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IN THE
District Court of the United States
FOR THE SOUTHERN DISTRICT OF NEW YORK

UNITED STATES OF AMERICA,
Plaintiff,
v.

THE INTERNATIONAL NICKEL COMPANY OF
CANADA, LIMITED, THE INTERNATIONAL
NICKEL COMPANY, INC., ROBERT C.
STANLEY, JOHN F. THOMPSON, and PAUL
D. MERICA,

Defendants.

Civil No.
36-31

COMPLAINT

*To the Honorable the Judges of the
District Court of the United States
for the Southern District of New York:*

The United States of America, Plaintiff, by its attorneys, acting under the direction of the Attorney General of the United States, brings this action against the defendants and complains and alleges as follows:

I

JURISDICTION AND VENUE

1. This complaint is filed and this action is instituted against the defendants under Section 4 of the Act of Congress of July 2, 1890, c. 647, 26 Stat. 209, as amended, entitled "An Act to protect trade and commerce against unlawful restraints and monopolies", commonly known as the Sher-

man Act, in order to prevent and restrain continuing violations by defendants, as hereinafter alleged, of Sections 1 and 2 of the Sherman Act.

2. Each of the corporate defendants has an office at 67 Wall St., Borough of Manhattan, City, County and State of New York. Each of said corporate defendants transacts business and is found within the Southern District of New York.

II

DEFENDANTS

Corporate Defendants

3. The International Nickel Company of Canada, Limited (hereinafter referred to as "Inco, Ltd.") a corporation organized and existing under the laws of the Dominion of Canada, with executive offices and principal place of business at 67 Wall St., New York, New York, is made a defendant herein. Inco, Ltd.'s principal executive officers, including the Chairman and President, the Executive Vice-President (and one other Vice-President,) the Treasurer, the Secretary and the Comptroller, maintain their offices and a permanent organization at 67 Wall Street, Borough of Manhattan, New York City, and are at that location actively and continuously engaged in transacting the business of Inco, Ltd. The Board of Directors and Executive Committee of Inco, Ltd. hold frequent meetings at said address, and the main files and accounts of Inco, Ltd. are there maintained and kept.

4. The International Nickel Company, Inc. (hereinafter referred to as "Inco, Delaware"), a corporation organized and existing under the laws of the State of Delaware, with offices and principal place of business at 67 Wall St., New York, New York, is made a defendant herein. From

1928 to 1936, the entire capital stock of Inco, Delaware was held by Inco, Ltd. In or about 1936, Inco, Ltd. transferred all of said capital stock of Inco, Delaware to Anglo-Canadian Mining and Refining Company, a Canadian corporation and wholly-owned subsidiary of Inco, Ltd.

Individual Defendants

5. Robert C. Stanley, a resident of Staten Island, New York, is made a defendant herein. From 1918 to 1921 he was Vice-President and a director, and from 1922 to 1928 President and a director, of The International Nickel Co., the predecessor of defendant Inco, Ltd. From 1928 to 1937 he was President and a director, and since 1937 he has been and now is President and Chairman of the Board of Directors, of defendant Inco, Ltd. Since 1928 he also has been and now is President and a director of defendant Inco, Delaware.

6. John F. Thompson, a resident of New Canaan, Connecticut, is made a defendant herein. From 1931 to 1937 he was Vice-President and a director, and since 1937 he has been and now is Executive Vice-President, of defendant Inco, Ltd. In 1928 he was Secretary, Treasurer and a director, from 1930 to 1935 he was Vice-President and a director, and since 1935 he has been and now is Executive Vice-President and a director, of Inco, Delaware.

7. Paul D. Merica, a resident of Millwood, New York, is made a defendant herein. Since 1934 he has been and now is a director, and since 1937 he has been and now is Vice-President, of Inco, Ltd. Since 1932 he has been and now is a director, and since 1936 he has been and now is Vice-President, of Inco, Delaware.

8. Each of the individual defendants has participated and now participates in the direction and management of the defendant corporations employing him or of which he is

an officer or director, and particularly in those corporate affairs, policies, and acts described in this complaint. Each of the individual defendants has authorized, ordered, or done some or all of the acts done by his corporation constituting the offenses hereinafter complained of.

III

DEFINITION OF TERMS

9. "Commercial nickel", as used herein, shall mean: (a) unwrought metallic nickel in the usual commercial forms including, but without limitation to, shot, ingots, cathodes, bricks, cubes, and powder; and (b) nickel contained in nickel oxide.

10. "Nickel products", as used herein, shall mean: (a) rolled metallic nickel in the usual commercial forms including, but without limitation to, sheets, strips, bars and rods; and (b) alloys of nickel, the nickel content of which is above sixty (60) per centum.

11. "Nickel-bearing materials", as used herein, shall mean nickel ores, concentrates, mattes and speisses.

IV

TRADE AND COMMERCE

A. The Commodities

12. Nickel is a grayish-white elemental metal which is used commercially both in its pure state and in combination with other metals. It is one of the most important non-ferrous metals and is characterized by excellent durability and corrosion resistance. When alloyed with other metals such as copper, iron and steel, it contributes qualities of high strength, toughness and resistance to corrosion.

13. Nickel does not occur in nature as a pure metal but is found in combination with other elements in mineral formations of various types. The ores that are worked primarily as sources of nickel fall generally into four classes namely: (a) sulphides, represented especially by the ores of the Sudbury region of Canada in which the nickel is found in combination with a high percentage of copper and some precious metals; (b) silicates or oxidized ores, found principally in New Caledonia; (c) arsenical ores, which are found in Canada and elsewhere; and (d) nickeliferous iron ores, such as those of Cuba.

14. Although the character of the nickel-bearing mineral deposits varies widely according to the location of the respective deposits, there are three basic steps in the production of refined nickel for commercial use. These are (a) mining, (b) smelting and (c) refining. After the ore has been mined and concentrated, it is smelted in blast or reverberatory furnaces to produce a "matte" containing a high percentage of nickel together with other elements. The matte so produced is then refined to produce metallic nickel, the method of refining varying with the nature of the basic ores and matte.

15. Nickel products are produced by rolling metallic nickel into various forms, such as sheets, bars, rods and strips, suitable for industrial consumption and fabrication, or by combining metallic nickel with other elements to form high-nickel alloys. Some high-nickel alloys are also refined and produced directly from nickel-copper matte smelted from Canadian ores, a notable example of this latter type of nickel product being the nickel-copper alloy commonly called "monel metal" which is produced by subsidiaries of Inco, Ltd.

16. While deposits of nickel bearing minerals have been found in a number of countries, for many years the ores of Canada and New Caledonia have furnished most of the

world's supply of nickel. In or about 1900, approximately two-thirds of the world's supply of nickel and nickel-bearing materials were of New Caledonian origin and about one-third was of Canadian origin. Since that time, however, the relative positions of these two sources of supply have changed materially. World production of nickel in 1939 was approximately 134,000 short tons and in 1943 approximately 172,000 short tons. Of this production, Canada furnished approximately 113,053 short tons in 1939 and approximately 143,882 short tons in 1943. Production from New Caledonian nickel-bearing materials in the same years was approximately 11,700 short tons and 5,800 short tons respectively.

17. The United States is the world's largest consumer of commercial nickel and nickel products and the world's largest manufacturer of industrial products containing nickel. Production of nickel in this country, however, has been relatively insignificant. Small amounts of nickel in the form of nickel salts have been recovered here as by-products in the electrolytic refining of copper and some secondary nickel has been recovered from scrap. The amounts so recovered have been of negligible volume as compared to consumption of nickel in various forms with the results that the United States imports almost all of its requirements of nickel and nickel-bearing materials and has been and is dependent upon foreign sources of supply.

B. Uses

18. Nickel is the metal most extensively used for alloying steels. Commercial nickel, nickel products and various alloys containing nickel are utilized in many industrial fields and have widely diversified applications in building materials; automotive, aircraft and railway equipment; heavy machinery; farm implements; machine tools; gun forgings; armor and deck plates; marine and chemical equipment; restaurant and kitchen fixtures; electrical resistance materials; stainless steel; and coinage.

19. Among the major industrial purchasers of commercial nickel and nickel products are steel mills, steel foundries, iron foundries, brass and copper mills, brass and bronze foundries, aluminum foundries, alloy manufacturers, electroplaters' supply houses, storage battery manufacturers and the chemical industries.

C. Defendants' Place in the Industry

20. Inco, Ltd. is the largest producer of nickel in the world and, together with its wholly-owned subsidiaries, controls and completely dominates the foreign and interstate commerce of the United States in commercial nickel, nickel products and nickel-bearing materials. The combined assets of Inco, Ltd. and its wholly-owned subsidiaries exceed two hundred and ninety million dollars (\$290,000,000.). For many years, Inco, Ltd. and its wholly-owned subsidiaries have produced, shipped and sold more than ninety (90) per centum of the commercial nickel, nickel products and nickel-bearing materials consumed in the United States and have also produced, shipped and sold a major part of the commercial nickel, nickel products and nickel-bearing materials consumed in other markets of the world.

21. Directly or through its subsidiaries, Inco, Ltd. has acquired and now owns the principal known deposits of nickel-bearing materials in Canada and has smelters and refineries in Canada. Inco, Delaware has a foundry at Bayonne, New Jersey and a rolling mill and refinery at Huntington, West Virginia. The Mond Nickel Company, Ltd., a wholly owned subsidiary of Inco, Ltd., has a nickel refinery at Clydach, Wales and a refinery for by-product precious metals at Acton, England.

22. Nickel-Bearing materials produced by Inco, Ltd. in Canada and commercial nickel produced by Inco, Ltd. and its wholly-owned subsidiary The Mond Nickel Company, Ltd., in Canada and England respectively, are shipped and

sold in foreign and interstate commerce into and in the United States. Inco, Delaware sells and ships in trade and commerce among the states of the United States commercial nickel received from Inco, Ltd. and The Mond Nickel Company, Ltd. and nickel products produced by Inco, Delaware at Huntington, West Virginia.

V

OFFENSES CHARGED

23. For many years up to and including the date of the filing of this complaint, the defendant corporations and their predecessors and the individual defendants continuously have been engaged in a combination and conspiracy to restrain and monopolize the trade and commerce among the several states of the United States and with foreign nations in commercial nickel, nickel products and nickel-bearing materials, and have attempted to monopolize and have monopolized said trade and commerce, all in violation of Sections 1 and 2 of the Act of Congress of July 2, 1890, c. 647, 26 Stat. 209, as amended, entitled "An Act to protect trade and commerce against unlawful restraints and monopolies," commonly known as the Sherman Act. Defendants are continuing and threaten to and will continue said offenses unless the relief hereinafter prayed for in this complaint is granted. The aforesaid combination and conspiracy, attempt to monopolize and monopolization, and the acts, acquisitions, contracts, agreements and understandings which formed a part of and were used in effectuation thereof, will be hereinafter more fully set forth and described.

A. Background and Development of Inco, Ltd.

24. At or about the beginning of the Twentieth Century, the interstate and foreign commerce of the United States in nickel and nickel-bearing materials was participated in by Canadian Copper Company, Orford Copper Company, and

American Nickel Works. Canadian Copper Company, a corporation organized in 1886 under the laws of the State of Ohio, was engaged in mining and smelting nickel bearing ores in Canada and, pending the development of commercially satisfactory refining processes, had entered into contractual arrangements for the sale of nickel-bearing materials to Orford Copper Company. Canadian Copper Company also refined some nickel and sold it to manufacturers in the United States. Orford Copper Company, a corporation organized in 1887 under the laws of the State of New Jersey, was engaged in refining nickel at its refinery located at Constable Hook near Bayonne, New Jersey, from nickel-bearing materials supplied by Canadian Copper Company and also from nickel-bearing materials of New Caledonian origin. American Nickel Works, a corporation organized under the laws of the State of Pennsylvania in 1902, was the successor to and acquired the assets of Joseph Wharton & Company which had facilities for smelting and refining nickel at Camden, New Jersey, and had a financial interest in nickel-bearing lands in Canada. Earlier, this company had engaged in smelting and refining nickel from ores mined at Lancaster Gap, Pennsylvania, but in or about 1893 mining operations at Lancaster Gap had been suspended.

25. On or about March 30, 1902, International Nickel Company, a holding company and corporate predecessor of Inco, Ltd., was organized under the laws of the State of New Jersey for the purpose, among others, of restraining and monopolizing the trade and commerce of the United States in commercial nickel and nickel-bearing materials by acquiring control of companies engaged in mining, smelting and refining of nickel-bearing materials and selling commercial nickel, and by acquiring and owning mineral lands and operating mines, smelters and refineries. The authorized capital of the new corporation was thirty-six million dollars (\$36,000,000). Of this authorized capital, stocks and bonds with a face value of approximately twenty-seven million

seven hundred thousand dollars (\$27,700,000.) were issued as the consideration for the acquisitions hereinbelow set forth in paragraph 26.

26. Following its organization, International Nickel Company acquired 99.6% of the capital stock of Canadian Copper Company, 100% of the capital stock of Orford Copper Company, and 100% of the capital stock of American Nickel Works. It also acquired 99% of the capital stock of The Vermillion Mining Company, a corporation possessing nickel-bearing lands in Canada; 98.7% of the capital stock of Anglo-American Iron Company, a corporation engaged in mining in Canada; and controlling interests in two foreign corporations owning nickel-bearing lands in New Caledonia. All the remaining capital stock of Canadian Copper Company, Vermillion Mining Company, Anglo-American Iron Company, and the two foreign companies owning nickel-bearing lands in New Caledonia was ultimately acquired by International Nickel Company. The combined assets of the companies so acquired by International Nickel Company were approximately thirty million dollars (\$30,000,000.).

27. The foregoing acquisitions of nickel mining, smelting and refining companies by International Nickel Company had the effect, as intended by International Nickel Company, of combining under one management all the principal companies then engaged in the foreign and interstate trade and commerce of the United States in nickel-bearing materials and commercial nickel.

28. By a series of intercorporate transactions during the period from 1902 to 1928, the assets of the respective corporations, control of which had been acquired by International Nickel Company as above described in paragraph 26, were amalgamated and transferred to The International Nickel Company, corporate successor of International Nickel Company, and to Inco, Ltd. which was organized in 1916 as a wholly-owned subsidiary of The International Nickel Com-

pany. Thus, by 1928 the corporate existence of American Nickel Works, Orford Copper Company, Canadian Copper Company, Vermillion Mining Company and Anglo-American Iron Company had been terminated and all assets and operations of these companies in Canada and the United States had been concentrated in Inco, Ltd. and The International Nickel Company respectively.

