STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

702 Woodlark Building

Portland, Oregon

Bulletin No. 8

AN INVESTIGATION

of the

Feasibility of a Steel Plant

in the

Lower Columbia River Area

near

PORTLAND, OREGON

By

RAYMOND M. MILLER

Consulting Metallurgist

REVISED EDITION—1940

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FOREWORD

The industry that is basically essential to any country, or large division of a country, is an iron and steel industry. Its importance is evidenced by the fact that the current index of steel operations is one of the most widely accepted indices of the general condition of business in a nation. Oregon has no basic steel industry and it lacks also many of the smaller, accessory industries which are commonly associated with steel production. All citizens of this state, - farmers, lumbermen, business men, mining people,- all would benefit by the installation on the lower Columbia of an iron and steel industry because that would increase the number of wage earners - the payrolls - and thus boost local consumption of Oregon's farm and industrial products. It would cause substantial production of some of Oregon's mineral resources that are now idle - iron ore, chromite, manganese, and possibly coal, and would increase the present consumption of limestone.

When this Department was started in July, 1937, it was determined that a more careful study, with particular attention to available market, should be made of the feasibility of an iron and steel industry for the lower Columbia, than had ever been made before. The following report is the result of this study.

The essence of this report is that an iron and steel industry is feasible for the lower Columbia area. This conclusion is based on the facts submitted which demonstrate the availability of all raw materials including iron ores, fluxes, and coking coal and also the fact that there is an available market to a lower Columbia steel plant very much in excess of the amount required for a steel plant of economic size.

The availability of cheap Bonneville power, although not a determining factor, presents a tangible incentive for the installation of steel ingot capacity in the lower Columbia.

The data contained in this report should serve as a basis for very careful consideration by any corporation now in the steel business and prepared to extend its field to a region where there is no ingot capacity, where at present the increase of population is accelerating constantly, and where the future of industrialization is practically guaranteed by the Federal government's intention to make available great blocks of cheap hydro-electric power from its Bonneville and Grand Coulee dams and other proposed river developments in this region.

The County Commission of Columbia County, Oregon, kindly cooperated with financial assistance toward the preparation of this report.

Preparation and issuance of this report is in line with the policy of the State Department of Geology and Mineral Industries to inform the general public and capital of possibilities in the development of Oregon's mineral resources.

Earl K. Nixon, Director

Portland, Oregon,
June 28th, 1938.

FOREWORD TO REVISED EDITION.

The original edition of this bulletin, issued in June 1938, has been completely exhausted. The present edition has been revised by the author up to September 1940. Almost all of the tables that give data on production, consumption, and costs, have been changed somewhat in the light of present available information.

Mr. Miller, metallurgical engineer for the Bonneville Power Administration, is in a better position even than before to present fully and clearly a picture of the feasibility of a steel industry for the Columbia River area.

Earl K Nixon, Director

Portland, Oregon,

September, 1940.

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AN INVESTIGATION OF THE FEASIBILITY OF A STEEL PLANT IN THE LOWER COLUMBIA RIVER AREA NEAR PORTLAND, OREGON

SUMMARY AND CONCLUSIONS

This report includes a general survey of the iron and steel markets available to a possible steel plant located in the lower Columbia River area, and describes the sources of ore, coal, limestone and scrap iron. The economics of a coking plant and of pig iron production have been examined, and estimates of cost are included to give a basis for comparison with costs of the competitive Eastern industry. The weight of evidence shows not only that a steel plant is possible of establishment near Portland to supply the local steel requirements, but that such a plant is needed to balance the producing capacity of the Pacific Coast against the total domestic, territorial, and Pacific export demands.

As a possible steel producing center Portland stands in the same relation to Coastal markets and Pacific export markets as Baltimore does to Atlantic coast and Atlantic export markets. Portland has the additional advantage that it has available a large reservoir of cheap hydroelectric power for driving the rolling mills and operating electric furnaces for refining and producing alloy steels.

The results of this study indicate that the probable costs of a well designed, integrated operation at Portland would compare favorably with those of the eastern United States mills. Although the raw material cost would be a little higher at Portland the transportation cost advantage on the finished steel more than outweighs this handicap.

The blast furnace appears to have a small advantage in cost over the electric furnace at the power rates assumed. However, the blast furnace is a large production unit, requiring capacity operation to be economical, while the electric furnace can operate in small units. Thus the electric furnace has the advantage of flexibility for small volume operation.

The following are the conclusions based on the facts as revealed by this investigation. For further details and substantiation of the various statements, reference should be made to the information and essential data contained in the body of the report.

1. Where and what is the extent of the steel market in which a Columbia River steel plant would operate?

A Columbia River steel plant, by virtue of a tidewater location and direct rail connections north, south, and to the east, would operate: (a) in the entire Pacific Coast and interior Western markets; (b) in the territorial Hawaiian, Alaskan, and in the Philippine Islands markets; (c) in the trans-Pacific markets of Japan, China, and other Asiatic countries, Australia, East Indies and other island markets; and (d) in the Pacific South American and Central American countries.

Excluding the tonnage of steel now supplied to the domestic market by the seven existing Pacific Coast steel plants, with a total capacity of 689,700 long tons, the market demand for finished iron and steel products as indicated by the data of this study amounts to more than 2,000,000 long tons annually. There were 864,629 long tons shipped by rail and water from Eastern mills to the Pacific area in 1934, the only year these data are available. Then in 1938 there were 1,204,475 long tons shipped to the territorial and export market. (See table 5). The large tonnage items are tinplate and terneplate, 386,640 long tons; black and galvanized sheet, 165,279 long tons; pipe and tubing, 256,626 long tons; structurals, 176,818 long tons; and bars and rods, 117,165 long tons. (See table 9).

2. What type of plant is recommended?

Under the conditions, a fully integrated operation is recommended, including pig iron plant, coke ovens, steel works and rolling mill. Ore, coal and limestone sources should be controlled, and reserves should be obtained for a 30- to 50-year operation. Tinplate is preferred as the principal product, with minor tonnages of sheet, bars, rod, and structurals recommended.

Data indicate that the market for tinplate is normally around 362,000 long tons in the entire Pacific domestic, territorial, and export market, which, in view of the continually increasing population of the Pacific Coast, and the expanding per capita consumption of tinplate, may be expected to increase steadily. Not only is this true with tinplate, but every other steel product will be consumed in increasing volume as industrialization (now in its infancy) steadily demands more and more steel.

3. What capacity is possible?

This report is based on a yearly output of 260,000 long tons of basic open hearth and electric steel ingot, or 180,000 long tons of finished steel products. As a basis for study, 160,000 long tons of pig iron is the capacity used, but this would vary with the percentage of scrap iron used in the open hearth charge.

4. Where is the ore supply, and what will ore cost at the furnace?

Columbia County, Oregon, has a supply of iron ore available for acquisition. It is a limonite ranging in grade from 51 percent to 58 percent dry analysis. The location is 5 to 15 miles from the navigable Willamette River slough, and only 25 miles north of Portland. Proven tonnage is small, but probable ore is several million tons. Estimated cost at the furnace is $0.0525 to $0.0755 per long ton unit.

The principal ore supply on which the plant must be based would be located at distant points. It is recommended that investigations be made of certain California and Chilean deposits. Costs of these ores delivered to Portland by special ore boats are estimated at $0.0825 to $0.0975 per long ton unit. Grade is well over 60 percent iron.

5. <u>Where is the coal supply and what will it cost at the plant?</u>

Coal beds are located in both western Oregon and Washington. Reserves are estimated in the billions. Pierce County, Washington, has millions of tons of coking coal of proven coking quality. Acreage is available for acquisition. Cost of Pierce County coal at Portland is estimated at $5.70 per ton.

6. <u>How much will coke cost, and can the oven gas be disposed of?</u>

It is estimated that, after crediting sale of by-products, the cost of coke to the pig iron plant should be about $6.70 per ton. If the plant is located near Portland the domestic and industrial user may offer an outlet for the oven gas, and the by-products should find a ready market. Fuel oil is available at $0.185 per million B t.u.

7. <u>Where is the limestone and what is its cost?</u>

Limestone, located in southwestern and northeastern Oregon, is of suitable grade for fluxing. Maximum cost is estimated at $3.50 per ton delivered, with a possible minimum cost of $2.50 per ton.

8. <u>How does the cost of assembly of materials compare with that of competing plants?</u>

Assembling ore, coal, and limestone at the pig iron plant, and moving pig iron to the steel plant is estimated to cost $8.25 per ton of pig iron at Portland, and $12.00 for the present California steel mills receiving pig iron from Utah, compared with $7.50 per ton at Lake Michigan points.

9. <u>What is the cost of pig iron?</u>

At present, purchased pig iron delivered at Portland is sold at around $25 per long ton, including $5.50 freight charge from Utah. Production at Portland would cost an estimated $21.75 per long ton including overhead and capital charges (table 23).

10. <u>How much scrap iron is available?</u>

Oregon and Washington exported 280,146 long tons of iron and steel scrap in 1939, while California exported 261,946 long tons. This is excess scrap for which no local demand now exists. Cost normally would probably average $9 to $11 per ton delivered.

11. <u>What would be the ingot cost?</u>

Using 55 percent pig iron and 45 percent purchased and mill scrap, the cost of producing basic open hearth ingot steel is estimated to be $25.74 per long ton (table 25).

Reducing the pig iron percentage and increasing the scrap, the cost of ingot should be reduced to a probable minimum of around $19 to $20 per long ton.

12. What special advantages would a steel plant have in the Columbia River area?

a. Portland has no steel capacity to offer competition in the local market.

b. The city is a central point of distribution for the entire Northwestern area.

c. The Pacific Northwest is now experiencing an uptrend in the population increase curve, stimulated by power and irrigation developments in the Columbia River area, which will bring a steady increase in the proposed plant's local market.

The total Pacific Coast population including its immediate interior market, comprising seven states, was 9,704,502 persons in 1930 with an indicated probable expansion to 15,800,000 persons by 1960.

d. Completion of the Bonneville dam power plant, 40 miles from Portland, with its 10 generators, will provide an ultimate of 518,400 kilowatts of electric power, at the lowest tidewater power rates in the entire United States.

e. Available iron ore within 25 miles of Portland, sufficient for at least a part of the plant requirements, affords low unit ore costs.

f. The plant would be within economic reach of the Pacific Coast's large coking coal fields.

13. What transportation advantages appear to be possible?

Tinplate transcontinental rail rates, Chicago to Seattle, Portland, San Francisco, or Los Angeles, are quoted at $17.25 per long ton in 80,000 pound minimum carlots, compared to a Portland to San Francisco water rate of $3.80 per short ton ($4.256 per long ton) on an 80,000 pound minimum carlot, and $6.20 per short ton ($6.94 per long ton) on a 20,000 pound minimum carlot. The Atlantic to Pacific Coast water rate is $10.19 per long ton in 30,000 pound minimum carlots. Other products will show similar differentials in favor of a plant in the Columbia River area.

14. What is the tax situation in Oregon?

Oregon has no tax on ore. The average 1939 tax levy on property in the counties near Bonneville dam and Portland amounted to 3.131 percent in Columbia, 3.264 percent in Multnomah, and 2.781 percent in Hood River county, based on actual property value. Oregon's corporation excise tax is 8 percent of the net income, but this may be offset, up to 50 percent of the tax, by the tax paid by the corporation on its personal property located in the state.

15. What is the attitude of the community toward a steel enterprise?

Business and civic leaders are quite generally desirous of bringing steel capacity into the area and will be favorable toward such cooperative efforts as are necessary and reasonably possible to insure its ultimate establishment and success.

General Conclusion

Thus the time appears ripe for new steel capacity to enter the Pacific Coast picture, and the Columbia River area. Because of its proximity to the coking coals of Washington, the tremendous electric power possibilities of the Columbia River, deep water navigation, cheap river barging of materials, proximity to a large iron ore area, and lack of present steel capacity, the Columbia River area seems to present a most favorable economic picture for a substantial operation.

INTRODUCTION

The purpose of this report is to present the facts relating to the status of steel on the Pacific Coast, and to indicate the commercial possibility of a steel plant, in or near the Portland metropolitan area, to supply the local iron and steel demands and to reach into other Pacific Coast and export markets. The report has been prepared for the Governing Board of the State Department of Geology and Mineral Industries, Earl K. Nixon, director, as a part of a survey of the mining and metallurgical industries of the State of Oregon.

Location: The port of Portland is fourth in size of the cities on the Pacific Coast, having a total population of about 325,000, and is the only large metropolitan area without a steel plant. It is the largest city of the state of Oregon, situated at the north end of the Willamette Valley near the confluence of the Willamette and Columbia rivers, and is an important Pacific Coast port of call for many of the coastwise, intercoastal, and deep-draft transoceanic steamship lines. It is the Pacific Coast terminus of the transcontinental Union Pacific System which serves the south bank of the Columbia, and the northern terminus of the Southern Pacific which serves the Willamette Valley and connects with the cities of San Francisco and Los Angeles. The transcontinental Northern Pacific and Great Northern Railways serve Portland over a Seattle-Portland line operated jointly with the Union Pacific. The Spokane, Portland & Seattle Railway, owned jointly by the Great Northern Railway and the Northern Pacific, serves the north bank of the Columbia River and connects Portland with the great Inland Empire of the Northwest at Spokane.

As a distributing center for iron and steel, Portland is strategically situated to supply the markets of southwestern Washington, western Oregon, and northern California. It is the natural gateway to the interior markets of eastern Washington and Oregon, Idaho and Montana. It can reach into competitive territory in the Puget Sound area by rail, and into the San Francisco and Los Angeles areas by water shipment.

The Market Situation

Population of the Market Area and Ingot Capacity. Excluding California, which has five steel mills, the population of the area in which an Oregon steel mill would have its market amounted to 3,500,620 persons in 1930. California's market had a total of 6,203,882 population in 1930, while the total market in which all Pacific Coast mills operate had 10,715,116 population in that year.

Table 1

Population of the Market Area Available to an Oregon Steel Mill, and Ingot Capacity of Existing Mills in 1938.

Market Area Available	Population 1930**	No. Steel Mills	Ingot Capacity, 1938	
			Per Year (Gross Tons)	Per Capita (Pounds)
From Northwest:				
Southwestern Washington, (7 counties)	193,961	--	-	
Northwestern Oregon (15 counties)	682,190	--	-	
Eastern and Southwestern Oregon	271,596	--	-	
Eastern and Northwestern Washington	1,369,435	2	155,000	
Idaho	445,832	--	-	
Montana	537,606	--	-	
Total Northwest*	3,500,620	2	155,000	99
From California:				
California	5,677,251	5	758,000	
Nevada	91,058	--	-	
Arizona	435,573	--	-	
Total California*	6,203,882	5	758,000	274
From Pacific Coast:				
Domestic market, Western states	9,704,502	7	913,000	
Territorial market, Hawaii	368,336	--	-	
Territorial market, Alaska	59,278	--	-	
Canadian market, British Columbia	583,000	--	-	
Total Pacific Coast*	10,715,116	7	913,000	191

*Does not include Wyoming, Colorado, New Mexico, and Utah, which are considered as the market of Colorado Fuel & Iron at Pueblo, Colorado.
** Data for 1940 census not yet available.

In the Northwest, two steel plants are located at Seattle, with a total ingot capacity of 155,000 gross tons yearly or a per capita capacity of only 99 pounds of ingot for the 3,500,020 population in the immediate Northwest market area. This compares with a per capita capacity in the California market area of 274 pounds of ingot, and with the total United States per capita production of ingot steel of 872 pounds in 1937, as shown in table 2.

