ratios are given, reckoning exchange at $4.75½. £30½ = 6.474c.; £54 = 11.462c.; £120 = 25.473c.; £137 = 29.082c.; £240 = 50.946c. Variations, £1 = 0.212277c.

Metal Markets

NEW YORK—Oct. 17

Once more we have to record a week of dullness. Lead was the only interesting feature, and the interest in it was associated with the sharp decline in its price on small business.

Copper, Tin, Lead and Zinc

Copper—Government specifications came forward from day to day, and the Copper Producers Committee, getting a line on the Government requirements, previously having had the foreign requisitions, was able to get its bearings and to release further copper to domestic manufacturers. Arrangements to even things up among manufacturers were made, and it is now the opinion that the essential requirements for October can be equitably filled.

The Metals Division of the National Association of Waste Materials Dealers held a meeting in New York on Oct. 17, and agreed to work in harmony with the War Industries Board on the basis of 23½c. for copper. It is considered probable that a sliding scale for scrap copper will be fixed, having in view its inferior value.

Eugene Meyer, Jr., having been released by the Treasury Department, has returned to the War Industries Board to take charge of the business in metals under Mr. Baruch.

Copper Sheets are quoted at 35c. per lb. for hot rolled, and 1c. higher for cold rolled. Wire is quoted nominally at 31c. per lb., f.o.b. mill.

Tin—Business in this metal was very small and there was scarcely any change in quotations during the week. At the close, Straits tin was quoted at 61¼c. and Banka at 59¼c.

Tin shipments from the Federated Malay States for the six months ended June 30 were 19,752 gross tons, a decrease of 1973 tons from last year.

Lead—At the close of last week, lead was easily to be had at 7¼c. The following day further concessions were offered. The American Smelting and Refining Co., recognizing the weakness in the metal and the failure of buying to develop, took the bull by the horns, and on Thursday afternoon reduced its price to 7c., but it had no sooner done so than it was undercut, transactions at 6⅞c. being reported. The reduction in price by the American Smelting and Refining Co. did not become generally known until the following Monday, but right through the week there was weakness and at the close lead was easily obtainable at 6¾c., either at New York or St. Louis. The business of the week amounted to only a moderate tonnage, and the fact that buying failed to develop on the sharp decline produces the feeling in the trade that the decline may go further. It was reported today that the Federal Lead Co. had reduced the production at its mines in Missouri to one-half.

Zinc—Business in this metal was light in volume, the most noteworthy feature being the sale of some round lots for export. At present prices, which are below the cost of production by many producers, there is no reason why foreign users of spelter should continue to hold aloof from this market. Many producers asked 8¼c., while others offered at 8@8¼c., in order to test the market, but they failed to make sales, it being evident that cheaper sellers were taking what business was being offered; in fact, some sales of 100-ton lots were made at 8c., but the bulk of the business of the week was done at about 7.90c.

Zinc Sheets—Price of zinc sheets has not been changed. Market is still at $19 per 100 lb. f.o.b. Peru, Ill., less 8% discount.

Other Metals

Aluminum—Further decline occurred in this metal, No. 1 ingots at New York being quoted at 38@39c. per lb. for small lots, market being comparatively inactive.

Antimony—The market continues dull, with producers and dealers able to sell nothing but small lots—10-ton lots, etc. On such business, 15@15½c. could be realized. This price is very low from the viewpoint of the Chinese producers, who are not interested in selling at less than 16c. We quote spot at 15@15½c., and futures at 15c., c.i.f., in bond.

Bismuth—Unchanged at $3.50 per pound.

Cadmium—This metal is quoted at $1.40 @1.50 per pound.

Nickel—Steady at 50c. per lb., premium of 5c. per lb. for electrolytic.

Quicksilver—This market was dull and scarcely more than nominal. We quote $99@100. San Francisco reports, by telegraph, $99, dull.

Gold, Silver and Platinum

Silver—This metal has continued to decline, exhibiting weakness and closing at 84⅞c. in New York and 43⅛d. in London.

Mexican dollars at New York: Oct. 10, 67⅛c.; 11, 67c.; 12, ... 13, 65c.; 15, 64⅝c.; 16, 64⅝c.