B. The Acquisition of The Mond Nickel Company, Ltd. and Organization of Inco, Delaware

29. In or about 1922, The Mond Nickel Company, Ltd. (hereinafter referred to as "Mond"), an English corporation, purchased a plant at Hyde, Pennsylvania and organized American Nickel Company, later known as American Mond Nickel Company, under the laws of the State of Pennsylvania. The company so formed engaged in the production of nickel products and acted as agent for Mond in the sale and distribution, in the United States, of nickel products and of commercial nickel shipped in foreign commerce from England to the United States.

30. In or about 1928, more than eighty (80) per centum of all nickel in the form of commercial nickel and nickel products shipped and sold in the United States was sold by The International Nickel Company, between ten (10) per centum and fifteen (15) per centum by American Mond Nickel Company, a wholly-owned subsidiary of Mond, and approximately five (5) per centum by United States Nickel Company, a subsidiary of the French company Hauts Fourneaux de Noumea.

31. In or about 1928 The International Nickel Company and its directors and officers, including the individual defendant Robert C. Stanley, together with Inco, Ltd., entered into negotiations with officials of Mond for the purpose of acquiring control of the nickel producing and selling facilities of Mond and its subsidiaries in the United States, Canada and in foreign countries.

32. During the course of such negotiations, and as a part of and in furtherance of the program to acquire control of Mond and its subsidiaries, a plan of reorganization was adopted by The International Nickel Company and defendant Inco, Ltd. whereby stockholders of The International Nickel Company exchanged their stock for shares in Inco, Ltd. and became stockholders of the latter. The name of The International Nickel Company was changed to Nickel Holdings Corporation and its corporate existence subsequently terminated upon the completion of the exchange of stock.

33. The above-mentioned exchange of stock was accomplished with the intent and effect of transferring control of all facilities, properties and subsidiaries of The International Nickel Company to Inco, Ltd. and of enabling the latter as a foreign corporation to acquire control over the nickel producing and selling facilities of Mond and its subsidiaries in the United States and elsewhere.

34. As a further part of the aforesaid plan of reorganization, in or about October 1928, defendant Inco, Delaware was incorporated under laws of the State of Delaware, as a wholly-owned subsidiary of Inco, Ltd., for the purpose of conducting all operations formerly conducted by The International Nickel Company in the United States. The plant for the production of nickel products at Huntington, West Virginia and the plant at Bayonne, New Jersey were transferred to Inco, Delaware together with all stock of certain subsidiary companies formerly controlled by The International Nickel Company. Inco, Delaware thereafter sold and fabricated commercial nickel and nickel products within the United States on behalf of Inco, Ltd., and participated in carrying out the combination and conspiracy, attempt to monopolize and monopolization herein alleged.

35. On or about January 1, 1929 defendants Inco, Ltd. and Inco, Delaware entered into an agreement for the sale

by Inco, Ltd. to Inco, Delaware of commercial nickel and nickel-bearing materials and for the sale by Inco, Delaware to Inco, Ltd. of nickel products. By the terms of said agreement Inco, Ltd. agreed not to sell commercial nickel or nickel-bearing materials to any manufacturer, middleman or customer in the United States except to or through Inco, Delaware. Inco, Delaware in turn agreed not to sell nickel products to any manufacturer, middleman or customer in Canada other than Inco, Ltd. The latter obligation on the part of Inco, Delaware was subsequently removed by amendment to this agreement in or about 1931, but the restriction upon sales by Inco, Ltd. has continued and is still in effect.

36. The corporate reorganization above described in paragraphs 32 and 34 having been effectuated, on December 20, 1928 an agreement was entered into between defendants Inco, Ltd. and the holders of shares in Mond providing for the acquisition of the stock of the latter company by Inco, Ltd. in return for stock of Inco, Ltd. This agreement was consummated in 1929 and Inco, Ltd. thereby acquired control of all assets and subsidiaries of Mond, including mines and smelters in Canada, refineries in Great Britain and American Mond Nickel Company in the United States, the stock of the latter company being transferred to Inco, Ltd. by Mond on or about April 30, 1929.

37. On or about June 30, 1929, an agreement was entered into between Inco, Ltd. and Mond, of which Inco, Ltd. had become the sole director and manager, for the transfer to Inco, Ltd. of all Mond's assets located in the continent of America in return for a cash consideration. Inco, Ltd. thereby acquired complete possession of all nickel mining, smelting and refining facilities together with all facilities for the processing, production and sale of commercial nickel and nickel products formerly owned and operated by Mond in Canada and in the United States.

38. On or about October 1, 1929, Inco, Ltd. transferred the capital stock of American Mond Nickel Company to Inco, Delaware. Thereafter, all activities of American Mond Nickel Company were terminated and its plant at Hyde, Pennsylvania was dismantled.

39. As a result of the acts and things hereinabove described in paragraphs 25 through 38, defendants Inco, Ltd. and Inco, Delaware restrained and monopolized the interstate and foreign commerce of the United States in commercial nickel, nickel products and nickel-bearing materials. Competition in the importation of commercial nickel, nickel products and nickel-bearing materials into the United States and in their production, distribution and sale in the United States was eliminated, and defendants Inco, Ltd. and Inco, Delaware became the suppliers of more than ninety (90) per centum of the requirements of the United States for these commodities.

C. International Agreements to Eliminate Foreign Competition

40. Inco, Ltd., its officers, directors, agents, affiliates and wholly-owned subsidiaries, including the individual defendants and defendant Inco, Delaware, from 1928 to the present time have adopted a policy and have utilized various devices with reference to foreign competition designed to curtail and suppress, and having the effect of curtailing and suppressing, shipments of commercial nickel, nickel products and nickel-bearing materials from foreign countries to the United States, and have thereby protected, strengthened and maintained the aforesaid combination and conspiracy, attempt to monopolize and monopolization by Inco, Ltd. and its subsidiaries. Inco, Ltd., its officers, directors, agents, affiliates and wholly-owned subsidiaries, have from time to time entered into agreements and understandings with nickel producing companies of foreign countries to limit world production, fix prices, and allocate and restrict sales in world markets, with the intent and effect, among other things, of suppressing competition in

the importation of commercial nickel, nickel products and nickel-bearing materials into the United States, and in the distribution and sale of these commodities in the United States. Said agreements and understandings by Inco, Ltd., its officers, directors, agents, affiliates and wholly-owned subsidiaries will hereinbelow be described in greater detail.

41. By 1931, Inco, Ltd, together with its wholly-owned subsidiaries had become the dominant producer, distributor and seller of commercial nickel, nickel products and nickel-bearing materials in the world and supplied a major portion of the world's requirements of nickel in various forms. A large part of the remaining world supply of nickel was at this time produced by two French Companies namely: Societe Anonyme Le Nickel (hereinafter referred to as "Le Nickel") and Societe Anonyme Caledonia Charbonnagos Minerais et Metaux de la Nouvelle Caledonie (hereinafter referred to as "Caledonia").

42. In or about the year 1931, Le Nickel and Caledonia caused to be organized under French law a new corporation called Caledonickel to acquire from them respectively full beneficial use of all their nickel producing properties for a period of 25 years beginning July 1, 1931. The corporate existence of both Caledonia and Le Nickel continued, each holding a 50% stock interest in Caledonickel. On or about July 1, 1931, Caledonickel took over all the assets and business of Caledonia and Le Nickel and thereafter conducted all operations theretofore conducted by said two corporations.

43. On or about October 23, 1931, Inco, Ltd. and its wholly-owned subsidiary Mond came to an understanding with Le Nickel, Caledonia and Caledonickel for the elimination of competition in the distribution and sale of commercial nickel, nickel products and nickel-bearing materials in all of the markets of the world. By this understanding Inco, Ltd. and its subsidiaries and affiliates were allocated the

United States and Canada (including Newfoundland) as their exclusive territory, and the remaining markets of the world were to be shared on the basis of agreed quotas and prices.

44. The above understanding was carried out by various contracts, arrangements and understandings including (a) the "Main Agreement" of October 23, 1931, which fixed quotas and established the procedure for price agreement between the parties, and (b) the "Agreement re (i) Disposal of Interest in Properties, (ii) Sales in North America" which embodied the allocation of the United States and Canada (including Newfoundland) to Inco, Ltd. and its subsidiaries as exclusive territory. These two contracts will be more fully described in Paragraphs 45 through 47.

45. The Main Agreement, entered into by and between Caledonickel, Inco, Ltd. and Mond, provided for the fixing of prices and quotas for sales by the respective parties of commercial nickel, nickel products and nickel-bearing materials in all countries of the world except Canada (including Newfoundland) and the United States and its territories and dependencies. Quotas were based on nickel content of materials and products (with the exception of nickel salts and monel metal) sold or delivered within the contract territory and were specified as follows:

Up to 5,000 tons—all Caledonickel

5,000 to 15,000 tons—Inco, Ltd. and Mond in equal parts

Above 15,000 tons—15% to Caledonickel, 85% to Inco, Ltd. and Mond in equal proportions

It was provided that all the parties would sell their products at uniform prices to be agreed upon from time to time, subject to such variations as might be agreed upon in respect of particular countries. Prices were to be set by unanimous agreement between the parties or, in the event of disagreement, by any two of the parties. By the latter provision,

Inco, Ltd. and Mond were empowered to control the price structure provided for by the contract. The term of the contract was from January 1, 1932 until December 13, 1943.

46. The Main Agreement was entered into by Inco, Ltd. and Mond in reliance upon the provisions and warranties of a second agreement coterminous with the Main Agreement and entitled "Agreement re (i) Disposal of Interest in Properties, (ii) Sales in North America." This agreement, designed to suppress possible competition from other companies and to prevent importation and sale of commercial nickel, nickel products and nickel-bearing materials into and in the United States, was executed between Inco, Ltd., Mond, Le Nickel, Caledonia and Caledonickel simultaneously with the Main Agreement and contained the following provisions:

(a) That if at any time during the life of the "Main Agreement," any nickel mines, plant equipment or other properties and assets used or useful in connection with the mining, production or manufacture of nickel, nickel products or nickel-bearing materials should be sold, leased or otherwise disposed of by Le Nickel, Caledonia or Caledonickel, said companies would promptly serve written notice thereof upon Inco and Mond giving full details relating to such disposal, and that unless all such properties so sold, leased or otherwise disposed of should have ceased to be used or useful in connection with the mining or production or manufacture of commercial nickel, nickel products or nickel-bearing materials, Inco and Mond or either of them might forthwith or at any time thereafter in their election terminate the "Main Agreement" by written notice served upon Caledonickel.

(b) That Le Nickel, Caledonia and Caledonickel warranted that Le Nickel and Caledonia and their respective subsidiaries and affiliates were not engaged in selling commercial nickel, nickel products and nickel-bearing materials in Canada (including Newfoundland) or in the

United States, its territories and dependencies, and that neither they nor Caledonickel had any desire or intention of doing business in said places nor any facilities for so doing; and

(c) That sales or deliveries of commercial nickel, nickel products or nickel-bearing materials by Caledonia, Le Nickel or Caledonickel or their respective subsidiary or affiliated companies into or to Canada (including Newfoundland) or the United States or its territories or dependencies, might cause the termination of the "Main Agreement" and the termination of all benefits accruing to said companies thereunder.

47. The contract provision designed to prevent the French companies from shipping, selling or delivering commercial nickel, nickel products or nickel-bearing materials in or into the United States read as follows:

"Nothing contained in the Main Agreement or herein or in any other Agreement between the parties hereto or any of them shall in any way restrict or hinder any of the parties hereto or any of their subsidiary or affiliated companies from selling leasing or otherwise disposing of any of their nickel-bearing materials or other products in North America on such terms and conditions as they may desire. If at any time during the period of the Main Agreement any nickel-bearing materials of Caledonickel and or Le Nickel and or Caledonia and or their respective subsidiary or affiliated companies should be sold by them or any of them and delivered upon such sale or subsequent thereto in connection with such sale or otherwise in North America by them or any of them Caledonickel Le Nickel or Caledonia (as the case may be) shall promptly serve written notice thereof upon Inco and Mond and if any such sales and or deliveries are in the opinion of the parties to the Main Agreement or a majority of them of sizeable amounts and or of any considerable frequency the parties hereto recognize that a new situation will have been created and

thereupon the Main Agreement shall ipso facto become terminated."

By this clause, Inco and Mond, constituting a majority of the parties to the Main Agreement, were empowered to terminate both agreements in the event the French companies, or any of them sold and delivered commercial nickel, nickel products or nickel-bearing materials into or in the United States.

48. For the purpose of further limiting and controlling world production, sale and distribution of commercial nickel, on or about February 21, 1933, Inco, Ltd. caused Mond to enter into a contract with a German corporation known as Norddeutsche Affinerie (hereinafter referred to as NDA), which was engaged in the refining of nickel. By the terms of said contract NDA appointed Mond as the exclusive distributor of NDA's nickel in Germany, Austria, Hungary, Czechoslovakia, Holland, Poland and Switzerland, and in return Mond undertook to market a certain quota of NDA's nickel. The quota allotted to NDA was based upon the combined sales of Inco, Ltd., Mond and Caledonickel under the provisions of the Main Agreement hereinabove referred to in paragraph 45, and the price to be received by NDA for nickel was the average price realized by the parties to the Main Agreement less a selling commission. It was also provided that NDA was not to contract to refine nickel from ores mined by a corporation known as Burma Corporation unless said contract covered the entire output by Burma Corporation of ore for refining, and unless all nickel so refined was to be marketed through Mond.

49. In or about 1933, I. G. Farbenindustrie, A.G. (hereinafter referred to as "I.G."), a corporation or association organized and existing under the laws of Germany, had developed or acquired certain processes suitable for the commercial production of nickel and processes useful in connection with the utilization of nickel powder, and was about to

engage in the production, sale and distribution of commercial nickel and nickel products.

50. For the purposes (a) of limiting and controlling world production, sale and distribution of commercial nickel and nickel products, (b) of preventing the development and exploitation of competitive nickel-bearing lands or enterprises producing nickel-bearing materials, and (c) of establishing interlocking interests with I.G. designed and tending to prevent exportations of commercial nickel and nickel products to the United States for sale therein in competition with Inco, Ltd. and its subsidiaries and affiliates, in or about 1934 Inco, Ltd. and Mond came to an understanding with I.G. for the elimination of competition in the distribution and sale of commercial nickel, nickel products and nickel-bearing materials in all of the markets of the world. By this understanding Inco, Ltd. and its subsidiaries and affiliates were allocated the United States and Canada (including Newfoundland) as their exclusive territory, and I.G. was to share in the remaining markets of the world on the basis of agreed quotas and prices.

