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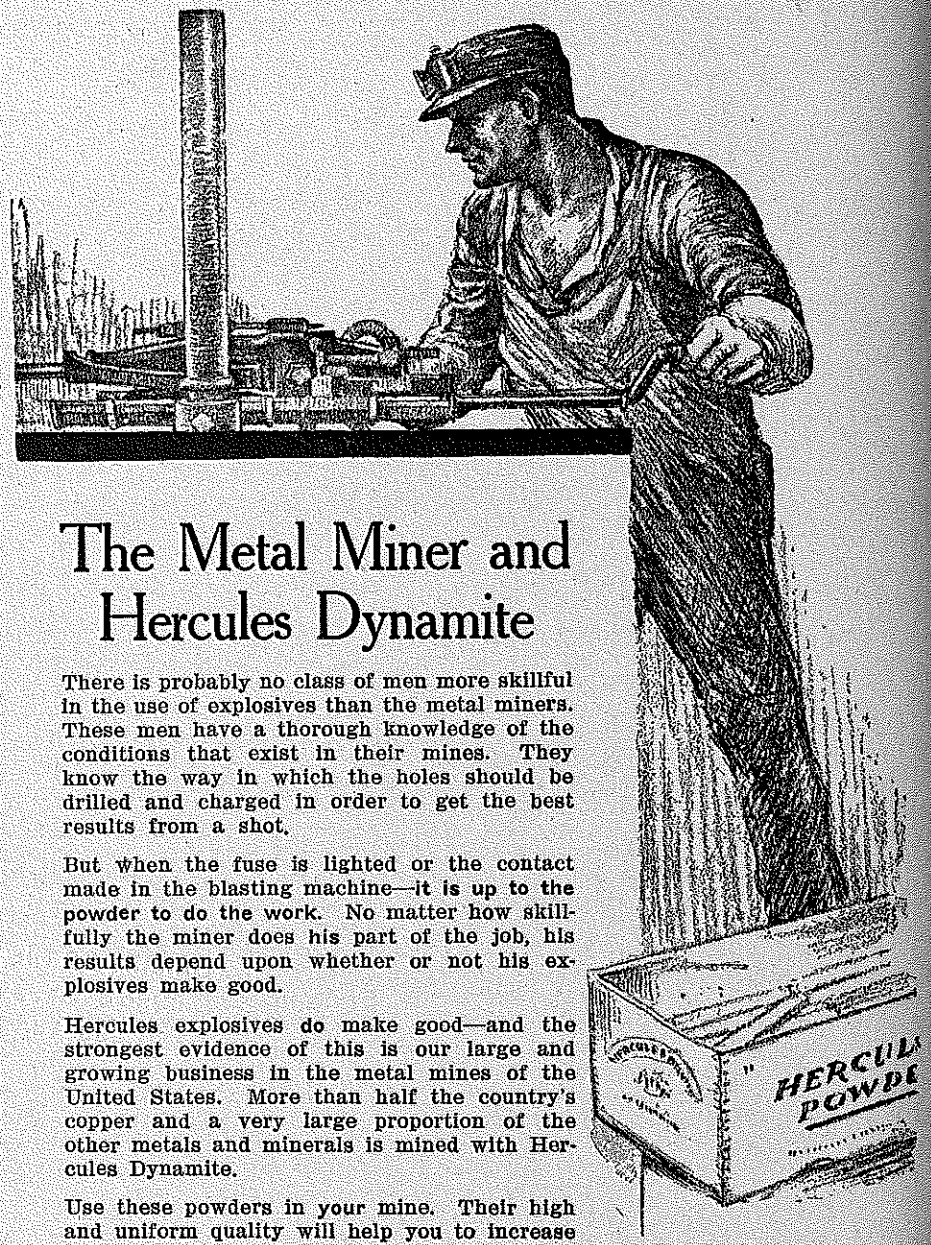

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CONTENTS

Use of Electricity in Metallurgical Processes*

By Robert M. Keeney, '10.

The development of electrometallurgical processes to a position of great industrial importance during the last decade was one of the noteworthy steps in the progress of metallurgy. This development has been of utmost importance to the central station, as most electrometallurgical plants, especially electric furnace processes, use power from the central station. In 1910 there were electrometallurgical or electrochemical power loads in about 25 cities in the United States and Canada, but today such loads are found in over 200 cities. Ten years ago so little was known of the characteristics of the electric furnace load that few power companies cared to have them on their lines. Today, with an electric steel furnace in practically every manufacturing city in the country, the load is considered a desirable one. The wide extension to so many communities is, of course, due mainly to installations of electric steel furnaces during the war. Although the number of steel furnaces installed was far greater than could have been foreseen ten years ago, and although many were installed mainly for war purposes, it does not appear that there has been an over-development in this respect. The quality of electric steel has become so established that the process is here to stay, and will probably supersede other processes for the production of castings, and superrefining will be widely used in the Bessemer and open hearth steel manufacture.

Disregarding electrochemical processes, electricity is used in the metallurgy of the following metals, either as a heating agent or for its electrolytic effects—pig iron, steel, cast iron, the ferro-alloys, aluminum, copper, brass, lead, zinc, gold and silver. Table I gives data regarding the quantity of power used in these processes in the United States and Canada as closely as can be estimated from information available. There is a total load of approximately 1,300,000 kv-a used in electrometallurgical processes in the United States and Canada, not including motor load.

Table I—Installed Power Capacity in Electrometallurgical Processes in the United States and Canada.

Process	Kv-a Load	Process	Kv-a Load
Pig Iron	none	Brass	23,000
Steel	600,000	Lead	1,400
Ferro-alloys	200,000	Zinc	60,000
Aluminum	350,000		
Copper	45,000	Gold & Silver	1,000

* The Electric Journal, May, 1920.

Pig Iron.

Although the electric smelting of iron ore was developed simultaneously in the United States and Sweden, and although in 1908 Dorsey A. Lyon erected at Heroult, California, the first electric furnace to produce pig iron commercially, the process is no longer in operation in this country. Pig iron is being produced in the United States by electric melting of scrap, but not smelting iron ore. The plant at Heroult was increased to 5,000 kilowatts capacity, but in 1914 production of pig iron was discontinued and the plant operated on ferro-alloys.

On the other hand, development in Sweden and some other countries has been steady. The furnace developed is similar to the shaft furnace installed by Lyon in 1908, which is especially adapted for production of low carbon and silicon iron, and not foundry iron. It operates best with charcoal as a reducing agent, and in fact proved a failure at Hardanger, Norway, in 1912, when operating with coke. At Notodden, Norway, a furnace of the pit type has been developed, which operates satisfactorily with coke and also produces foundry iron. The last two furnaces operated at Heroult, California, were also of the low pit type, and could be operated with coke and charcoal mixed for production of foundry iron.

Electric furnaces for smelting of iron ore are now installed as shown in Table II. In 1910 there were two furnaces of a total power input of 3,500 kilowatts.

Table II—Electric Furnaces Smelting Iron Ore.

Country	Type of Furnace	Number of Furnaces	Size of Units Kv-a	Transformer Capacity Kv-a
Sweden	Shaft	19	2,000 to 7,000	64,000
Norway	Pit	3	1,200	3,600
Norway	Shaft	1	3,000	3,000
Switzerland	Shaft	2	3,000	6,000
Japan	Shaft	2	3,000	6,000
Italy	Shaft	6	3,000	18,000

At the present time there are installed 33 electric pig iron furnaces of from 2,000 to 7,000 kv-a, a total load of 100,600 kv-a, having a production capacity of 250,000 tons of pig iron per year. During the war, production costs have favored electric smelting, so that electric pig iron is now being produced in Sweden for five dollars per ton less than blast furnace charcoal iron. This is in spite of an average increase in power cost of from eight to twelve dollars per horsepower-year.

The electric iron smelting furnace produces pig iron with a power consumption of from 2,000 to 3,000 kw-hrs. per ton of pig iron, the lower figure being for white iron and the higher for gray iron. The electrode consumption varies from 13 to 20 lb. per ton of pig iron. As the furnace operates with the arc buried in molten slag, the electrical load is very steady, with few fluctuations except while tapping. In a plant designed for efficient handling of electrodes, it should be possible to attain an average load factor of 80 percent.

The Swedish furnaces use three-phase, 25 or 60 cycle power, with a secondary transformer range of 50 to 100 volts, but usually operate at 80 volts. The furnace has six electrodes, with one of the three transformers to a pair of electrodes. The high tension side is connected in delta. The load on the furnace is not regulated by raising or lowering the electrode, as on ferro-alloy furnaces, but by voltage control on the primary. On 25 cycles, the power-factor is 95 percent, but on 60 cycle current it may be as low as 80 percent.

Electric furnace production of pig iron will hardly develop to any great extent in the United States along the line of development in Sweden, because of the cost of power, but the writer believes that the time is coming, particularly in the western states, when pig iron, more specifically cast iron, will be made by melting of scrap iron, scrap steel, iron ore, coke and lime in the electric furnace to produce iron for direct castings or for pig iron. During the war, a considerable quantity of low phosphorus pig iron was made in Canada and the United States by electric melting of steel scrap. The production late in 1918 was 4,000 tons per month. Six plants were in operation in Canada and two in the United States. While it is not probable that these plants are operating today, there seems to be a future for the process, especially in foundries where the cost of pig iron is high due to freight. The writer knows of one city where the foundries pay $50 per ton for pig iron laid down at their plants. Iron in the ladle could be made by the electric process for $35 per ton.

The metallurgy of synthetic electric furnace cast iron was worked out on a large scale by C. A. Keller* in France during the war. Three plants were erected with a total power input available of 40,000 kv-a. During the war 150,000 tons of castings were made with metal cast direct from these electric furnaces, of which there were 16 of from 1,000 to 2,200 kv-a size. The power consumption was from 675 to 800 kw-hrs. per ton of cast iron, with all electrode consumption of 15 to 20 lb. per ton of cast iron. Any grade of iron desired can be produced. All of the furnaces were of the single-phase type with two electrodes in series. The process was conducted as a continuous operation, the furnace being kept full of charge. With large units, the load is very steady, but it is probable that in the operation of small 500 kilowatt units there might be momentary overloads. These would be no worse than in a steel melting furnace. The power-factor of the Keller single-phase furnace is about 80 percent on 60 cycles. The furnace is operated at 50 to 70 volts.