The holdings of the Indian government in the note reserve on Aug. 31 were 3840 lakhs of rupees in silver coin and bullion. Stocks in Bombay on the same date were 2100 bars.

Stocks of silver in Shanghai on Aug. 31 were $15,600,000 in dollars and 31,000,000 oz. sycee; a decrease of $100,000 in dollars but an increase of 8,800,000 oz. sycee over Aug. 15.

Platinum—Good business is reported at $103@105.

Palladium — We quote $120@125, with strong demand.

Zinc and Lead Ore Markets

Joplin, Mo., Oct. 13—Blende, per ton, high, $76; basis 60% Zn, premium, $75; medium to low, $70 to $60; calamine, per ton, 40% Zn, $38@35; average selling price, all grades of zinc, $62.73 per ton.

Lead, high, $89.23; basis 80% Pb, $90@80; average selling price, all grades of lead, $82.54 per ton.

Shipments the week—Blende 8033 tons, calamine 365 tons, lead 1237 tons. Value, all ores the week, $630,510.

Platteville, Wis., Oct. 13—Blende, basis 60% Zn, $67 base for premium grade down to $62 base for medium grade. Lead ore, basis 80% Pb, $80 per ton. Shipments reported for the week are 3104 tons of zinc ore, 72 tons of lead ore, and 547 tons of sulphur ore. For the year to date the figures are: 114,075 tons of zinc ore, 6116 tons of lead ore, and 22,250 tons of sulphur ore. Shipped during the week to separating plants, 3562 tons of zinc ore.

Other Ores

Molybdenum Ore — In active demand. Sales reported at $2.20 per lb. on the basis of 90% molybdenum sulphide, and $1.80 on the basis of 75%.

Pyrites—Spanish lump quoted at 15c. per unit on basis of 10s. ocean freight, buyer to pay war risk, excess freight and any duty. Ocean freights are 35s. for northern ports, 40s. for south Atlantic and 42s. 6d. for Gulf ports.

Tungsten Ore — We quote high-grade wolframite unchanged at $23@25. This is for the highest grade, assaying 70% wolfram trioxide, and free from undesirable impurities. Considerable supplies of such ore are now offered in the market. An ore of 60% grade, which used to be standard, is now called low-grade, and was quoted this week at about $20 per unit. Owing to the change in the metallurgy of tungsten, there are heavier penalties for impurities than formerly. In the older hydro-metallurgical processes, tin and copper were readily removed, while these impurities are now penalized by alloy manufacturers using electric furnaces. Tin or copper exceeding 0.03 and 0.04% are objectionable for electric-furnace work. Scheelite ores carrying 63 to 65% WO_3 and from 2 to 3% tin and from 1 to 1.2% copper, sold recently for $20, while ores carrying the same amount of tungstic acid, free from objectionable amounts of tin and copper, brought $24.

Iron Trade Review

PITTSBURGH—Oct. 16

The second batch of prices arranged by agreement between the Government and the iron-and-steel industry was announced at Washington late last week, the prices referring to steel only and being as follows: Billets, 4 x 4-in. and larger, $47.50; smaller billets, $51; sheet and tinplate bars, $51; slabs, $50; all per gross ton, f.o.b. Pittsburgh or Youngstown; wire rods, $57 per gross ton, f.o.b. Pittsburgh; grooved steel skelp, 2.90c.; universal mill skelp, 3.15c.; sheared skelp, 3.25c.; shell-steel rounds, over 3 in. to and including 5 in. 3.25c.; above 5 in. to 8 in., 3.50c.; above 8 in. to 10 in., 3.75c.; over 10 in., 4c. per lb., f.o.b., Pittsburgh. The first batch of prices was announced Sept. 24: Lake Superior iron ore, unchanged from 1917 schedule, making Mesabi nonbessemer, $5.05 at Lake Erie dock; foundry and basic pig iron, valley, $33; steel bars, 2.90c.; shapes, 3c.; plates, 3.25c, f.o.b. Pittsburgh.

At this writing it is expected at any moment Washington will announce a third batch of prices, to include pig iron of other grades at valley furnaces, also pig iron in other districts, three or four descriptions of iron and steel scrap, and the finished steel products, sheets, pipe and wire, with possibly a few others.