51. The above understanding was carried out by two contracts which Inco, Ltd. caused Mond to enter into with I.G. on or about April 28, 1934, and which were designated respectively as the "Main Agreement" (hereinafter referred to as the "I.G. Main Agreement") and the "Patent Agreement." These two contracts will be more fully described in Paragraphs 52 through 58.

52. The I.G. Main Agreement and Patent Agreement recited the existence of the contracts between Inco, Ltd., Mond, Caledonickel and NDA hereinabove referred to and described in paragraphs 44 through 48, and provided that the two agreements with I.G. were intended to secure to Inco, Ltd. and Mond the following benefits:

a. That the maintenance of the respective price levels for commercial nickel and nickel products under the

agreements between Inco, Ltd., Mond, Caledonickel and NDA, should not be adversely affected by any activities of I.G., its controlled companies or licensees, under the refining processes owned or controlled by I.G.

b. That activities of I.G., its controlled companies or licensees, should not disturb the status quo in the nickel mining or nickel ore supply situation throughout the world by encouraging the development, exploitation or working of nickel enterprises, nickel properties, or nickel ore supplies other than those of Inco, Ltd., Mond or their subsidiaries and affiliates, and should not have the effect of bringing onto the world market amounts of commercial nickel, nickel products or nickel-bearing materials except from Inco, Ltd., Mond or their subsidiaries and affiliates.

c. That the nickel content of the total quantity of commercial nickel and nickel products resulting from the operation of I.G.'s refining processes by any persons other than Inco, Ltd., Mond and their subsidiaries and affiliates and coming onto the market in each year should be limited to the quota allotted to I.G. by the I.G. Main Agreement.

The benefits intended to accrue to I.G. from the contract were stated to be as follows:

a. Continuity of a reliable supply of nickel-bearing materials.

b. Assurance of a market for nickel and a stable price.

53. By the terms of the I.G. Main Agreement, Inco, Ltd.'s subsidiary Mond was to supply I.G. with nickel-bearing materials sufficient to enable I.G. and its controlled companies to produce commercial nickel in the amounts stipulated by the contract as I.G.'s quota. The quota amount of commercial nickel produced by I.G., with a limited exception for retention by I.G. for its own consumption or for

sale in fabricated forms, was to be offered for sale through distributing organizations utilized by Inco, Ltd., Mond or their affiliated companies, and sold at prices fixed by Inco, Ltd., Mond and Caledonickel under the agreement hereinabove described in paragraph 45. I.G. agreed not to buy nickel ores elsewhere than from Inco, Ltd. and Mond or their affiliates, with the exception of material having a nickel content of a maximum of 50 tons in any year desired for purposes other than production of commercial nickel and nickel products, and also agreed not to investigate, finance or acquire any interest in any nickel enterprise or property.

54. By the terms of the Patent Agreement, I.G. agreed that, during the term of the agreement, it would not, without written consent of Mond, license or permit any person, firm or corporation other than Inco, Ltd. or Mond or subsidiaries and affiliates of the latter, to operate I.G.'s refining processes for the purpose of, or in connection with, the treatment of nickel-bearing materials for the production of commercial nickel, nickel alloys or any other products, the production and sale of which would be likely adversely and substantially to affect the enjoyment by Inco, Ltd. and Mond of the benefits intended to be secured to them by these contracts as above set forth in paragraph 52. I.G. further agreed to protect such refining processes throughout the world by taking out and enforcing letters Patent thereon, or to permit and assist Mond to do so in any case where I.G. was unwilling to take out or maintain in force a patent thereon in any country.

55. With respect to I.G. processes comprehending the use of nickel powder, I.G. agreed that it would upon request grant Inco, Ltd. or Mond an exclusive license or licenses, with the right to sub-license, for the United States, its territories and dependencies, Canada (including Newfoundland), United Kingdom and Ireland, and a non-exclusive license or licenses for the rest of the world. The licenses granted for the United States, its territories and dependencies were to be

non-exclusive if request therefor were not made within two years from the date of the Patent Agreement, and those for Canada (including Newfoundland), United Kingdom and Ireland could be converted into non-exclusive licenses if within 2 years I.G. were not satisfied that the processes were being satisfactorily developed in said countries.

56. The Patent Agreement further recited three pre-existing commitments relating to the use of I.G.'s refining processes in other fields of production. One of such commitments was to Standard Oil Company for use of these processes in producing specified products and their substitutes in the hydrocarbon field; a second was to Aluminum Company of America for use of the processes in the production of magnesium and its alloys; and the third was to three French companies for use of the processes in the production of magnesium and its alloys. By the terms of the Patent Agreement, I.G. was permitted to fulfill such obligations but agreed that in the event I.G. might have reason to suppose that either of the two American companies, or the French companies, or any of their assignees or licensees intended to operate the refining processes for any purpose which might result in the production of commercial nickel, nickel alloys or any other products the production or sale of which might adversely and substantially affect the enjoyment by Inco, Ltd. and Mond of the benefits intended to accrue to them as hereinabove described in paragraph 52, I.G. would use its best efforts to induce such companies, their assignees or licensees to purchase their requirements of commercial nickel, nickel alloys or other products as aforesaid from I.G. or Mond in lieu of engaging in their production. Similarly, in the event of contemplated use by any person or company of any of I.G.'s processes relating to the use of nickel powder, I.G. agreed to endeavor to persuade such person or company to purchase its requirements of nickel-bearing materials, commercial nickel or nickel alloys from I.G. or Mond.

57. The I.G. Main Agreement specifically provided that no commercial nickel, nickel products or nickel-bearing ma-

terials should be sold by I.G. or its subsidiaries and affiliates in or for export to or for delivery in the United States, its territories and dependencies or Canada (including Newfoundland). Sub-paragraph (e) of paragraph 11 of this contract read as follows:

"Notwithstanding anything contained in this Agreement, I.G. and/or its controlled companies shall not sell any nickel bearing materials or commercial nickel or nickel alloys other than nickel alloys in any fabricated form in or for delivery in the United States of America, its territories and dependencies or Canada (including Newfoundland) or other than through the Distributors."

58. The term of both the I.G. Main Agreement and the Patent Agreement was from January 1, 1934 to December 31, 1943. By letter to I. G. dated April 28, 1934, signed by defendant Robert C. Stanley and attested by defendant Paul D. Merica, Inco, Ltd. guaranteed full and complete performance by Mond of each and every obligation of Mond under both the aforesaid contracts.

59. In or about 1937, I.G. proposed to erect an additional refinery for production of nickel in Germany and desired to have the I.G. Main Agreement modified in various particulars, especially with regard to the quota assigned to I.G. Negotiations for this purpose were conducted between I.G. and Mond resulting in an agreement with respect thereto which was ratified by Inco, Ltd. and incorporated in a contract between Mond and I.G. executed on or about May 14, 1937 as a modification of the I.G. Main Agreement. Said contract, entitled "Supplemental Agreement," among other things provided for an increased quota for I.G., permitted I.G. to stockpile stated amounts of nickel-bearing materials, required Mond to cooperate with the German authorities in developing the use of nickel in Germany, established a new basis for the resale price of nickel produced by I.G. and imposed further limitations upon the right of I.G. to export

nickel from Germany. The provisions of the I.G. Main Agreement, except as modified by the Supplemental Agreement, remained in full force and effect and the latter was declared to be co-terminous with the I.G. Main Agreement. Inco, Ltd. by letter to I.G. extended to the Supplemental Agreement its guarantee of performance by Mond of the I.G. Main Agreement and Patent Agreement.

60. On or about June 16, 1937, a corporate reorganization of Le Nickel was effected pursuant to which exploitation of the nickel producing and other nickel interests theretofore managed by Caledonickel, together with all commercial operations connected therewith, were transferred to and assumed by Le Nickel and certain of its subsidiaries, and Caledonickel and Caledonia were dissolved. Thereafter, by agreement with Inco, Ltd. and Mond, Le Nickel assumed all benefits and obligations under the understanding and contracts hereinabove referred to and described in paragraphs 43 through 47.

61. The aforesaid agreements and understandings of Inco, Ltd. and its wholly-owned subsidiary Mond with foreign producers were designed to curtail and suppress and have had the effect of curtailing and suppressing the importation of commercial nickel, nickel products and nickel-bearing materials into the United States and the sale thereof in interstate commerce, in competition with Inco, Ltd. and Inco, Delaware; and have thereby materially aided in preserving, protecting, furthering and maintaining the aforesaid combination and conspiracy to restrain and monopolize, attempt to monopolize and monopolization of the foreign and interstate commerce of the United States in commercial nickel, nickel products and nickel-bearing materials, in violation of Sections 1 and 2 of the Sherman Act.

EFFECTS OF THE VIOLATIONS OF LAW

62. By reason of the combination and conspiracy, attempt to monopolize and monopolization hereinabove alleged, and the various acts, acquisitions, contracts, agreements and understandings described above, the defendants: (a) have monopolized and now hold a monopoly of the business of importing commercial nickel and nickel-bearing materials into the United States; (b) have monopolized and now hold a monopoly of the manufacture of nickel products in the United States; (c) have monopolized and now hold a monopoly of the distribution and sale of commercial nickel and nickel products in trade and commerce among the several States; (d) have restrained and suppressed competition in the importation of commercial nickel, nickel products and nickel-bearing materials into the United States, and in the distribution and sale of these commodities among the several States; and (e) have for many years possessed and exercised the power to fix arbitrary prices for commercial nickel distributed and sold in trade and commerce among the several States, and by virtue of the aforesaid monopolization and monopolies possess the power to fix and will continue to fix such prices. Defendants Inco, Ltd. and Inco, Delaware and their wholly-owned subsidiaries import and sell in foreign and interstate commerce more than ninety (90) per centum of the commercial nickel, nickel products and nickel-bearing materials consumed in the United States.

63. Defendants for many years have furthered and extended their monopolization and monopolies by extending and maintaining their participation in and control of the business of importing commercial nickel and nickel-bearing materials into the United States and of manufacturing, distributing and selling commercial nickel and nickel products in the United States. Since new enterprises desiring to engage in the nickel industry would be subject to the great hazard necessarily involved in venturing into a business so

completely monopolized by the defendant corporations, the monopolization by the defendants and the dominant position acquired by them has had and will continue to have the effect of excluding others from competition with defendants in the production and sale in foreign and interstate commerce of nickel-bearing materials, commercial nickel and nickel products.

VII

PRAYER

WHEREFORE, plaintiff prays:

(1) That the aforesaid combination and conspiracy, attempt to monopolize and monopolization be adjudged and decreed to be unlawful, and that the agreement, understandings, acquisitions and practices alleged in this complaint be adjudged and decreed to be in violation of the Sherman Act.

(2) That the Court adjudge and decree that the defendants have combined and conspired in restraint of and to monopolize, have attempted to monopolize and have monopolized the aforesaid foreign and interstate trade and commerce of the United States in violation of Sections 1 and 2 of the Sherman Act.

(3) That defendants and each of them and their officers, directors, agents, representatives, and all persons and corporations acting or claiming to act on behalf of them be perpetually enjoined from combining and conspiring to restrain or monopolize, attempting to monopolize or monopolizing trade and commerce among the several States of the United States or with foreign nations with respect to commercial nickel, nickel products or nickel-bearing materials, and that they be perpetually enjoined from engaging in or participating in practices, contracts, relationships or understandings, or claiming any rights thereunder, having the purpose or effect of continuing, reviving or renewing any of the aforesaid violations of the Sherman Act.

(4) That defendants and each of them and their officers, directors, agents, representatives, successors, assignees, and

all persons acting or claiming to act on behalf of them be perpetually enjoined from entering into any contract, agreement, understanding or arrangement in any way restraining, or intended to restrain, any foreign producer or seller of commercial nickel, nickel products or nickel-bearing materials from exporting to or selling in the United States, its territories or possessions any of such commodities.

(5) That Inco, Ltd. and Inco, Delaware be required to take such steps with respect to their respective properties and assets as may be necessary to terminate and dissipate the effects of the aforesaid restraints and monopolization and prevent further violations of the Sherman Act, under such terms and conditions and according to such a plan or program as may be approved by and subject to the supervision of the Court.

(6) That Inco, Ltd. and Inco, Delaware be effectively divorced and separated and the aforesaid exclusive dealing contract between them be cancelled in such manner and to such an extent that effective competition may be created and maintained in the future in the sale of commercial nickel and in the manufacture and sale of nickel products; and that Inco, Ltd. and its subsidiaries be required to make such divestitures and conveyances of their stockholdings and properties as shall be necessary to accomplish such effective divorcement and complete separation of Inco, Ltd. and Inco, Delaware, under such terms and conditions and according to such a plan or program as may be approved by and subject to the supervision of the Court.

(7) That in order to preserve and protect competition in the production, distribution and sale of commercial nickel, nickel products and nickel-bearing materials, each individual defendant herein be perpetually enjoined from simultaneously holding office or directorates in more than one of the corporate defendants herein, or their successors or assignees, and from simultaneously holding or controlling, directly or indirectly, any of the capital stock of more than one of the corporate defendants herein, or their successors or assignees;

and that each corporate defendant and any successor or successors of such corporate defendant be perpetually enjoined from holding, directly or indirectly, through subsidiary corporations, agents, representatives, assignees or otherwise, any of the capital stock of the other corporate defendant, or of any successor or successors of such other corporate defendant.

(8) That the plaintiff have such other, further and different relief as the nature of the case may require and the Court may deem just and proper.

(9) That the plaintiff recover the costs of this suit.

(10) That pursuant to Section 5 of the Sherman Act an order be made and entered herein requiring such of the defendants as are not within this district to be brought before the Court in this proceeding as parties defendant and directing the marshalls of the Districts in which they severally reside to serve summons upon them.

.....
Manuel M. Gorman
Special Assistant to the Attorney General

.....
Tom C. Clark
Attorney General

.....
Wendell Berge
Assistant Attorney General

.....
Herbert A. Berman
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.....
John F. X. McGohey
United States Attorney

Department of Justice, Antitrust Division,
30 Broad Street, New York 4, New York

IN THE
District Court of the United States
FOR THE SOUTHERN DISTRICT OF NEW YORK

UNITED STATES OF AMERICA,
Plaintiff,

v.

THE INTERNATIONAL NICKEL COMPANY OF
CANADA, LIMITED, THE INTERNATIONAL
NICKEL COMPANY, INC., ROBERT C. STAN-
LEY, JOHN F. THOMPSON, and PAUL D.
MERICA,
Defendants.

Civil
No. 36-31

ANSWER OF
DEFENDANTS

The International Nickel Company of Canada, Limited, The International Nickel Company, Inc., Robert C. Stanley, John F. Thompson and Paul D. Merica, the defendants named in the above entitled action, state herein their answer to the complaint. Each paragraph herein has the same number as the paragraph of the complaint which it answers.