Another use of the electric furnace is in refining gray iron from the cupola. Cupola iron, after treatment in the basic electric furnace, shows a marked decrease in sulphur and increase of transverse strength. At present the process appears adaptable only for the very highest grade of castings. The electric furnace is also being used in production of malleable iron castings, and has been considered as a mixer for keeping molten blast furnace pig iron hot before casting into pipe.

Steel.

The most marked increase in the use of electricity in metallurgical processes during the past decade has been in the electric furnace production of steel. In 1904 there were four small electric furnaces in operation in Europe. In 1910 there were sixty-seven furnaces in operation, eleven not working, and thirty-six in course of construction throughout the world. Of this total of 114 furnaces, seven were installed in the United States and Canada with a total power input of 5,600 kv-a and a charge capacity of 40 tons per heat.

On January 1, 1920,† there were installed or under construction in the United States and Canada 363 furnaces with a total charge capacity per heat of about 1,600 tons and a power input of about 600,000 kv-a. Of the 363 furnaces, 323 were installed in the United States and 40 in Canada. The number of electric steel furnaces in the world is estimated at 875.

The production of electric furnace steel in the United States in 1917 was 304,543 gross tons. Probably 1918 and 1919 will show a production of over 400,000 gross tons for each year. Almost 50 percent of the 1917 production was alloy steel. Of the 323 furnaces in the United States, 54.5 percent are being used for making castings.

The most marked development of the electric steel furnace has been in the production of ingot alloy steels for automobile construction and high speed steel. The electric furnace operating with a basic lining produces tons of high-grade alloy steels per heat as compared with the crucible furnace producing pounds. Lower grade raw materials can be used, because of the refining to remove phosphorus and sulphur which can be readily performed in the electric furnace. The electric furnace has proven particularly successful in the production of alloy ingots, such as chrome-vanadium steel, turning out a product better in quality than similar open hearth steel with a much lower loss of alloys by oxidation. For the production of high-speed steel in large heats the electric furnace proved well adapted during the war, it being common practice to pour five ton heats of steel valued at three to five dollars per pound. However, the substitution of the electric furnace for the crucible furnace will be very gradual, because it is not yet demonstrated that average electric high-speed steel is quite equal in quality to the highest grades of crucible high-speed steel. To meet the grade of the highest quality crucible steels, the electric furnace product must be made from the most pure raw materials available, and even then, considering electric steel versus crucible steel from condition existing in each case, it does not seem possible that melting conditions can be as closely controlled in the electric furnace as in the crucible.

A future probable large development, in electric steel, is the use of the furnace for finishing molten converter and open hearth steel. The Illinois Steel Company has installed ten 30-ton electric furnaces to treat steel which has been first blown in the Bessemer converter, then held in the open hearth, for eventual transference to the electric furnace. This process was used to a small extent in the early days of electric furnace steel production in this country, and a few years will probably see its general adoption.

From the viewpoint of the central station the most important phase of electric steel development is in the electric furnace production of steel castings. Except for manufacturers of high-speed steel, most companies producing alloy steels generate their own power and do not buy from the central station. This is especially true in large plants using the duplex process for refining molten steel. On the other hand, practically all foundries buy their power. Electric steel castings can now be made much cheaper than converter castings, and at as low a cost as open hearth castings. The grade of the castings is better than the product of either of the other methods.

A great advantage of the electric furnace over the open hearth is the rapidity with which heats are made, so that it does not require handling of large quantities of metal as in the case of the open hearth. Within a few years the electric furnace will probably replace all other processes for making steel castings, and most castings will be produced without refining, by melting scrap on an acid bottom.

As a central station load, the electric steel furnace gives the least desirable load of any of the uses of electricity mentioned in this paper. This fact does not make it an undesirable load, however. In fact, it is a very desirable load, although its load factor is low compared with that obtained in some other electrimetallurgical processes. This is because most foundries operate on a ten hour day instead of a twenty-four hour day. On a ten hour day operation, a load factor of 18 to 30 percent is obtained. On a twenty-four hour day the load factor will vary from 40 to 55 percent when making castings. The low load factor, as compared with other electrometallurgical industries, is caused by time lost in charging and pouring when the power is off. Due to greater length of time between pouring, a furnace producing ingots on a basic bottom with refining should have a higher load factor than those mentioned, but this is offset by the present common practice of running with about half or one-third load during the refining period at the end of a heat. A furnace refining molten steel instead of melting cold scrap should attain a load factor of 75 percent on twenty-four hour operation.

The power consumption varies from 550 kw-hrs. per ton when melting scrap on an acid bottom for castings, to 800 kw-hrs. per ton when making alloy steel ingots requiring refining. The voltage on the only type of single-phase furnace now used is about 140 volts on the arc, 220 volts open circuit. On two and three-phase furnaces, the voltage is from 90 to 110 volts. The power-factor of the single-phase furnace mentioned varies from 50 to 70 percent. The two and three-phase furnaces have power-factors of from 85 to 95 percent. The electrode consumption is 15 to 25 pounds per ton of steel.

During recent years, the tendency in electric steel furnace construction has

* Trans-American Electrochemical Society, 1920, C. A. Keller.

† C. F. Cone, The Iron Age, Jan. 1, 1920.

been to increase the power input per ton; to use three-phase current and automatic regulators; not to have large reactances in the primary circuit; and not to build furnaces with a bottom electrical connection, at least a connection carrying all of the load. In fact, now that the basic Heroult patents have expired, most new types of furnaces appear to be the original Heroult furnace embellished and camouflaged. The power input per ton of charge has been increased from 170 kw in the early furnaces to 500 kw in the most recent steel casting furnaces. One furnace has been built with electrical connections so that the secondary voltage may be reduced one-half during refining. The use of three-phase current has become almost standard, either as three-phase current in the furnace or three-phase converted to two-phase. Few single-phase furnaces are being built. The single-phase furnace with a bottom contact, however, blazed the way for rapid melting of scrap for steel castings on an acid bottom.

The use of heavy reactance in the circuit is being discarded, and furnaces are generally operated with a moderate reactance and automatic regulators. Common reactances are 7 to 15 percent in the transformer. The bottom contact, as used for carrying all of the current, has apparently gone out of use with the abandonment of single-phase furnaces, although it is still used for putting a small part of the current through the bottoms of some two-phase and three-phase furnaces.

The central station can better the load factor of the electric foundry furnace by making it an object for the customer to operate his furnace 24 hours per day, through the decreased cost per kw-hr. he obtains. Of course, this depends on the peaks in the power company's industrial and lighting load, but there is at present a tendency to install small furnaces for 24 hour operation rather than large furnaces for ten hour operation, and it is to the advantage of both parties that this tendency be encouraged. The furnace with a moderately high power-factor, 85 percent, has proven to be a better load than the furnace with a very high power-factor, 95 percent, because it is not so sensitive to short-circuits in the furnace, and at the same time there is enough reactance present to render electrode regulation easy with regulators. The use of furnaces with heavy reactances and hand regulation of electrodes should be discouraged, as the heavy reactance is not necessary, if regulators are installed.

Electric furnaces of the carbon resistance type have been installed in considerable number for the heat treatment of forgings and castings. The furnaces are ingeniously designed with a very complete automatic control of temperature, and control movement through the furnace of the piece being treated. The heating element is a resistor of granular carbon confined in carborundum fire sand troughs, which results in a uniform load without surges, and a power-factor of 98 percent or better. The load on the furnace is controlled by variation of secondary voltage with taps on the secondary of a special type of transformer. The electric heat treatment of steel is certain to become common practice even at a higher cost because of the ease of control and uniformity of the results obtained. Single-phase furnaces of 900 kilowatts power input have been installed alone, or with two or three connected in balance on a three-phase circuit and operated successfully. A further advance is the adaptation of this type of electric furnace to the soaking pit for large steel ingots and billet reheating furnaces.

Another type of electric heating treating furnace was developed during the war, in which the heating unit consists of a calorite ribbon mounted on a cast iron supporting plate and insulated therefrom by suitable refractory material. The furnaces are of the cylindrical, vertical type and take three-phase, 440 volt current. Units of 400 kilowatts capacity have been built. The current is automatically thrown off and on as the temperature rises above or falls below the desired point. These furnaces were designed for the heat treating of gun barrels, but can readily be adapted for the industrial uses of the future.

Ferro-Alloys.

The war demand brought the electric furnace ferro-alloy capacity to a point which, with the arrival of a more normal peace demand for ferro-alloys, puts the industry in much the same condition as existed in the European calcium carbide industry in 1899, when over-production and patent litigation compelled most plants to look for new products, which strangely proved to be ferro-alloys. The increase in installed furnace transformer capacity for ferro-alloys production was enormous from 1915 to 1918. In 1910 there were only two plants in the United States and Canada which produced ferro-alloys in the electric furnace. They had a total transformer capacity of possibly 20,000 kv-a. On January 1, 1920, there were forty plants with a combined transformer capacity of 200,000 kv-a. At the date of writing, probably 75 percent of these plants are not operating. Many of them are in the hands of a receiver and will eventually be dismantled. Probably not over a half a dozen of the plants erected during the war, for war purposes, paid back their plant investment before the armistice. Companies which were organized with sufficient operating capital will doubtless, with proper management, return the investment in time. It will be slow, because the market has been dead for all alloys, except ferrovanadium, until two months ago, when the price of ferromanganese began to advance from as low as $100 per ton until now it has reached the war price of $250 per ton. This is due to failure of imports of ore. Between the buyers and the government war materials policy, the domestic ore producers got such a shaking down after the armistice that it will be a long time before there will be any quantity of domestic ore produced, except by ferro-manganese manufacturers operating their own mining properties.

With the enormous increase in plant capacity, the United States easily led the world in production of ferro-alloys when the armistice was signed. The plant capacity of ferrosilicon had increased from 10,000 or 15,000 tons per year to 100,000 tons per year. Instead of importing ferrotungsten and ferrochrome, large quantities were exported. Ferrovanadium, which had always been exported, was shipped abroad in larger quantities than ever. But the two most important developments have been the electric smelting of manganese ores and the increased use of molybdenum in steel.

In 1914 there were no electric smelting plants built mainly for production of ferromanganese. Two plants at Niagara Falls made it electrically at irregular intervals, presumably to keep their furnaces in operation when the market for other alloys was dull. On Armistice Day there were ten plants of total transformer capacity of 55,000 kv-a, and production capacity of about 80,000 tons per year. At the close of 1918 about 15 percent of the ferromanganese production of the United States was being made in electric furnaces. With two exceptions these plants are now out of operation, the two largest having resumed work when the price of ferromanganese advanced several months ago.