Table 2

Per Capita Production of Ingot Steel in the United States
1925-1939, inclusive

Year	Per Capita Production	Year	Per Capita Production	Year	Per Capita Production
	(pounds)		(pounds)		(pounds)
1939	866*	1934	460	1929	1,040
1938	489*	1933	413	1928	962
1937	872*	1932	242	1927	848
1936	850	1931	463	1926	942
1935	594	1930	734	1925	881

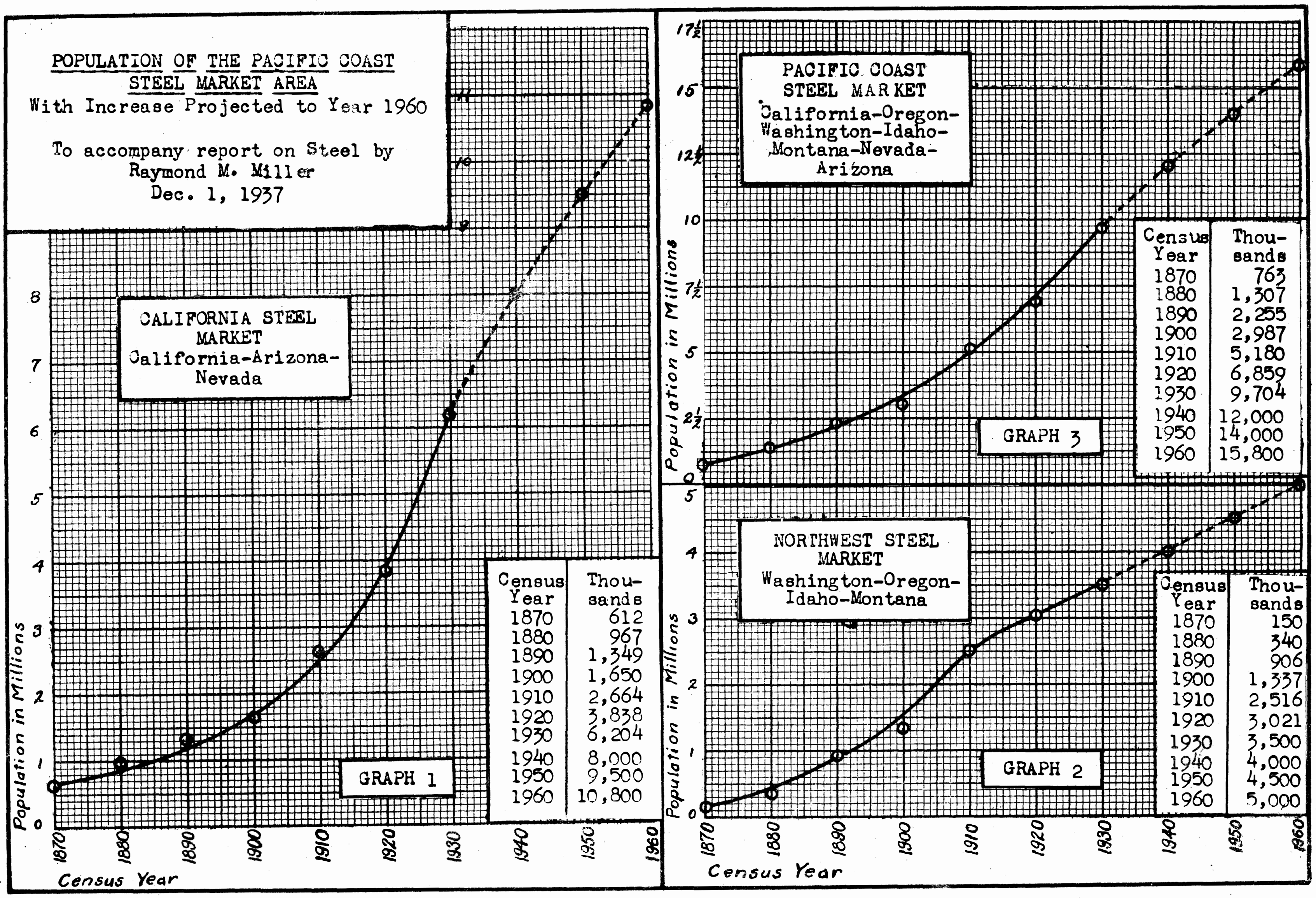
* Based on 1937 population estimate of 129,257,000.

It is thus evident that if the Western states' consumption of steel is anywhere near the per capita for the United States as a whole, their steel plant capacity is totally inadequate to supply the present requirements.

Population growth. While California has the largest population and is growing fast, developments in the Northwest point to a steady growth of the population here that should not be ignored in its relation to the future steel markets. The heavy rainfall and equable climate in the coastal area, and the huge Columbia Basin reclamation project in central Washington are extraordinary factors which are operating to attract new farm population from less favored areas in the drouth-stricken prairie states and from eastern flood areas, while the harnessing of the Columbia River, by building a series of power and navigation dams from Bonneville near Portland to Grand Coulee in central Washington, is an added factor which will operate during succeeding generations to stimulate industrial growth and build up the urban population to compare with the industrialized eastern states.

To what extent these factors will increase the average rate of population growth and thus expand the steel requirements cannot be foretold, but it is quite evident that with new farm population the canning fruit and specialty crops will be increased, thus bringing a steadily increasing demand for steel for tinplate, already one of the heavy tonnage products of the area. In addition, the steadily growing urban industrial and commercial population added to this increasing agricultural population will increase the need for steel sheet and plate, bar, rod, strip and structurals, pipe, wire, bolts, nuts and rivets, iron and steel castings, and all other iron and steel products.

The curves of figure 1 show the population growth of the Pacific Coast steel market area, 1870 to 1930, with projections to indicate the normal growth expectancy for the next 30 years, to 1960. Graph 2 includes the states of Washington, Oregon, Idaho and Montana only; graph 1 is California, Nevada, and Arizona, while graph 3 is the sum of 1 and 2. Graph 3 does not include the territorial or export market. Chiefly, the population growth will take place in the three Pacific Coast states, Oregon, Washington and California, which already have nearly 85 percent of the total population of these seven states.


POPULATION OF THE PACIFIC COAST STEEL MARKET AREA
With Increase Projected to Year 1960
To accompany report on Steel by Raymond M. Miller
Dec. 1, 1937
CALIFORNIA STEEL MARKET
California-Arizona-Nevada
Census Year | Thousands
1870 | 612
1880 | 967
1890 | 1,349
1900 | 1,650
1910 | 2,664
1920 | 3,838
1930 | 6,204
1940 | 8,000
1950 | 9,500
1960 | 10,800
GRAPH 1
Population in Millions
Census Year
PACIFIC COAST STEEL MARKET
California-Oregon-Washington-Idaho-Montana-Nevada-Arizona
Census Year | Thousands
1870 | 763
1880 | 1,307
1890 | 2,255
1900 | 2,987
1910 | 5,180
1920 | 6,859
1930 | 9,704
1940 | 12,000
1950 | 14,000
1960 | 15,800
GRAPH 3
NORTHWEST STEEL MARKET
Washington-Oregon-Idaho-Montana
Census Year | Thousands
1870 | 150
1880 | 340
1890 | 906
1900 | 1,337
1910 | 2,516
1920 | 3,021
1930 | 3,500
1940 | 4,000
1950 | 4,500
1960 | 5,000
GRAPH 2

Graph 2 shows that the Northwest population should normally rise to 5,000,000 persons by 1960 which would be a 43 percent increase over the 1930 Census. Actually, the present indications are that this will be exceeded, but whether it is or not, the area has a definitely increasing market for steel which will require a continually increasing steel plant capacity.

Source of Steel Supply. The local steel production is principally in San Francisco and Los Angeles with some tonnage at Seattle. Aside from the local production, the Coast requirements are obtained from: (1) Atlantic Coast mills by intercoastal water shipments; (2) from the Chicago, Indiana, Ohio and Pennsylvania mills by transcontinental rail movement; and (3) from the Colorado Fuel & Iron Co. mills at Pueblo, Colorado, by rail shipment to Northwest and California points. Very little steel is imported. The ingot capacities of the local producers are shown in table 3.

Table 3

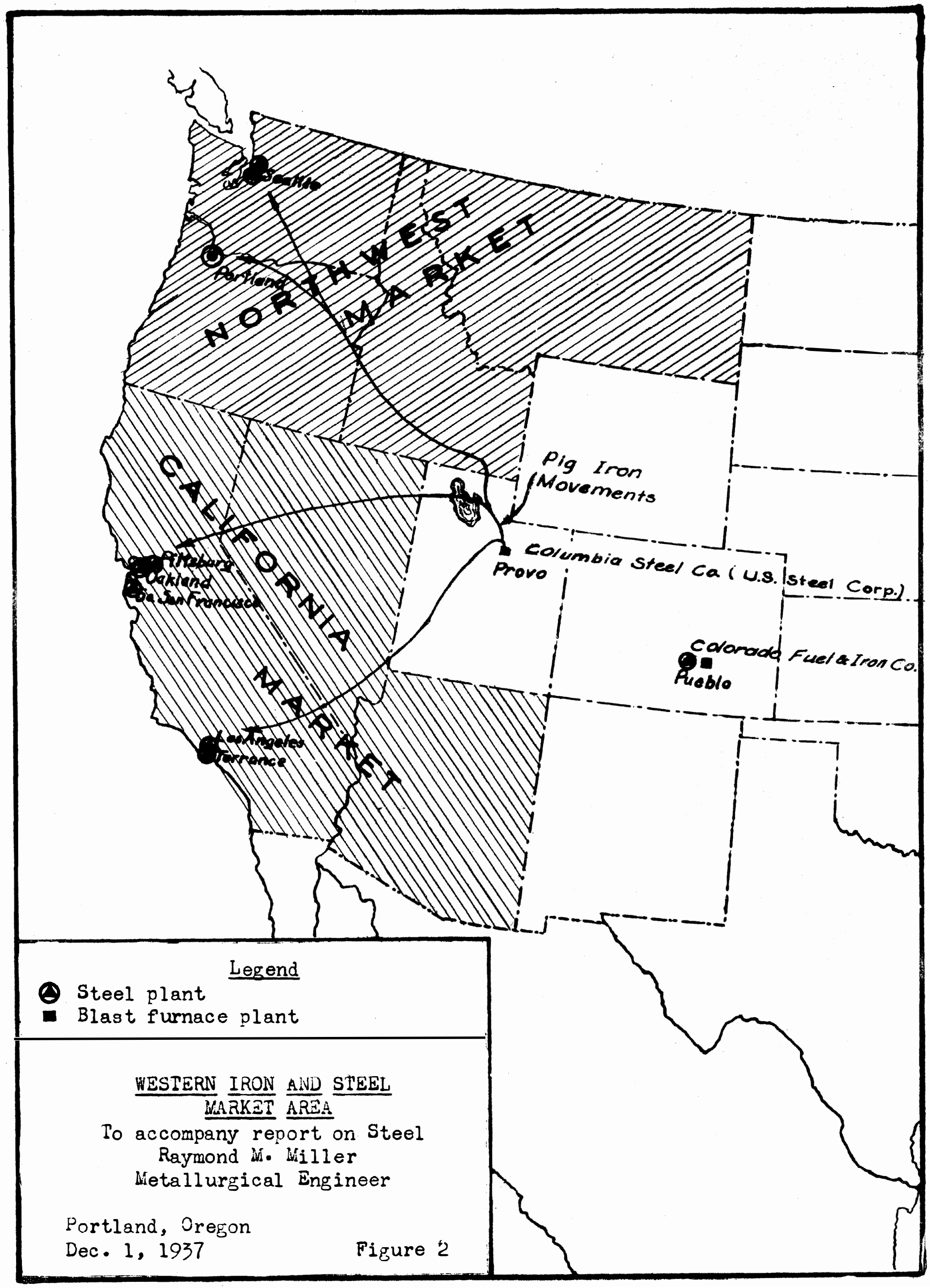
Ingot Capacities of the Present Steel Mills on the Pacific Coast by Companies and Location, Year 1938 (in long tons of ingot annually)*

Pacific Coast Ingot Capacity	No. Mills	Los Angeles Area	San Francisco Area	Seattle	Total Pacific Coast
		(tons)	(tons)	(tons)	(tons)
Columbia Steel Co. (subs. U.S.Steel Corp.)	2	182,500	259,000	-	441,500
Bethlehem Steel Co.	3	85,000	155,000	140,000	380,000
Northwest Steel Rolling Mills	1	-	-	15,000	15,000
Judson Steel Corporation	1	-	76,500	-	76,500
Total	7	267,500	490,500	155,000	913,000

*All are open hearth except Northwest Steel Rolling Mills, which produces electric ingot. See table 4.

The capacity of finished hot rolled products totals 689,700 long tons, chiefly of bars and light structural shapes, with some output of plates, sheets, splice bars and tie plates, and wire rod.

For comparison, the Colorado Fuel & Iron Company, whose market includes the Pacific Coast, has a total ingot capacity at Pueblo, Colorado, of 888,000 long tons, and a rolling capacity of 663,500 long tons of finished hot rolled products, most of which is in railroad rails and track material, with a smaller capacity of bars, structurals, and wire rod which is finished into wire fencing and other products.



Legend
- Steel plant
- Blast furnace plant

WESTERN IRON AND STEEL
MARKET AREA
To accompany report on Steel
Raymond M. Miller
Metallurgical Engineer

Portland, Oregon
Dec. 1, 1937

Figure 2

Table 4

Steel Plant Capacity on the Pacific Coast in 1938*, by Products and Companies (in gross tons of 2240 pounds).

Pacific Coast Steel Capacity 1/	California	Seattle	Total
	(gross tons)	(gross tons)	(gross tons)
Total Ingot	758,000	155,000	913,000
Finished hot rolled products: total	561,200	128,500	689,700
Splice bars and tie plates	21,700	12,000	33,700
Structural shapes	89,900	26,100	116,000
Concrete reinforcement bars	150,200	42,000	192,200
Other bars	130,500	33,900	164,400
Black plate	35,200	-	35,200
Black sheet, hot rolled	83,200	-	83,200
Universal plate	-	14,500	14,500
Wire rods	42,000	-	42,000
Forging blooms and billets	8,500	-	8,500
Other finished products:	250,700	15,000	265,700
Fabricated reinforcing	13,000	15,000	28,000
Fabricated structurals	10,000	-	10,000
Galvanized sheets	49,700	-	49,700
Tinplate	34,700	-	34,700
Wire, plain and galvanized	49,500	-	49,500
Wire, other products	7,700	-	7,700
Nails, staples	17,900	-	17,900
Bolts, nuts, spikes, rivets	18,500	-	18,500
Black sheets, full pickled	3,000	-	3,000
Rope and strand, springs	6,700	-	6,700
Forgings	8,500	-	8,500
Steel Castings	31,500	-	31,500

Steel Plant Annual Capacities Operating Company 1/	No. of Plants	Steel Ingot	Finished Hot Rolled Products	Other Finished Products
		(gross tons)	(gross tons)	(gross tons)
Columbia Steel Co. 2/	2 3/	441,500	305,500	200,700
Bethlehem Steel Co.	3 4/	380,000	324,000	65,000
Judson Steel Corporation	1 5/	76,500	48,200	-
Northwest Rolling Mills Inc.	1 6/	15,000	12,000	-
Total	7	913,000	689,700	265,700

* Source: Iron and Steel Works Directory, 1938: American Iron and Steel Institute.