The extent to which prices submitted by the industry are being modified by the War Industries Board or the President, who has the last word in these matters, is not known, but it is frankly admitted throughout the trade (1) that the original or basis prices are very fair and calculated to yield quite satisfactory earnings, and (2) that the prices for the various commodities are in strict accord with each other, distributing earnings equitably in the different departments in accordance with cost of production and capital investment.

The new conditions are being imposed on the trade with a minimum of disturbance. Buyers with scarcely an exception were already well covered and deliveries are proceeding on contract. There had been scarcely any business done in the open market for many weeks before price fixing was undertaken. The attitude of all producers, so far as can be ascertained, is that they will strive earnestly to carry out both the spirit and the letter of the agreement. Some confusion has been caused by a few buyers assuming that the agreement upon one price for all, the Government, its Allies and the general public meant that producers would be ready to sell promptly to the public at these prices whatever material might be called for. That is not correct as the producers could not do so when they already have so much tonnage on their books and when the Government has assured them that it will shortly place orders for 6,000,000 or 7,000,000 tons of steel in addition to about 3,000,000 tons it has already bought. What the producers agreed upon, with respect to the public, was that they would not sell at higher than the fixed prices. Their position now is that they will take care of their customers.

Pig Iron—Transactions in small lots are being made almost daily, at the fixed prices, but as a rule only between furnaces and their regular customers, and there is practically no forward business. There is little unsold iron for the balance of this year. High-priced contracts are expected to be carried out. We quote foundry, malleable and basic at $33, valley, and bessemer at $36.30, valley, a tentative price that is expected to be confirmed at Washington.

Steel—At its top the billet market was $95 to $100. About three weeks ago a sale of 1000 tons of 4 x 4-in. billets sold at $60 and just before prices were fixed at Washington there were sales at a trifle less than $60, Pittsburgh, including one sale at $60.50, Philadelphia. We quote billets, 4 x 4-in., and larger at $47.50, small billets, $51; slabs, $50 and sheet bars, $51, all f.o.b., Pittsburgh or Youngstown, and wire rods at $57, Pittsburgh.

Ferroalloys

Ferromanganese—Buyers are out of the market entirely, except in very occasional instances when a consumer is caught short. It is expected that the Government will set prices much lower than those lately ruling, which for six months or more have been predicated upon a possible famine, the famine not developing up to date, as stocks are fully up to normal. The market has weakened somewhat and there are sellers for early shipment at not over $340.

Coke

Connellsville—Production and shipments are about the same as formerly. No particular change is observable since the order a week ago for a 100% car supply for the region. Sales of spot coke at the fixed price of $6 are increasing but are still very light, the coke being shipped chiefly upon contracts at higher figures, or upon contracts calling for the market price, such contracts being now adjusted to a $6 level. There is considerable inquiry in the market but some operators think this is chiefly from furnaces that have contracts at above $6 per ton.

STOCK QUOTATIONS

N. Y. EXCH.†	Oct. 16
Alaska Gold M.	3½
Alaska Juneau	3
Am.Sm.& Ref.,com.	86½
Am. Sm. & Ref., pf.	103
Am. Sm. Sec., pf., A	93
Am. Sm. Sec., pf. B.	‡93
Am. Zinc	14¾
Am. Zinc, pf	48
Anaconda	65⅞
Batopilas Min	1¼
Bethlehem Steel	74
Bethlehem Steel, pf.	93
Butte & Superior	18
Cerro de Pasco	31½
Chile Cop	16
Chino	44
Colo.Fuel & Iron	36¼
Crucible Steel	65
Dome Mines	8¼
Federal M. & S.	14¾
Federal M. & S., pf.	38¾
Great Nor., ore ctf.	27⅝
Greene Cananea	36
Gulf States Steel	90
Homestake	102
Inspiration Con.	44½
International Nickel	29⅞
Kennecott	34
Lackawanna Steel	77¾
Miami Copper	30¼
Nat'l Lead, com.	45
National Lead, pf.	100
Nev. Consol	18
Ontario Min	4½
Quicksilver	1
Quicksilver, pf.	1¼
Ray Con	22¼
RepublicI.&S.,com.,	75½
Republic I. & S., pf.	99
Sloss-Sheffield	38
Tennessee C. & C.	12¼
U. S. Steel, com	103½
U. S. Steel, pf	114
Utah Copper	84
Va. Iron C. & C.	55