I

1. They deny that there are or have been violations by defendants or any of them of section 1 or section 2 or any other section of the Act of Congress of July 2, 1890, commonly known as the Sherman Act, either as alleged in the complaint or otherwise and whether designated "continuing" or otherwise.

2. They admit that the corporate defendant The International Nickel Company, Inc. has an office at 67 Wall

Street, Borough of Manhattan, City, County and State of New York. They admit that said corporate defendant transacts business and is found within the Southern District of New York. Except as so admitted, they deny each and every averment in this paragraph.

II

3. They admit that defendant The International Nickel Company of Canada, Limited is a corporation organized and existing under the laws of the Dominion of Canada. They admit that certain of the principal executive officers of The International Nickel Company of Canada, Limited, including the Chairman and President, the Executive Vice President (and one other Vice President), the Treasurer, the Secretary and the Comptroller, as officers of The International Nickel Company, Inc., a Delaware corporation, occupy offices maintained by said Delaware corporation at 67 Wall Street, Borough of Manhattan, New York City, and at that location from time to time perform duties as officers of The International Nickel Company of Canada, Limited. They admit that the Board of Directors and Executive Committee of The International Nickel Company of Canada, Limited hold frequent meetings at said address and that certain of its files and accounts are there maintained and kept by The International Nickel Company, Inc. Except as so admitted, they deny each and every averment in this paragraph.

4. They admit the averments in this paragraph.

5. They admit the averments in this paragraph except they aver that from 1918 to 1921 Robert C. Stanley was Vice President and a director, and from 1922 to 1928 was President and a director, of The International Nickel Company, a New Jersey corporation which, for a period

ending in 1928, held the capital stock of defendant The International Nickel Company of Canada, Limited.

6. They admit the averments in this paragraph except they aver that defendant John F. Thompson was Vice President and a director of The International Nickel Company of Canada, Limited from 1931 to 1936 and since 1936 has been and now is Executive Vice President and a director of said Company.

7. They admit the averments in this paragraph except they aver that defendant Paul D. Merica has been a Vice President of The International Nickel Company of Canada, Limited since 1936.

8. They admit that each of the individual defendants has participated and now participates in the management of the defendant corporations employing him or of which he is an officer or director. Except as so admitted, they deny each and every averment in this paragraph.

III

9. They aver that the term "commercial nickel" has been defined by plaintiff only to explain its use in the complaint and that as so defined it has been limited to unwrought refined nickel and nickel oxide. To avoid confusion, however, the term will be used in this answer with the same meaning as set forth in this paragraph of the complaint.

10. They aver that the term "nickel products" has been defined by plaintiff only to explain its use in the complaint and that as so defined it has been limited to certain high-nickel rolling mill forms and certain high-nickel alloys and does not include the much larger production of other nickel rolling mill forms and other alloys

of nickel. To avoid confusion, however, the term will be used in this answer with the same meaning as set forth in this paragraph of the complaint.

11. They aver that the term "nickel-bearing materials" has been defined by plaintiff only to explain its use in the complaint and that as so defined it has been limited to certain unrefined nickel-bearing materials. To avoid confusion, however, the term will be used in this answer with the same meaning as set forth in this paragraph of the complaint.

IV

12. They admit the averments in this paragraph.

13. They admit that nickel does not occur in nature as a pure metal but is found in combination with other elements in mineral formations of various types. They admit that the ores worked primarily as sources of nickel are: sulphide ores, found in Canada, the Union of Soviet Socialist Republics and elsewhere, containing copper, nickel, iron, sulphur, silicon and other elements, including some precious metals; and silicates and oxidized ores found in New Caledonia, Celebes, Cuba and elsewhere. Except as so admitted, they deny each and every averment in this paragraph.

14. They admit that the character of nickel-bearing mineral deposits varies widely and that there are generally three series of steps in the production of "refined nickel for commercial use", by which term they understand plaintiff to refer to commercial nickel. They admit that these three series of steps are (a) mining (b) reduction and (c) refining. They admit that after the ore has been mined, it is reduced by concentrating, roasting, smelting in blast or reverberatory furnaces and converters,

or by other means, to make a product, which is sometimes a "matte" containing a higher percentage of nickel, together with other elements. They admit that this reduced product is then treated further to reduce or refine it. They admit that the nature of all these operations varies with the nature of the ores. Except as so admitted, they deny each and every averment in this paragraph.

15. They admit that nickel products are produced by rolling metallic nickel and certain high nickel alloys into various forms, such as sheets, bars, rods and strips, suitable for industrial fabrication and use; they admit that high nickel alloys are produced by combining metallic nickel with other elements. They admit that some high nickel alloys are also produced directly by refining a nickel-copper matte or other partially reduced product from Canadian ores, as in the case of the nickel-copper alloy produced and marketed by The International Nickel Company of Canada, Limited and its subsidiaries under the trade mark "Monel". Except as so admitted, they deny each and every averment in this paragraph.

16. They admit that extensive deposits of nickel-bearing minerals have been found in a number of countries but for many years the ores of Canada and New Caledonia furnished most of the world's supply of nickel. They admit that in or about 1900 approximately two-thirds of the world's supply of nickel and nickel-bearing materials were of New Caledonian origin and about one-third was of Canadian origin. They admit that since that time the relative positions of these two sources of supply have changed materially. They admit that of world production of nickel, Canada furnished approximately 113,053 short tons in 1939 and approximately 143,882 short tons in 1943. Except as so admitted, they are without knowl-

edge or information sufficient to form a belief as to the truth of the averments in this paragraph.

17. They admit that more commercial nickel and nickel products are purchased in, and more industrial products containing nickel are manufactured in, the United States than in any other country. They admit that production of nickel in the United States has been small. They admit that small amounts of nickel in the form of nickel salts have been and are recovered in the United States as by-products in the electrolytic refining of copper and that secondary nickel has been and is recovered from scrap. They admit that the amounts so recovered have been small as compared to total imports of nickel in various forms; they admit that the United States imports the greater part of the nickel and nickel-bearing materials used therein and, in this sense and to this extent, has been and is relying upon sources of supply outside of the United States. Except as so admitted, they deny each and every averment in this paragraph.

18. They admit that commercial nickel, nickel products and various other alloys containing nickel are utilized in many industries; they admit that end products employing commercial nickel, nickel products or various other alloys containing nickel (including stainless steel) have widely diversified applications in automotive, aircraft and railway equipment; heavy machinery; farm implements; machine tools; gun forgings; armor and deck plates; marine and chemical equipment; restaurant and kitchen fixtures; electrical resistance materials; and coinage. Except as so admitted, they deny each and every averment in this paragraph.

19. They admit the averments in this paragraph in so far as they relate to commercial nickel. They admit that

among the major industrial purchasers of nickel products are the chemical industries, electroplaters' supply houses and steel mills. Except as so admitted, they deny each and every averment in this paragraph.

20. They admit that The International Nickel Company of Canada, Limited is the largest producer of nickel in the world. They admit that the combined assets of The International Nickel Company of Canada, Limited and its wholly-owned subsidiaries, as stated in the most recent consolidated balance sheet of the Company and its subsidiaries and without taking into account liabilities and all appropriate reserves, exceed two hundred and ninety million dollars (\$290,000,000). They admit that for many years The International Nickel Company of Canada, Limited and its wholly-owned subsidiaries have produced and sold a major part of the commercial nickel and nickel products purchased in markets of the world outside the United States. Except as so admitted, they deny each and every averment in this paragraph.

21. They admit that The International Nickel Company of Canada, Limited owns the greater part of the principal known deposits of nickel-copper ore in the Sudbury District of the Province of Ontario, Canada and has smelters, a nickel refinery and a copper refinery in the Province of Ontario, Canada. They aver that said Canadian corporation has been in existence since 1916; that its principal nickel-copper ore deposits have been owned by it or its direct predecessor, Canadian Copper Company, since about 1886; that all said ore deposits are located in the Sudbury District, Province of Ontario, Canada; that by 1922 all its nickel refining activities had been concentrated in Canada where its mines, smelters and hydroelectric developments have always been located; and that all of

the Company's product is, and always has been, derived from Canadian nickel-copper ores. They admit that The International Nickel Company, Inc. has a foundry at Bayonne, New Jersey, and a rolling mill with some refining facilities, at Huntington, West Virginia. They admit that The Mond Nickel Company, Limited, a wholly-owned subsidiary of The International Nickel Company of Canada, Limited, has a nickel refinery at Clydach, Wales and a refinery for precious metals at Acton, England. Except as so admitted, they deny each and every averment in this paragraph.

22. They admit that certain nickel-bearing materials produced by The International Nickel Company of Canada, Limited in Canada and commercial nickel produced by The International Nickel Company of Canada, Limited and its wholly-owned subsidiary, The Mond Nickel Company, Limited, in Canada and Great Britain respectively, are purchased in Canada and Great Britain by The International Nickel Company, Inc. and shipped into and in the United States, and that such commercial nickel is sold by The International Nickel Company, Inc. in the United States. They admit that The International Nickel Company, Inc. sells and ships in trade and commerce among the states of the United States commercial nickel received from The International Nickel Company of Canada, Limited and The Mond Nickel Company, Limited in Canada and Great Britain respectively and nickel products produced by it in the United States at Huntington, West Virginia. Except as so admitted, they deny each and every averment in this paragraph.

V

23. They deny each and every averment in this paragraph.

24. They admit that, at or about the beginning of the Twentieth Century, Canadian Copper Company, a corporation organized in 1886 under the laws of the State of Ohio, was engaged in mining and smelting nickel-copper ores in Canada and had entered into contractual arrangements for the sale of nickel-copper matte to Orford Copper Company. They admit that Canadian Copper Company also refined some nickel experimentally. They admit that Orford Copper Company, a corporation organized in 1887 under the laws of the State of New Jersey, was engaged in refining nickel at its refinery located at Constable Hook near Bayonne, New Jersey from nickel-bearing materials supplied by Canadian Copper Company and was there engaged also in refining other metals. They admit that American Nickel Works, a corporation organized under the laws of the Commonwealth of Pennsylvania in 1902, acquired certain assets from Joseph Wharton, which assets included facilities at Camden, New Jersey capable of use for smelting and refining metals, including nickel, and included also an undivided one-third interest in certain lands in Canada having some nickel-bearing minerals. They admit that earlier said Joseph Wharton had engaged in smelting and refining nickel from ores mined at Lancaster Gap, Pennsylvania and that in or prior to 1893 mining operations at Lancaster Gap were terminated. Except as so admitted, they are without knowledge or information sufficient to form a belief as to the truth of the averments in this paragraph.

25. They admit that on or about March 30, 1902 International Nickel Company, a holding corporation, was organized under the laws of the State of New Jersey. They admit that the authorized capital of International Nickel Company was thirty-six million dollars (\$36,000,000). They admit that, of this authorized capital, stocks and

bonds with an aggregate par value and principal amount of approximately twenty-seven million seven hundred thousand dollars (\$27,700,000) were issued as the consideration for the acquisitions set forth in paragraph 26 of the complaint. Except as so admitted, they deny each and every averment in this paragraph 25 of the complaint.

26. They admit the averments in this paragraph except that they are without knowledge or information sufficient to form a belief as to the truth of the averment that The Anglo-American Iron Company was engaged in mining in Canada and except that the averment in this paragraph that the combined assets of the companies acquired by International Nickel Company were approximately thirty million dollars (\$30,000,000) is not sufficiently definite or certain to permit of admission or denial and in consequence they are unable either to admit or deny said averment.

27. They deny each and every averment in this paragraph.

28. They admit that The International Nickel Company was organized in 1912 under the laws of the State of New Jersey in connection with a recapitalization of International Nickel Company, that The International Nickel Company of Canada, Limited was organized in 1916 under the laws of the Dominion of Canada and that, upon the organization of said Canadian Company, it became a wholly-owned subsidiary of The International Nickel Company. They admit that the assets of American Nickel Works were transferred in 1905 to Orford Copper Company, that the assets of The Vermillion Mining Company of Ontario and The Anglo-American Iron Company were transferred in 1911-1912 to Canadian Copper Company, that the assets of Orford Copper Company were trans-

ferred in 1912 to The International Nickel Company and that the assets of Canadian Copper Company were transferred in 1918 to The International Nickel Company of Canada, Limited. They admit that after such transfers the corporate existence of the transferor subsidiary companies was terminated. Except as so admitted, they deny each and every averment in this paragraph.

29. They admit that in or about 1922 The Mond Nickel Company, Limited, a corporation organized under the laws of Great Britain, purchased a plant at Hyde, Pennsylvania and organized American Nickel Corporation, later known as American Mond Nickel Company, under the laws of the Commonwealth of Pennsylvania. They admit that American Mond Nickel Company engaged in the production of certain nickel products and acted as commission agent in the sale, in the United States, of nickel pellets and nickel salts produced by The Mond Nickel Company, Limited and shipped from Great Britain to the United States. Except as so admitted, they deny each and every averment in this paragraph.

30. They admit the averments of this paragraph in so far as they relate to the nickel contained in commercial nickel and nickel products except they aver that the percentages set forth do not take into account the nickel contained in scrap and secondary metal.

31. They admit that in 1928 defendant Robert C. Stanley and other persons, who were directors and officers of The International Nickel Company of Canada, Limited or The International Nickel Company, had discussions with certain stockholders or directors of The Mond Nickel Company, Limited respecting the possibility of some fusion of interests between The International Nickel Company of Canada, Limited and The Mond Nickel Company,

Limited in order to avoid a duplication of capital expenditures in operating a common ore body. Except as so admitted, they deny each and every averment in this paragraph.

32. They admit that, in accordance with the terms of a Deposit Agreement dated as of October 30, 1928, a Plan of Exchange was declared operative under which stockholders of The International Nickel Company exchanged their stock for shares of stock of The International Nickel Company of Canada, Limited and thereby became stockholders of the latter. They admit that on December 19, 1928 the name of The International Nickel Company was changed to Nickel Holdings Corporation and its corporate existence subsequently terminated by reason of its dissolution under the laws of New Jersey. Except as so admitted, they deny each and every averment in this paragraph.

33. They deny each and every averment in this paragraph.

34. They admit that in October 1928 defendant The International Nickel Company, Inc. was incorporated under the laws of the State of Delaware and that all of its capital stock was subsequently issued to The International Nickel Company of Canada, Limited, in consequence of which it became a wholly-owned subsidiary of said Canadian corporation. They admit that the plant for the production of nickel products at Huntington, West Virginia and the plant at Bayonne, New Jersey, together with the stock of certain corporations and other assets, were transferred by The International Nickel Company to The International Nickel Company, Inc. They admit that The International Nickel Company, Inc. thereafter sold commercial nickel and produced and sold nickel

products within the United States . Except as so admitted, they deny each and every averment in this paragraph.