1/ For a description of the plants, see Vol.II, sect.3,4: The Feasibility of Establishing an Iron and Steel Industry in the Lower Columbia River Area Using Electric Pig Iron Furnaces, by Raymond M. Miller, 1936, published by War Dept., Corps of Engineers, Portland, Oregon.

2/ Subsidiary of United States Steel Corporation.

3/ Pittsburg, Calif., Torrance, Calif.

4/ Seattle, Wash., San Francisco, Calif., Los Angeles, Calif.

5/ Emeryville, Calif.

6/ Seattle, Wash., electric furnace plant.

TOTAL IRON AND STEEL MARKET AVAILABLE TO A PROPOSED OREGON STEEL MILL

Aside from the Portland market, which is as yet relatively small, an Oregon steel mill would find its outlet in the Washington, California, and interior Western states markets. Its chief competitors would be the seven Pacific Coast mills in the San Francisco Bay, Los Angeles, and Seattle industrial areas. Since the aggregate capacity of these mills is entirely insufficient to supply the West Coast market, as this study clearly reveals, considerable tonnages of tinplate, black and galvanized sheets, pipe and tubing, structurals, wire and other finished and semi-finished products must be supplied from the mills of Colorado and the Eastern states.

Not only is this true, but the markets bordering the Pacific Ocean, comprising our own territorial Alaska and Hawaii, the Philippine Islands, Pacific South America, Central America and Mexico, have a substantial requirement supplied from United States mills. In addition, a considerable tonnage is shipped into the Asiatic and Oceanic Island countries across the Pacific. These markets are shown in detail in the tables.

Source and Accuracy of Data. While exact records on these are impossible to obtain completely for any corresponding period, some definite data have been gathered on each of the market areas by which the total market can be indicated. Of these data, the figures most subject to uncertainty are the movements of domestic iron and steel by rail and water into the domestic Pacific Coast market.* Since no organized statistics on these movements are available, and since such sources as may be drawn upon contain no uniformly kept records, the writer cannot vouch for either the completeness or the accuracy of the figures herein given. It is believed that they do represent a close approach to the situation and may in total be considered as an indication of the actual movements taking place.

Imports and the foreign and territorial exports are Department of Commerce figures, from publications of the Bureau of Foreign and Domestic Commerce, which are given in sufficient detail that entire dependence can be placed on their accuracy.

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* Compiled by Gordon Fernald, engineering assistant, Corps of Engineers, War Department, Portland, Oregon, in 1935 from records of the railroads terminating on the Pacific Coast, and from records of inter-coastal movements terminating at Pacific Coast ports, as published by the Maritime Commission, and the Panama Canal record.

Extent of Pacific Market. Owing to this lack of data on the Pacific Coast production, and on the tonnage of shipments from Coast mills to the territorial and the Pacific export markets of the different classes of products, it is not possible to evaluate the total market in complete detail, but inasmuch as the entire territorial and export markets are reached by water from the Columbia River with as much ease as from other Pacific Coast ports, these logically may be considered as available markets for a Portland area steel mill.

Further, the movements of steel products from Eastern mills into the Pacific Coast area are an indication of the large domestic need unsatisfied by the present capacity. Although a large part of this tonnage is destined to the California market, a Portland plant can reach this area by coastwise water shipment much more easily and at lower cost than the more distant Eastern mills. Thus California may be considered as an available market for a mill on the Columbia River.

The total available market in which a mill in the Columbia River area could compete would be that part of the requirements of the Pacific Coast States in excess of that supplied by the seven Coast steel mills, plus the entire Pacific territorial and export market, as shown by the following tabulation:

Table 5

Market for Steel Available to a Northwest Steel Mill (in long tons of 2240 pounds).

Iron and Steel Products Received in the Pacific Market Area (1934)*	Extent of Market Available to a Northwest Steel Mill (long tons)
Receipts in Pacific Coast customs districts from Eastern United States, and imports as detailed in Table 6	839,110
Extent of market in non-contiguous territories and the Philippines, supplied by U. S. mills detailed in Table 7	254,521
Exports to Pacific countries from U. S. mills detailed in Table 8	949,954
Total market available to Northwest mill*	2,043,585

* Not including that portion of the domestic market supplied by Western steel mills, which is equal to the Western production less the shipments to territorial and export markets.

Domestic and Territorial Market

Domestic Pacific Coast Market. The data for the iron and steel entering the West Coast states for consumption and export include movements from the eastern and Atlantic Coast states by transcontinental rail shipment and by intercoastal waterborne shipping plus the small tonnage of imports received. In 1934 the domestic receipts from intercoastal water and transcontinental rail shipments amounted to 839,110 long tons, while foreign imports for that year amounted to 25,519 long tons. Since 1934 both domestic receipts and foreign imports have steadily increased.

Table 6

Receipts of Iron and Steel Products in the Pacific Coast Customs Districts of the United States, Year 1934, from Eastern and Atlantic Coast States by Rail and Water Shipments, together with Imports, Year 1938 (in long tons of 2240 pounds).

Items Received	Domestic Receipts, Year 1934			Imports Year 1938
	Inter-Coastal Water**	Trans-Continental Rail**	Total	
	(long tons)	(long tons)	(long tons)	(long tons)
Total Receipts	559,149	279,961	839,110	46,425
Hot rolled products:	118,262	52,706	170,968	20,186
Bars and rods				7,463
Boiler plate				341
Sheets, black and galv.	60,685	2,419	63,104	2,135
Structurals	49,117	46,420	95,537	9,227
Rails	7,528	2,051	9,579	1,020
Track material	872	1,916	2,788	-
Other finished products:	268,849	202,025	470,874	19,561
Tinplate and terneplate	53,586	160,892	214,478	8
Pipe and tubing	180,035	22,992	203,027	12,055
Wire and Manufactures	29,877	15,729	45,606	4,431
Nails, bolts, nuts, rivets	5,351	2,412	7,763	3,067
Undistributed as to class	172,038	25,230	197,268	6,688
Distribution of Receipts:				
Oregon and Washington	75,518	97,968	173,486	10,287
California	483,631	181,993	665,624	36,138

* Foreign Commerce and Navigation of the United States, 1938.

** Compiled from records of the railroads terminating on the Pacific Coast, and from customs records of water movements into the five customs districts. Year 1934 is the only year for which these data are available.

Territorial Market. Shipments of iron and steel into the non-contiguous territories of the United States, including the Philippine Islands, amount to about 250,000 long tons annually. The Philippines present the largest market of this group with its principal requirements being black and galvanized sheets, bars, rods, wire rod, cast iron pipe and fittings, tinplate and terneplate, structurals, nails, bolts, nuts, rivets, wire, pipe and tubing. Hawaii is second with its chief requirements tinplate, structurals, bars, rods, wire rod, cast iron pipe and fittings, pipe and tubing. Alaska's chief item is tin cans. Table 7 shows this market in detail.

Table 7

Exports of Iron and Steel Products from the United States to its Non-Contiguous Territories and The Philippines, Stated Years (in long tons of 2240 pounds)

Item	Destination: Alaska** 1939	Hawaii** 1939	Philippine* Islands 1938	Extent of Territorial Market
	(tons)	(tons)	(tons)	(tons)
Total Exports	45,279	102,071	107,171	254,521
Ingots, blooms, billets, slabs			163	163
Hot-Rolled Products:	4,594	22,998	63,067	90,659
Bars, rods, wire rod	1,369	8,399	24,537	
Boiler plate, other plate	416	2,150	3,222	
Sheets, black and galv.	1,003	4,403	25,234	
Structurals	1,806	7,231	7,933	
Rails		535	1,093	
Track Material		280	1,048	
Other finished products:	7,910	69,610	30,306	107,826
Tinplate and taggers, terne	998	59,344	8,940	
Pipe and tubing	1,646	5,266	4,690	
Wire and manufactures	3,893	2,360	5,528	
Nails, bolts, nuts, rivets	1,206	2,258	7,848	
All other products	167	382	3,300	
Tin cans	30,447	3,227	2,190	35,864
Iron Products:	2,328	6,236	11,445	20,009
Pig iron			734	
Castings	1,986	208	87	
Cast iron pipe, fittings	342	6,028	10,624	

* Compiled from Foreign Commerce and Navigation of the United States, 1938.
** Compiled from December Monthly Report of the Department of Foreign Commerce and Navigation, 1939.

Pacific Export Market. This market is shown in detail in Table 8 which follows on the next page.

Table 8

United States Exports* of Iron and Steel Products to Countries Bordering the Pacific Ocean by Classes of Products, Year 1938 (in long tons of 2240 pounds).

Item	Destination: Pacific South America[1]	Central America[2]	Mexico	Japan	China and Kwantung	All Other Trans-Pacific[3]	Total Pacific Market
	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)
Total Pacific Exports	138,110	41,430	49,333	484,800	118,458	117,823	949,954
Ingots, blooms, billets, slabs	2,279	121	139	97,713	639	892	101,783
Hot-rolled products:	74,366	23,223	21,295	49,383	99,642	78,481	346,390
Bars, rods, wire rod	14,953	4,585	799	29,119	20,357	6,970	
Boiler plate, other plate	7,540	2,172	1,977	12,074	38,054	12,585	
Sheets, black and galv.	16,267	4,611	12,863	1,515	4,863	30,067	
Structurals	19,575	7,702	3,368	5,086	14,292	8,054	
Rails	14,241	2,695	1,477	1,549	20,276	18,960	
Track material	1,790	1,458	811	40	1,800	1,845	
Other Finished products:	56,015	7,346	21,589	21,424	11,622	36,198	154,194
Tin and terneplate	8,490	243	8,646	12,799	5,738	16,955	
Pipe and tubing	25,584	3,426	5,894	244	63	4,925	
Wire and manufactures	15,189	2,325	3,961	105	1,004	1,039	
Nails, bolts, nuts, rivets	2,015	292	288	173	66	9,717	
All other[4]	4,737	1,060	2,800	8,103	4,751	3,562	
Tin cans	9	61	1,550		2	49	1,671
Cast iron products:	5,441	10,679	4,760	316,280	6,553	2,203	345,916
Pig iron	1,909	6,818	2,896	316,280	6,553	2,047	
Castings	404	49	39			32	
Cast iron pipe, fittings	3,128	3,812	1,825			124	

* Compiled from Foreign Commerce and Navigation of the United States, 1938.

1 Chile, Peru, Bolivia, Ecuador, Colombia.

2 Honduras, Costa Rica, Guatemala, Panama, San Salvador, Nicaragua, British Honduras.

3 Includes Hongkong, Siam, French Indo-China, India, Ceylor, Netherland East Indies, Malaya, French Oceania, Australia, New Zealand.

4 Steel castings, forgings; horseshoes; car wheels and axles; strip, hoop band and scroll iron and steel

Market Competition. It is obvious that exploitation of any of the various markets involves competition, not only with Eastern United States mills, particularly the eastern Pennsylvania and Maryland mills, but also with the growing Japanese steel industry in the Asiatic market.

In the South and Central American market, competition to be met comes from the Atlantic Coast, and undoubtedly some of the market would be unavailable. However, for the available portion, a Portland plant shipping ore from Chile would be in as advantageous a position to compete, both in the matter of cost of production and shipment as return cargo in ore boats, as would the Atlantic Coast mills.

Principal Tonnage Products. Although the total extent of the market available is indicated to be over 2,000,000 long tons, because of the diversity of the products represented it could be only partially exploited from a single mill. Nevertheless, this total presents a large volume market with sufficient tonnage requirements of a few classes of products to warrant establishment of an economic-sized steel works and rolling mill. The principal tonnage products are summarized below.

Table 9

Summary of Principal Tonnage Products Received in the Pacific Market, Domestic, Territorial and Foreign Export (in long tons)

Principal Tonnage Products	Domestic Receipts*	Territorial Market**	Pacific Export Market***	Total Pacific Market
	(long tons)	(long tons)	(long tons)	(long tons)
Tinplate and terneplate	214,478	69,282	102,871	386,630
Sheets, black and galvanized	63,104	30,640	70,186	163,930
Bars and rods	-	34,305	76,783	111,088
Structurals	95,537	16,970	58,077	170,584
Pipe and tubing	203,027	11,602	40,136	254,765
Total	576,146	161,799	348,053	1,086,997

* From table 6, exclusive of imports, which amount to less than 50,000 tons.

** From table 7.

*** From table 8.

Freight Rates on Intercoastal Steel Shipments. Steel products shipped by water from Atlantic Coast ports to the Pacific Coast ports are quoted by the U. S. Intercoastal Westbound tariff at the rates shown in table 10, for the specified minimum carlot shipments indicated.

Table 10

Cost of Water Shipment of Steel Products Atlantic Coast Ports to Pacific Coast Ports* (Group A Lines).

Intercoastal Water Freight Rates	Minimum Carload	Rate per 100 Pounds	Rate per Long Ton
	(pounds)	(cents)	
Ingots, blooms, billets	50,000	52½	$11.76
Rails, not over 40' in length**	40,000	55½	12.43
Railway track material	40,000	66½	14.90
Structural shapes and bars	36,000	60½	13.55
Structural shapes, fabricated	36,000	66½	14.90
Plates and sheets, 16 gage or heavier not bent (black, galvanized or terne)	36,000	52½	11.76
Sheet, 17 gage or thinner, not bent (black, galvanized or terne)	36,000	60½	13.55
Tin and terne plate, or electro-galvanized sheet, 26 gage or thinner	36,000	45½	10.19
Skelp, not bent	36,000	46	10.30
Pipe, wrought iron or steel***	36,000	55½	12.43
Wire rod, wire	30,000	44½	9.97
Bolts, nuts, rivets	36,000	53	11.87
Grinding balls	40,000	51	11.42

* United States Intercoastal Tariff, Westbound No.10. Amended tariffs as of May 1, 1940. Group B rates are 2½ cents lower per 100 pounds.
** Over 40' but not exceeding 60' add 10½ cents per 100.
*** Not over 12" diameter, or exceeding 42' in length.

Transcontinental Rail Rates. Table 11 shows the existing rates on steel products from the Midwestern mills to the Pacific Coast for specified minimum shipments. Rates, though quoted per hundred pounds, have been calculated to long tons. Skelp takes a uniform special rate for a 45 long ton minimum of $17.44 per ton from the Midwestern field Pittsburgh to Chicago. Tinplate and terne have a uniform special rate for an 80,000 pound minimum carlot of $17.25 per long ton from all eastern mills. All other steel products have much higher rates. As the Pacific Coast receives a large tonnage of steel from the Midwestern mills, the rates shown in table 11 indicate the substantial advantage a Columbia River mill would have in its own market.

For comparison, the coastwise water rate for pipe and tubing moving between Oakland and Portland is quoted at $7.11 per long ton for a 36,000 pound minimum carlot. The Chicago rail rate on this item for a 40,000 pound minimum carlot is quoted at $30.91 per long ton, which indicates a differential of $23.80 per ton in favor of a Portland plant serving the San Francisco Bay area.

Table 11

Rail Rates* on Transcontinental Shipments of Iron and Steel Products to the Pacific Coast, for Specified Minimum Carlots (per long ton of 2240 pounds).

Steel Shipments to Pacific Coast Points	From Chicago Gary	From Youngstown Pittsburgh	From Johnstown	Minimum Carlot
				(pounds)
Ingots, blooms, billets, plates	$24,64	$28.45	$32.03	80,000
sheets (black,galvanized)	27.10	30.91	34.50	50,000
Wire rods	30.91	34.50	38.30	40,000
Tin plate or terneplate	17.25	17.25	17.25	80,000
	28.45	-	-	50,000
Rails	22.00	25.70	29.39	80,000
Skelp	17 44	17.44	-	100,800
Structural shapes**	24.64	28.45	32.03	60,000
	24.64	28.45	32.03	40,000
Pipe, wrought iron or steel	24.64	28.45	32.03	60,000
	30.91	34.45	38.30	40,000
	39.42	43.46	47.26	30,000
Wire	24.64	28.45	32.03	40,000

* As of July 1940.