Through the interest of one of the largest smelting companies in the world in a Colorado molybdenite deposit, which is probably the most extensive known deposit of molybdenite, large scale investigation of the use of molybdenum in steel has resulted. This work shows that the addition of small quantities of molybdenum to chrome, nickel, chrome-nickel or chrome-vanadium steel, results in a steel of greater strength and toughness, which is easily forged, easily heat treated and easily machined. Probably 300 tons of ferromolybdenum were produced in 1918 as compared with less than 25 tons in previous years. There was a very small production in 1919. Some electrical characteristics of electric ferro-alloy furnaces are given in Table III.

Table III—Electric Ferro-Alloy Furnaces.

Product	Size of Furnace Kv-a	Phases, Usual Type	Secondary Phase Voltage	Percent Power-Factor	Percent Load Factor	Percent Overload Swing	Load Curve
Ferrosilicon	750 to	1	80	92	80-85	25	Smooth
Ferrosilicon	7500	3	120	70	80-85	10	Smooth
Ferromanganese ...	1200 to	3	65-75	85	80-85	10	Very Smooth
Ferromanganese ...	5630	3	115-120	70	80-85	10	Very Smooth
Ferrochromium	1000 to	3	65-75	95-90	80-85	25	Smooth
Ferrochromium	1500	3	75	85-90	80-85	25	Smooth
Ferrotungsten	75 to 250	1 to 3	55-75	90	50-70	50	Irregular
Ferromolybdenum.	75 to 250	1	55-75	90	50-70	50	Irregular
Ferrovanadium	150 to 500	1	55-75	90	70-80	25	Smooth
Ferro-uranium	75 to 150	1	55-75	70	70-80	50-100	Very Irregular
Ferrotitanium	500	1	55	85	80	50	Irregular

Practically all ferrosilicon furnaces are now installed in three-phase units. If it is desirable to install units of less than 1,500 kv-a capacity, a single-phase furnace with two vertical electrodes in series is usually built. There is at least one plant in this country equipped with single-phase furnaces of this type. The ferromanganese furnace gives about the smoothest and most easily controlled load of any of the ferro-alloy furnaces.

Ferrochrome is made in both single-phase furnaces and three-phase furnaces. Before the war some engineers from the largest point of ferro-alloy production,

Niagara Falls, claimed that ferro-chrome could not be made in a furnace of over 1,000 kw capacity. This was proven to be a fallacy by the recent installation of a 1,500 kw furnace in Denver which operates more satisfactorily than a smaller furnace at the same point.

Ferrotungsten is almost universally made in the single-phase furnace of the Siemens type with the bottom forming one electrode. The metal is allowed to build up in the furnace and the furnace torn down to remove it. This results in a considerably more irregular load curve than with the larger tapping furnaces. One plant, now dismantled, successfully made ferrotungsten in a three-phase furnace.

The characteristics of ferromolybdenum operation are much the same as for ferrotungsten, except that when the 55 percent molybdenum alloy is being made, it can be produced in a tapping furnace instead of a knockdown furnace. Electric furnace ferrovanadium is usually produced in a single-phase furnace, either of the Siemens type or series type. Ferro-uranium is made in small furnaces of the Siemens type. Due to absence of slag in the operation, the load is very irregular, and considerable reactance is usually used in the circuit, especially if automatic regulators are not used. The load characteristics of a ferrotitanium furnace are somewhat similar to those of ferro-uranium.

In commercial production of these ferro-alloys, ferrosilicon, ferromanganese and ferrochromium can be made in three-phase furnaces as readily as in single-phase furnaces, and there is no reason for permitting installation of single-phase furnaces for their production. Ferrotungsten, ferro-molybdenum, ferrovanadium, ferro-uranium and ferrotitanium must be made in single-phase furnaces. At least the operation is much more apt to succeed in a business way. For this reason, a power company should not object to installation of single-phase furnaces by a company desiring to make these alloys. It may be noted that the line of division in these alloys is between metals of a low melting point and metals of a high melting point. Silicon, manganese, and chromium have comparatively low melting points when electric furnace temperatures are considered, while the melting point of tungsten, molybenum, vanadium, uranium and titanium is high.

There appears to be no reason for the installation of heavy external reactances for the production of any ferro-alloys, except possibly ferrotitanium and ferro-uranium. For these alloys, either regulators or reactances are probably necessary. In the operation of plants without regulators and with regulators, on the same ferro-alloys, in the same size furnaces, no marked difference in the straightness of the load curve is noticeable. The regulator saves the time of one man on three furnaces or three electrodes when hand control is used. A good man will get as good a load curve as a good automatic regulator but, of course, the regulator eliminates the human element.

Recently the writer put in operation a ferro-alloy plant with the understanding that the primary circuit was 4,500 volts. Furnace transformers were installed with a ratio of 4500-75. During the twenty-four hours, the secondary furnace voltage varied from 72 to 85 volts, depending on whether the industrial load of the town was on or off. This results in two things—it ran up the demand charge because the furnace would run at the same amperage with higher voltage unless watched continuously, and means the production of a poorer grade of metal when running a knockdown furnace, as the button will not be so compact with high voltage. The difficulty was not caused by anything in the furnace transformer, which had a reactance of seven percent, as the same ratio of variation was shown on the 110 volt lighting circuit. In another case a large furnace was installed on a power line which the power company claimed was more than heavy enough. It resulted in a line drop of 25 percent, which made the furnace voltage so low that enough power could not be gotten into the furnace to keep it hot. Ferro-alloy furnaces are run on certain voltages because practice has proven these voltages to be the best. Of course, in 3,000 to 4,000 kilowatt furnaces it is sometimes necessary to raise the voltage above the desired limit for good metallurgical practice, in order to get power into the furnace.

The electric smelting load, at the present time exemplified by ferro-alloy furnaces, is probably one of the best loads a power company can get, and in the future may prove a much larger load with application of electricity to smelting of non-ferrous ores.

Aluminum.

Since the separate discoveries by Hall and Heroult in 1886, that aluminum could be produced by electrolysis of alumina with a fluoride electrolyte, the yearly production of aluminum has increased to a world output of 489,000,000 pounds ‡ in 1918. Aluminum is now fourth in quantity production of non-ferrous metals, being surpassed only by copper, zinc and lead in the order named. It will probably pass lead and zinc within twenty years. In variety of uses it is only surpassed by iron and copper. All aluminum is produced in a direct-current, electrolytic cell with a molten electrolyte, usually heated by the passage of the current. The world output of 1918 required about 700,000 kv-a, and the estimated installed power capacity being used for aluminum in the United States at the present time is 350,000 kv-a. The production of the United States in 1918 was 225,000,000 pounds. France was the next largest producer with a production of 48,000,000 pounds. In 1910 the production of the United States was only 12,000,000 pounds and the installed power capacity about 75,000 kv-a.

‡ J. W. Richards, The Mineral Industry, 1918.

The practical metallurgy of aluminum, as practiced in the United States, has been kept as secret as possible. In one of the most recently constructed plants the furnaces or cells take 20,000 amperes of direct current at seven volts. Seventy of these furnaces are connected in series on a 500 volt, direct-current line. Power is supplied to the battery by a 10,000 kilowatt, direct-current generator direct driven by a water wheel. In most European plants, the direct connection of the water wheel to the direct-current generator has been common practice, because the aluminum plants were generally built at the power site. This practice has not been common in this country because the power source has usually been the high-tension line of a central station. The power consumption is about 15 kw-hrs. per pound of aluminum. The load is ideal for a central station.

In addition to the use of electricity in the production of aluminum, it is also used for melting aluminum in furnaces of the resistance type. A carbon resistor furnace of 500 kw capacity has been put on the market for this purpose.

Copper.

Since 1883, electricity has been used in this country to refine copper. There are nine electrolytic copper refineries in the United States. Direct current is supplied from motor-generator sets or converters. In electrolytic copper refining, pure copper is produced from blister copper by suspending the blister copper as an anode in a solution of $CuSO_4$ acidulated with H_2SO_4, the current depositing pure copper on a copper cathode, the impurities forming an anode mud. The electrolytic copper refining capacity of the United States is 1,349,000 tons per year, requiring about 45,000 kv-a. Power is generally supplied at 145 to 220 volts, and the cells are usually connected in multiple. The greater part of the electrolytic copper refining capacity of the United States is located on New York harbor, and power is generated by steam in the power plant of the refinery. Seven to eleven pounds of copper are deposited per kw-hr.

The electrolytic deposition of copper from leaching plant solution is in practice on a large scale at Ajo, Arizona. The power installation is 15,000 kv-a, of which only one-half is required to operate the plant. As high as 2.5 pounds of copper have been deposited per kw-hr.

An increasing quantity of electricity is being consumed in the large copper smelting plants for removing dust from smelter smoke. A new Cottrell smoke treatment plant has been completed at Anaconda, which uses approximately 1,000 kw. This use of power will be increasing until almost every smelting plant is equipped. The process is also being used on manganese furnaces and lead furnaces.

There has been a remarkable growth of the use of the electric furnace for melting brass and non-ferrous metals. From one silver melting furnace of the carbon resistor type in 1914, the number had grown to 261* on March 1, 1920. Of these furnaces, 61 are carbon resistor furnaces, 118 are induction furnaces, and 82 are arc furnaces of various types. Furnaces are being used to melt brass castings, wrought brass, bronze, copper and nickel. The total estimated installed transformer capacity is 23,000 kv-a, of which one-third is for carbon resistor furnaces, one-half for arc furnaces, and the balance for induction furnaces. The carbon resistor furnaces operate at 98 per cent power-factor, giving a very steady load. The most common size has 105 kv-a transformer capacity. The induction furnaces are built in the smallest units of any of these furnaces, taking 30 to 60 kw load with a power-factor of 70 to 85 per cent. The indirect rotating arc furnace operates at 80 to 90 per cent power-factor, and is built in sizes up to 300 kv-a. Depending on the kind of brass being melted, the power consumption varies from 250 to 400 kw-hrs. per ton.

The electric brass furnace is rapidly becoming an important load for the central station. Except for the single-phase feature it makes a good load for a power

* E. F. Cone, The Iron Age, May 4, 1920, p. 655.

company. It is built in such small units that the fact it is single-phase should not prove seriously objectionable.

Lead.