N. Y. CURB†	Oct. 16
Big Ledge	1¼
Butte & N. Y.	.75
Butte C. & Z.	8¼
Butte Detroit	1/16
Caledonia	.58
Calumet & Jerome	1¼
Can. Cop. Corpn	1⅝
Carlisle	3½
Cashboy	.05½
Con. Ariz. Sm.	1¼
Con. Coppermines	7⅜
Con. Nev.-Utah	.08
Emma Con	⅜
First Nat. Cop.	2 1/16
Goldfield Con.	.32
Goldfield Merger	.03½
Greenmonster	3/16
Hecla Min.	5 5/16
Howe Sound	4½
Jerome Verde	1 1/16
Kerr Lake	5⅜
Louisiana	⅜
Magma	44½
Majestic	.31
McKinley-Dar-Sa.	.60
Milford	1⅜
Mohican	.25
Mother Lode	.30
N. Y. & Hond	13
Nipissing Mines	7½
Ohio Cop	⅜
Ray Hercules	3½
Richmond	‡.57
Rochester Mines	.43
St. Joseph Lead	17½
Standard S. L.	.50
Stewart	.28½
Success	.11
Tonopah	5¼
Tonopah Ex.	1 11/16
Tribullion	.25
Troy Arizona	.15
United Cop.	.50
United Verde Ext.	32
United Zinc	2½
Utica Mines	.14
Yukon Gold	2

SAN FRAN.*	Oct. 16
Alta	.02
Andes	.10
Best & Belcher	.03
Bullion	.02
Caledonia	.10
Challenge Con.	.05
Confidence	.05
Con. Virginia	.10
Gould & Curry	‡.01
Hale & Norcross	.03
Jacket-Cr. Pt.	.05
Mexican	.15
Occidental	.60
Ophir	.14
Overman	.04
Savage	.03
Seg Belcher	‡.02
Sierra Nevada	.16
Union Con	.77
Utah Con	.01
Belmont	3.75
Jim Butler	.78
MacNamara	.17
Midway	.08
Mont.-Tonopah	.15
North Star	.07
Rescue Eula	.12
West End Con.	.62
Atlanta	.07
Booth	.03
Comb. Frac.	‡.02
D'field Daisy	.02
Florence	.10
Jumbo Extension	.15
Kewanas	.07
Nevada Hills	.13
Nevada Packard	.19
Round Mountain	.23
Silver Pick	.10
White Caps	.95
Big Jim	‡.62½
United Eastern	3.60

BOSTON EXCH.*	Oct. 16
Adventure	1½
Ahmeek	91
Algomah	.25
Allouez	56
Ariz. Com., ctfs.	8¼
Arnold	.25
Bonanza	.21
Butte-Balaklava	.40
Calumet & Ariz.	66
Calumet & Hecla	495
Centennial	13
Copper Range	50¼
Daly West	1¾
Davis-Daly	4¾
East Butte	9½
Franklin	4
Granby	73
Hancock	10
Hedley	‡17
Helvetia	.25
Indiana	1½
Isle Royale	27½
Keweenaw	2
Lake	6¼
La Salle	3
Mason Valley	4¾
Mass	6¾
Mayflower	1¾
Michigan	1¼
Mohawk	70
New Arcadian	2
New Idria	10½
North Butte	13½
North Lake	.55
Ojibway	1¼
Old Dominion	40½
Osceola	70
Quincy	76
St. Mary's M. L.	59
Santa Fe	1
Seneca	7
Shannon	5⅜
Shattuck-Ariz	19
So. Lake	2¼
So. Utah	.15
Superior	6½
Superior & Bost.	2¾
Trinity	4½
Tuolumne	1¼
U. S. Smelting	51
U. S. Smelt'g, pf.	47⅞
Utah Apex	2⅝
Utah Con	12½
Utah Metal	3
Victoria	2⅜
Winona	2
Wolverine	38
Wyandot	.50