** Different Minimum Carlot depends upon the size of car used. Rate for each is the same.

Freight Rates to Pacific Markets. A comparison of water rates from Atlantic Coast and Pacific Coast ports to trans-Pacific countries, shows no advantage for the latter. However, since most Eastern mills are inland requiring a rail transfer to the dock, and a Columbia River mill would be at tidewater, a transportation cost spread would exist between the inland Eastern and Columbia River mills in favor of the Pacific Coast shipper.

Table 12

Comparison of Water Freight Rates to Trans-Pacific Markets, from Atlantic Coast and Pacific Coast Points.

Water Freight Rates	To Trans-Pacific Points	From Pacific Coast Ports*		From Atlantic Coast Ports**
		(short ton)	(long ton)	(long ton)
Structural shapes, fabricated	Japan	$14.50	$16.24	$16.00
	Hongkong,Manila	14.50	16.24	16.00
	Shanghai	15.00	16.80	16.50
Plates, sheets and structural shapes not fabricated	Japan	13.50	15.12	15.00
	Hongkong,Manila	13.50	15.12	15.00
	Shanghai	14.00	15.68	15.60
Structurals, plates Sheets and tinplate	Hawaii***	7.25	8.12	12.32

*Rate applies per 2000 pounds or 40 cubic feet, whichever produces the greater revenue. Second column is a calculation to a long ton basis.

**Rate applies per 2240 pounds or 40 cubic feet whichever produces the greater revenue.

***Quoted rate in effect August 1, 1940; all other rates as of July 1940.

Conclusions

The foregoing study points out the obvious advantage to a Columbia River steel producer selling in the Pacific markets. The present steel requirements would support a plant of several hundred thousand tons capacity, provided the production costs were about equal to those of the Atlantic tidewater plants. The principal competitors would be the Columbia Steel Company, and the Bethlehem Steel Corporation plants in the San Francisco and Los Angeles markets, and a Bethlehem Steel Corporation plant at Seattle, while of some concern in the Pacific market is the Bethlehem plant at Sparrows Point, Maryland, which has the advantage of port to port rates and its own steamship line, the Calmar, operating in the intercoastal service. This type of competition indicates that a steel mill of any importance must be in the hands of a financially strong group, established in the industry, with experienced operating personnel, and with at least a portion of the market assured to them.

Owing to the large tonnage of tinplate consumed on the Pacific Coast, and with the substantial territorial and export market as indicated by the customs statistics, there obviously should be considerable attention directed to this product. But in addition a Columbia River mill would have the local market for bars and structurals, black and galvanized sheet, and a substantial territorial and foreign export market for these products to absorb further tonnages.

In the matter of freight rates a Columbia River plant could deliver to any Pacific Coast point, or to the Hawaiian market, with a substantial cost advantage over the Atlantic Coast shipper, and would be in a much more favorable position than the inland Illinois, Indiana, Ohio, West Virginia and western Pennsylvania mills for supplying these markets.

The present rate structure for the trans-Pacific traffic places the Atlantic shipper on a basis of equality with the Pacific Coast shipper, although the inland eastern steel mills are at some disadvantage by reason of the mill to port transportation cost.

With a steadily growing population and increasing industrial activity, the Pacific Coast presents an expanding market for steel, in large part now dependent upon the Eastern mills, and therefore is an excellent field for expansion of steel capacity. It is particularly promising as a new field for an independent producer whose markets on the Pacific Coast are growing, and who desires to protect and expand them by locating a new producing unit at an advantageous point for maintaining low production and delivery costs.

On the other hand either Bethlehem Steel Corporation or U. S. Steel Corporation would derive certain advantages from a Columbia River location. U. S. Steel has no Northwest mill, and could with advantage establish a tinplate mill to supply the Pacific market, obtaining pig iron from their own Provo, Utah, blast furnace plant, and utilizing low-cost Bonneville power for their rolling mill. Bethlehem has no Pacific Coast source of pig iron, and could locate in the Columbia River area bringing ore from Tofo, Chile, using Bonneville power for their plant operation, and shipping pig iron to their California and Seattle plants, and steel to California in returning ore boats.

THE TINPLATE AND TERNEPLATE MARKET AVAILABLE TO AN OREGON TIN MILL

Summary

In the following review of the tinplate market accessible to a Pacific Coast mill it is indicated that the consuming territory and foreign countries, that can be advantageously supplied by an Oregon tin mill, received from eastern United States mills, by both rail and water shipment, a total of roundly 350,000 long tons of tinplate and terneplate for consumption in 1934. In addition to this the Columbia Steel Company's 31,400-ton tin mill at Pittsburg, California, was operated to supply part of the Western market.

Thus the total tinplate tonnage reaching the consumers in a possible Oregon plant's market area was about 375,000 long tons in 1934 as shown in table 20.

Considering the declining market for United States tinplate in the Orient, due to the establishment of new Japanese tonnage capacity recently, the maximum market for tinplate which should be considered as normally available to United States producers on the Pacific Coast would be about <u>362,000 long tons</u> as indicated in table 20.

Increasing farm population on the Pacific Coast with increased agricultural crops for canning should bring this tonnage up appreciably, however. Considering that the National tinplate consumption per capita was only 25 pounds in 1934, and increased to 36 pounds per capita in 1936, it seems evident that a tin mill projected on the basis of the indicated 1934 figures would have a comfortable margin of safety in its market requirements by the time the plant could be built and placed in operation.

Further than this, the region is young industrially with a high rate of population increase and expanding industrial activity, which seems to assure a more rapid future increase in demand for other classes of steel. This makes possible a diversification of steel products for which markets already exist, with especial emphasis on tinplate as the heavy tonnage product.

Assuming that the entire trans-Pacific, Central and South American markets become ultimately unavailable to an Oregon tinplate producer, and subtracting the production of the California tin mill, <u>the available market remaining still totals 266,000 long tons annually</u>. All of this must be shipped from Eastern tinplate mills at freight rates ranging from $10.19 per long ton via intercoastal water shipments from Atlantic Coast ports to Pacific Coast ports, to a minimum of $17.25 per long ton by transcontinental rail shipment from the Midwestern district to Pacific Coast points.

Statistics of the Markets Available

United States Per Capita Consumption. The United States tinplate mills produced an average of about 2,332,000 long tons of tinplate annually in the three years 1936, 1937, and 1939, omitting the year 1938 which was subnormal.

The average annual tinplate imports during these three years amounted to 193 long tons, and the average annual exports amounted to 303,527 long tons. The apparent annual tinplate consumption, which is the production plus imports minus exports, thus amounts to roundly 2,029,000 long tons.

This is equivalent for the estimated 1940 population of 132,000,000 persons to an average per capita consumption of 34.5 pounds as compared with 36 pounds in 1936, and 31 pounds in 1929. Although the consumption curve does not trend steadily upward a pronounced increase is shown over the past decade, due not only to the uptrend in population, but also to extension of the use of tinplate to new fields in packing and packaging foods and other products.

Domestic Pacific Coast Market. The eleven Western states which constitute the domestic market area for a Pacific Coast tinplate mill have 11,897,022 population or 9.7 percent of the total United States population recorded by the 1930 census.

On a per capita basis, assuming these eleven states to be average consumers of tinplate, the average annual Western requirement of tin and terneplate would amount to only 184,000 long tons, which is several thousand tons under the actual requirements as indicated by this statistical study and shown in table 6.

The Pacific Coast states are heavy consumers of tinplate due to their importance as suppliers of canned fruits, vegetables, fish and milk to other sections of the country and the world, and due to the fact that Coast can factories supply formed and semi-formed tin cans to the Alaskan fish canneries and other canneries on the Pacific seaboard.

Further, these states may be expected not only to retain their present position of importance as canners of foodstuffs, but to increase their contribution to the national canned food supply as the land area is brought more fully under intensive cultivation through increasing agricultural population and land use, aided by irrigation projects now under way. Thus the tinplate requirement of the year 1934 as shown in table 6 may be considered conservatively low as a measure of the future needs of the territory.

Table 13

Movements of Tinplate and Terneplate into the Pacific Coast Markets by Rail and Water, Year 1934.

Tin and Terneplate Movements Year 1934	By Transcontinental Rail*	By Intercoastal Water	Total
	(long tons)	(long tons)	(long tons)
To -			
Northwest	61,500	12,200	73,700
California	99,400	41,400	140,800
Total	160,900	53,600	214,500

* Figures are taken from records of the railroads entering the Pacific Coast states and contain some estimates due to imperfect segregation on the records. The probable error is about 5 percent on the low side.

Table 14

Freight Rates on Tinplate and Terneplate, Eastern Mills to Pacific Coast Points by Transcontinental Rail and Intercoastal Water Shipments (per long ton).

To	Minimum Car Lot	From		
		Chicago Gary Mills	Pittsburgh Youngstown Mills	Intercoastal Water Rate from Atlantic Coast
	(pounds)	(long ton)	(long ton)	(long ton)
Pacific Coast Points by:				
Transcontinental Rail	80,000	$17.25	$17.25	-
Transcontinental Rail	50,000	28.45	-	-
Intercoastal Water	36,000	-	-	$10.19*

* In effect July, 1940, U. S. Intercoastal Tariff No. 1C, Group A rate; Group B rate, 56 cents lower.

The tonnage of tinplate and terne shown in table 13 are the movements for the year 1934 from Eastern mills by cross-country rail transport, and by ocean shipping via the Panama Canal to the Pacific Coast customs districts, including San Diego, Los Angeles, San Francisco, Portland and Seattle. A large proportion of the tinplate tonnage moves to the can factories in these districts, and some tinplate and manufactured tin cans move from the Pacific Coast to the territorial markets. Thus, while the tonnage shown indicates the actual market available to a Portland tin mill, not all of it is consumed within the Pacific Coast districts.

Table 15

Shipments of Tinplate and Terneplate and Tin Cans from Continental United States into the Territories of Hawaii and Alaska, Years 1926 to 1939 inclusive.*

Year	Tinplate-Terneplate Shipments from United States		Total Territorial Shipments of Tin Plate	Shipments of Tin Cans from United States		Total Territorial Shipments of Tin Cans
	Into Hawaii	Into Alaska		Into Hawaii	Into Alaska	
	(long tons)	(long tons)	(long tons)	(long tons)	(long tons)	(long tons)
1926	28,440	10,887	39,327	124	19,719	19,943
1927	25,741	13,748	39,489	310	15,858	16,168
1928	27,293	6,530	33,823	165	21,168	21,233
1929	28,373	7,939	36,312	149	20,524	20,673
1930	42,418	4,970	47,388	165	22,045	22,200
1931	38,718	3,367	42,085	113	17,284	17,397
1932	14,781	5,436	20,217	313	17,439	17,752
1933	34,234	5,797	40,031	328	20,623	20,951
1934	23,552	5,201	28,753	704	28,305	29,009
1935	41,184	2,866	44,050	814	24,927	25,741
1936	53,800	3,221	57,021	985	36,797	37,782
1937	46,197	1,501	47,698	941	32,692	33,633
1938	55,347	588	55,935	1,468	25,276	26,744
1939	59,344	998	60,342	3,227	30,447	33,674

* From December Monthly Reports of United States Department of Foreign Commerce and Navigation, 1926-1939.

Territorial Tinplate Market. Alaska and Hawaii are both heavy consumers of tin cans for canning. Hawaii has two can factories located at Honolulu and Haiku producing cans for the pineapple pack, which is one of the Territor's chief industries. The Alaska fish canners, on the other hand, purchase the largest part of their cans already formed or semi-formed from can factories in the United States. The shipments of tinplate and tin cans to these territories are shown in table 15.

Including both tinplate and tin cans the territorial market for tinplate is normally around 80,000 to 90,000 long tons, all of which is accessible to a Portland steel plant. About 30 to 35 percent of this total is consumed as tinplate in the United States and shipped as cans to Alaska. Although no records are available to substantiate this, it is likely that practically all of the Alaska formed and semi-formed can tonnage originates on the Pacific Coast, and thus would be represented in the tinplate tonnage consumed on the Pacific Coast.

Table 16

Freight Rates on Tin Cans to Alaska Cannery Districts from Seattle*

Water Freight Rates Seattle to -	Formed Cans	Semi-formed Cans
	(per cubic foot)	(per cubic foot)
Ketchikan, to Skagway, Sitka	$0.15	$0.18
Cordova, to Kodiak, Seldovia	0.1625	0.1925

* Alaska Steamship Co.; Tinplate movements discontinued and thus no rates are quoted.

For shipment of tinplate and terne to Hawaii from Atlantic Coast ports, the Matson Navigation Company quotes a rate, subject to change without notice, of $11.00 per short ton of 40 cubic feet, equivalent to $12.32 per long ton, as compared with $8.12 per long ton to Hawaii from Pacific Coast ports.

Trans-Pacific Tinplate Market. The principal importers of United States tinplate on the Pacific Ocean are Japan, China, and the Philippines, whose total receipts in 1938 amounted to 27,477 long tons of tinplate and terneplate, while all other Asiatic consumers took 16,955 long tons the same year.

The Asiatic export market has been an important outlet for United States tinplate in past years, but with the growth of the Japanese tinplate industry since 1929, the United States' share of the market has been declining. The intention of Japanese interests appears to be to make Japan independent of tinplate imports and to compete in other Asiatic countries for the available market. This may ultimately reduce the United States' trans-Pacific exports to Japanese-owned and-controlled territory to a position of little or no importance if it does not eliminate them altogether, and may seriously restrict our sales in other Asiatic and Oceanic markets.

It is obvious, therefore, that the trans-Pacific market should not be counted upon, except possibly for the Philippine requirement, as an outlet for Pacific Coast tinplate, although an Oregon plant should be in a much better competitive position to hold the non-Japanese-controlled market, than are Eastern producers.

Table 17

United States Exports of Tinplate and Terneplate
to Trans-Pacific Markets, Years 1936, 1937, 1938.

United States Exports to:	1936	1937	1938
	(long tons)	(long tons)	(long tons)
Trans-Pacific Markets:			
Japan	18,299	42,689	12,799
China and Kwantung	22,941	45,265	5,738
Philippine Islands	10,010	12,848	8,940
All other trans-Pacific*	12,648	31,729	16,955
Totals	63,898	132,531	44,432

* Hongkong, British India, Ceylon, British Malaya, Australia, New Zealand, Netherlands East Indies, Siam.

Trans-Pacific Freight Rates. Prior to the current hostilities in the Orient, freight rates on tinplate were quoted at $7.83 from Pacific Coast ports, and $8.50 from Atlantic Coast ports to Japan, China, and the Philippines, but the difficulties of shipping, together with increased insurance rates and high operating costs in the war zone, has brought about a heavy increase in rates as shown in table 18.

Table 18

Freight Rates on Tinplate from Pacific Coast and Atlantic Ports of the United States to Japan, The Philippines and China (per long ton).

To	From			
	Pacific Coast Ports		Atlantic Coast Ports*	
	1940	1937	1940	1937
Japan	$15.12	$ 7.83	$15.00	$ 8.50
Hongkong, China; Manila, P.I.	15.12	7.83	15.00	8.50
Shanghai, China	15.68	8.41	15.60	9.00

* Not including rail haul where shipments are made from inland points, which if added will bring the total transportation cost to those mills several dollars higher. Only the 200,000-ton Sparrows Point mill of Bethlehem Steel would have this low rate.