Electricity is used for the refining of lead bullion by the Betts process at Trail, British Columbia; East Chicago, Indiana; Omaha, Nebraska; and New Castle on Tyne, England. The general layout of a plant is similar to that of an electrolytic copper refinery. Cast anodes of lead bullion and lead cathodes of electrolytic lead connected in multiple are suspended from copper bars across a rectangular tank in which there is an electrolyte containing lead fluosilicate and free hydrofluosilic acid. The current enters the anode, passes through the electrolyte to the cathode, dissolves lead from the anode and deposits it on the cathode. The impurities form anode mud or slime, which is refined to recover metals of value. The electrolytic lead refining capacity of the United States and Canada is about 90,000 tons of lead per year. The installed power capacity is about 1,400 kv-a. Fifteen pounds of lead are deposited per kw-hr. Power is generally supplied at 90 to 115 volts, and the cells connected in various arrangements.

Zinc.

The commercial application of electrolytic precipitation of zinc from sulphate solution in the hydrometallurgy of zinc is less than five years old. The first recorded production in the United States was 10,963 tons in 1916, which in 1918 had increased to 38,885 tons. The electrolytic zinc production of 1918 was 7.3 per cent of the total production of the United States. At the present time there are four commercial plants for production of electrolytic zinc in the United States and one in Canada, with a total production capacity of about 300 tons of zinc per day. One plant has been built in Australia and two in Tasmania.

The secret of successful electrolytic preparation is to precipitate the zinc from a pure electrolyte. Sheet lead anodes and sheet aluminum cathodes are used. The zinc is stripped from the aluminum cathode and melted for casting into ingots. The power consumption in one plant is as low as 1.7 kw-hrs. per pound of zinc precipitated. In others it is as high as 2.5 kw-hrs. per pound of zinc. In one plant three-phase current is delivered at 44,000 volts, transformed to 2,300 volts, and converted to 250 volt direct-current by synchronous motor-generator sets. Sixty cells are connected in series, with the voltage per cell 3.5 volts. The installed transformer capacity of electrolytic zinc plants in the United States and Canada is about 60,000 kv-a.

A large 1,000 kw melting furnace of the carbon resistor type was put in operation in 1919 for melting the zinc cathode of an electrolytic zinc plant. In the first weeks of operation the furnace melted zinc with a power consumption of 70 to 80 kw-hrs. per ton of metal charged and a metal loss in dross of 0.024 per cent.

Although there has been considerable experimenting in the United States and Canada during the past ten years on electric smelting of zinc ores, nothing has been done in commercial production. Electric smelting of zinc ore and dross has been practiced commercially in Sweden since 1901. Two plants are in operation in that country of a total transformer capacity of 15,000 kv-a. A large part of this capacity has been used for smelting dross. When smelting ore the main difficulty has been in production of blue powder instead of zinc. Single-phase furnaces of 350 to 750 kv-a size are used. Although the blue powder difficulty appeared practically solved by experimenters in the United States several years ago, nothing commercially has resulted.

The use of electricity in metallurgical processes for treatment of ores is certain to increase slowly. The operation of the Anaconda plant has shown that zinc can be produced electrolytically at a profit with zinc at its normal price. Electrolytic plants will probably prove most successful in large units, and the growth will be toward a few large installations rather than a few small ones. All the plants erected to date use central station power. These plants give an excellent load of high load factor and high power-factor.

Gold and Silver.

Electrolytic refining of gold and silver bullion has been practiced for a number of years in the United States mints at Philadelphia, Denver and San Francisco, and the New York assay office. It is also used in the refinery of one Perth Amboy smelting plant. In silver refining, an electrolyte of silver nitrate solution is used. In gold refining the electrolyte is a trichloride solution of gold. The power involved in these installations does not exceed 500 kilowatts.

Several electric melting furnaces were installed in United States mints during the war, which proved successful for melting silver dollars, nickel and copper.

Future Development.

Increased load of central stations from metallurgical processes depends on several factors: (1) cost of power; (2) location and freight rates; (3) the price of coal and oil now used as fuels in metallurgical processes; (4) industrial demand for the highest grade metals and alloys. In melting steel and non-ferrous metals and electrolytic refining of metals, a power cost of one cent per kw-hr. is reasonable, but a smelting or electrolytic reduction process, except when producing the higher priced ferro-alloys, such as ferrovanadium, cannot stand this price. The smelting furnace operator does not expect the two mill power of Sweden, but in most cases he must have five mill power. The cost of power limits the following electrometallurgical processes to hydroelectric power: smelting of iron ore, ferro-alloy production, aluminum, electrolytic zinc precipitation, and electric smelting of non-ferrous ores.

Location and freight rates will have a considerable influence on the substitution of electrical processes for combustion methods. Western foundries will probably be making iron castings by electric melting of scrap iron and steel or by smelting a mixture of scrap and iron ore instead of by melting pig iron shipped from the East with a $12 to $18 freight rate added to the eastern market price, once somebody has demonstrated the saving possible. Many large western smelters have ceased operation because of high costs and shortage of ore. This may result in installations of electric furnaces for treatment of high grade ores and flotation concentrate.

The price of coal and oil has reached such a point in many western smelting centers, where hydroelectric power is available, that if electric furnaces were developed to a point where they could be substituted for combustion furnaces, substitution of electric furnaces would undoubtedly result. This development is certain to come before many years, if fuel prices remain high, particularly oil.

Modern industry demands high grade products. Even if electric furnace steel costs slightly more than open hearth steel, the requirement of the best steel possible for present day industrial purposes is certain to result in a large increase in the production of electric furnace steels and non-ferrous alloys. This will eventually increase the consumption of electrically produced ferro-alloys.

In summary, a considerable increase of the uses of electricity is to be expected in the following processes:

1. Iron castings from scrap or a duplex process of cupola melting with electric furnace refining.
2. Steel castings and alloy steels.
3. Ferro-alloys.
4. Aluminum.
5. Brass melting.
6. Electrolytic zinc.
7. Electric smelting of non-ferrous ores.

Electric Power Made Economical.

"The present tendency of modern power equipment, both steam and hydraulic, is toward the growth of large central power stations and interconnected distribution systems," is the belief of engineers of the General Electric Company.

This leads them to predict that these power stations will be situated at points of cheap coal supply or of hydroelectric development and will supply power for cities and industries over a wide section of country. The same systems will also furnish power for the railways in their territories. The Montana Power Company may be cited as an illustration. This company has 12 hydraulic power stations feeding into a common distribution system at 100,000 volts. The total installed capacity is approximately 175,000 kilowatts (235,000 horsepower). Power is furnished to the Chicago, Milwaukee & St. Paul R. R. and for other purposes. The average 24-hour demand for the 440 miles of the C. M. & St. P. electrification is approximately 15,000 kilowatts (20,000 horsepower).

Speed?

The speed of submarine telegraphy is illustrated by the fact that five minutes are usually sufficient to cover a complete buying and selling operation between the London Stock Exchange and Wall Street. The distance between these two points is about 4,000 miles and it takes the message less than a minute for the journey.

Electric Development in Japan.

It is stated that there are 715 electrical utility undertakings in Japan, including 625 power plants, 42 electric railways, and 48 companies operating both power plants and tramways. This is an increase of 40 companies over last year, and evidences the growing popularity of electricity in that country.

Summarized Extracts from Commencement Address of John Barrett

Director General of the Pan-American Union, the official international organization of the American republics in Washington, and former United States minister to Argentina, Panama, and Colombia, before the Colorado School of Mines, Golden, Colorado, Monday, May 10, 1920.

It is most fitting that the **Pan-American opportunity and responsibility of the United States should be discussed before the Colorado School of Mines.** There is no foreign field today so potential for the men, the capital and the commerce of the United States as that of our twenty sister American republics. There is no educational institution in the country that can do more than this one to make the United States a leader in the development of that field.

The Colorado School of Mines has a unique position not only in the United States but throughout both Latin America and Asia as well. It is known from Mexico and Cuba south to Argentina and Chile, and from Japan to India, as one of the leading schools of its kind in the wide world. Its young men, therefore, with its influence back of them, should figure prominently in the new era of both material and political relationship that is developing between the United States and foreign lands and especially with its sister American republics.

While from my knowledge of their progress and possibilities, and from my experience among them as United States Minister and Special Commissioner, I have profound respect for the countries and peoples of Asia; today I am emphasizing the Pan-American opportunity and what it means to the young men of this institution and of the entire country.

Think of what Pan-America and Pan-Americanism means! Pan - America means, geographically, everything on the Western Hemisphere from the Arctic to the Antarctic, and, politically, it signifies the twenty-one independent republics of the new world from the United States on the north to Argentina and Chile on the south. Some day, and I believe it is not far distant, Canada will be included politically as well as geographically. And then what a magnificent front to all the world the Pan-American Union, the organization of all the American countries for the development of commerce and intercourse, friendship and peace among them, will present to the rest of the world. Pan-Americanism means the cooperation of all these countries for their common good of the world.

That section of Pan-America of which we speak today includes the twenty countries which extend from Cuba and Mexico south. Think of it! They cover an area of nearly 9,000,000 (nine million) square miles, or approximately three times the connected area of the United States; they support a population rapidly approaching 100,000,000 (one hundred million), or almost equal to that of the United States; they conduct a foreign trade in excess of $3,000,000,000 (three billion) per annum, of which today, though it is not generally appreciated, the United States has the largest share. Whether it continues to hold this position of leadership, which it gained during the war, will depend largely upon the commercial, financial and shipping interests of the United States and the work and ambition of such young men as are graduating from the Colorado School of Mines.

The young men of the United States should awake to the immeasurable future of our sister American republics, the majority of which are, materially, and especially in mining and mineral possibilities, where our great west was fifty years ago. As one who has studied every part of Latin America and traveled extensively over its mountain ranges and through its river valleys, I honestly believe that Latin America is going soon to experience a mining and mineral development which will astonish the world. It already has a wonderful record in this respect, but, as conditions of transportation, communication, stability of government, safety of investment and better knowledge of these countries come, there will be a corresponding discovery and exploitation of natural riches beyond anything ever experienced in the history of the United States.

RADIO BARRAGE RECEIVERS.

Dr. Alexanderson, the well-known wireless engineer has developed what he calls a barrage receiver, which permits receiving stations to turn a deaf ear to all other messages except the particular one which they desire to hear. In a recent lecture Dr. Alexanderson outlined a comprehensive plan for a world-wide system of radio communication, which, he believes, will send messages at the rate of 100 words per minute.

TECHNICAL REVIEW

GENERAL.