BOSTON CURB*	Oct. 16
Alaska Mines Corp.	.37
Bingham Mines	11
Boston Ely	.65
Boston & Mont.	.50
Butte & Lon'n Dev.	.12
Calaveras	2¼
Calumet-Corbin	.01
Chief Con	2⅜
Cortez	.10
Crown Reserve	.22
Crystal Cop	.61
Eagle & Blue Bell	2½
Houghton Copper	.75
Intermountain	1½
Iron Cap, Com	14
Iron Cap Cop., pf.	13⅜
Mexican Metals	.30
Mines of America	1¾
Mojave Tungsten	.35
Nat. Zinc & Lead	.28
Nevada-Douglas	1 1/16
New Baltic	1¼
New Cornelia	15
Oneco	.40
Pacific Mines	.35
Rex Cons	.12

SALT LAKE*	Oct. 15
Bannack	.26
Big Four	.01
Cardiff	4.00
Colorado Mining	.13
Daly	1.95
Daly-Judge	8.25
Empire Copper	1.27½
Gold Chain	.17
Grand Central	.57
Iron Blossom	.56
Lower Mammoth	.03
May Day	.05
Moscow	.11
Prince Con	.97
Silver-King Coal'n	2.97
Silver King Con	3.50
Sioux Con	.04
So. Hecla	.93
Tintic Standard	1.47½
Uncle Sam	.04
Wilbert	.25
Yankee	.08

TORONTO*	Oct. 15
Adanac	.15
Bailey	.04¾
Beaver Con	.35
Chambers Ferland	.12
Coniagas	3.80
Davidson	.34
Hargraves	.09
La Rose	.40½
Peterson Lake	.09
Temiskaming	.29
Wettlaufer-Lor	.07
Dome Exten	.10
Dome Lake	.15
Foley O'Brien	‡.60
Hollinger	4.50
McIntyre	1.38
Newray	.55
Porcu. Crown	.39
Schumacher	‡.42
Teck-Hughes	.42
Vipond	.25
West Dome	.16

STOCK QUOTATIONS—Continued

COLO. SPRINGS	Oct. 16
Cresson Con	4.87½
Doctor Jack Pot	.03
Elkton Con	.03
El Paso	.15
Gold Sovereign	.02¼
Golden Cycle	1.74
Granite	‡.40
Isabella	.07
Mary McKinney	.06½
Portland	1.30
United Gold M.	.16
Vindicator	.46

LONDON	Oct. 2		
Alaska Mexican	‡£0	5s	0d
Alaska Tre'dwell	‡ 1	0	0
Burma Corp.	4	1	3
Cam & Motor	0	9	6
Camp Bird	0	9	6
El Oro	0	11	6
Esperanza	0	9	9
Mexican Mines	5	8	9
Nechi, pfd.	0	13	0
Oroville	0	19	6
Santa Gert'dis.	0	15	6
Tomboy	0	18	6

* Bid prices. † Closing prices. ‡ Last Quotations.

MONTHLY AVERAGE PRICES OF METALS

Silver	New York			London		
	1915	1916	1917	1915	1916	1917
Jan.	48.855	56.775	75.630	22.731	26.960	36.682
Feb.	48.477	56.755	77.585	22.753	26.975	37.742
Mar.	50.241	57.935	73.861	23.708	27.597	36.410
April	50.250	64.415	73.875	23.709	30.662	36.963
May	49.915	74.269	74.745	23.570	35.477	37.940
June	49.034	65.024	76.971	23.267	31.060	39.065
July	47.519	62.940	79.010	22.597	30.000	40.110
Aug.	47.163	66.083	85.407	22.780	31.498	43.418
Sept.	48.680	68.515	100.740	23.591	32.584	50.920
Oct.	49.385	67.855	......	23.925	32.361	......
Nov.	51.714	71.604	......	25.094	34.192	......
Dec.	54.971	75.765	......	26.373	36.410	......
Year	49.684	65.661	......	23.675	31.315	......

New York quotations cents per ounce troy, fine silver; London, pence per ounce, sterling silver, 0.925 fine.