Pacific South and Central American Exports. These countries are relatively small importers of United States tinplate and an Oregon tinplate producer would have little or no advantage in this market.

Table 19

Tinplate Exports to Pacific South and Central American Countries, from United States Mills, Years 1936, 1937, 1938.

Destination	1936	1937	1938
	(long tons)	(long tons)	(long tons)
Mexico	13,754	13,842	8,646
Central America	71	180	243
Total	13,825	14,022	8,889
Pacific South America			
Chile	5,609	5,588	2,915
Peru	4,777	4,495	3,099
Colombia	2,275	4,371	2,306
Bolivia and Ecuador	530	134	145
Total	14,191	14,588	8,465
Total Central and South America	28,016	28,610	17,354

Conclusion

Summarizing the above tables and statements, it is concluded that table 20 below correctly evaluates the available market. It is a composite estimate based upon the latest available figures for Pacific Coast receipts from eastern mills, with a conservative estimate of the production of the only western tin mill, plus the export market for 1938. Column two of this table is a reasonable estimate of the market normally available.

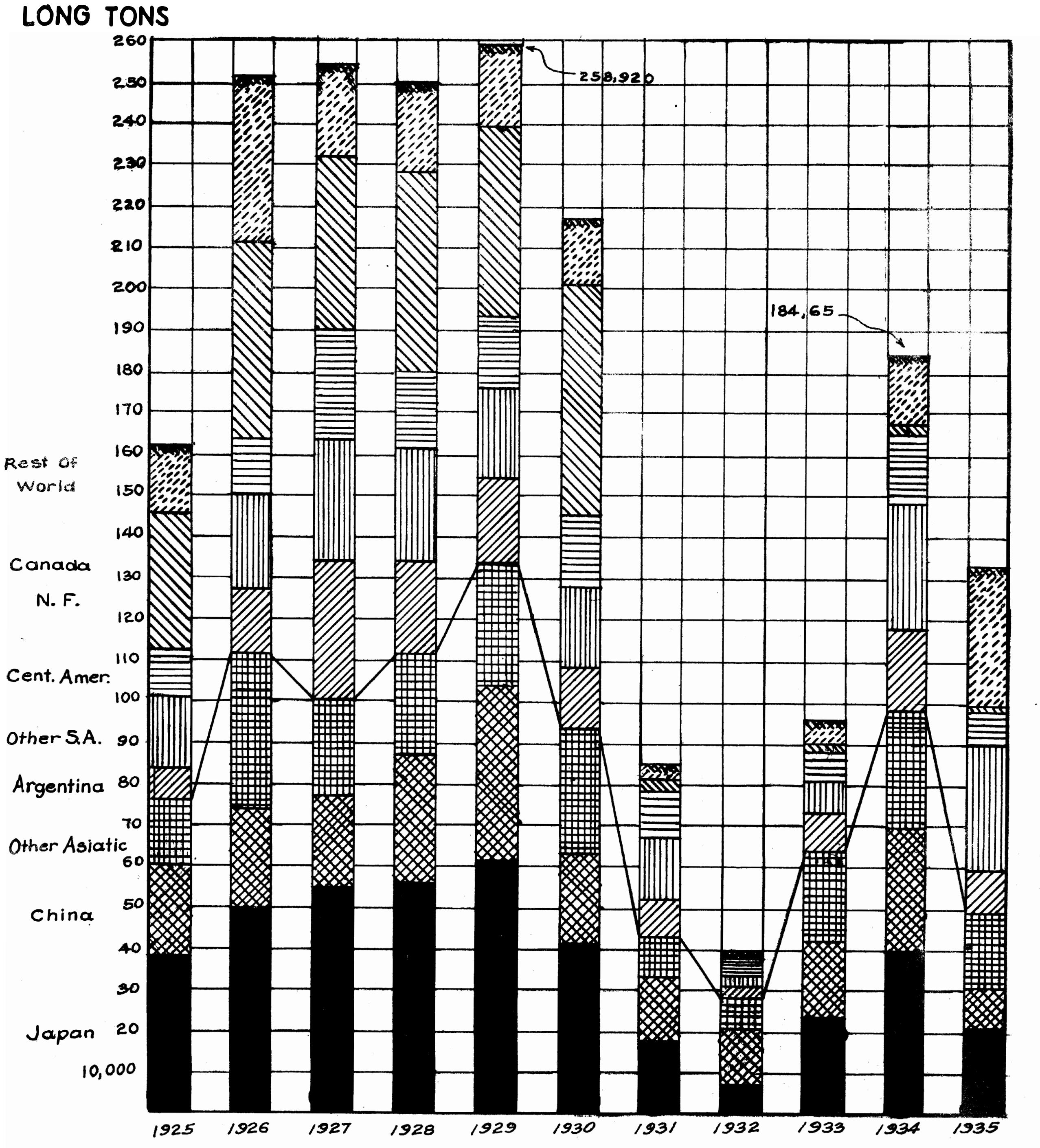
Table 20

Estimate of the Domestic and Export Tinplate Market Considered Normally Available to an Oregon Tinplate Plant.

Tinplate Market Territory	1934	1938	Normal Market Estimated Available
	(long tons)	(long tons)	(long tons)
Pacific Coast production (estimated)	26,000		
Pacific Coast receipts in 1934* (Calif., Oreg., Wash.)	181,000		207,000
Alaska receipts in 1934**	33,505	25,834	30,000
Territorial Hawaii	22,500	56,815	55,000
Trans-Pacific exports	92,783	44,432	50,000
Central and South American exports	20,516	18,999	20,000
Total	375,304		362,000

* After deducting tonnage of tinplate and tin cans shipped to Alaska.
** Includes tin cans.

TINPLATE EXPORTS



THE RAW MATERIALS FOR AN IRON AND STEEL INDUSTRY NEAR PORTLAND

Ore Supply

Three sources of ore supply are available: (1) the Columbia County limonite deposits, located about 20 to 30 miles northwest of Portland, near Scappoose, Oregon; (2) the Southern California magnetite-hematite deposits; and (3) foreign ores located along the Pacific Slope from British Columbia to Chile.

The rather limited extent of the local deposit makes it necessary to find one or more distant sources which could be depended upon for the needed tonnage and grade, in the event that a steel plant of economic size were contemplated, in which case the Oregon ore would be used as a supplemental source in proportion to its desirability for mixing in the furnace charge.

The problem with distant ores is transportation, which limits the prospects of foreign deposits to those within short distance of tidewater and docksite, and within reasonably short distance by water transportation to a tidewater plant site at Portland.

On the other hand, the problem of the Columbia County ore is the limited tonnage and high phosphorus content, while it has the obvious advantage of proximity and thus low transportation cost to a Portland plant.

Both the local and distant ores could be utilized with advantage though the basis of an operation must be the distant source involving organization of a special ore boat fleet with loading out docks and unloading equipment to handle the necessary tonnage efficiently. Because of the heavy capital expenditures involved for both the mine plan and ore traffic, and the steel works, the proven ore tonnage could not be less than 10,000,000 to 20,000,000 tons, while the probable ore should be sufficient to give promise of increased capacity and lengthened life of the enterprise beyond the necessary amortization period.

(1) Columbia County, Oregon, Limonite

Located in an area about 20 to 25 miles north of Portland, to the northwest of the town of Scappoose in Columbia County, is the most important iron ore deposit of Oregon. The full extent of the bodies is unknown, as the area has been only partially explored. Where proven by open cuts, trenching and drill records, the ore is shown to occur in beds from 2½ to 16 feet thick or more, as both bog and residual deposits, originating from the weathering and alteration of Tertiary basalt flows with which the ore is always associated.

Known occurrences cover a large area, the beds resting upon altered basalt, or upon a residual clay which has resulted from the alteration of basalt, or is enclosed between successive basalt flows, all of which are underlain by sedimentaries and igneous rocks, also of Tertiary age.

The topography is steep, the elevation ranging between 50 feet at Scappoose to 2100 feet above sea level at the Ironcrest property 8 miles westward. Erosion and stream cutting has resulted in steep canyons and deep valleys, and the exposure of the underlying formations leaves the basalt covering the higher land areas as a capping.

The ore is characteristically a soft limonite with thin bands of hard ore, ranging in grade from about 40 percent Fe natural to around 58 percent Fe dry, with high silica and alumina, high phosphorus and some manganese. Tests made from drill and other samples taken from proven sections of the fields show the following analyses:

Analysis	Percent (1)	Percent (2)	Percent (3)	Percent (4)
Iron (Fe) dry	53.24	51.0	54.11	46.20
Phosphorus (P)	0.414	0.849	0.487	0.381
Manganese (Mn)	1.42	1.24	0.436	0.25
Sulphur (S)	0.041	0.025	0.017	0.026
Silica (SiO_2)	5.29	3.58	5.096	10.35
Alumina (Al_2O_3)	3.00	7.47	3.387	9.41
Lime (CaO)		trace	0.009	0.56
Ignition Loss	19.50	14.34	12.941	12.18

(1) Composite of 13 samples by Edw. P. Scallon, Jan.26, 1920; range of Fe analysis 48.6% to 58.71%, Ironcrest field.
(2) Composite of 18 drill samples by Elmer and Hogg, Feb. 1922; Colport Development Co. property.
(3) Composite of 7 samples, by Walter Butler, St.Paul, Minn., 1920.
(4) Composite of 7 samples by Dwight Woodbridge, Duluth, Minn., April 1921; Ironcrest field.

The deposits which have been examined and to some extent developed include the Ironcrest,* the Colport Development Co., and the Oregon Charcoal Iron holdings, while undeveloped beds include the Bunker Hill and Ladysmith claims about 12 to 14 miles north and west of Scappoose. The tonnages reported in the various properties are as follows:

Property	Developed Ore (tons)	Probable Ore (tons)	Grade Dry (%Fe)	Developed by
Ironcrest	413,000	3,600,000	46-53	Test pits
Colport Development Co.	541,000	955,000	51	Drilling
Oregon Charcoal Iron Co.	500,000	-	40-55	Drilling
Total	1,454,000	4,555,000		

* Developed and probable ore placed at 1,000,000 tons in 1922; since then the owners have carried on additional exploitation, extending the area of known ore reserves by drilling and pits, estimating the probable ore at 4,000,000 tons, as shown.

1. The Ironcrest Property. This property is located on the crest of the high ground at an elevation of 2000 feet, 8 miles directly west by mountain road from Scappoose on what is described as the $S\frac{1}{2}$ of Section 35, Twp.4 N., R. 3 W., about 1 mile west of the Pisgah Home. It was examined in 1921 by Dwight Woodbridge who reported the ore to vary from 12 to 16 feet thick, with a width of 150 to 175 feet, and a developed tonnage of 413,000 tons, which may be increased by further test pitting in unexplored territory. Estimates based on subsequent exploration place the total developed and probable ore at about four million tons. The overburden is shallow and the ore can be handled by steam shovel or dragline excavators, which are the methods advised by Woodbridge in 1921.

The deposits are accessible to a permanent standard gage logging railroad, which passes through the middle of the area and can be moved by construction of a short spur to the properties. Movement over this road would be to Scappoose, where arrangements could be made to transfer to barges for shipment on the Willamette River to the furnaces wherever located, or to transfer to the Spokane, Portland & Seattle Railroad for shipment to the plant.

Cost of ore at the furnace, assuming steam shovel methods and rail transfer, would be estimated about as follows:

	Estimated Cost of Ore per Ton
Stripping and mining	$1.00
Rail transfer to Scappoose	0.60
Barging and unloading	0.50
Total estimated cost	$2.10
Cost per long ton unit, natural	0.0525

2. The Colport Development Co. The Colport property, comprising 210 acres, is described as in Section 34, Twp. 4 N., R.2 W., and Section 3, Twp.3 N., R.2 W., Willamette Meridian, about $2\frac{1}{2}$ miles northwesterly from Scappoose, Columbia County, Oregon. It has been examined and explored by Wm. W. Elmer and Geo. C. Hogg, who conducted a testing campaign in the field during 1921, and submitted a report* to the company under date of February, 1922, showing the availability of 540,903 tons of developed ore, and estimating the possibility of another 955,367 tons on the property not proven. Basis of calculations was 161 pounds per cubic foot for soft ore and 224 pounds for hard ore.

The ore is a residual limonite in a bedded deposit dipping northeastward 2 to 6 degrees, with both floor and roof of iron bearing clay, and lying at a depth of from a few feet to 148 feet. Thickness of beds as shown by drill

* Report on the iron deposit of the Colport Development Co. and the possibilities of manufacturing and marketing a product, February 1, 1922: Wm. W. Elmer and Geo. C. Hogg.

records, open cuts and tunnels, varies from 3 to 6½ feet with analyses ranging from 46.5 to 57 percent Fe dry, and averaging 43.6 percent natural or 51 percent dry for a composite of 18 drill samples, and 50.24 percent dry for the entire block of proven ore.

Being located only 2½ miles from Scappoose and less than a mile from the North Fork of Scappoose Creek, the location of the logging railroad over which the timber of the area is being shipped, the transportation and handling problem will be comparatively simple. However, the beds can only be mined by underground methods which increases the f.o.b. cost estimate considerably over that of the Ironcrest ore. Elmer and Hogg have estimated the cost of mining at $2.00 per ton working the mine by a main entry and laterals, which would indicate a cost at the furnace as follows:

	Estimated Cost per Long Ton
Underground mining	$2.00
Royalty	0.15
Rail transfer to Scappoose	0.50
Barge transfer to furnace, with unloading	0.65
Total estimated cost	$3.30
Cost per long ton unit, natural	0.0755

3. Oregon Charcoal Iron Co. This property, comprising 380 acres, is adjacent to that of the Colport group and is described as located in Section 3, Twp.3 N., R.2 W., Willamette Meridian, about 2 miles northwesterly from Scappoose, and also accessible by a short rail haul down the valley of the North Fork of Scappoose Creek to Scappoose. Both the Colport and Oregon Charcoal Iron properties could be worked together; the ores are similar, and are evidently continuations of the same beds. The elevation is about 600 feet above sea level.

The beds, which dip northeasterly, have a thickness of 4½ to 13 feet, and lie under from a few feet to a maximum of 200 feet of overburden. Reported analyses from open cut samples show a grade of about 54 percent Fe dry, while drill samples analyzed 47.5 to 53.1 percent Fe dry. The total tonnage in 20 acres of the property which has been explored is estimated to be 500,000 tons, with some expectancy of further tonnage in other sections.

Conclusions

The foregoing three properties have a developed tonnage of 1,454,000 tons which could be laid down, at an Oregon furnace somewhere near Portland, at a cost of approximately 6.75 cents per unit natural. The remaining 1,555,000 to 5,000,000 tons would have to be proven by further test pitting and drilling, while some possibility exists for developing additional tonnage in other parts of the Columbia County field, in particular the Bunker Hill and Ladysmith claims, which are known to carry ore, but of unknown extent.

Exploitation of these ore bodies will involve consolidation of all holdings with construction of a few miles of rail line, shovel equipment for the Ironcrest, mine equipment for the underground workings, and ore cars for the rail transfer from all properties.

(2) California Iron Deposits

Among some of the promising ore deposits of California, high in iron, and with tonnage sufficient, if proven, to supply a large iron operation, are: (1) the Ship Mountain Iron Mine; (2) The Cave Canyon; both in San Bernardino County, southern California, east and slightly north of Los Angeles; and (3) the Eagle Mountain deposit in Riverside County.