35. They admit that a Memorandum of Agreement was made as of January 1, 1929 between The International Nickel Company of Canada, Limited and The International Nickel Company, Inc., which related, among other things, to the sale of commercial nickel and certain nickel-bearing material by the Canadian corporation to the Delaware corporation and to the sale of nickel products by the Delaware corporation to the Canadian corporation. They admit that a Memorandum of Agreement was made as of January 1, 1931 between said parent company and its subsidiary which, among other things, amended the aforesaid Memorandum of Agreement made as of January 1, 1929. They refer to the Memoranda of Agreement themselves, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of their terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

36. They admit that an agreement in writing, dated December 20, 1928, was made between The International Nickel Company of Canada, Limited, certain holders of shares of The Mond Nickel Company, Limited and all other holders of such shares who should thereafter become parties thereto; they admit that said agreement provided, among other things, for the sale to The International Nickel Company of Canada, Limited of shares of The Mond Nickel Company, Limited, in consideration of shares of The International Nickel Company of Canada, Limited. They admit that this agreement was consummated in 1929 and that The International Nickel Company of Canada, Limited acquired thereby all or substantially all the issued capital shares of The Mond Nickel Com-

pany, Limited, a British corporation among the assets of which were mines and a smelter in Canada, a nickel refinery and a precious metals refinery in Great Britain and the stock of various subsidiaries, including American Mond Nickel Company; they admit that the stock of American Mond Nickel Company was transferred to The International Nickel Company of Canada, Limited by The Mond Nickel Company, Limited on or about April 30, 1929. Except as so admitted, they deny each and every averment in this paragraph.

37. They admit that on or about April 16, 1929, The International Nickel Company of Canada, Limited became sole director and manager of The Mond Nickel Company, Limited. They admit that an agreement in writing was made on June 30, 1929 by The International Nickel Company of Canada, Limited and The Mond Nickel Company, Limited providing for the sale to the Canadian corporation for a cash consideration of all assets of The Mond Nickel Company, Limited located in Canada and elsewhere on the continent of America. They admit that said agreement was executed and that, as a result, The International Nickel Company of Canada, Limited acquired said assets, including facilities for nickel mining and smelting and for the sale of commercial nickel and nickel products theretofore owned and operated by The Mond Nickel Company, Limited in Canada. Except as so admitted, they deny each and every averment in this paragraph.

38. They admit the averments in this paragraph.

39. They deny each and every averment in this paragraph.

40. They deny each and every averment in this paragraph.

41. They admit that, in 1931 and for many years before, The International Nickel Company of Canada, Limited, together with its wholly-owned subsidiaries, was the largest producer and seller of commercial nickel and nickel products in the world. They admit that a large part of the remaining world production of nickel was in 1931 and for many years before produced by two French companies namely: Societe Anonyme Le Nickel and Societe Anonyme Caledonia Charbonnages Minerais et Metaux de la Nouvelle Caledonie. Except as so admitted, they deny each and every averment in this paragraph.

42. They admit the averments in this paragraph.

43. They deny each and every averment in this paragraph.

44. They admit that an agreement in writing, named therein the "Main Agreement", was made under date of October 23, 1931 by The International Nickel Company of Canada, Limited, The Mond Nickel Company, Limited and Caledonickel. They admit that an agreement in writing, named therein "Agreement re (i) Disposal of Interest in Properties (ii) Sales in North America", was made under date of October 23, 1931 by The International Nickel Company of Canada, Limited, The Mond Nickel Company, Limited, Societe Anonyme Le Nickel, Societe Anonyme Caledonia Charbonnages Minerais et Metaux de la Nouvelle Caledonie and Caledonickel. They refer to said agreements, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of their terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

45. They admit the execution of the Main Agreement, as identified in paragraph 44 hereof, and they refer to

said agreement, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

46. They admit that the Main Agreement states that it was entered into by The International Nickel Company of Canada, Limited and The Mond Nickel Company, Limited in reliance upon the warranties and agreements contained in "Agreement re (i) Disposal of Interest in Properties (ii) Sales in North America". They refer to said agreements, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of their terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

47. They admit that the "Agreement re (i) Disposal of Interest in Properties (ii) Sales in North America", as identified in paragraph 44 hereof, contained, among other provisions, the language quoted in this paragraph. Except as so admitted, they deny each and every averment in this paragraph.

48. They admit that an agreement in writing was made on February 21, 1933 by The Mond Nickel Company, Limited and Norddeutsche Affinerie, a German corporation which was engaged in the refining of metals, including some nickel. They refer to said agreement, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

49. They admit that in or prior to 1933, I. G. Farbenindustrie Aktiengesellschaft, a corporation or associa-

tion organized and existing under the laws of Germany, had developed or acquired certain processes for the production of nickel powder from matte containing nickel and for the utilization of such powder. Except as so admitted, they are without knowledge or information sufficient to form a belief as to the truth of the averments in this paragraph.

50. They deny each and every averment in this paragraph.

51. They admit that on April 28, 1934, The Mond Nickel Company, Limited and I. G. Farbenindustrie Aktiengesellschaft entered into two agreements in writing, one of which was therein named the "Main Agreement" and the other of which was therein named the "Patent Agreement". They refer to said agreements, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of their terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

52. They admit that the Main Agreement and the Patent Agreement were executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreements themselves, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of their terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

53. They admit that the Main Agreement was executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreement itself, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provi-

sions. Except as so admitted, they deny each and every averment in this paragraph.

54. They admit that the Patent Agreement was executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreement itself, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

55. They admit that the Patent Agreement was executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreement itself, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

56. They admit that the Patent Agreement was executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreement itself, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

57. They admit that the Main Agreement was executed by the parties thereto, as identified in paragraph 51 hereof. They refer to the agreement itself, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. Except as so admitted, they deny each and every averment in this paragraph.

58. They admit that the Main Agreement and the Patent Agreement were executed by the parties thereto,

as identified in paragraph 51 hereof. They refer to said agreements, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of the provisions governing the terms of said agreements. They admit that by letter, dated April 28, 1934, signed by defendant Robert C. Stanley and attested by defendant Paul D. Merica, The International Nickel Company of Canada, Limited guaranteed full and complete performance by The Mond Nickel Company, Limited of each and every obligation of The Mond Nickel Company, Limited under both the Main Agreement and the Patent Agreement.

59. They admit that in 1937 I. G. Farbenindustrie Aktiengesellschaft was desirous of augmenting its capacity for refining nickel by erecting a new refinery in Germany with a capacity of about two thousand tons per annum; they admit that negotiations for the purpose of modifying the Main Agreement were conducted between the parties thereto and the changes agreed upon were incorporated in an agreement in writing, named therein "Supplemental Agreement", made on May 4, 1937 between said parties to the Main Agreement. They refer to said Supplemental Agreement, which will be produced upon the trial or at any other time directed by this Court, for a complete statement of its terms and provisions. They admit that The International Nickel Company of Canada, Limited by letter extended to the Supplemental Agreement its guaranty of performance by The Mond Nickel Company, Limited of the Main Agreement and the Patent Agreement. Except as so admitted, they deny each and every averment in this paragraph.

60. They admit the averments of this paragraph except they aver that the "understanding and contracts", the benefits and obligations of which were assumed by

Societe Anonyme Le Nickel, were only those agreements in writing identified in paragraph 44 hereof.

61. They deny each and every averment in this paragraph.

VI

62. They deny each and every averment in this paragraph.

63. They deny each and every averment in this paragraph.

VII

SEPARATE DEFENSE OF THE INTERNATIONAL NICKEL
COMPANY OF CANADA, LIMITED

64. The International Nickel Company of Canada, Limited avers that it is a corporation organized and existing under the laws of the Dominion of Canada and is not and has not at any time been an inhabitant of, or found in, the United States and this Court lacks jurisdiction over this defendant.

WHEREFORE, the defendants demand judgment dismissing the complaint.

SULLIVAN & CROMWELL

By Inzer B. Wyatt
(A Member of the Firm)

Attorneys for Defendants,
48 Wall Street,
New York 5, New York.

October 23, 1946.

NO. 36-31 CIVIL

IN THE
District Court of the United States
FOR THE SOUTHERN DISTRICT OF NEW YORK

UNITED STATES OF AMERICA,
Plaintiff,

v.

THE INTERNATIONAL NICKEL COMPANY
OF CANADA, LIMITED, *et al.,*
Defendants.

FINAL JUDGMENT

Judgment filed July 2, 1948

IN THE
District Court of the United States
FOR THE SOUTHERN DISTRICT OF NEW YORK

UNITED STATES OF AMERICA,
Plaintiff,

v.

THE INTERNATIONAL NICKEL COMPANY OF
CANADA, LIMITED, AND THE INTERNATIONAL
NICKEL COMPANY, INC.,

Defendants.

Civil Action
No. 36-31

FINAL JUDGMENT

The plaintiff, United States of America, having filed its complaint herein on May 16, 1946, and the defendants having appeared and filed their answer to such complaint denying any violation of law; and all parties hereto by their attorneys having severally consented to the entry of this final judgment herein; and the defendant The International Nickel Company of Canada, Limited, a foreign corporation, having consented to accept jurisdiction of this Court solely for the purposes of this judgment;

NOW THEREFORE, without trial or adjudication of any issue of fact or law herein, and without any admission by the defendants with respect to any such issue, and before the taking of any testimony herein, and upon the consent of all the parties hereto, it is hereby

ORDERED, ADJUDGED AND DECREED, as follows:

I

This Court has jurisdiction of the subject matter of this action and all the parties hereto and the complaint states a cause of action against the defendants under Sections 1 and 2 of the Act of Congress of July 2, 1890, c. 647, 26 Stat. 209, as amended, entitled "An Act to Protect Trade and Commerce Against Unlawful Restraints and Monopolies", commonly known as the Sherman Act.

II

When used in this final judgment, the following terms have the meanings assigned respectively to them below:

(a) "Inco Ltd." means the defendant The International Nickel Company of Canada, Limited, a corporation organized and existing under the laws of the Dominion of Canada, its successors and assigns.

(b) "Inco Delaware" means the defendant The International Nickel Company, Inc., a corporation organized and existing under the laws of the State of Delaware, and any subsidiary or division of Inco Ltd. which at the time is producing rolling mill products in the United States.

(c) "Nickel-bearing materials" means nickel ores, concentrates, mattes and speisses, used or intended to be used in whole or in part for their nickel content or the production of nickel.

(d) "Rolling mill products" means rolled or extruded metallic nickel and rolled or extruded non-ferrous alloys of nickel the nickel content of which is above fifty (50) per centum, in the usual commercial forms, including, but without limitation to, sheets, strips, bars, rods and tubing, and machined forgings of metallic nickel or of such alloys of nickel; and, if at the time Inco Delaware is producing and marketing

in the United States any sheets, strips, bars, rods, or tubing made of metallic nickel or of alloys of nickel the nickel content of which is above fifty (50) per centum by any process employed as a substitute for rolling or extrusion, the term "rolling mill products" shall also mean such products made by such process; and if at the time Inco Delaware is producing and marketing in the United States any articles made of metallic nickel or of alloys of nickel the nickel content of which is above fifty (50) per centum which are more advanced than "rolling mill products" as above defined and which are not made from "rolling mill products" as above defined, the term "rolling mill products" shall also mean such articles; provided, however, that "rolling mill products" shall not include any cast product or any product of a kind produced primarily for use as a source of nickel, such as for remelting, dissolving or plating. For the purposes of this definition "non-ferrous alloys of nickel" means alloys which contain less than ten (10) per centum of iron; and also alloys containing ten (10) per centum or more of iron which Inco Delaware at the time is producing and marketing in the United States.

(e) "Rolling mill producer" means any person, other than Inco Delaware, engaged or about to engage in the production of rolling mill products in the United States but, except as defendants may elect otherwise, shall not include any person that is or controls, or is controlled by or is under common control with, a person engaged in the business of marketing on a commercial scale nickel-bearing material, nickel oxide or unwrought metallic nickel.

(f) "Rolling material" means (1) such kinds of unwrought metallic nickel in the usual commercial forms, including, but without being limited to, shot, ingots, cathodes, bricks, cubes and powder and (2)

such kinds of nickel-copper matte or other material (such as a nickel oxide sinter) the metal content of which is likewise predominantly of nickel, as Inco Ltd. and its other subsidiaries may at the time be providing to Inco Delaware for the production by it in the United States of rolling mill products; provided, however, that "rolling material" shall not mean any material to the extent that it is used by Inco Delaware for experimental production or for the production of a product to be further processed and primarily sold outside the United States by Inco Ltd. or any of its subsidiaries.

III

Inco Ltd. and Inco Delaware are hereby ordered and directed for a period of twenty years after the date of entry of this judgment:

(a) Subject to the provisions of Section IV, upon the request of rolling mill producers, to offer to sell and to sell rolling material to them for the production of rolling mill products within the United States, and for a reasonable inventory for such purpose, without any condition or restriction on the use of, sale or marketing of rolling mill products produced therefrom.

(b) To sell any rolling material sold to rolling mill producers pursuant to sub-paragraph (a) of this Section III at a price and other terms of sale as favorable as the prevailing current price and other terms of sale for the same kind of material then being charged by the defendants and their subsidiaries to other unaffiliated, non-governmental consumers in the United States; or if the particular kind of rolling material is not being sold on a commercial scale by the defendants and their subsidiaries to such other consumers, at a price not exceeding:

(i) if it is a sintered rolling material containing more copper than is contained in nickel oxide sinter then being sold to such other consumers as aforesaid but containing by weight substantially the same percentage of oxygen and substantially the same aggregate percentage of nickel and copper, the prevailing price per pound of nickel content then currently being charged on such sales of such nickel oxide sinter plus, per pound of copper content in excess of the approximate average amount in such nickel oxide sinter, a fair United States market price for refined copper, or

(ii) if it is some other rolling material, the prevailing price per pound of nickel content then currently being charged on sales of the most nearly comparable material to such other consumers as aforesaid, reasonably adjusted for the estimated saving or increased expense experienced by Inco Delaware in converting such rolling material into rolling mill products of a kind for which such rolling material is primarily suited, plus the market price for any additional metals of value contained,

and in each such case on as favorable other terms of sale as those generally being granted by the defendants and their subsidiaries to such other consumers.