Copper	New York Electrolytic		London Standard		London Electrolytic	
	1916	1917	1916	1917	1916	1917
Jan.	24.008	28.673	88.083	131.921	116.167	142.895
Feb.	26.440	31.750	102.667	137.895	133.167	148.100
Mar.	26.310	31.481	107.714	136.750	136.000	151.000
April	27.895	27.935	124.319	133.842	137.389	147.158
May	28.625	28.788	135.457	130.000	152.522	142.000
June	26.601	29.962	112.432	130.000	137.455	142.000
July	23.865	26.620	95.119	128.409	125.500	140.409
Aug.	26.120	25.380	110.283	122.391	126.304	137.000
Sept.	26.855	25.073	113.905	117.500	134.071	135.250
Oct.	27.193	......	122.750	......	142.523	......
Nov.	30.625	......	134.659	......	155.432	......
Dec.	31.890	......	145.316	......	162.842	......
Year	27.202	......	116.059	......	138.281	......

Tin	New York		London	
	1916	1917	1916	1917
January	41.825	44.175	175.548	185.813
February	42.717	51.420	181.107	198.974
March	50.741	54.388	193.609	207.443
April	51.230	55.910	199.736	220.171
May	49.125	63.173	196.511	245.114
June	42.231	62.053	179.466	242.083
July	38.510	62.570	168.357	242.181
August	38.565	62.681	169.870	243.978
September	38.830	61.542	171.345	244.038
October	41.241	......	179.307	......
November	44.109	......	186.932	......
December	42.635	......	183.368	......
Av. year	43.480	......	182.096	......

Lead	New York		St. Louis		London	
	1916	1917	1916	1917	1916	1917
January	5.921	7.626	5.826	7.530	31.167	30.500
February	6.246	8.636	6.164	8.595	31.988	30.500
March	7.136	9.199	7.375	9.120	34.440	30.500
April	7.630	9.288	7.655	9.158	34.368	30.500
May	7.463	10.207	7.332	10.202	32.967	30.500
June	6.936	11.171	6.749	11.123	31.011	30.500
July	6.352	10.710	6.185	10.644	28.137	30.500
August	6.244	10.594	6.088	10.518	29.734	30.500
September	6.810	8.680	6.699	8.611	30.786	30.500
October	7.000	......	6.898	......	30.716	......
November	7.042	......	6.945	......	30.500	......
December	7.513	......	7.405	......	30.500	......
Year	6.853	......	6.777	......	31.359	......

Spelter	New York		St. Louis		London	
	1916	1917	1916	1917	1916	1917
Jan.	16.915	9.619	16.745	9.449	89.810	48.329
Feb.	18.420	10.045	18.260	9.875	97.762	47.000
Mar.	16.846	10.300	16.676	10.130	95.048	47.000
April	16.695	9.459	16.525	9.289	99.056	54.632
May	14.276	9.362	14.106	9.192	94.217	54.000
June	11.752	9.371	11.582	9.201	68.591	54.000
July	8.925	8.643	8.755	8.473	50.750	54.000
Aug.	8.730	8.360	8.560	8.190	51.587	54.000
Sept.	8.990	8.136	8.820	7.966	52.095	54.000
Oct.	9.829	......	9.659	......	54.159	......
Nov.	11.592	......	11.422	......	56.023	......
Dec.	10.665	......	10.495	......	55.842	......
Year	12.804	......	12.634	......	72.071	......

New York and St. Louis quotations, cents per pound, London, pounds sterling per long ton.

Pig Iron, Pitts.	Bessemer‡		Basic‡		No. 2 Foundry	
	1916	1917	1916	1917	1916	1917
January	$21.60	$35.95	$18.78	$30.95	$19.70	$30.95
February	21.16	36.37	18.93	30.95	19.51	30.95
March	21.81	37.37	19.20	33.49	19.45	35.91
April	21.65	42.23	18.95	38.90	19.45	40.06
May	21.78	46.94	19.11	42.84	19.58	43.60
June	21.95	54.22	18.95	50.05	19.34	50.14
July	21.95	57.45	18.95	53.80	19.20	53.95
August	21.95	54.17	18.95	50.37	19.22	53.95
September	22.88	46.40	19.58	42.24	19.53	48.58
October	24.61	......	21.26	......	21.51	......
November	30.07	......	28.18	......	26.55	......
December	35.16	......	30.95	......	30.79	......
Year	$23.88	......	$20.98	......	$21.15	......

‡ As reported by W. P. Snyder & Co.