Utilization of ores from this region would require construction of an ore loading dock at San Pedro and short rail spurs to the mines, with a longer rail transfer in between. This transportation feature is the principal objection to these deposits, but if costs can be maintained, for both the longer rail haul and short water shipment to Portland, at a figure equal to the short rail transfer and long water shipment from other suitable deposits, the use of these California ores might be found entirely feasible. This requires a field investigation, however, to gain a more detailed knowledge of the deposits themselves, and to determine the possible rates available to San Pedro for a large movement. Following are descriptions from available information.

1. SHIP MOUNTAIN. Located in San Bernardino County, 2½ miles east of Siam, a station on the Atchison, Topeka and Santa Fe Railway, 270 miles from San Pedro, this property is owned by Earl W. Paul of Upland, California, and could probably be leased on a royalty basis.

The ore is exceptionally pure, and is high grade, a large shipment showing 60 percent iron on the average. While only 38,000 tons are proven, the probable ore is reported to be upward of 9,000,000 tons. Reported analyses are as follows:

Analysis	(1) Percent	(2) Percent	(3) Percent
Iron	70.4	70.05	65.9
Phosphorus	0.006	0.007	0.002
Sulphur	1.070	0.010	0.080

The low phosphorus content, if these analyses can be considered representative, indicates that the ore could be used for producing high grade irons, or as mixing ore with the Scappoose limonite to bring the total phosphorus of the furnace charge down to the desired figure for basic iron.

Based on Lake Superior quotations, this ore would be valued, delivered at Portland furnace, at $6.75 per long ton including the phosphorus premium of 65.55 cents, while the probable cost should not exceed $5.85 per long ton, or $0.0975 per long ton unit delivered to Portland, distributed according to the following estimate:

Estimate	Cost per Long Ton	
Mining Cost*	$1.50	
Rail transfer, 270 miles	2.45	
Water transportation	1.50	
Unloading	.40	
Total	$5.85	(60 percent Fe)

* Including all charges and royalty.

2. CAVE CANYON Located in San Bernardino County, 1/2 mile north of Baxter, a station on the Union Pacific Railroad, 225 miles east of the port of San Pedro, California, the Cave Canyon deposit is estimated to contain 10,000,000 tons of a magnetite-hematite ore averaging around 60 percent iron, 1.8 percent silica, and 0.122 percent phosphorus. Being in the non-Bessemer class this ore, on the basis of Lake Superior prices, would be valued at 9.903 cents per long ton unit or $5.95 per long ton delivered at Portland, against an estimated cost as follows:

Estimate	Cost per Long Ton	
Mining Cost	$1.00	
Rail transfer, 225 miles	2.05	
Water transportation	1.50	
Unloading	0.40	
Total cost at Portland	$4.95	(60 percent Fe)
Cost per long ton unit	0.0825	

This assumes surface mining with all items estimated as low as would be practically possible. However, in view of lack of information on this deposit, the mining cost estimate must be subject to question, with a possibility that it may be substantially higher. It presents a definite prospect for reasonably low costs and will bear examination.

3. EAGLE MOUNTAIN. 1/ Located in Riverside County, in the Eagle Mountains, 45 miles east of Mecca on the main line of the Southern Pacific Railroad about 160 miles from Los Angeles, the Eagle Mountain iron deposit is estimated from exposures to contain 28,000,000 tons, with a possibility that exploration may increase the estimate by

1/ Burch, Albert: Report on Eagle Mountain Iron Deposits, June 1909, unpublished.

112,000,000 tons. Samples believed to represent fairly the exposed ore show 58 to 66 percent iron; some are Bessemer grade. The average of 20 analyses reported is as follows:

Eagle Mountain Ore	Average Analysis	Low Analysis	High Analysis
	%	%	%
Iron (Fe)	62.505	58.52	66.00
Phosphorus (P)	0.0796	0.0946	0.036
Sulphur (S)	0.169	0.206	0.137
Silica (SiO_2)	4.00	4.90	1.50
Alumina (Al_2O_3)	0.31	0.25	0.20
Lime (CaO)	0.51	1.55	0.30
Magnesia (MgO)	0.63	2.42	0.28

Much of the ore is minable by open pit methods, though in the later stages of development it would probably be mined by glory hole. Burch* estimated the total cost of mining, including fixed charges, exploration and development, to be not over $0.80 per ton.

Exploitation of this deposit requires construction of a 50-mile branch rail line over an easy route from the mine southward to the Southern Pacific, or over an equal distance to the Atchison, Topeka and Santa Fe to the north. Transportation cost for the approximately 200-mile rail haul, should be about $1.90 per ton to San Pedro docks provided sufficient tonnage were moved to justify such a rate. Year round operation is possible.

Delivery cost at a tidewater plant near Portland is estimated as follows:

Estimate	Per Long Ton
Mining Cost	$0.80
Rail transfer, 200 miles	1.90
Water transportation	1.50
Unloading	.40
Total cost at Portland	$4.60 (62.5 percent Fe)
Cost per long ton unit	0.0735

Conclusions.

The advantage to be anticipated from utilization of these California deposits is in the possibility presented to carry semi-finished and finished steel, lumber, or other Northwest products on the return trip to the

* Burch, Albert: op. cit.

San Francisco and Los Angeles markets, thus making possible both low cost ore shipment, and minimum cost of steel deliveryto compete in this large Pacific Coast market.

Acquisition of any of these properties would, if development substantially proved the probable ore and the indicated analyses, give a Portland operation an adequate ore supply of an excellent grade for an integrated steel operation.

(3) Foreign Ore Deposits.

A number of deposits of high grade ore along the Pacific slope have been pointed out by Hodge*, one of which might be used as the main source of supply of a Portland steel plant. The foreign field should be thoroughly surveyed to determine the suitability of available deposits for development. The principal requirement is that the deposit be close to tidewater, and that sufficient tonnage be shipped to maintain a low delivered cost.

Drawing ore supplies from distant foreign sources for an industry at Portland is a definite possibility. Bethlehem Steel Corporation has already set the example with its Tofo iron mine shipping from Cruz Grande, Chile, through the Panama Canal, to Sparrows Point, Maryland, a distance of about 4600 miles, in special ore boats.

In the absence of personal observation and study, the writer prefers not to recommend nor propose any of the deposits herein briefly described, this being the province of the engineer employed to survey the field. The purpose here is to call attention to the existence of properties which appear to have the necessary quality, grade and probable tonnage to warrant further study as sources of ore for an integrated iron and steel operation at Portland.

Chile. Chilean iron ore shipped to the United States totaled 938,376 long tons in 1934, and 788,725 long tons in 1935, valued at respectively $2.04 and $1.85 per ton at point of origin. This was mainly if not entirely from the Tofo mine, and went largely to the Sparrows Point and Bethlehem plants of the Bethlehem Steel Corporation. Delivery of ore from Chile to Portland would involve several hundred miles longer haul, but without Panama Canal toll should be at a slightly lower per ton cost than to Atlantic Coast points.

It appears obvious that the long water transportation involved is not a serious difficulty, though it does mean that to maintain a low unit cost, rail transfer to tidewater must be very short, mining cost must be low, and grade of ore must be high.

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* Available Raw Materials for a Pacific Coast Iron Industry: Edwin T. Hodge, published by U. S. Army, Corps of Engineers, 523 Pittock Block, Portland, Oregon.

1. TOFO MINE. Located in the Department of La Serena, Province of Coquimbo, Chile, 30 miles north of La Serena, and 4½ miles east from Cruz Grande, the ocean shipping port with which the property is connected by a 15-mile railway. Distance is 5569 miles from Portland. Special ore boats of 20,000 tons capacity are used for the traffic, with a travel time of 18 days to Atlantic Coast points.

The ore is a high-grade hematite, mined by quarry methods, and transferred by company railroad to special 30,000 ton loading pockets at Cruz Grande, where boats are loaded out in 1½ to 5 hours' time. The grade reported by Joseph Daniels in 1924 as an average of several months' analyses is as follows: Fe, 66%; phosphorus, 0.07%; manganese, 0.22%; Silica, 2.0%. Reserves reported are upwards of 100,000,000 tons of proven ore, which is being mined at the rate of nearly 1,000,000 tons yearly. Costs indicated by Daniels in 1924 are as follows:

	Per Long Ton
Mining and crushing	$0.306
Development and contingencies	0.170
Transportation	0.071
Export Tax	0.125
Other Tax	0.007
Royalty	0.250
Total production cost	$0.929

Fixed charges, including interest on investment, depreciation, etc., should bring this total close to $1.60 per ton, while transportation to Portland may be estimated at $3.80 per ton, including unloading, bringing the total ore cost up to $5.40 per long ton or $0.0818 per long ton unit.

On the basis of Lake Superior Bessemer ore at Lake Erie ports, base priced in 1937 at 10.194 cents per unit, Tofo ore of the above analysis would be valued at $6.73 per ton at Portland dock.

Obviously Tofo ore would not be available to an independent competitor except through a business arrangement with Bethlehem Steel Corporation which could be made advantageous to both parties.

2. TALTAL DEPOSITS. A number of iron ore deposits are located near and would have their outlet at the shipping port of Taltal, Department of Taltal, Province of Antofagasta, Chile. The ore consists of magnetite and hematite with grades reported from 55 percent to 65 percent iron.

Chief among these is the Potrero Mines with an estimated 12,000,000 to 40,000,000 tons of ore, about 3½ miles north of Taltal, and adjoining the cove of Hueso Parado, while 3 miles distant is the Norte Magnetico deposit showing an exposure of 162 feet length by 325 feet width of ore. Several ore bodies are said to be uncovered in the area, each of more than 30 feet width. About 4 miles east of Taltal, near Breas railway station, are the Cachina iron deposits with high grade hematite, 10 feet thick, and analyzing

55 to 59 percent iron.*

Reporting upon the Taltal district after a visit in 1924, Daniels** pointed out the ready accessibility of the Potrero ore, its proximity to the Coast, and the possibility of providing shipping facilities within a few thousand feet of the deposit. A typical analysis is as follows:

Analysis	Percent
Iron (Fe)	62 - 65
Phosphorus (P)	0.003 - 0.054
Manganese (Mn)	0.04
Sulphur (S)	trace
Silica (SiO_2)	3.1 - 8.7

On a per unit basis using the 1937 base price for Lake Superior ore, this ore laid down at Portland would be worth between 9.903 and 10.194 cents or $6.14 to $6.44 per long ton, neglecting phosphorus premiums or penalties, which would be well above the probable cost wherever surface methods can be used.

The Taltal district should be carefully investigated.

3. ALGARROBO. Located in the Department of Freirina, Province of Atacama, about 24 miles southwest of Vallenar, the Algarrobo deposit is reported to be one of the largest in Chile with an estimated 20,000,000 tons in sight and 87,500,000 tons calculated probable ore. The ore occurs in lenses of magnetite, the largest of which is 80 meters wide by several hundred meters long. The analysis is reported as follows: ***

Analysis	Percent
Iron (Fe)	68
Phosphorus (P)	0.025 - 0.064
Sulphur (S)	0.028

Based on the above analysis and the base price for Lake Superior Bessemer ore of 9.903 to 10.194 cents per unit for 1937, and neglecting phosphorus premiums or penalties, the Algarrobo ore would have a value delivered at Portland of $6.73 to $6.93 per long ton. It appears that low-cost surface mining would be possible, giving lowest per ton costs of ore in the cars, but a fairly long rail transfer to the shipping port of Huasco is involved.

* Mineral Deposits of South America: Miller and Singewald, McGraw-Hill Book Co., 1919.

** Daniels, Joseph: Professor of Mining, Engineering and Metallurgy, University of Washington, Seattle, Washington.

*** Miller, Benjamin L., and Singewald, Joseph T., Mineral Deposits of South America: McGraw-Hill Book Co., p. 267.

The Algarrobo deposit appears from the meager information available to be a desirable prospective ore source for interests seeking to build a substantial long-lived iron and steel enterprise on the Pacific Coast, and should be one of the first examined. Its availability, however, is not known. Owners in 1924 were reported to be Wm. H. Muller & Co., and Gutehoffnungshutte through a jointly controlled Dutch-German syndicate.

Coal, Coke and Limestone

The Northwest has abundant supplies of fuels and fluxes for iron and steel, within a radius of 200 miles of Portland - properties which are purchasable, or available tonnage for purchase.

Coal. Coal beds are located along the western flank of the Cascade Range from Whatcom County, in northwestern Washington, to Lewis and Cowlitz counties in southwestern Washington, as well as in the Coast Range of northwestern Oregon from Columbia County northwest of Portland to Coos County on the Oregon coast 200 miles south. These coals range from lignites to anthracite, with most of it of sub-bituminous rank. The important beds, so far as steel production is concerned, are located in the state of Washington, the original reserves of which have been estimated at 63,877,000,000 tons of all ranks as shown below, only 111,222,000 tons having been mined up to 1930.*

Rank	Estimated Coal Reserves State of Washington (Short tons)
Sub-bituminous	52,442,000,000
Bituminous	11,412,000,000
Anthracite and semi-anthracite	23,000,000
Total	63,877,000,000

Estimate of Coking Coal Reserves. The economically available coking coals are in Pierce County, about 150 miles directly north of Portland, and served by the Northern Pacific Railway. The tonnage is estimated at 125,000,000 tons.*

The Wilkeson-Carbonado field, which has been worked since the '80's, was estimated in 1924 to contain 48,700,000 tons** calculated to washed coal after allowing for mining loss. Acreage in this field is available for acquisition, ownership resting with the Northern Pacific Railroad subsidiary, Northwestern Improvement Co., Smith Tower, Seattle, Washington.

* Analysis of Washington Coals: The Coal Fields of Washington, S. H. Ash; Tech. Paper 491, U. S. Bureau of Mines, 1931, p. 11.

** Daniels, Joseph: Private Report to Puget Sound Steel Co., Seattle, Wash., Feb. 1925.

The following are typical analyses from the principal operating properties of the Pierce County field:

Analysis	No. 2 Wilkeson	No. 5 Wilkeson	Fairfax No. 1	Carbonado No. 8
	%	%	%	%
Fixed Carbon	63.6	60.7	63.8	49.6
Volatile	19.8	29.9	21.3	32.3
Sulphur	0.5	1.2	0.7	0.5
Ash	16.6	9.4	12.0	15.0
B.t.u. per pound	12,770	14,090	13,240	12,340

Owing to the high ash content, typical of the Washington fields, Pierce County coal must be washed, which results in a relatively high cost. Production is only about 2½ tons per man-day, with costs being about $3.75 to $4.00 on board cars at the mine.

As the logical procedure would be to locate the coke ovens at the proposed steel plant, the coal would be shipped via the Northern Pacific to Portland, taking a rate of $1.71 per short ton. Thus the total delivered cost would be $5.46 per short ton at the ovens.

A typical ash analysis* of a No. 2 Wilkeson coal sample carrying 16.7 percent ash is as follows:

Ash Analysis	Percent
Silica	44.6
Alumina	34.6
Iron	13.1
Lime	4.7
Magnesia	1.2
Phosphorus	0.61
Percent of dry coal	16.7

Coke. The Pierce County coal will yield 70 percent coke, of which about 5 percent is breeze and nut coke. The blast furnace requires roundly 1 ton of furnace coke to produce a ton of pig iron. Thus to produce 160,000 tons of pig iron annually there will be needed 160,000 tons of furnace coke, and there will be available for sale 12,000 tons of breeze and nut.