The German Nitrogen Syndicate. By Prof. N. Caro. (C. & M. E., April 14, 1920.)

The question of the possibility of Germany's applying her greatly increased nitrogen output to the fertilization of the soil is well treated. As a fertilizer, nitrogen was formerly used with phosphoric acid in the ratio of one to three, but it is believed that this ratio can be changed to two to one without impoverishment of the soil. Foreign competition is to be feared only as long as the price of coal, coke, water-power, and labor continues to rise in Germany. American competion is centered in Alabama, where water-power, coal, marble, pyrite, and phosphate rock make it possible to produce ammonium phosphate at a very low cost. Other countries produce about three hundred thousand tons of lime-nitrogen annually. To facilitate the distribution of the products a Government-controlled nitrogen syndicate has been established. J. A. H.

Rehabilitation of Silver. By Senator Charles S. Thomas. (E. & M. J., April 17, 1920.)

Beginning with a consideration of the vast war debts contracted by the world, Senator Thomas shows the intimate connection between permanent peace and financial stability. The world's gold supply amounting to only about one-sixth of its currency and one-thirtieth of its debt, a safe balance can be reached only by rehabilitating silver, and fixing a ratio of exchange between it and gold. Such a step could not possibly increase production to the danger point as the present annual silver production is only one-fourth the demand. J. A. H.

The Future of Interior Alaska. By R. H. Stretch. (M. & S. P., April 24, 1920.)

The purpose of this article is, in general, to distinguish the milder regions of Alaska from the arctic northern part, and, more particularly, to give the essential differences between the coast and the interior. Coastal Alaska extends inland to the summit of the Alaskan range and is principally a land of fisheries, mines and forests. Arctic Alaska is drained into the Arctic Ocean and its commercial importance depends on furs and whales. Interior Alaska produces gold at present but its climate is favorable for farming. The total area of Alaska is 600,000 square miles, of which the Interior comprises one-third. In the Interior there is a population of about 12,000, but aside from gold, they have exported absolutely nothing over the railroad on which the Government has spent $52,000,000. At present the prosperity of the country waxes and wanes with the condition of the mining industry, but with governmental encouragement the land could export great quantities of agricultural products. J. A. H.

Consumption of Inorganic Nitrogen in the United States. By Major D. P. Gaillard. (C. & M. E., April 28, 1920.)

The consumption of nitrogen may be agricultural, industrial, or military. In the fertilization of the soil, inorganic nitrogen, especially Chilean nitrate and ammonium sulphate makes up about 60% of the whole, while the remainder is organic, mostly cottonseed meal and animal tankage. At present the annual consumption is about 7,500,000 tons of fertilizer, with the high prices indicating that the consumption is regulated by the supply rather than by the demand. It is estimated that over 150,000,000 tons of mixed fertilizer could be advantageously used each year on the soil of the United States. In the last two years cottonseed meal and animal tankage have been used so broadly for feeding that they are now only secondarily utilized as fertilizers. This fact makes it probable that by 1930, organic material will be available for only one-tenth of the fertilizer supply. This means that 285,000 tons of nitrogen must be supplied by inorganic sources. In the industries, two-thirds of the nitrogen is in the form of nitrates, the remainder being ammonia. At the normal rate of increase, the 1919 consumption of 97,500 tons of nitrogen will be increased to 150,000 tons in 1930. In 1918, 150,000 tons of nitrogen were used in making explosives, but the annual consumption should now decrease to the pre-war tonnage of 1,500. J. A. H.

A New Type of Catalyzer for Hydrogenation. By W. D. Richardson. (C. & M. E., April 28, 1920.)

Benjamin W. Elder, the inventor of the new type, proved that an effective catalyzer could be made by the action of an abrasive upon bulk nickel. The principle of the thing is that an abrasive in

oil rubbed across the nickel produces a suspension in oil of the finely divided nickel necessary for catalytic action. Grinding by means of two nickel discs rotating in opposite direction and supplied with hot oil did not produce a practical amount of material. Cast iron tumbling mills had to be abandoned because the iron as well as the nickel was abraded. Porcelain-lined mills were slightly abraded but the only disadvantage was the necessity of relining the mills. The ideal mill would be constructed with a lining of the same metal as the charge, since this would prevent the dilution of the catalyzer with silica from a porcelain lining. The Elder catalyzer is more cheaply prepared and is superior in activity to many of the chemically prepared agents. It may also be recovered from the hardened oil by filter pressing and be reused. An ingenious application of the process is grinding and hydrogenating simultaneously. Scientifically, the invention is of great importance as it makes it possible to control the ratio of mass to exposed surface.

J. A. H.

Recataloging the World's Largest Library. By Harrison W. Craver. (M. & M., May, 1920.)

The present catalog of the Engineering Societies Library, consisting of four parts, is to be supplanted by an author catalog and a classed subject catalog. The author catalog will contain names of authors, societies, periodicals, joint authors, and analytical author entries, as well as cross reference cards. Classification will extend to the books themselves and to the cards representing the works in the library. By this system the reader may learn what books by a given author are in the library, and what books deal with a given subject.

J. A. H.

Tin—Its Political and Commercial Control. By James M. Hill. (E. & M. J., May 1, 1920.)

The $131,000,000 worth of tin mined in 1913 was used in making tin cans, alloys and minor products. Although most of the element is found in placer deposits, lode deposits, almost always associated with silicious igneous rocks, have been successfully exploited in the last few years. These are generally found at the contact of the intruded and intrusive rock, and near the top of the intruding mass. The only commercial ore of tin, cassiterite, carrying 78.6 percent of tin, occurs in placers which carry about one pound of tin per cubic yard, or in lodes which average from one to forty percent. British tin, which is nearly always protected by heavy export duties, is mined in England, the Malay Peninsula, South Africa, Australia, Tasmania and India. The only other deposits of any importance are in Bolivia, the British East Indies, Siam and China. Although small quantities are mined in Japan, Spain, Portugal, and the United States. England thus controls practically the world's supply, while the United States must depend on importations.

J. A. H.

Supply of Inorganic Nitrogen in the United States. By Major D. P. Gaillard. (C. & M. E., May 5, 1920.)

This article deals with the sources which must supply the inorganic nitrogen whose consumption was detailed in a previous paper by Major Gaillard. The by-product coke-ovens, now in use or under construction, from which come a large part of the nitrogen supply, can produce 82 percent of the 1919 consumption of coke. Bee-hive ovens have stood the competition of the by-product oven with no appreciable falling off of production. At the present rate of increase, 159,500 tons of nitrogen should be produced from coal in 1920. In the same year 80,000 tons should be derived from fixation plants. At the present rate of increase we will have to import 183,500 tons, equivalent to over 1,000,000 tons of Chilean nitrate.

J. A. H.

Synthetic Acetic Acid and Acetone. By J. T. Rooney. (C. & M. E., May 5, 1920.)

War-time necessity in the manufacture of acetone for cordite led the English to subsidize the Canadian Electro-Products Co., which developed the synthesis of acetic acid from calcium carbide, water and air. An experimental plant was constructed to determine the best metallic containers, the preparation of yellow mercuric oxide, the utilization of air as an oxydation agency, and the best catalysts. Acetylene is admitted into the bottom section of a duriron kettle, rises through a six percent solution of sulphuric acid, and the portion which is converted to aldehyde is bailed off and condensed. This 35 percent solution of aldehyde is pumped to the still house and concentrated to 99 or 100 percent. Pure acetaldehyde is pumped into aluminum lined iron tanks and oxydized to acetic acid by the admission of air under pressure. This crude acetic acid is distilled to a purity of 99.8 per cent. The acid was decomposed to acetone in 72 conversion tubes packed with lime-coated iron balls, and wound with 290 feet No. 12 nichrome ribbon. Mercuric oxide catalyst was produced electrolytically in a caustic soda solution, using metallic mercury as the anode. The mercury was recovered by centralizing with soda ash the sediment in settling tanks. When the United States entered the war a similar plant was built in the same locality to supply us with cellulose acetate varnish for airplanes. For commercial purposes the synthetic process is equal to the wood distillation process and should even supplant the latter.

J. A. H.

The Lorraine Iron Field and the War. By Alfred H. Bridges. (E. & M. J., May 8, 1920.)

The Lorraine iron field lies within easy reach by water, of the great European markets, and also within reach of coking coal. They therefore constituted a menace to the German iron industry, as they dipped into French territory and France might place restrictions on exportation. During the occupation of France, all competitive steel plants and coal mines were systematically destroyed, while the iron mines, necessary to German industry, were left unharmed. At present France is crippled by the lack of coal to treat her iron, while Germany is almost as seriously impeded by lack of iron ore to treat in her furnace.

J. A. H.

Pre-War Legislation Affecting Nitrate Plants. By Chester H. Jones. (C. & M. E., May 12, 1920.)

The question of nitrogen fixation by steam power vs. water power at present appears to be a question of politics. The Du Pont Company agreed in return for water power sites for the plant to furnish to the United States any part or all of its production of nitrate acid at a price which, in the opinion of the Secretary of War, should allow a reasonable profit. The Smith Bill, which provided for government ownership of fixation plants, was supported by Oscar Underwood of Alabama, who reminded the House of Representatives that President Taft had vetoed the Coasa River project, a private enterprise which offered similar plans. The opponents of the bill bill claimed that it was a plan to allow the American Cyanamid Co. a monopoly. The Underwood amendment providing for a rental of the government plants to private corporations in times of peace was rejected. The Smith Bill was indefinitely postponed, but its substance was incorporated in the National Defense Bill, which became a law. The clause in the Army Bill, which authorized the expenditure of twenty-four million dollars in Alabama Power Co. holdings was attacked by James Frear of Wisconsin, who said the money was being given to a private experiment. North Chattanooga, Tennessee, was indorsed by the Secretaries of the Interior, Agriculture and War, and the Chief of Ordnance, as the best location, but the President acted upon other advice, and selected Muscle Shoals, at Sheffield. Three different committees investigated the best process before it was finally decided to use the modified Haber process. Nicholas Longworth of Ohio remarked that its (the Muscle Shoals project) abettors and supporters have been knocking at the doors of Congress for some time.

J. A. H.

Shall Americans Go Abroad to Mine? By H. Foster Bain. (M. & S. P., May 22, 1920.)