IV

The obligations set forth in Section III of this final judgment shall be subject to the following:

(a) At any time when the total quantity of any kind of rolling material which Inco Ltd. and Inco Delaware may decide to offer to sell for the production of rolling mill products in the United States by rolling mill producers and to deliver to Inco Delaware's

plants for the production of such products, is or may be insufficient to provide both to all rolling mill producers and to Inco Delaware the full amounts which they may desire for such purpose, sub-paragraph (a) of Section III shall (in so far as the quantity which Inco Ltd. and Inco Delaware are to offer to sell and to sell is concerned) be construed to require only the following: that with respect to the aforesaid total quantity of such kind of rolling material Inco Ltd. and Inco Delaware shall in good faith endeavor without discrimination to share such total quantity, on the basis of relative bona fide needs for the production of rolling mill products in the United States, as between (i) the amount sold to all rolling mill producers in the aggregate pursuant to said subparagraph (a) on the one hand, and (ii) the amount delivered to Inco Delaware's plants for their own production of rolling mill products in the United States on the other hand. The determination of such relative bona fide needs may be made by Inco Ltd. and Inco Delaware in advance from time to time for periods not exceeding one year. Nothing in this judgment shall affect or limit the right of Inco Ltd. and Inco Delaware to determine the total quantity of rolling material and of each kind thereof which they may offer to sell for the production of rolling mill products in the United States by rolling mill producers and deliver to Inco Delaware's plants for the production of such products.

(b) Inco Ltd. and Inco Delaware need not sell during any calendar year to any rolling mill producer (i) who does not notify Inco Delaware during the previous November of his desire to purchase rolling material under Section III during such year; or (ii) who does not upon request contract with Inco Delaware for such year, or if relative bona fide needs are then being determined pursuant to sub-paragraph (a) of this Section IV and are being determined for a

period of less than a year then for such period, to purchase the rolling material which may be sold to him pursuant to Section III, or such part thereof as Inco Delaware may desire to have covered by contract.

(c) Deliveries of rolling material need be made only in carload shipments distributed reasonably uniformly through the year. Sales of rolling material need not be made to any rolling mill producer who does not undertake to buy for the production of rolling mill products in the United States a minimum during the calendar year of 108 short tons of nickel contained. At the election of Inco Ltd. or Inco Delaware any sale may be made by Inco Ltd. or any of its subsidiaries.

V

Inco Delaware is hereby ordered and directed to present to the libraries of Massachusetts Institute of Technology, Cambridge, Mass., Columbia University, New York, N. Y., University of Pennsylvania, Philadelphia, Pa., University of Michigan, Ann Arbor, Mich., University of Illinois, Urbana, Ill., University of Alabama, University, Ala., Texas A. & M. College, College Station, Tex., Colorado School of Mines, Golden, Colo., California Institute of Technology, Pasadena, Calif., and University of Washington, Seattle, Wash., a copy of the written manual heretofore prepared by Inco Delaware and submitted to the Department of Justice descriptive of processes and methods used by Inco Delaware in its commercial practice as of October 1947 in the production of rolling mill products from sinter and nickel-copper matte at its Huntington, W. Va. rolling mill, and entitled

"NICKEL-COPPER MATTE AND SINTER
Processes and Methods of Producing
Rolling Mill Products—October 1947
The International Nickel Company, Inc.
Huntington Works"

and to provide 300 copies of such manual to the Library of Congress of the United States.

VI

Inco Ltd. and Inco Delaware and their officers, directors, agents and employees and any persons acting or claiming to act under, through or for any of them, be and they hereby are severally and jointly enjoined and restrained from selling nickel-bearing materials or rolling material to any producer of nickel-bearing materials or rolling material on the express or implied condition that such producer shall not import all or any part of its production of nickel-bearing materials, of rolling material or of rolling mill products into the United States, its territories or possessions, or selling rolling material to any producer of rolling mill products on the express or implied condition that such producer shall not import rolling mill products produced by it into the United States, its territories or possessions. This Section VI shall not be deemed to adjudicate or determine the legality or illegality of nor shall it apply to agreements, undertakings or understandings between Inco Ltd. and any of its subsidiaries or between any such subsidiaries.

VII

For the purpose of securing compliance with this judgment and for no other purpose, duly authorized representatives of the Department of Justice shall, upon written request of the Attorney General or an Assistant Attorney General, and on reasonable notice to the defendants, be permitted, subject to any legally recognized privilege (1) access, during the office hours of Inco Delaware, to all its books, ledgers, accounts, correspondence, memoranda and other of its records and documents in its possession or under its control relating to any matters contained in this judgment; (2) access at

reasonable times to such records and documents of Inco Ltd. as may be then located in the United States in the possession or under the control of Inco Ltd. relating to any matters contained in this judgment; and (3) subject to the reasonable convenience of the defendants and without restraint or interference from them, to interview such of their officers or employees as may be in the United States, who may have counsel present, regarding any such matters; and upon such request the defendants shall submit such reports in writing with respect to the provisions of Sections III, IV and VI of this judgment as might from time to time be reasonably necessary to the enforcement of this judgment; provided, however, that no information obtained by the means provided in this Section shall be divulged by any representative of the Department of Justice to any person other than a duly authorized representative of such Department except in the course of legal proceedings in which the United States is a party for the purpose of enforcing or securing compliance with this judgment, or as otherwise required by law.

VIII

None of the defendants, their officers, directors, agents or any persons acting or claiming to act under, through or for any of them shall be in contempt of this judgment for doing anything outside the United States which is required, or for not doing anything outside the United States which is unlawful, under the laws of the government of the dominion, province, country or state in which Inco Ltd. or any of its subsidiaries may be incorporated or chartered or in the territory of which Inco Ltd. or any such subsidiaries may be doing business. In any such case Inco Ltd. shall advise the plaintiff thereof as promptly as is practicable and thereupon the plaintiff may apply to this Court, with full opportunity to the defendants to be heard, for such relief consistent with the provisions of this judgment as the Court may deem appropriate.

IX

This Court shall enter an order dismissing the complaint herein and vacating this judgment in its entirety upon the petition of the plaintiff (a) at any time after January 1, 1957, or (b) at any time after the obligations of the defendants under Section III shall have become inoperative by reason of the fact that Inco Delaware is not using rolling material provided by Inco Ltd. or its other subsidiaries for the production of rolling mill products in the United States; and in any new proceeding instituted by the plaintiff under the Sherman Act after the entry of any such order this judgment shall not be deemed a bar to the granting of appropriate relief or to the defendants' interposing any defense other than that such relief is barred by this judgment.

Without limiting the provisions of Section X hereof, Inco Ltd. or Inco Delaware shall be entitled to have Sections III and IV hereof vacated upon a showing to the Court upon 30 days' notice to the Attorney General that Inco Ltd. and its subsidiaries in the sale of rolling material are in substantial competition with nickel containing material produced by others and either sold in the United States or sold for use in the United States, provided that an application for such purpose shall not be made oftener than once every two years.

X

Jurisdiction of this cause is retained for the purpose of enabling only the Attorney General or Inco Ltd. or Inco Delaware to apply to the Court at any time for such further orders and directions as may be necessary or appropriate for the construction or carrying out of this judgment; for the modification or termination of any of the provisions thereof (and in the event any laws, requirements or requests of any government or governmental body make observance of this

judgment unduly burdensome or are inconsistent with the terms of this judgment the right of the defendants to apply for such relief as the Court may deem appropriate is hereby expressly recognized); and for the enforcement of compliance with this judgment, and for the punishment of violations thereof.

DATED: July 2d, 1948

HAROLD R. MEDINA

United States District Judge

We hereby consent to the entry of the foregoing judgment.

FOR THE PLAINTIFF:

HERBERT A. BERGSON

JOHN F. X. MCGOHEY

HERBERT A. BERGSON
Assistant Attorney
General

JOHN F. X. MCGOHEY
United States Attorney

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MANUEL M. GORMAN

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Attorney General

FOR THE DEFENDANTS:

SULLIVAN & CROMWELL

.....

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GEORGE C. SHARP

By

A member of the firm

ISSEKS, MEYERS & VERDON

.....

ISSEKS, MEYERS & VERDON

ERNEST S. MEYERS

By

A member of the firm

THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET · NEW YORK 5, N. Y.

HENRY S. WINGATE
ASSISTANT TO THE PRESIDENT

July 2, 1948

Mr. Sigmund Timberg
Anti-trust Division
Department of Justice
Washington, D. C.

Dear Mr. Timberg:

As indicated by the notes I have made on the copy I have sent you of the text of the manual referred to in Section V of the Consent Judgment being entered today, certain of our patents are used in the conversion of sinter and nickel-copper matte into metal ingots; those which will be unexpired as of January 1, 1949 are U. S. Patent numbers 2138459; 2150094; 2150095; 2159048 and 2406582.

I confirm that it will be the policy of this Company in selling sinter or nickel-copper matte pursuant to the Consent Judgment (a) to be willing to enter into negotiations with the rolling mill producer for a license under the above-numbered U. S. Patents authorizing such producer to employ said patents in the conversion of such sinter or nickel-copper matte into metal to be used for the rolling mill producer's production of rolling mill products in the United States, and (b) to impose only reasonable royalties and reasonable conditions in any such license.

Very truly yours,

THE INTERNATIONAL NICKEL COMPANY, INC.

By Henry S. Wingate
Assistant to the President

HSW:LG

(Filed in Court - July 2, 1948)

NICKEL-COPPER MATTE AND SINTER

**Processes and Methods of Producing
Rolling Mill Products — October, 1947**

**The International Nickel Company, Inc.
Huntington Works**

NICKEL-COPPER MATTE AND SINTER

Processes and Methods of Producing
Rolling Mill Products — October, 1947
The International Nickel Company, Inc.
Huntington Works

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NICKEL-COPPER MATTE AND SINTER

Processes and Methods of Producing
Rolling Mill Products - October, 1947
The International Nickel Company, Inc.
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F O R E W O R D

Since the construction of the Huntington, West Virginia plant in 1922, it has extensively used a nickel-copper matte as a basic raw material in the production of rolling mill products. Starting in 1947 the plant has been shifting over from the use of nickel-copper matte to the use of sinter. Pending consumption of its remaining supply of matte, both sinter and matte are being used.

The following text is descriptive of processes and methods used by the plant in its commercial practice as of October 1947 in the production of rolling mill products from these basic raw materials.

CHAPTER I

CALCINING

Raw Materials

Of the two basic raw materials mentioned above only nickel-copper matte requires calcination or roasting. The matte is in the form of rough irregular slabs two or three inches in thickness and weighing up to 100 pounds. A sample analysis is as follows:

<u>Nickel-Copper Matte</u>	
Nickel*	52.77%
Copper	24.78%
Sulphur	21.98%
Iron and impurities	0.47%

Sizing for Roasting

The first step in preparing matte for roasting is the reduction of the slabs to properly sized particles. Accordingly, the slabs of matte are reduced to about 1½" pieces in a jaw-crusher, reduced to about ¾" pieces in a cone crusher and finally ground dry to minus 14 mesh in a ball mill.

Particle size distribution is an important factor, since large particles reduce the rate of sulphur elimination and particles smaller than minus 325 mesh tend to be lost in the furnace gases. A sample screen analysis of a ground matte suitable for roasting

*In accordance with the practice of the trade, all analyses of nickel content given in this manual include the accompanying cobalt as nickel.

in end-fired, mechanically rabbled furnaces of the Edwards' type, which are used, is as follows:

<u>Screen Size (U.S. Std.)</u>	<u>% On</u>	<u>% Cumulative</u>
12	0.0	0.0
14	0.1	0.1
20	6.4	6.5
30	9.7	16.2
50	21.6	37.8
100	15.2	53.0
200	12.3	65.3
325	12.5	77.8
thru 326	22.2	22.2

Roasting

The rate at which sulphur is eliminated for a given particle size distribution is determined by the relationship between several important factors:

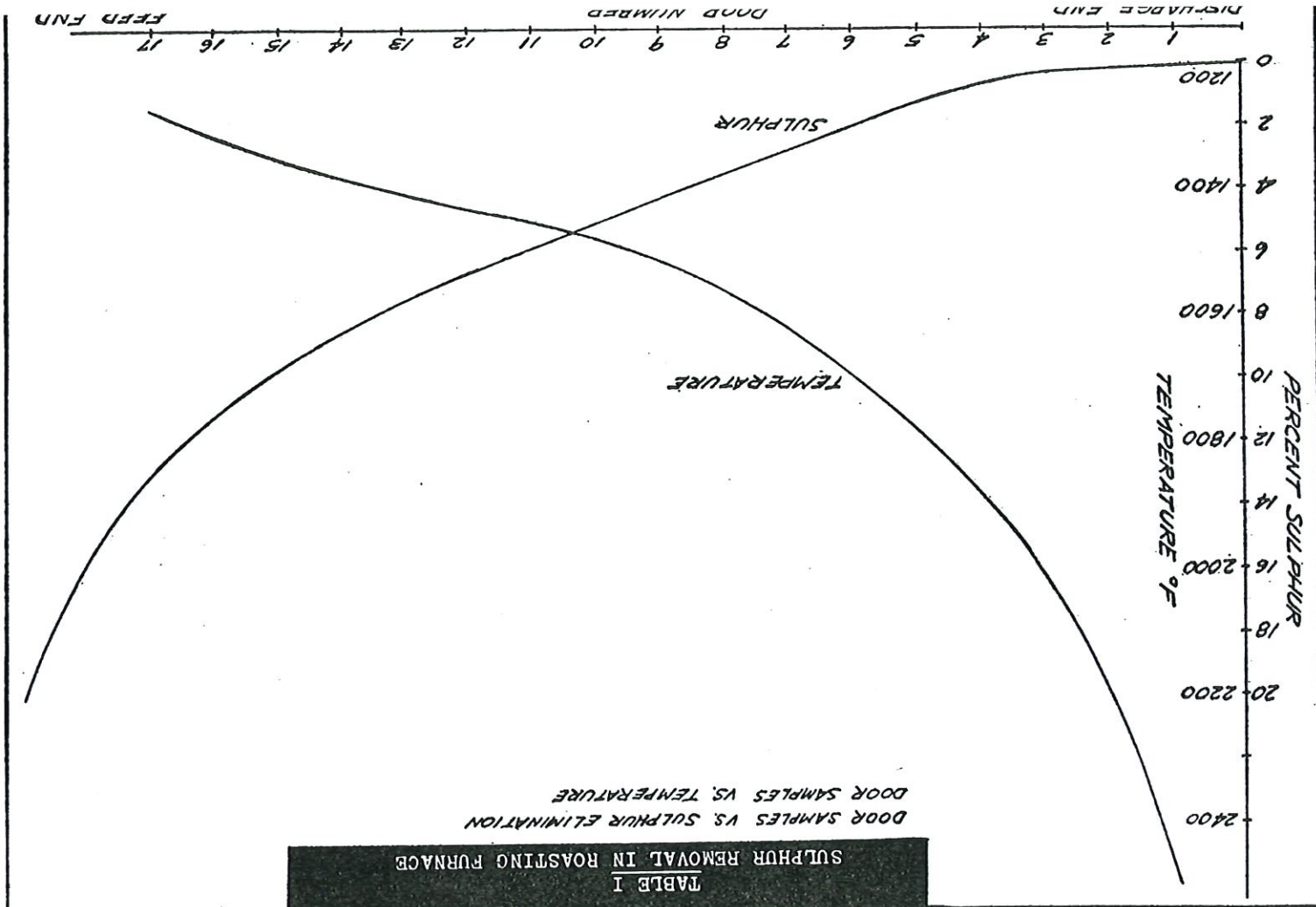
- a. furnace atmosphere
- b. rate of feed
- c. degree of agitation
- d. furnace temperature conditions

To effect sulphur elimination, the furnace atmosphere is maintained highly oxidizing. Typically the oxygen varies between about 2 to 10%. The fuel used is low sulphur natural gas. The rate of feed and degree of agitation as the matte is advanced through the furnace is such as to provide for an average exposure of 4 hours in the furnace. The temperature

gradient in the furnace runs from approximately 1250° F. at the charging end to 2550° F. at the discharge end, since as the sulphur is progressively removed the temperature at which fusion begins is progressively correspondingly higher. Fusion, which would result in increasing the particle size and thereby adversely affect oxidation of the sulphur, is avoided by controlling the rate of feed and speed of travel of the material through the furnace.