Altogether, this will require 246,000 tons of coal with the following approximate yields when coked:

Coal	246,000 tons
Furnace coke, 65%	160,000 tons to blast furnace
Breeze, 5%	12,000 tons burned or sold
By-Products	Per ton of Coal coked
Oven gas	11,000 cubic feet @ 600 B.t.u.
Tar	6.8 gallons @ 160,000 B.t.u.
Light Oils	2.5 gallons
Ammonia	8 pounds

* Analysis of Washington Coals: Tech. Paper 491, U.S. Bureau of Mines, pp.100-1.

Estimated Cost of Coke		Per ton of Coal	Per ton of Coke
Coal, delivered		$5.46	$8.15
Conversion cost*		2.75	3.93
Total		$8.21	$12.08
By-product credit		3.77	5.38
Gas @ $0.28/M cu.ft.	$3.08		
Tar @ $0.35/gal.	0.24		
Light Oil	0.35		
Ammonia	0.10		
Net cost per ton of coal		$4.44	
Net cost per ton of coke, f.o.b. oven			$6.70

* Including charge for blast furnace top gas @ $0.16 per million B.t.u.

In this estimate it is assumed that the coke oven is part of an integrated operation comprising coke oven, blast furnace, steel works and rolling mill. It is assumed also that the general design would provide for burning the 90 B.t.u. blast furnace top gases under the coke ovens, and for discharging the 600 B.t.u. coke oven gas into the gas mains to be sold for domestic use. Tar would be used by the open hearth department which would be charged 21.7 cents per million B.t.u. or the equivalent of fuel oil at $1.35 per barrel. The light oil and ammonia would be sold on the market.

Below are coke analyses for Wilkeson and Fairfax coals resulting from large scale oven tests.

Pierce County Coke Analysis	Wilkeson*	Fairfax*	#2 Wilkeson	#5 Wilkeson
	%	%	%	%
Fixed Carbon	82.18	82.68	84.76	87.2
Volatile	1.23	1.30	2.14	0.5
Ash	16.59	16.02	12.72	12.3
Sulphur	0.54	0.47	0.83	1.0
Moisture	6.59	4.03	0.38	-
Phosphorus	-	-	0.084	-
Thermal value B.t.u. /#			12,088	12,440

Limestone. The limestone resources of the Northwest are abundant, though located at some distance from Portland. The Grants Pass district in southwestern Oregon, areas in northeastern Oregon, the Stevens county district of northeastern Washington, and areas in northwestern Washington, contain lime rock of sufficiently high grade for fluxing purposes; but because of their distance the rock now being shipped to Columbia River sulphite pulp mills incurs transportation costs of $2.10 to $2.75 per ton.

* Coke yields: Wilkeson 72.57%; Fairfax 76.84%. From by-product coking tests, Koppers Co., Pittsburgh.

Beaver Portland Cement Company is one of the principal suppliers of stone to the pulp mills, with a quarry in the Grants Pass district about 3 miles from Wilderville on the California and Oregon Coast railroad which connects with the Southern Pacific at Grants Pass. Stone from this district has the following reported analysis:

	Percent
Lime (CaO)	55.10
Magnesia (MgO)	tr.
Silica and insoluble	0.06
Alumina (Al_2O_3)	
Iron (Fe_2O_3)	0.90
Loss on Ignition	43.88
$CaCO_3$	98.39

With a rail rate to Portland quoted at $2.10 per ton, and an estimated quarry cost of $1.00, the delivered cost to a consumer in the Columbia River area should be about $3.50 per ton for stone from this district, including delivery to the loading bins at Wilderville.

Oregon Portland Cement Company owns a cement plant at Oswego, just south of Portland, and a limestone quarry at Lime, northeastern Oregon. The company does not now supply other than its own requirements, but could do so. Freight from Lime to Portland is now $2.30 per ton, and the quarry cost should be estimated at about $1.00 f.o.b. cars, making a total cost to a Columbia River consumer about $3.30 per ton delivered.

The analysis* is reported as follows:

	Percent
Lime (CaO)	54.76
Magnesia (MgO)	0.75
Silica (SiO_2)	1.13
Alumina (Al_2O_3) and Iron (Fe_2O_3)	0.43
Loss on Ignition	43.04
$CaCO_3$	97.80

* Selected; quarry run lower grade.

Other sources of high grade limestone are northeastern Washington, with a freight rate of $2.75 per ton to the Columbia River area; and northwestern Washington, with a similar rate. While there is no scarcity of available limestone, the probable cost of high grade rock for fluxing should not be estimated at less than $3.50 laid down in the Columbia River area.

Iron and Steel Scrap

The Pacific Coast is a heavy exporter of iron and steel scrap, which in the interest of the country should be kept at home and reprocessed to the maximum extent possible. Chiefly these exports have been purchased by Japanese and shipped to Japan as a raw material for its government subsidized steel industry, enabling them to increase production and at the same time decrease costs, which in effect constitutes a further subsidy of a competing industry by the United States producers who permit this valuable raw material to be exported.

Already Pacific Coast steel works are utilizing a large percentage of scrap in the production of their ingot, and the answer to the complete utilization of this raw material is further steel capacity.

The five Pacific Coast customs districts and Hawaii exported 377,216 long tons of iron and steel scrap, tinplate scrap and waste, and waste-tinplate in 1938, and 542,092 long tons in 1939, as shown in table 21.

Table 21

Exports of Scrap Iron and Steel and Tinplate Scrap from Pacific Coast Customs Districts, Years 1935, 1936, 1937, 1938, 1939, (in long tons).

Pacific Coast and Territorial Scrap Exports	1935*	1936*	1937*	1938*			1939**
	Iron, Steel, and Tinplate Scrap			Iron and Steel Scrap	Tinplate Scrap	Waste, Waste-Tinplate	Iron, Steel Tinplate Scrap
	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)
Customs District:							
San Diego	6,087	3,034	5,712	8,601	-	-	5,515
Los Angeles	84,948	67,551	108,559	159,846	655	50	197,387
San Francisco	69,000	55,854	52,962	57,726	1,524***	111	59,044
Oregon	71,416	54,323	115,622	84,015	-	-	160,756
Washington	59,187	40,516	59,852	55,564	700***	50	119,390
Alaska	-	5,484	-	10	-	-	-
Hawaii	1,546	7,421	10,978	9,364	-	-	-
Total Export	292,184	234,183	353,685	375,126	2,879	211	542,092

* U.S.Dept. of Commerce, Foreign Commerce and Navigation of the U.S.,1935-1938.
** Iron Age, July 4, 1940; p.67.
*** Includes tinplate circles, strips, cobbles, and scroll shear butts.

Steel scrap on the Pacific Coast is normally quoted at $10.50 to $11.00 per ton for No.1 heavy melting, and $9.50 to $10.00 for No.2 heavy melting steel, though varying somewhat above and below these figures depending upon demand.

Freight rates by coastwise boats from California to Portland are as follows per short ton of 2000 pounds:

Iron and Steel Scrap Water Rate*		Rate Per Short Ton	Minimum Carload
From:	To:		(pounds)
San Francisco	Portland	$4.80	30,000
Los Angeles	Portland	6.00	30,000
San Diego	Portland	7.50	30,000

* Pacific Coastwise Freight Tariff Bureau, Tariff no.29, July 1940.

THE ELECTRIC POWER SITUATION

Bonneville Dam. The Bonneville project is located at tidewater, 40 miles east of Portland, on the navigable Columbia River 144 miles from the mouth. It was built as a combined power and navigation project, providing ultimately 518,400 kilowatts in ten generator units of which Nos.1 and 2 units, each of 43,200 Kw. capacity, are now installed and operating, two 54,000 Kw. units, Nos.3 and 4, are being installed for operation in early 1941, and the remaining six units, each to be of 54,000 Kw. capacity, will be installed as fast as the power demand warrants.

Power rates set by the Bonneville Power Administration in charge of power sale have been quoted as follows:

Bonneville Power	Switchboard Rate* (at site)	Rate on Transmission System*
Firm power	(per Kw. yr.) $14.50	(per Kw. yr.) $17.50

* Based on 85 percent power factor.

These rates are to be charged for the output of the initial units, the period of contract being for 20 years with a provision for review not less frequently than once in 5 years. Subsequent installation of additional generator units is expected to result in a reduction of the quoted rates.

The administrator will deliver power at the switchboard directly to a damsite industrial consumer, who must construct his own tranmission line to his plant. Power is three-phase, 60 cycle, generated at 13.8 Kv. Delivery to "at site" consumers will be at generator voltage.

Consumers located outside of the 15-mile limit may receive power over the Bonneville transmission system either by direct connection or through the distribution system of the utilities in whose distributing area the plant may be located. Power delivered directly to a consumer will be sold by the Bonneville Power Administrator at a uniform rate anywhere on the transmission system. If delivered through the distribution system of a public or private utility the additional charge, if any, would be subject to negotiation with that agency.

Bonneville Schedule A-2. This schedule provides a rate of $14.50 per kilowatt of contract demand per year for firm power, and is applicable to any location within a distance of 15 miles above or below the dam. This is the at-site or switchboard rate.

Bonneville Schedule C-2. The C-2 schedule provides a rate of $17.50 per kilowatt of contract demand per year for firm power, and is applicable to any location in the Pacific Northwest reached by the Bonneville transmission lines.

Bonneville Schedule H-1. This is the dump power schedule providing a flat rate of 2.5 mills per kilowatt hour of actual usage, and is available at any point on the transmission system designated by the Administrator. Dump power is sold only when, as and if available, but as a condition the purchaser is required to maintain standby capacity. Use of dump power at 2.5 mills per kwh. is equivalent in cost to use of at-site firm power at 66 percent load factor.

Bonneville Schedule F-1. This schedule is for low load factor loads. It provides a service charge of 75 cents monthly per kilowatt of contract demand, with an energy charge of 2.5 mills per kilowatt hour of usage.

Power Rate for a Steel Plant

The calculated rate for a steel plant given in the first edition of this report was based upon the power rates quoted in the Bonneville schedules in 1938. However, since publication of the report the rate base has undergone a change, and the secondary power rate has been eliminated. This leaves only the firm power rates quoted at 1.65 mills at the generators, and at 2 mills transmitted, together with the 2.5-mill dump power rate, upon which to base an operation.

Since the dump power rate is higher than the firm power rate, its usefulness to a steel plant is limited to that variable portion of the demand that may be supplemental to the base load of firm power.

Thus a contract would be designed to provide a firm power demand adequate for all normal capacity operation, and for any excess over this demand dump power may be used when, as and if available.

Rate for Electric Furnaces. Since costs must be based upon normal operation, the basis to be used for electric furnace calculations in this report will be the firm power rate, as follows:

Plant Location	Rate
1. At Portland	2.00 mills per kwh.
2. At the dam-site	1.65 mills per kwh.

If electric smelting is to be practiced a power cost differential of 75 cents to $1.00 per ton of pig iron would exist in favor of a damsite location using the 1.65 mill rate.

Rate for Blast Furnace. If blast furnace smelting were practiced it is considered to be of more importance to locate a plant in the vicinity of Portland to dispose of coke oven gas, and to obtain low transportation costs on the fuel and flux, than it is to reduce the power cost for the rolling mill by a damsite location. The rate to be used here, therefore, should be that of the C-2 schedule, i.e., 2.00 mills per kwh.

ELECTRODES

Carbon electrodes for electric steel furnaces, or for electric pig iron furnaces, must be shipped from Niagara Falls. The quoted prices on the amorphous carbon, nipple jointed electrode, 17 inches diameter and larger, are as follows per 100 pounds.

Electrodes	Per 100 pounds	Cents per pound
Prices f.o.b. Niagara Falls	$6.50	6.5
Freight to Portland*	1.19	1.19
Total cost, delivered	7.69	7.69

*Minimum shipment 45,000 pounds; for 30,000 minimum, rate is $1.60.

THE POSSIBLE SETUP FOR A PORTLAND STEEL WORKS AND ROLLING MILL

Capacity. For consideration of the economics of a steel plant in the Columbia River area, it is proposed that the plant have a capacity of 180,000 long tons of finished rolled steel products, of which 100,000 tons are black plate for tinning, and 80,000 tons are black sheet, merchant and reinforcing bar, structurals, and possibly wire rod for wire manufacture.

Table 22

Proposed Capacity of a Portland Steel Works and Rolling Mill (in long tons of 2240 pounds).

Pacific Market Deficiency Product	Indicated Deficiency*	Proposed Capacity	Percent of Deficiency
	(tons)	(tons)	(tons)
Tinplate	362,000	100,000	27.6
Sheets	160,000	35,000	21.9
Bars, rods	110,000	10,000	9.0
Structurals	170,000	30,000	17.6
Castings		5,000	
Proposed capacity		180,000	22.4
Ingot requirement:		260,000	
Pig Iron	55%	160,000	
Scrap Iron	45%	132,000	

* Requirement of Pacific Market not met by Pacific Coast production.

While the above tonnages are set forth for the purpose of dealing with a concrete proposal, it is quite probable that other combinations of products or tonnages may be more suited to the working out of a definite enterprise. The tinplate needs of the Pacific market may justify confining the entire plant to this product, provided suitable arrangements would be made with the principal consumers, American Can Co. and Continental Can Co., to supply their need. This involves questions of policy, present contractual relations or financial tieups, the nature of which the writer has made no attempt to discover, and cannot presume to anticipate. On the other hand the total tonnage might be divided among the various other products including skelp for pipe manufacture, or rail and track material, forged balls for ball mills, plate and sheet, structurals and bar.

In consideration of the type of product and the tonnage possible, it should be borne in mind that the Columbia River area, of which Portland is the hub, has no steel capacity other than castings plants and fabricators, and that the normal rolled steel market of a growing industrial area, chiefly bars, structurals, sheets, pipe and castings, would be supplied and possibly controlled by the proposed plant. Thus, whatever the future of the area may be, a plant now entering the field would be in the best position to progress and maintain its position in the local market, while gaining a foothold in the more distant domestic and export markets.

The ingot capacity for the proposed steel works would be 260,000 long tons, assuming 89 percent conversion from pig iron and scrap, for which gas and oil fired basic open hearth furnaces would be required. If steel castings or alloy steels were contemplated some tonnage might be converted in the electric furnace.

It is unlikely that more than 55 percent pig iron would be used in the furnace charge, which would indicate a requirement of 160,000 long tons annually. The minimum scrap iron usage would be about 45 percent or 132,000 long tons annually as compared with some 375,000 tons exported in 1938 from Pacific Coast customs districts.

The Pig Iron Plant

Two possibilities exist for obtaining the necessary pig iron for the works: (1) shipment from the Columbia Steel Co. plant at Provo, Utah, by rail; and (2) establishment of a coke oven and pig iron plant to operate in connection with the steel works.

1. Should United States Steel Corporation or its Pacific Coast subsidiary be interested in expanding its capacity into the Portland area, the logical move would be to increase the capacity of the Provo plant by addition or a second blast furnace and to ship its pig iron by rail to the Columbia River. This would involve a transportation cost of $5.50 per long ton laid down, but would be preferable from this company's viewpoint to developing a foreign ore source and shipping ore in by water.

From every point of view United States Steel should find such an operation desirable, since it has no steel capacity north of the

San Francisco Bay area, and could well afford to establish itself near Portland, not only to bring its Pacific Coast capacity up in those products in which the Pacific Market is deficient, but to move closer to a developing Northwest market to which it now must ship from California or from the Eastern States.