Our great increase of business before we entered the war has placed in American hands a surplus of capital which can be soundly invested only in foreign industries. Foreign finance differs from ours in that industries are founded on other people's money, while here the public is not generally called in until the proposition is successful. The war has, however, caused in many countries a national jealousy, which puts great impediments in the way of foreign capital. It is very probable that this spirit is only temporary and will give way before national necessity.

J. A. H.

GEOLOGY.

Political and Commercial Geology Series —The Iron Ores of the World. By E. C. Harder and F. T. Eddingfield. (E. & M. J., May 8, 1920.)

The most important sedimentary iron ores enriched after deposition, are in the Lake Superior District; those which have experienced no further enrichment are found in the eastern United States, in Newfoundland, in Lorraine, Luxemburg, and southern Germany, in England and in Brazil. Iron ores associated with siliceous igneous rocks are found in Sweden, the United States, Cuba, Chile, and Manchuria; with basic igneous rocks, in Norway, Sweden, and the Adirondacks. Igneous contact ores are found on practically every continent. The greatest iron-producing countries are the United States, Germany, France, and Great Britain.

J. A. H.

Chrome-Ore Deposits of North Carolina. By J. Volney Lewis. (E. & M. J., May 15, 1920.)

The chrome-ore of North Carolina lies in a belt 200 miles long and from 5 to 25

miles wide. The prevailing rocks of the Appalachians are Pre-Cambrian gneisses and schists, intersected by lenses of peridatite, from which have been mined asbestos, talc, corundum, serpentine, iron, genthite, and chrome. In the last forty years less than 400 tons of chromite were mined in North Carolina, but most of it was of good quality. The maximum percentage of chromic oxide is 67.86, but this is almost never reached as chromite is closely associated with spinel, hercynite and magnetite. No large bodies of ore have been discovered and as no large reserves are in sight the production can probably not exceed a few hundred tons a year. J. A. H.

MINING.

The Friction of Ventilating Currents. By Walter S. Weeks. (M. & S. P., April 24, 1920.)

The resistance to air flow varies with the square of the velocity, the density of the air, and the character of the rubbing surface. The air-pressure in a drift or tunnel is measured by a V-tube filled with water, one leg being connected with the point of initial pressure, the other with the point of final pressure. The law of natural splitting is: the quantity of air flowing per minute in a given split is to the total quantity flowing in all the splits starting at the same point and ending at the same point, as the pressure potentiation of the given split is to the sum of the pressure potentials of all the splits. The article includes the values of K under given conditions and gives examples of calculations used in splitting air for drifts of varying lengths and cross-sections. J. A. H.

The Lake Asphalt Industry. By J. Strather Miller Jr. (C. & M. E., April 21, 1920.)

Asphalt is of two types, natural and artificial, the latter a product of the distillation of asphaltic oils. It is believed that natural asphalt results as a secondary product from the hardening by condensation and polymerization, of thin bitumen or matlhas. Definitions vary but all agree that the substance is a solid or semi-solid bitumen, consisting of a mixture of hydro-carbons, and melting upon the application of heat. The largest amounts of natural asphalt come from lakes in Trinidad, West Indies; and Bermudez, Venezuela. Trinidad Lake is about one mile from the sea and covers 114 acres. Borings indicate a depth of at least 135 feet, proving an almost inexhaustible supply, as thirty-eight years of mining have reduced the level only seven feet. The asphalt is dug, loaded into steamers by an overhead cable, and the cavity of a day's dragging is refilled in two days. Bermudez Lake covers about two thousand acres and is from three to ten feet deep. The asphalt is pushed in small cars to the railroad and hauled seven miles to ships. Refining consists in driving off the water in an open still at a temperature of 375° F. The refined asphalt is fluxed with a petroleum residuum to give it the proper consistency for pavements. It is then called asphalt cement and shipped in hardwood barrels. The mineral matter is present in a colloidal state, that is, in a state which defies precipitation, yet lacks some of the characteristics of a true solution, as proved by the use of the ultra-microscope. J. A. H.

Boundary District, British Columbia. By C. M. Campbell. (E. & M. J., April 24, 1920.)

Within the last twenty years this region has produced over twenty million tons of low-grade copper ore. The more desirable features of the country are a pleasant climate, picturesque scenery, productive soil, educational advantages, absence of labor troubles, and excellent transportation facilities. The only labor difficulties have been in the Crow's Nest Pass, where strikes of coal miners have often impeded the industries of the whole Boundary District. The most important years of the mining industry were in 1900 and 1901, when claims which later became the chief assets of the largest companies were staked. The British Columbia Copper Co. was organized in 1896, acquiring the Montreal and Boston Co., and the Dominion Copper Co., and is now renewing operations as the Canada Copper Corporation. The common practice of mining is in untimbered stopes supported by pillars of ore which are eventually drawn. Various mines have in the past operated about Phoenix, but at present the principal work in the district is being done at the Rock Candy Mine. J. A. H.

The Rand Mining Industry. By A. Cooper Key. (E. & M. J., May 1, 1920.)

The working costs on the Rand have risen to 23 S. per ton because of higher wages to white workers, shorter hours and lessened efficiency, increased assessments, higher prices of supplies, and a shortage of native labor. Since 1914, these causes have resulted in a reduction in tonnage of almost one and three-quarter million tons. Another feature is decrease of ten per cent in the running time of the mills, due to the Sunday Law, lack of ore, and the granting of two more holidays. In the last five years the profit has fallen from 36% to 20%. This means that the mines are crushing a third more tonnage than in 1908, and yet making little better than half the profit. The natives are adding to the precarious position by asking for wage increases aggregating £105,000 monthly. The gold premium, which has run as high as 38%, has saved the situation, at least for this year. In the last few years Safety First propaganda has been spread so successfully that the mortality rate for 1919 was very little more than half of that for 1908. Many individual mines have reduced their death rate in a remarkable manner. J. A. H.

The Future of Chromite in the United States. By Samuel H. Dolbear. (M. & S. P., May 1, 1920.)

American industries, generally depending on importations of chromite were supplied with 82,350 tons of home-mined ore in 1918. In spite of the embargo of 1918, over 100,000 tons were imported in that year, causing a sudden cessation of the demand. The pre-war consumption of 48,000 tons before 1915, with probably increase of about 15 percent annually, keeping pace with the requirements of industry. The declining American chrome industry is the object of a bill providing a duty of $35 a ton for imported 50 percent chromite. In no way could we produce sufficient chromite for the prosecution of war unless our resources are investigated more thoroughly. J. A. H.

Systematic Prospecting. By Wilbur H. Grant. (E. & M. J., April 17, 1920.)

Prospecting is explained as one of the most important steps in the production of things made from inorganic substances. The difficulties of success demand that prospecting should be an organized effort backed by time and capital. Experienced geological engineers should be in charge. J. A. H.

The Romance of Mining Discovery. By J. A. Rickard. (M. & S. P., May 8, 1920.)

Ore-finding has always been due to luck from the day when the son of Japhet stubbed his toe on a copper outcrop, through the times of Lucretius when forest fires caused the metal to collect in molten pools, and down to the discovery of the Rammelsberg, when a hunter's horse pawed his way to a silver bed rock. The Freiberg district was discovered by Bohemian peasants; the richest mines of South America were accidentally discovered by natives, and the Mt. Morgan Mine of Australia was shown to prospectors by a shiftless sheepherder. The Broken Hill district was discovered by slightly more scientific means, while the mineralized granite of the Independence Mine in Colorado was noticed by a carpenter who could find no placer gold upstream from it. The Camp Bird was located on ground abandoned by a prospector who had assayed his ore for silver instead of gold. The Alaska Treadmill Mine was bought from a French Canadian for five dollars at a profit of some millions. The United Verde Extension was the result of thorough scientific investigation, resulting in an expenditure of over $800,000 before the main ore body of 45 percent copper was found. The Bunker Hill Mine has long been associated with a burro who remained fascinated by its glittering outcrop until his owner found him; it should rather be associated with the treachery of a prospector who tried to rob the men that employed him. J. A. H.

The Bunker Hill Enterprise—IX. By J. A. Rickard. (M. & S. P., May 15, 1920.)

The locators of the mine made their first mistake in contracting for the concentration of their ore without proposing any definite definition of the word "ore". At that time the mine was being badly worked in an effort to maintain a high production of concentrates. S. T. Reed was then sold the mine on the strength of a twenty-one-foot ledge of galena. He made Victor Clement superintendent of the mine at a salary of $500 a month and expenses. Shortly after this the finances of the company became embarassed, but they were put on a firm basis through the efforts of John Hays Hammond, D. O. Mills and W. H. Crocker. Shares in the company which were then sold freely for $2.21, are now worth $50. Among the officers of the company were John Hays Hammond, General N. H. Harris and Frederick Bradley, who is still president. The future of the mine was assured by the Kellogg tunnel, which reached the main vein in 1904, thereby affording lowering the cost of haulage and the cost per ton of mining. The cost per ton went from $2.57 in 1902 to $1.40 in 1905, and is now up to $3.70. Clement's widow eventually sold her stock to Daniel Guggenheim for slightly less than a million dollars. J. A. H.

Mining in Narrow Stopes. By E. A. Colburn. (M. & S. P., May 15, 1920.)

The mining of narrow veins demands

special precaution to prevent the ore from being mixed with waste. These veins are therefore generally leased, as it is notable that miners are more efficient when working for themselves than when working for a company. Stripping hard streaks by shooting down the walls before separating the ore, or gauging soft veins by scooping out the ore before the walls as shot down, are unprofitable practices because much ore is lost with the waste. The best practice is to pulverize the ore by drilling a hole in the vein and charging it heavily, while one hole in the wall is charged lightly, so that the waste may easily be separated from the ore. In general, the position of the holes will be determined by the conditions surrounding the vein. J. A. H.

Largest Capacity Gold-Mining Dredge in the World. By H. L. Peake. (E. & M. J., May 15, 1920.)

The record capacity dredge, with 20 cu. ft. buckets, was built twenty-eight miles from a railway, so that steel was eliminated from its construction, and a sawmill built on the spot. It is 152 feet long, 68 feet wide, and 13 feet deep, with a monthly capacity of 450,000 cubic yards. Eighty-three buckets, each weighing 5,650 pounds, without the connecting pin, will carry any size boulder to the 4,400 sq. ft. of gold-saving tables, fed by a 10-inch water pipe. Motors with a total of 1,590 horsepower will operate the dredge. J. A. H.

The Spassky and Atbasar Copper Mines in Siberia—I. By J. Mackintosh Bell. (M. & S. P., May 22, 1920.)