The mechanically rabbled furnaces have hearths 12' 11" by 70' 0" and are fed continuously at a rate to maintain a layer of matte approximately four inches in thickness at the charging end. This layer progressively decreases in thickness as the material approaches the discharge end. In this operation the matte is converted from a sulphide into an oxide. The hot oxide is automatically discharged into removable drums located below the floor level where it is blended with charcoal in order to obtain a partial reduction of the oxide to metallics to improve the later melting furnace efficiencies. The capacity of each furnace approximates 20 tons per day of partially reduced nickel-copper oxide containing sulphur of the order of 0.030 per cent. Each furnace consumes about 322,000 cu. ft. of gas per day which at 1150 B.T.U. per cu. ft. is a heat input at the rate of 15,000,000 B.T.U. per hour.

The sulphur removal is graphically illustrated in Table I (curve shown on page 5).



CHAPTER II

MELTING AND REFINING

The materials entering into melting and refining operations are in the form of oxides; one form called here nickel-copper oxide is the end product of the process dealt with in Chapter I. The other is a sinter (comparable in the combined nickel plus copper and the oxygen content with the nickel plus copper and the oxygen content of the nickel oxide sinter sold to the steel trade, the nickel plus copper being of the general order of 75% by weight).

Open Hearth Furnace Practice

Furnace charges are made up by mixing the oxide or sinter with low sulphur petroleum coke amounting to 15% by weight of the charge. A mechanical mixer provides the thorough and intimate mixing of the oxides and petroleum coke that is required for most effective reduction in the furnace. The desired nickel to copper ratio in the alloy is obtained by adding copper. The major portion of the copper required is added in the open hearth furnace at the time the charge of sinter and petroleum coke are introduced. The final addition of copper is made in the electric furnace after duplexing, as described below, and after the copper content of the melt has been determined by chemical analysis.

The open hearth furnace is constructed of first quality acid fire brick to operate at high temperatures. The fuel is low sulphur natural gas.

The furnace charge is leveled off to expose the largest possible area to the flame and also to minimize deflection of the flame against the fur-

nace roof. The flame is adjusted on the reducing side as an aid in reduction of the oxides to metallics. The atmosphere is regulated to contain 6 to 8% CO while carbon is burning off and approximately 2% CO there-after.

An effort is made to adjust the reducing agents, so as to have the heat melt down with about 0.25 - 0.40% carbon. This gives a faster and more efficient operation of the furnace and is desirable for subsequent refining operations. An oxidizing melt down is invariably slow and results in gassy metal.

No slag producing materials are added, but slag does result from the fusion of the refractories and from dross in the oxides and petroleum coke. The skimming of this slag is begun when the charge is partially melted and is continued at intervals until the charge is completely melted.

When the charge is completely melted and all slag has been removed, the metal temperature is brought up to about 2700° F. to prepare for tapping. Typical carbon and sulphur analysis at this stage is:

C	0.35%
S	0.090%

The increase in sulphur content is a consequence of the presence of sulphur in petroleum coke. The desired maximum sulphur content of petroleum coke is 1%.

By having sufficient carbon (0.25 - 0.40%), the reducing conditions essential for further desulphurization are assured. While the metal is being tapped into a fire-brick lined ladle, 1% manganese in the form of ferro-manganese is added to the stream. Metallic magnesium equal to 1¼ to 1½ times by weight

of the known sulphur content is then plunged into the molten metal contained in the ladle. The magnesium is wired firmly in "U" shaped iron holders which are on the ends of long iron rods or handles. Holders and a portion of the handles are protected by a coating of lime slurry which is carefully dried before any contact with molten metal is made. The magnesium combines with part of the sulphur and floats to the top as magnesium sulphide.

Cryolite is then put on the metal surface to form a slag $\frac{1}{4}$ " to $\frac{1}{2}$ " thick which collects the insoluble magnesium sulphide that rises to the top of the metal in the ladle. With the ladle slightly tilted, this slag is then skimmed off. Approximately one-half of the sulphur contained is removed by this operation.

Duplex Process

Duplexing is the double operation of reduction of oxides by melting in the presence of carbon in an acid lined Open Hearth followed by final refining in basic lined direct arc type electric furnaces. The electric furnace is lined with magnesite brick as bottom and side wall to a point above the normal slag line. The bottom is finished and maintained with dolomite. For roof and side walls above the slag line either fire clay or silica brick are used.

Hot metal as prepared in the Open Hearth and treated with manganese and magnesium is transferred to the electric furnace. The metal as received is first skimmed clean of any slag which may have remained from the previous operation. A white slag consisting of about 3 parts by weight of fluorspar and 2 parts of lime is then put on the bath in sufficient quantity to cover the entire surface to a depth of 1 to

2 inches. As soon as this slag is fused, a mixture of finely divided carbon with some lime is scattered over the white slag. The finely divided carbon may be coke breeze or derived from grinding scrap carbon and graphite electrodes. Within a short time the slag is converted into a carbide type, characterized by an acetylene odor when it is immersed in water. The removal of the final sulphur from the bath is then accomplished as follows. A master alloy of calcium-silicon (33% Ca) is added in quantities sufficient to provide calcium in amount equal to 1% to 1½ times the sulphur contained. The calcium-silicon is plunged into the molten metal in the same manner as the magnesium was plunged into the ladle. (The sulphur content has been determined by chemical analysis in samples taken after the metal has been transferred to the electric furnace.)

After about 45 minutes the carbide slag which now contains calcium sulphide is skimmed. Extreme care is exercised in the removal of this slag since the subsequent oxidizing treatment would result in the return of sulphur to the bath from residual amounts of slag.

Carbon content is next lowered to the desired level by addition of oxide. The addition of oxide at this point removes any excess calcium and silicon remaining in the molten metal after the desulphurizing operation. A finishing white slag of lime and fluorspar sufficient to cover the surface is then put on the molten bath and samples are sent for the chemical determination of carbon and manganese. Corrections for these elements are made if necessary.

Deoxidation

After the desired carbon and manganese contents have been obtained the metal is deoxidized and degasified by first adding .15% silicon in the form

of metallic silicon, followed by .015% phosphorus as copper phosphorus master alloy containing 15% phosphorus. Then .05% metallic magnesium is added followed by .025% titanium as nickel-titanium (45% titanium) and .0025 - .005% zirconium as nickel-zirconium (28% zirconium). In making the additions the metal is maintained at a temperature just over 2700° F. to insure rapid and complete solution of the deoxidizing and degasifying elements. The metal is tapped as soon as possible after the additions are made to prevent excessive loss. This is the standard practice for a nickel-copper alloy in which the nickel to copper ratio is approximately 2.2:1; in the case of substantially higher nickel to copper ratios, the silicon addition is decreased to .10% and the zirconium increased to .010%.

Teeming

At a temperature of 2700° F. the molten metal, after deoxidation and degasification, is tapped into the teeming ladle. The last slag is carried over with the metal into the ladle where, due to its density, it floats on top and so protects the metal from oxidation by the atmosphere and aids in retaining temperature while the metal is being teemed. A period of 1 to 2 minutes is allowed after the ladle is filled to permit the slag to collect on the surface. The metal is then teemed into cast iron molds provided with cast copper bases or "stools" and tile-lined hot tops. An insulating blanket of Armstrong refractory impregnated cork is placed on the ingot top.

The temperature of the cast iron molds at the start of teeming is about 300° F. to prevent undue thermal shock from contact with the molten metal. No dressing is used on mold surfaces since dress in the metal as a consequence of the use of dressing is a greater hazard than is surface roughness of the ingots.

Speed of teeming is controlled by varying the size of the ladle outlet nozzle. The nozzles used range from one having a $\frac{1}{2}$ " opening for 10" x 10" x 40" ingots, a $1\frac{1}{2}$ " opening for 14" x 14" x 60" ingots, to a practical top limit of a 2" opening for larger ingots. Clay nozzles are used in conjunction with graphite stopper heads.

In starting teeming, metal is poured slowly until an 8" or 10" pool is formed at the bottom of the mold to take the full flow from the nozzle with a minimum of splashing.

Following the teeming operation, the ingots are cooled and stripped from their molds.

A sample analysis of a melt produced into ingots as described is as follows:

C	.15
Mn	1.00
Fe	1.50
S	.005
Si	.15
Cu	30.00
Ni	Balance

Arc Furnace Practice - Cold Charges

Cold charge melts as distinguished from the "duplex" melts are the means by which metal returns from process are converted directly in the arc-type electric furnace into alloy ingots.

Cold charges consist of clean metal returns from process. The heavier material is charged on the bottom of the furnace followed by lighter material

on top. General practice is to melt down as rapidly as possible to avoid excessive oxidation and to retain a carbon content of .25 - .35 per cent in the molten bath. Should the carbon content drop below this range, it is increased by addition of petroleum coke or charcoal.

After the charge is melted and skimmed clean of any dross or fused refractories, a lime-fluorspar slag is put on identical to that used for "duplex" melts. From this point the refining closely parallels that of duplex melts. The molten metal is desulphurized by addition of calcium-silicon alloy. It should be noted, however, that during the lowering of carbon, and the removal of excess calcium and silicon with oxide, the greater part of the residual deoxidizers present in the metal returns used are also removed. Therefore it is necessary to carry out complete deoxidation and degasification in the same manner as is used for the duplex melts. The same percentages of deoxidizers are added in the same order. Similarly the melts are teemed and the ingots treated as described under duplexing.

CHAPTER III

CONDITIONING OF INGOTS, BLOOMS AND BILLETS FOR HOT FORGING AND HOT ROLLING

The metal is not free scaling under conditions obtained in furnaces heating for hot rolling and forging. As a consequence, surface defects introduced in casting, forging, or rolling cannot be eliminated by means such as scale breaking, and it is necessary to resort to extensive conditioning or overhauling of the metal surface at various stages of manufacture. For the usual mill production, this involves overhauling the surface of the cast ingot by milling and machine or hand chipping defects not removed by milling; machine chipping blooms forged from the milled and chipped ingot; and machine chipping of billets rolled from the blooms. For other products, details of overhauling are modified as later described for most economical practice consistent with maintenance of quality.

For most products, the metal is cast into 14" x 14" x 60" ingots. For rounds for extrusion into tubing, ingots of 18" x 18" x 40" and 18" x 18" x 68" size are cast. Forgings as such and slab forgings for further processing into sheet or strip products are regularly produced from 14" x 14" x 60", 18" x 18" x 40", 18" x 18" x 60" and larger ingots up to 30" x 30" x 60" size. Slabs for hot rolling into plate are produced from cast ingots 18" x 30" x 48" or 18" x 30" x 60" size.

Milling

Except as later noted all cast ingots are overhauled by milling the side surfaces but not the ingot head until a minimum of 75% of the surface ex-

hibits no porosity, slag inclusions, folds or cracks; the remaining surface imperfections are removed as described later under Chipping. The corners of the ingots are milled to approximately 2" radius. This results in an average milling loss of 5% of the ingot weight.

Ingots in sizes 14" x 14" and 18" x 18" cross sections are milled on special Ingersoll milling machines. These machines mill one side and one corner of two ingots in one operation with up to ¾" stock removal in each pass. The side cutters are of inserted tooth type 24" in diameter containing two rows of 40 teeth each, the inner row being offset ½" to effect step cutting. The radius cutters are ten inches in diameter and contain 10 inserted teeth with formed cutting surface. All cutter teeth are of heat treated high speed tool steel. Ingots larger than 18" square and including 30" square cross sections are milled on Cincinnati Hydromatic milling machines. These are conventional type milling machines having inserted tooth head 8" in diameter containing 10 teeth of heat treated high speed tool steel.

Ingots for forged rounds for extruded tubing and for forgings to be subsequently machined, are not milled as the defects present in the ingot skin will be removed in machining operations. Exceptionally for critical machined forgings, the ingots may be milled and chipped before forging and perhaps overhauled at an intermediate stage.

Chipping

Milled ingots are overhauled by hand or machine chipping to remove isolated defects present after milling and the refractory at the junction of the ingot head and body.

Machine chipping is performed on Bonnot - Lenz Billeteers by a rotating head carrying 8 or 10 cutting tools of heat treated high speed tool steel. This machine is designed to permit longitudinal movement of a carriage carrying a cutter along the length of the material being chipped as well as vertical and lateral movement of the cutter head in the carriage to locate the cutter over any defect to be removed. The billeteer machine is limited to ingot sizes of 14" x 14" maximum cross section. Ingots larger than this size are hand chipped after milling. Hand chipping is performed with conventional type air hammers and chisels.

For the usual products, the ingots are forged to 8" x 8", or 4" x 11" blooms; the former for rolling into billets for the various merchant mill products and the latter for rolling into sheet bar. The blooms are inspected for defects which are then removed on the billeteer chipping machines. Forged slabs for direct rolling into strip or sheet are given an over-all grind with swing grinding machines as defects introduced by forging cannot otherwise be satisfactorily removed in this product.