2. Should Bethlehem Steel Corporation be interested, it should consider increasing its Tofo, Chile, operation, adding additional ore boats, and establishing a pig iron plant in connection with a steel works in the Columbia River area. Since this company has now no Pacific Coast source of pig iron for its Seattle, San Francisco and Los Angeles steel works, a furnace at Portland would supply an existing need, while a Columbia River steel works would supplement its Seattle plant in supplying the Northwest with steel, and provide its Pacific tinplate market with a source of supply closer than the Sparrows Point plant at Baltimore. Its returning ore boats would carry pig iron, steel and lumber to California, and possibly California fuel oil to South American points.

The corporation would also have available low-cost Bonneville power for its rolling mill, and could go into the production of "Bethanized" or electro-coated wire for the Western and export market, by establishing a wire plant and purchasing its zinc concentrates from western mines.

3. An independent producer would have to develop his own ore source, and acquire the Scappoose limonite ore to supply his pig iron plant. This would involve a large investment in equipping and developing the mines, building ore docks, ore boats, and unloading docks for the traffic.

Both the independent and the Bethlehem Steel Corporation would have to acquire a coal property and install coking ovens, while U. S. Steel with its blast furnace plant already in operation in Provo, Utah, would be concerned only with increasing its capacity there.

Discussion of the Pig Iron Plant. The principal factor which has retarded the development of producing capacity on the Pacific Coast, while the needs for iron and steel have been steadily expanding, has been the problem of coking coal of the usual quality desired for the blast furnace. While coal reserves amount to billions of tons in Western Washington between the Columbia River and the Canadian border, the ash content is generally high and the grade is largely non-coking lignitic to bituminous. Pierce County, Washington, has bituminous coal of coking grade, which, though requiring washing to bring the ash down to as low as 10-14 percent. is nevertheless suitable for blast furnace coke when coked in by-product ovens, as demonstrated by actual tests in standard size ovens.*

Establishment of a blast furnace on the Pacific Coast to operate with Pierce County coke, therefore, is a metallurgical possibility, though the cost of coke at the ovens will be higher than that in the Pittsburgh district, or at the Provo, Utah, plant, due to high cost mining and the necessary

* Report to the Puget Sound Steel Company on Wilkeson and Fairfax-Washington Coals by Chicago By-Product Coke Company, Chicago, Ill., July 1-8, 1925.

washing to reduce the ash content. The Portland Gas & Coke Co., which is producing ordinary coke from petroleum residues, is carrying some research to determine the feasibility of producing coke with texture and other qualities acceptable for blast furnace uses.

Considering the high cost of coke, having the necessary structural strength to be suitable for blast furnace smelting, the possibility that electric power might be economically substituted for that part of the coke used in fusing the charge has been explored. A study in 1936 indicated that electric smelting would be economically feasible provided seasonal power could be obtained for 1 mill per Kwh., or firm power for 1.5 mills per Kwh., the indicated production cost being about $21.00 per long ton with labor cost averaging $0.50 per hour.. With a firm power rate of 1.65 mills the cost of power per ton of pig iron would be increased about $0.30, while with the 2.00 mill rate the increase would be about $1.40 per ton of pig iron.

Estimated Cost of Blast Furnace Pig Iron. A blast furnace could be located at any point in the Portland area suitable for transportation to obtain lowest cost of coal and limestone delivery. It could be suitably located for running a pipe line for coke oven gas to the city of Portland for disposal through the city gas mains, and for delivering coke from the ovens to the city for sale to domestic consumers.

Assuming a pig iron requirement of 160,000 long tons, the estimated cost of production in a 500-ton blast furnace in the Portland area would be as shown below, per long ton of basic pig iron:

Table 23

Estimated Cost of Production of Basic Pig Iron at a Location near Portland (per long ton of 2240 pounds)

	Amount	Unit Value	Total Cost
	(tons)		(per ton)
Ore mixture, long tons	1.42	$5.40	$8.70*
Coke, short tons	1.00	6.70	6.70
Limestone, short tons	0.46	3.50	1.60
Labor			1.60
Relining			0.30
All other costs			1.70
Total plant cost			$20.60
By-product credit			0.85
Net plant cost			$19.75
Overhead and capital charges			2.00
Total estimated cost per long ton			$21.75

* Including cost of manganese ore addition.

Tofo ore is used as the basis at a cost of $5.40 per long ton or $0.0818 per long ton unit delivered. If Oregon ore were used exclusively at a delivered cost of $3.30 per long ton or $0.0755 per long ton unit the ore cost would be reduced to $7.60 per ton of pig iron, but the higher coke and limestone usage required for the lower grade ore offsets any saving here.

The coke cost assumes a coke oven plant alongside the blast furnace, with Pierce County coking coal being received by rail at a total cost of $5.95 per ton laid down, underfiring ovens with blast furnace top gases, charging tar and coke oven gas to the open hearth department, and selling the surplus oven gas for domestic use in the Portland gas mains.

The by-product credit is the surplus top gas of the blast furnace calculated at 57,500 cubic feet of 92 B.t.u. heat content per cubic foot charged to the coke ovens, and other departments, at 16 cents per million B. t. u.

Estimated Cost of Electric Furnace Pig Iron. The electric furnace, while not being used in the United States for pig iron production, is successfully operating in Sweden and Norway where water power is cheap and coke cost is high. Its utility in the Portland area would depend entirely upon the rate available for power, a 1.5 mill per Kwh. firm power rate being about the maximum that would be economically possible for electric iron smelting with the present Swedish or Norwegian furnace.

The characteristic of electric smelting is the small units and the resulting flexibility in producing varying analysis irons, but as this is unnecessary for the production of basic steel-making iron, it would have no special advantage in the proposed operation near Portland.

Production of 160,000 tons of pig iron yearly would require approximately 45,000 kilowatts of power and a plant of ten 5000 Kwh. furnaces. Power required averages close to 2400 Kwh. per ton of basic pig iron, and up to 3000 Kwh. where high silicon foundry irons are produced. Electrode consumption depends upon the power input and furnace conditions, but may be placed at 20 pounds per ton of pig iron for the Soderberg type electrode that is in general use in the Scandinavian furnaces.

Of the two types of furnace in use, the Norwegian Spigerverk or Tysland-Hole pit type of furnace would be most suited to the Portland area, as it is designed for the use of coke breeze in the charge, whereas the Swedish shaft type, in appearance likethe blast furnace, is designed for charcoal as the reducer.

As the electric power is the source of heat, and carbon is used only for reduction, the coke used is less than half that required in the blast furnace, the amount being dependent upon the grade of pig iron and the type of ore, as well as upon the furnace conditions and the composition of the exit gas. It will usually take 850 to 900 pounds of coke or charcoal per long ton of pig iron. Either magnetite or hematite can be smelted.

Table 24 is an estimate of the cost of electric smelting in a pit type furnace using the same ore as in the blast furnace cost estimate with a record of the cost of production of blast furnace pig iron in the Eastern Pennsylvania field for comparison.

Table 24

Estimated Cost of Basic Pig Iron Production at Portland by Electric Smelting, Using Chile Ores (per long ton).

Item	Unit Cost	Amount	Cost of Basic Pig Iron With Power at 1.65 mills per Kwh.	Eastern Pennsylvania Maryland Field** Year 1929
Materials				
Ore mixture	$5.40	1.42	$8.70*	$8.23
Flux	3.50	0.285	1.00	0.47
Coke***	5.90	0.426	2.51	5.90
Power, Kwh.	-	2400	3.97	
Electrodes****	0.05	20	1.00	
Total materials			$17.18	$14.60
Plant cost				
Labor and superintendence			$ 2.70	
Repairs, other expense			0.85	
Total Plant cost			$ 3.55	$ 2.80
By-product credit			0.95	0.89
Net plant cost			$ 2.60	$ 1.91
Fixed charges			2.11	2.41
Total cost per long ton of electric pig iron			$21.84	$18.92

Ore Analysis	(Percent)	Pig Iron Analysis	(Percent)
Iron (Fe)	66	Iron (Fe)	94.0
Alumina (Al_2O_3)	--	Carbon (C)	3.75
Silica (SiO_2)	2.0	Silicon (Si)	0.9
Phosphorus (P)	0.7	Phosphorus (P)	0.1
Sulphur (S)	-	Sulphur (S)	-
Manganese (Mn)	0.22	Manganese (Mn)	1.75

* Including cost of Manganese ore addition.

** Blast furnace costs for 789,282 long tons of foundry iron 1929-1930.

*** Cheaper coals can be used for electric furnace coke, as structural strength is unnecessary. Thus the coke cost is lower than the furnace grade for the blast furnace.

**** Unit cost is for Soderberg electrodes. If preformed carbon electrodes are used the cost would be $0.54 additional.

Owing to the large amount of slag produced with low-grade ores it is desirable in electric smelting to use ores of 60 percent iron or over in order to keep the heat losses and thus the power consumption down to a reasonable point. For this reason the high-grade Chile hematite or magnetite ores are preferable to the lower grade Columbia County, Oregon, limonite ores although mixtures of the two would be satisfactory as a furnace charge.

The above cost estimate is valid for the assumed conditions only. The probable cost will be possible of estimation only when certain of the factors as to ore supply and grade, flux and fuel, and plant location can be more accurately fixed. The costs assumed are believed to be reasonably expectable.

The Steel Plant

The steel works proposed for the Portland area would require an annual output of about 260,000 long tons of ingot, chiefly basic open hearth, with a small tonnage of electric ingot for refined or alloy steels and castings. Some discussion has arisen as to the possibility of a plant using electric furnace conversion for the total tonnage, but this can be eliminated with an integrated operation of the type herein considered. From the viewpoint of fuel cost alone, the lowest cost probably available for electric power would be about 48 cents per million B.t.u. at 1.65 mills per Kwh. as compared to 18.5 cents for fuel oil, and less for pig iron furnace top gases. Obviously then, use of the electric furnace in the Portland area would be confined to the refining of steel for producing the higher grades of steel and steel alloys, as is done in other sections of the country. No further consideration need be given to the electric furnace except as auxiliary equipment.

Fuel for the Steel Plant. In providing the fuel requirements for the steel works and rolling mill, it is probable that considerable fuel oil will be necessary to supplement the pig iron furnace top gases and the coke oven by-product gas and tar.

The August 1940 posted price of fuel oil at the oil company docks on the Willamette River, North Portland, is $1.10 per barrel of 42 gallons, about 336 pounds, averaging 18,500 B.t.u. per pound or 6,216,000 B.t.u. per barrel. If the steel works is located near Portland the maximum cost of barging to the works would be $0.05 per barrel, resulting in a total cost of $1.15 per barrel or $0.185 per million B.t.u. of thermal value.

Using Blast Furnace. Out of a total of approximately 24,000,000 B.t.u. in the 2000 pounds of coke charged to the blast furnace per ton of pig iron produced, about 48 percent or 11,500,000 B.t.u. is withdrawn from the furnace in the top gases, and used in underfiring the coke ovens, firing the hot blast stoves, as well as in steam generation for driving the blowing engines or turbo blowers for the blast, the surplus being converted to electric power in turbo generators. Thus with the fuel requirements of the pig iron plant and coke ovens taken care of, the remaining needs of the open hearths, soaking pits and heating furnaces must be taken care of by the tar and coke oven gas of the coke plant, or by fuel oil.

Since the coke ovens will be required to produce 172,000 tons of furnace coke and screenings annually from about 246,000 tons of Pierce County coking coal, there will be available annually 2,700,000,000 cubic feet of oven gas averaging about 560 B.t.u. per cubic foot debenzolized, or 11,000 cubic feet per ton of coal coked.

The open hearth requires 5,000,000 B.t.u. more or less per long ton of ingot production, or a total of 1,300,000 million B.t.u. for the yearly production of 260,000 long tons. This is about 73 percent of the thermal content of the coke oven gas and tar available.

However, as the oven gas might be substantially sold through the city gas mains at a price in excess of the value of fuel oil of equivalent thermal content, it would be preferable to sell the gas and buy oil, and therefore the open hearths and heating furnaces should be charged for the heat needed at the rate of about $0.185 per million B.t.u. which is the 1940 fuel oil value at $1.15 per barrel delivered to a plant near Portland.

Using Electric Pig Iron Furnaces. The picture is somewhat different using the electric furnace for pig iron production as there is needed for reduction only about 850 pounds of coke, with about 10,400,000 B.t.u. per ton of pig iron output, of which about 6,000,000 B.t.u., or 20,000 cubic feet of gas of 300 B.t.u. heat content per cubic foot pass out in the top gas.

The coke requirement being only 70,000 tons from 100,000 tons of coal, the tar and coke oven gas will also be reduced, but as there are no hot blast stoves to heat, and the fuel needed to underfire the ovens and drive the blowing engines is correspondingly reduced, the smaller volume and richer pig iron furnace top gases can be diverted substantially to the open hearth furnaces along with the by-product coke oven gas and tar. Thus both the coke ovens and open hearth heat requirements would be taken care of, leaving only the soaking pit and heating furnace fuel to be supplied by purchase of fuel oil.

As in the case of the blast furnace setup it would appear advisable to market the coke oven gas and purchase fuel oil for both the open hearths and heating furnaces to supplement the pig iron furnace top gas. Thus the ingot is charged with 50 percent furnace top gases at 16 cents per million B.t.u. and 50 percent fuel oil at 18.5 cents per million, averaging 17.25 cents per million B.t.u. and the electric furnace is credited with 6,000,000 B.t.u. in the top gases at 16 cents per million. The coke oven will receive the market price for its by-product gas.

Estimated Cost of Steel Ingot. For purposes of estimate of the probable cost at a Portland location, a ratio of 55 percent pig iron to 45 percent scrap has been used as a basis, while the actual ratio on the Pacific Coast is very much lower, in some cases 100 percent scrap iron being used. The cost of purchased and mill scrap and scale charged to the open hearth has been set at $10.00 per ton. Local scrap should be obtained at a lower figure while shipments from California may be higher. Fuel cost is based on 100 percent fuel oil. Fluxes and refractories costs are based on current prices. Labor wage rates in the Northwest are generally comparable to those of the mid-western field. Common labor is paid 40 to 50 cents an hour, while the semi-skilled labor in Northwest industries receives 50 to 65 cents an hour. On the basis of the trend toward boosting wages in the industry, 60 cents has been used as the probable average hourly labor cost at Portland. Other items are in line with regular practice in the steel industry. Considered as a whole the estimate is an indication of the probable costs rather than an accurate analysis which it is not possible to make. It includes overhead and capital charges against all materials used, but does not include these charges for the steel works operation, which should be added to arrive at the overall cost of ingot.

Table 25

Estimated Cost of Open Hearth Steel Ingot at a Portland Plant, based on 1937 Cost of Labor and Materials (per long ton of 2240 pounds).

Items for Producing Steel Ingot	Amount	Unit Value	Cost Per ton of Ingot
	(Lbs.)	(per ton)	
Materials Costs			
Pig Iron	1380	$21.75	$13.40
Scrap, scale	1140		5.45
Fluxes:			
Limestone	210	3.50	0.37
Fluorspar	8		0.14
Ferro-alloys			0.55
Fuel oil, gallons or equiv.	34		0.93
Operating Costs			
Labor			2.30
Relining, renewals			1.05
Molds and stools			0.40
Refractories			0.45
Other items			0.70
Total Furnace Cost	2240		$25.74*

* For a charge of 45 percent total scrap and 55 percent pig iron. Increasing scrap provides reduction of ingot cost to a probable minimum of $19 to $20 per ton.

SUMMARY AND CONCLUSIONS

The reader is referred to the first pages of this report for the summary and conclusions.

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