The Spassky Copper Mine Co., controlled by English and French capitalists, worked successfully until the beginning of the war when difficulties culminating in the Bolshevik revolution, the counter-revolution of the Cossacks, and the overthrow of Kolchak, forced the mine into the hands of the Bolsheviki. The more important rocks of the Kirghing steppes are Devonian quartzites and phyllites, post-permo-carboniferous igneous rocks, and both marine and fresh-water tertiaries and pleistocenes. Around Spassky the country is level with low and isolated ridges crowned by fantastically-shaped outcrops. The Zupensky ore deposit is a crescent, striking to the northeast and northwest, and generally dipping to the south. The material was deposited in a zone of shearing by ascending waters containing bornite, chalcocite and chalcopyrite. The modern methods of mining are more systematic than the old practice of open-pit mining, and the primitive blast furnace formerly used has been replaced by new Russian furnaces. In two years the mine hoisted 64,288 tons of ore averaging more than 21 percent copper. J. A. H.

Manganese-Ore Mining in India. By E. N. J. Slater. (E. & M. J., May 22, 1920.)

The importance of managanese in the manufacture of steel has caused it to be mined in the Caucasus, Brazil, and India, which latter country now leads the world in production. The deposits consist of braunite, psilomelane and pyrolusite. In mining, these three minerals are separated as well as possible because they require slightly different treating. The success of the mines are due to the efficiency of Captain C. R. Valentine, the engineer in charge. The mines at Kumsi are worked as open pits, in which long-wall coal mining practice is practiced. The ore is taken to the railway on a gravity plane and hauled twenty-eight miles to Shimoga on a railway of two-foot gauge. At Shankargulla there is another valuable deposit which is being worked by the same method. J. A. H.

METALLURGY AND ORE DRESSING.

Aluminum Rolling Mill Practice.—V. Finishing Operations. By Robert J. Anderson and Marshall B. Anderson. (C. & M. E., April 14, 1920.)

The operations of rough rolling and shearing thin sheets are minutely described. Highly polished sheets are finished by running them in packs through rollers equipped with buffs. Slight buckles and waves may be removed from sheets from 8 to 17 gauge by running them through a flatter. Commercial aluminum is sheared to rectangles or circles. Strip aluminum is rolled without slabbing or roughing, coiled, and sold as coils, rectangles, squares, or circles. To prevent discoloration upon annealing, strips are run through a vat of gasoline, a vat of sawdust, and up through a set of revolving brushes to a self-coiler. The required degree of hardness may be obtained by annealing the sheets at various gauges before the required gauge is reached. The usual practice in annealing is to place the metal, loaded on cars, in gas, oil, or electric furnaces and heat at about 370° C for from 18 to 30 hours. Finished sheets are inspected by two men, who note the weight of metal accepted or rejected, and the reason for its rejection. The more common causes for rejection are blisters, slivers, roll marks, scratches, cracks, and stains. Proper investigation of the causes of rejection suggests preventive measures for the reduction of scrap losses. J. A. H.

The Elastic Development of Steel. By Sidney Cornell. (C. & M. E., April 14, 1920.)

This article deals with the government tests to which bayonets and steel parts of weapons had to conform during the late war. The writer's tests proved that the greatest tensile strength of steel was not obtained at the highest hardness. The English test for flexure, applied by bending the bayonet two and a half inches from the vertical, resulted in the condemnation of one million Remington bayonets, and investigation into the cause of the trouble. Tables and graphs are given to show the relation of strength and hardness to the drawing and hardening temperatures. J. A. H.

Primitive Smelting. By C. A. Grabull. (E. & M. J., April 17, 1920.)

Ancient methods of smelting have been successfully revived in some parts of Mexico on account of the unsettled condition of the country. High-grade ore is treated in a furnace equipped with a one-man-power bellows. The molten mass is tapped into a hole in the floor and the slag is removed in layers. J. A. H.

Genesis of Ferrite. By Federico Giolitti. (C. & M. E., April 21, 1920.)

The purpose of the present paper is to prove, by microscopic analysis, that ferrite meshes are discontinuous chains of crystals, and do not outline the original austenitic grain boundaries. Micrographs are printed of the appearance of steel quenched at different temperatures in the course of the experiments. Analogous results were obtained by quenching at a definite temperature partially cemented steel with a varying carbon content. The conclusion drawn is that the formation of the mesh-like structure in hypo-enteclaid steels is different from the formation of cementite in hyper-enteclaid steels. J. A. H.

Manufacture of Carbon Electrodes for Electric Furnace Purposes. By Walter L. Morrison. (C. &. M. E., April 21, 1920.)

This paper covers the manufacture of electrodes by the "rammed process," which consists in pressing the material into a mold before baking. The raw materials used are pitch, coal, coke, and graphite. The tar and pitch are melted before being mixed with ground carbon; the coal and other carbonaceous materials are calcined to lower the volatile content. For this latter operation the best furnace is of the vertical electric-resistance type, using a voltage of 60, with 5 to 10 amperes per square inch of cross-section. The molds are from six to nine feet long either solid or in two pieces of boiler plate, reinforced and bolted. Large electrodes are baked on end, in gas, oil, or powdered coal furnaces, controlled by pyrometers. The calcined raw materials are ground and mixed with just enough tar and pitch to make them adhere in a ball. The mixture is then shoveled into the mold and worked down by a ram operating on the principle of the stamp mill. If pressure is necessary it is applied in three steps: to the bottom only, to the top and bottom, and to the bottom only. J. A. H.

By-Product Coke-Ovens of the Granby Consolidated Company, at Anyox, B. C. By W. A. Williams. (M. & S. P., April 24, 1920.)

The coking plant of the Granby Consolidated Mining, Smelting & Power Company is equipped with thirty ovens having vertical flues. The gas is conducted through ascension pipes to the collecting main and thence to the by-product building. Here it is cooled and the remaining traces of tar are collected in a 200,000-gallon tank at the rate of eight gallons per ton of coal. After much of the ammonia has been precipitated by passing the gas through a bath of sulphuric acid, the rest is collected by distillation of the mother liquor. Light oils are removed by scrubbing the gas with shale oil. After the light oil has passed through the crude oil still, the crude products are washed in sulphuric acid and sent to the pure oil still, where C. P. benzol, C. P. toluol, and refined solvent naphtha are produced. J. A. H.

Volatilization in Assaying. By Frederic P. Dewey. (C. & M. E., April 28, 1920.)

The foremost authorities on assaying are quoted as believing that the loss of gold and silver by volatilization in assaying is negligible. Records of cupel fumes indicate that high losses of silver are due to dusting or other mechanical causes. The actual volatilization of silver amounts to about 0.015 percent. Various assayers have attempted to determine the boiling point and the volatilization of gold, but their figures vary so much that they are useless. Silver is said to melt at 960 degrees, and to boil at slightly over

2,000 degrees. It unites with oxygen in various proportions, but little is known of this. Lead boils at 1,640 degrees, but volatilization begins at 800 degrees. Feathering indicates air conditions rather than temperature conditions. Other metals, such as arsenic, antimony, tellurium, and mercury may be distilled without carrying over appreciable amounts of the gold with which they may be mixed. The determination of silver by cupellation is unreliable because the absolution by the cupel is so erratic. J. A. H.

Relationship Between Dendritic Structure and Ferrite Mesh. By Federico Giolitti. (C. & M. E., May 19, 1920.)

The experiments described in this article were made on samples unaffected by shrinkage. Figures were made by photographing the ferrite exhibited by the nitric amylic solution, then photographing the dendritic structure developed by hot sulphuric acid, and making the print from the superimposed negatives. Single heating, followed by leisurely cooling, did not suppress or subdivide the dendritic structure. As the temperature increased ferrite was displaced by austenite, but as the sample cooled ferrite was redeposited. Dendritic structure was destroyed by a triple quench after prolonged heating at very high temperatures. Under mechanical tests the nature of the fracture of each sample followed by parallel steps the features of the heat treatment. The cause of the crystalline fracture seemed to be connected very closely with the state of the ferrite meshwork. Samples containing no ferrite had the largest contraction, as the elements of the large ferrite meshwork constitute a surface of lesser resistance. It follows, then, that the elimination of the large ferrite crystals will elevate the breaking point of the steel. J. A. H.

THE MAGNESITE INDUSTRY IN AUSTRIA.*

W. C. Phalen.

Location.

Though the term "magnesite" is generally applied to the iron-bearing carbonate of magnesium, such as is found in Austria and Hungary, by some Austrian magnesite is referred to as bruennerite. The mineral bruennerite has become of commercial importance only in Austria. The important deposits are found in Styria, lower Austria and northern Hungary. It is of interest to know that the world's largest deposit of spathic iron ore, or iron carbonate ($FeCO_3$), occurs in Eisenerz, Styria, while the world's largest deposit of spathic bruennerite is found at Veitsch in the same province.

The Styrian and lower Austrian deposits are located much nearer the Adriatic Sea than are the deposits of northern Hungary; and it is from the former that most of the exported magnesite has come. They are located southwest of Vienna, and extend west from Semmering through the Murz Valley to Tyrol. The chief deposits reckoning from east to west are those of Semmering, Veitsch, Breitenau, Trieben, Radenthein, and Dienten.

The largest and most important deposit is that at Veitsch located near Mitterdorf, on the South Austrian Railroad in the Murz Valley, Styria. Here the magnesite, which occurs in the form of a lens, is quarried on the slope of a hill in a series of terraces about 50 feet apart. The entire work extends through a vertical distance of 500 feet. The huge magnesite lens is nearly three-quarters of a mile long, and over 1,000 feet in width, and probably extends to a considerable depth.

The formation containing the magnesite extends eastward beyond Vienna into Northern Hungary, where magnesite is quarried beyond Jolsva and Nyustya in the Gomor district. In spite of the remote location of these deposits as compared with those in Styria, magnesite was shipped from them before the war to the port of Fiume, a distance of 360 miles, for overseas shipments to other parts of Europe and to America.

Composition.

The average analysis showing the composition of the Austria-Hungary mineral is as follows:

Magnesia	38 to 44%
Lime	1 to 3%
Ferrous oxide and alumina	2 to 7%
Silica	1 to 5%
Carbon Dioxide	50%
Water	

Character of the Sintered Product

The magnesite occurs as lenticular masses in a belt of Carboniferous rocks consisting mainly of metamorphosed shales, sandstones, conglomerates, and limestone. It is grayish in color when fresh, and contains sufficient ferrous carbonate to blacken it when calcined. It turns brown owing to the oxidation of the ferrous carbonate when exposed to the air. The quantity of carbonate of iron is variable and different analyses show that it ranges up to 13 or 14%.

* From U. S. Bureau of Mines War Minerals Investigation.

For the most part, only the sintered article has been imported into the United States. This material has achieved an enviable reputation for its uniformity both as to chemical and physical characteristics. The homogeneity of the sintered Austrian magnesite is doubtless due in part to the averaging effect of the different operations, such as crushing, dressing, sintering, and mixing, an effect which is not obtainable in mere hand samples.

There is comparatively little variability in the sintered magnesite as marketed, and five analyses of this sintered magnesite as quoted by Cornu† are as follows:

Magnesia (MgO)	85.53 to 90.07%
Lime (CaO)	0.96 to 3.52%
Ferrous Oxide..(Fe_2O_3)..	7.43 to 9.96%
Alumina (Al_2O_3)	0 to 2.22%
Manganese Oxide (Mn_3O_4)	0.51 to 0.76%
Silica (SiO)	0.26 to 1.34%

Mining and Preparation.

The methods of mining and preparing magnesite in Austria and Hungary are similar at most of the different plants. On the outskirts of the village of Veitsch, about 56 miles southwest of Vienna, is found one of the largest deposits, and one which has been worked the longest. Since the methods of mining and preparation here are fairly typical, they will be outlined.

As stated above, the magnesite quarry at Veitsch is worked in a series of steps or levels about 50 feet apart vertically. The material is blasted out of the solid by the ordinary methods of rock quarrying. It is next broken in pieces which can be handled readily by one man, and the dolomite and quartz are carefully picked out. Even in the best of the deposit, there is a large quantity of this gangue material, and estimates of the waste rock vary from 50% to 66 2-3% of all the material quarried. Terrace quarrying and working conditions in general like these at Veitsch are practiced at Breitenau and at Eichberg.

The coarse quarried material is cobbed to free it as far as possible from impurities like schist, dolomite, and quartz, and the lumps are sorted.

The cleaner portions of the magnesite are reduced to pieces about the size of a man's head. Less pure portions have to be broken into pieces about the size of a man's fist. These dressing operations involve a considerable loss of magnesite in the form of small fragments—too small to be burned in shaft kilns. The raw material thus obtained in the quarries at Veitsch is transported by gravity planes to the sintering kilns at the foot of the hill.

† F. Cornu: Zeit. f. Prakt. Geol. 1908.

PERSONALS

'95.

Lewis B. Skinner has opened offices as Consulting Chemical and Metallurgical Engineer, care the Colorado Iron Works Co., Denver, Colorado. The Western Chemical Mfg. Co. has been sold to the General Chemical Co., and he expects to introduce to a much wider range of usage the Skinner Waster, reverberating volatilization process, ore classifiers, mechanical muriatic acid and salt coke furnace, and other patented features. He also will engage in construction of chemical and metallurgical plants and overhaul those now running.

Robert S. Stockton is superintendent of operation and maintenance, C. P. R. Department Natural Resources, Strathmore, Alberta, Canada.

H. E. Merryman's present address is 316 E. Colorado Ave., Colorado Springs, Colo.

'96.

George B. Mitchell is with the Foundation Co., Lima, Peru.

'97.

Thos. H. Woods is manager Camp Bird, Ltd., Ouray, Colo.

'00.

George W. Nicholson is mine superintendent, United Verde Extension Copper Co., Jerome, Arizona.

'01.

Frank E. Lewis is mine engineer of the Cananea Consolidated Copper Co., Cananea, Sonora, Mexico.

'03.

Harry J. Wolf, of 42 Broadway, New York, made examinations recently in Arizona, Nevada and Utah.

Harry G. Palsgrove is general manager of the Cascade Silver Mines & Mills Co., Neihart, Montana.

'05.

L. L. Middlekamp is located at 1109 Lakeview Boulevard, Seattle, Wash.

P. Jay Lonergan, Jr., is now located at Leavenworth, Wash.

'06.

Max Ball is general manager of the Matador Petroleum Co., Cheyenne, Wyoming. The Matador Petroleum Co. has been organized to carry on the activities heretofore conducted in the Rocky Mountain States by the Roxana Petroleum Co. of Oklahoma, the Roxana Petroleum Corporation and the Shell Co. of California.

'08.

Henry L. Jacques has moved from Los Angeles to 718 Brand Boulevard, San Fernando, Calif.

Byron M. Johnson is efficiency engineer for the El Oro Mining & Railway Co., El Oro, Estado de Mexico, Mexico.

'09.

Ernest J. Ristedt is ventilation engineer for the Old Dominion Co., Globe, Arizona.

'10.

Charles E. Dyer is now located at Durango, Colo.

'11.

Samuel R. Brown has accepted a position as mill superintendent with the Cascade Silver Mines & Mills Co., Neihart, Montana.

'12.

Frank B. Saxton is superintendent of the Mary McKinney Mine, Cripple Creek, Colo.

'13.

Herman Dauth's present address is care Tonopah-Belmont Development Co., Tonopah, Nevada.

Frank A. Downes has been transferred from the Denver office of the Dorr Co. to their New York office.

'14.

A. F. Carper is mining engineer for the Tonopah Mining Co., Tonopah, Nevada.

Theo. H. M. Crampton, formerly consulting engineer with J. P. Stocksdale, Phoenix, Arizona, has moved to 1247 Ocean Ave., Santa Monica, Calif., where he has opened offices as consulting engineer with Frank A. Crampton.

Mr. and Mrs. A. F. Carper announce the birth of Armistead Fitzgerrell Carper Jr., on May 15, 1920, Tonopah, Nev.

Mr. Louis F. Clark's address is care Andes Copper Mining Co., Potrerillos, Chile, Casilla 230, via Antofagasta, Chile, South America.

Melvin Brugger's address is Caixa 347, Loanda, Angola, West Africa.

'17.

Reginald P. Oliveros, formerly with the Primos Exploration Co., Empire Colo., is now mining engineer for the Tonopah-Divide Mining Co., Tonopah, Nev.

Sidney S. Small has changed his address from Lynn Haven, Fla., to Room 505 Unity Bldg., 185 Devonshire St., Boston, Mass.

Lee K. Worth is assistant engineer for the Midwest Refining Co., Salt Creek, Wyoming.

'20.

Fred L. Serviss has accepted a position with the Utah Fuel Co., with headquarters at Salt Lake City, Utah.

Herbert K. Linn has gone to Tampico, Mexico.

Antonio D. Alvir is temporarily employed by the Smuggler Union at Telluride, Colo.

Arthur C. Kinsley has taken a temporary position with the Sunnyside Mining & Milling Co., Eureka, Colo. He expects to go to Monterrey, N. L., Mexico, as soon as conditions better there.

E. B. Bunte expects to leave soon for Anapolis, Maryland, where he has accepted a position in the engineering department of the U. S. Naval Academy.

C. L. Boeke will sail from New York the latter part of June for Rancagua, Chile, S. A., where he has accepted a position with the Braden Copper Co.

EX-MINES NOTES.

'11.

Lyon Smith is Superintendent of the ferro-alloy plant of the York Metal and Alloy Co., York, Pa.

Barnaby Conrad is a partner in the New York firm of George H. Burr & Co., dealers in commercial paper and bonds. He is located at Kohl Bldg., San Francisco, Calif.

'14.

David H. Orr has accepted a position as shift boss with the Inspiration Cons. Copper Co., Inspiration, Arizona.

'15.

H. G. Grauting and family are located in Golden temporarily.

WHERE ARE THESE MEN?

Samuel W. Laughlin, '10
Max T. Hofius, '17
Wallace Lee, '04
Floyd Weed, '97
E. B. Wood, '09
Frank W. Royer, '99
Edwin H. Platt, '00
Harlow D. Phelps, '10
Henry W. Kaanta, '15
Harry E. Nelson, '97
Daniel B. Gregg, '13

SCHOOL NEWS.

Dr. Victor C. Alderson sailed from New York for Liverpool the latter part of May. After a trip to London, and examination of the oil shale plants of Scotland, he will return to America about July 15th.

Prof. F. M. Van Tuyl, head of the geology department, was married to Miss Euphama Jane Green on May 5th at Chicago, Ill.

Electric shovels have come to play an important part in the mining of coal during recent years. Some of the larger shovels are capable of making a cut approximately 120 feet at the bottom and 200 feet at the top.

PROFESSIONAL CARDS

Certificate Holders Quarter Ending March 31, 1920.

Albion Malleable Iron Co., Albion, Mich.
American Malleable Co., Owosso, Mich.
Belle City Malleable Iron Co., Racine, Wis.
Chain-Belt Co., Milwaukee, Wis.
Chicago Malleable Castings Co., West Pullman, Chicago, Ill.
Chisholm-Moore Mfg. Co., Cleveland, O.
Columbus Malleable Iron Co., Columbus, O.
Danville Malleable Iron Co., Danville, Ill.
Dayton Malleable Iron Co., Dayton, O. and Ironton, O.
Eastern Malleable Iron Co.
  Naugatuck Malleable Iron Works, Naugatuck, Conn.
  Bridgeport Malleable Iron Works, Bridgeport, Conn.
  Troy Malleable Iron Works, Troy, N. Y.
  Wilmington Malleable Iron Works, Wilmington, Del.
  Vulcan Iron Works, New Britain, Conn.
Erie Malleable Iron Co., Erie, Pa.
Federal Malleable Co., West Allis, Wis.
Haskell & Barker Car Co., Michigan City, Ind.
Illinois Malleable Iron Co., Chicago, Ill.
Iowa Malleable Iron Co., Fairfield, Ia.
Laconia Car Co., Laconia, N. H.
Marion Malleable Iron Works, Marion, Ind.
National Malleable Castings Co., Cleveland, O., Chicago, Ill., Indianapolis, Ind., Toledo, O., E. St. Louis, Ill.
Northern Malleable Iron Co., St. Paul, Minn.
Northwestern Malleable Iron Co., Milwaukee, Wis.
Pittsburgh Malleable Iron Co., Pittsburgh, Pa.
Rockford Malleable Iron Works, Rockford, Ill.
Ross-Meehan Foundries, Chattanooga, Tenn.
St. Louis Malleable Casting Co., St. Louis, Mo.
Stowell Co., South Milwaukee, Wis.
T. H. Symington Co., Rochester, N. Y.

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