The forged and conditioned 8" x 8" blooms are rolled on a 24" breakdown mill into billets for further conversion into the various merchant mill products. The billets produced on the 24" mill are inspected for defects and these are removed by billeteer chipping or by hand chipping. The forged 4" x 11" blooms are rolled into sheet bar on the 24" mill. The sheet bars are inspected for defects and these are removed by hand chipping before rolling into sheet products.

CHAPTER IV

FORGING

Heating

The time of heating preparatory to forging the ingots is just long enough to insure that the desired temperature (preferably 2150° F.) is reached uniformly throughout the material. Excessively long periods at the high temperature are avoided. Heating times generally required for various size ingots are listed below:

14" x 14" x 60" ingots	3½ to 4 hours
18" x 18" x 40" "	6 to 8 hours
26" x 26" x 60" "	10 to 12 hours
30" x 30" x 50" "	12 to 14 hours

The ingots are heated in batch type, side-door furnaces, directly fired through the back wall using low sulphur natural gas. The furnace atmosphere is regulated so as to contain an excess of carbon monoxide and hydrogen with no free oxygen present; in other words, heating is conducted in a reducing atmosphere.

Forging

By forging, cast ingots are converted to forged blooms for later production into hot rolled billets and sheet bars which are in turn hot rolled to strip, bar stock and sheet, and large rounds and shapes outside the limits of hot rolling equipment are produced. For these operations, three reciprocating steam hammers rated at 16,000 lbs., 10,000 lbs., and 3,500 lbs. are used.

The 16,000 lb. steam hammer, which has a die face 9" x 31", is used principally for forging the standard size ingots (14" x 14" x 60") into blooms 8" x 8" x approx. 1,300 lbs. and blooms 4" x 11" x approx. 1,300 lbs., for later conversion to strip, bar stock and sheet; larger ingots up to 30" x 30" x 58" (16,500 lbs.) are forged into miscellaneous sections including slabs. In addition, this hammer is used to produce forged rounds and squares from 4½" to 24".

The 10,000 lb. steam hammer, which has a die face of 9" x 28", is used to forge ingots within the size range 10" x 10" to 14" x 14" and to produce miscellaneous forged sections which are too large for the 3,500 lb. hammer and not large enough to produce economically on the 16,000 lb. hammer.

The 3,500 lb. steam hammer has a die face 8½" x 18½". This hammer is used principally for forging billets, slabs, rounds and rings and smooth forged squares, hexagons and rectangles which are not large enough to economically forge on the 10,000 and 16,000 lb. hammers.

The die blocks for these hammers are made of a composition that is resistant to abrasion, warping and fire cracking. A sample chemical analysis of the steel is as follows:

<u>C</u>	<u>Mn</u>	<u>Si</u>
.50-.60	.45-.65	.15-.25
<u>Ni</u>	<u>Cr</u>	<u>Mo</u>
1.40-1.75	.70-.80	.70-.80

The 16,000 lb. and 10,000 lb. hammers are served by electrically operated manipulators. Likewise the ingot heating furnaces are served by an electrically operated machine for charging the cold in-

gots and withdrawing the heated ingots. The transfer of the heated ingots from the latter to the former is accomplished through the use of turn tables suitably located in the separate tracks on which these machines travel. The 3,500 lb. hammer and its complementary heating furnaces are manually served.

Ingots, after heating to approximately 2150° F. as previously discussed, are first subjected to relatively light forging reductions on all four sides preliminary to the heavy roughing down operations. This precaution is necessary only when the metal to be forged is in the "as cast" condition. Heavy reductions are confined to the period during which the metal is within the temperature range 2150°-1700° F. When it is necessary to forge below 1700° F., only light reductions are made. The overall reduction in cross-sectional area following any heating operation is at least 50% to accomplish grain refinement.

The forging limitations on slabs are as fol-

lows:

<u>Thickness, in.</u>	<u>Max. width, in.</u>
3	14
4 to 5	24
6 to 18	30

The forging limitations on rounds are as fol-

lows:

<u>Diameter, after Rough Machining, in.</u>	<u>Max. length, ft.</u>
4½ to 5	22
5½ to 6	25
6¾ to 7	30
7¾ to 8	35
8¾ to 9	43
9¾ to 10	40
10¾ to 24	12,000 lb. rod

The sectional limitations for smooth forged hexagons are from 2 $\frac{1}{4}$ " to 8"; for squares from 2 $\frac{1}{2}$ " to 6"; for rectangles 1 $\frac{1}{2}$ " to 2" x 8" or less and 2" to 6" x 10" or less.

The mechanical properties of finished forgings, as distinguished from blooms, billets and slabs, are dependent upon the size of the finished piece and the finishing temperature used. High tensile properties are obtained by finish forging near the lower end of the hot working temperature range (1000 - 1400° F.).

For certain applications forgings are subjected to low temperature annealing within the range 1000 - 1300° F. This treatment moderately decreases hardness, yield strength and ultimate breaking strength, at the same time moderately increasing the elongation and reduction of area values as illustrated in Table II below. It also effectively minimizes warpage after machining.

T A B L E II

THE EFFECT OF TEMPER ANNEALING ON PROPERTIES
OF A 6" DIA. FORGED ROUND

Temp. ° F.	Time at Temp.	Yield Strength (.2% offset) psi	Tensile Strength psi	Elong. in 2" %	Red. of Rockwell "B" Area %	Hardness
as forged	-	61,000	91,500	36.5	71.7	89
1200	6 hrs.	50,500	88,500	42.0	72.7	83
1290	2 hrs.	43,500	87,000	44.0	72.8	79

CHAPTER V

MERCHANT MILL ROLLING

Heating

Heating the metal preparatory to hot rolling is carried out in batch-type, side-door furnaces direct-fired through the back wall using low pressure premix type burners. The fuel is low sulphur natural gas and the furnace atmospheres are maintained reducing, that is to say combustion is controlled to give approximately 5% hydrogen plus carbon monoxide with no free oxygen present. The temperature to which the metal is heated will vary from a high of approximately 2150° F. for large sections such as 8" x 8" and 4" x 11" blooms to a low of about 1900° F. for small sections such as 2" x 2" billets. No reheating is normally required during the rolling of standard shapes.

Rolling Billets and Sheet Bars

Forged 8" x 8" and 4" x 11" blooms, after overhauling by mechanical chipping, are hot rolled to billets and sheet bars on a breakdown mill. This mill consists of a stand of 3-high 24" diameter roughing rolls with tilting tables on front and back sides and a stand of 2-high finishing rolls. The mill is driven by a 1200 horsepower motor with a speed of 353 rpm, a gear reduction of 4.5 to 1 giving a roll speed of 77½ rpm.

The passes, reductions per pass and sizes obtained in rolling an 8" x 8" bloom into billets are shown in Table III.

TABLE III

BREAKDOWN MILL Passes, Reductions per Pass, and Sizes of Billets Produced

Pass	Roll Opening Inches	Reduction Per Pass - %	Billets Pro- duced, Inches
1	8 x 7	12.3	
2	8 x 6	14.3	
3	6 x 7	12.5	
4	6 x 6	14.3	6 x 6
5	6 x 5	16.6	5 x 6
6	6 x 4	20.0	4 x 6
7	4 x 5	17.0	4 x 5
8	4 x 4	20.0	4 x 4
9	4 x 3½	12.5	
10	4 x 3	14.3	3 x 4
11	3 x 3	25.0	3 x 3
12	3 x 2½	17.0	
13	2½ x 2½	17.0	2½ x 2½

In hot rolling 4" x 11" blooms to sheet bar, reductions of 20 - 25 per cent per pass are applied. The blooms are not edge rolled and consequently the finished width of the sheet bars varies slightly but is approximately 11½". The thickness of the finished sheet bars is from .280" to 2¾", depending upon the gauge and length of the sheets to be produced subsequently.

TABLE IV

BREAKDOWN MILL

Passes, Reduction per Pass for Sheet Bar

Pass	Roll Opening Inches*	Reduction per Pass - %*
1	2-3/4 x 11-3/4	31
2	2-1/16 x 11-3/4	25
3	1-9/16 x 11-7/8	25
4	1-1/8 x 11-7/8	28
5	13/16 x 12	28
6	5/8 x 12	23 1/2
7	Varied to suit foot-weight (.280 to 2 3/4)	

*Roll openings and corresponding reductions per pass shown are nominal and may be varied by moving top or bottom rolls up or down according to the various foot-weights produced. Width of opening remains constant.

Rolling Rods, Bars, Flat Stock, etc.

In a typical operation billets produced on a breakdown mill are overhauled and rerolled into rounds, shapes, flats or strip on one of a series of mills depending upon the sizes to be produced. For example:

(a) The 20" mill consists of four stands of 3-high 20" diameter rolls and a finishing stand of 2-high 20" diameter rolls. It is driven by a 1000-horsepower motor with a speed of 400 rpm, a gear reduction of 7.5 to 1, giving a roll speed of 53.3 rpm.

Rounds from 4 1/2" to 2" diameter in steps of 1/16" are produced on this mill by the "hand round" method. In making these rounds, only two 3-high stands

and the 2-high finishing stand are used. The finishing stand has rolls with a series of circular grooves ranging from 4½" to 2" diameter. As an example, Table V shows the development of a 3" diameter round starting with a 5" x 6" billet.

T A B L E V

20" Mill - Development of a 3" Dia. Round

<u>Pass</u>	<u>Stand</u>	<u>Size of Roll Opening</u>	<u>Reduction %</u>
1	3-high	5" x 5"	16.6
2	3-high	5½" x 3¾" (Corners rounded)	24.0
3	2-high	4" dia.	21.0
4, 5	2-high	3¾" dia.	12.0
6, 7	2-high	3½" dia.	12.0
8, 9	2-high	3¼" dia.	14.0
10, 11, 12 and 13	2-high	3" dia.	14.0

The 20" Mill is also used to produce strip in widths from 18½" to 3-13/16" and in thicknesses from .125" to .250". In rolling strip, the first 3-high stand consists of one "flat" and one edging pass. In the second stand there is a set of step rolls. The remaining stands have cylindrical ("flat") rolls. Reductions per pass of 15-30 per cent are used in making strip.

Flats 10" to 4" wide and ¼" to 1½" thick are also produced on this mill. Flats are rolled in the same manner as strip, except that two edging passes are usually applied.

(b) The 14" Mill has four stands of 3-high 14" diameter rolls and one stand of 2-high 14" diameter rolls. It is driven by an 800 horsepower

motor through a reduction gear to deliver a roll speed of 99 rpm. This mill requires billets 3" x 4" or smaller and produces rounds 2" to 1-1/16" diameter; squares and hexagons 2 3/8" to 1-1/16"; flats 1" x 4" to 1/2" x 1 1/2" and strip from 3/8" to 2" wide x 1/4" to 1/2" thick.

In Table VI is given the development of a 1 1/2" diameter round from a 3" x 3" billet.

The rolling of strip and flats on the 14" Mill is similar to the 20" Mill in setup and reductions.

T A B L E VI

14" Mill - Development of a 1 1/2" Dia. Round

<u>Pass</u>	<u>Size of Roll Opening</u>	<u>Shape of Opening</u>	<u>Reduc-</u>	
			<u>tion per</u>	<u>Pass - %</u>
1	2 1/4" x 2-29/32" (Diagonal)	Diamond	27.3	
2	1 1/2" x 2-9/64" (Diagonal)	Diamond	12.8	
3	1 1/8" x 2 1/4"	Rectangle	10.4	
4	2"	Modified Oval	4.5	
5	1-13/32" x 2 3/8"	Oval	26.4	
6	1 1/2" dia.	Round	18.4	

(c) The 10" Mill is similar to the 14" and 20" Mills in that it has four stands of 3-high rolls and a finishing stand of 2-high rolls. The mill is driven by a variable speed 500 horsepower motor through a reduction gear to deliver roll speeds from 130 - 180 rpm. Billets 2" x 2" x 55 lb. or smaller are fed to the mill to produce rounds 1 1/4" to 3/4" diameter, flats from 7/16" x 1 1/4" to 3/8" x 1 1/8" and .125" strip from 1/2" to 2-5/16" wide. This mill produces other sections as squares, hexagons, octagons, half rounds, half ovals and angles.

Rolling Wire Rod

The 9" Mill used for the production of wire rod and narrow strip consists of 12 stands of rolls set up in three sections - (1) roughing, (2) intermediate and (3) finishing. The roughing section is made up of 3 stands of 14" diameter rolls; the first stand is 3-high, the second and third stands are 2-high. This roughing section is driven by a 1000 horsepower motor delivering a roll speed of 158 rpm and reduces a $2\frac{1}{2}$ " x $2\frac{1}{2}$ " billet x $1\frac{1}{4}$ " major axis oval approximately 5/16" minor axis x $1\frac{1}{4}$ " major axis in 9 passes. This breakdown oval is fed to the intermediate section by a runway. The intermediate section is made up of 5 stands of 2-high 9" diameter rolls. In the intermediate section the oval is converted to a 5/16" square in 5 passes of alternate square and oval shapes. Rods 5/16", 3/8" and 7/16" diameter, as well as strip .125" x 3/4" to 1-9/16" wide, are finished from this second section of stands. For making smaller sized rounds, 1/4 - 9/32" dia., the 5/16" square from the second section is automatically looped to the finishing section of 4 stands of 2-high 9" diameter rolls. This last section finishes the wire rod in four passes by going to an oval, square, oval and finally to a round. The intermediate and finishing sections are driven by a 500 horsepower motor with the intermediate section of rolls traveling at 325 - 400 rpm and the finishing section of rolls turning at 440 rpm.

In making wire rod, the reductions per pass range from 15 to 45 per cent.

CHAPTER VI

EXTRUSION

The extrusion process is used to convert solid rounds into tubular products. The sequence of operation is as follows:

1. The material to be extruded is supplied in the form of long hot rolled or forged rounds.
2. The rods are turned to remove surface imperfections and to produce uniform diameter.
3. The surface of the turned rods is conditioned further by chipping with pneumatic chisels to remove any imperfections persisting after turning.
4. The turned rods are sawed into short lengths suitable for use in the extrusion press.
5. The short lengths ("billets") are heated to 2060° F. - 2175° F. in a reducing atmosphere.
6. The billets are extruded to form tubes.
7. The tubes are sawed to the desired length.

Rod Turning

The machine employed for turning the rounds is commonly termed a "Bar Peeler", and consists of a rotating cutting head through which the rounds are fed by an hydraulic mechanism. The cutter head is driven by a 200 hp dc motor with a speed range of 360 to 1400 rpm. The motor drives through a two speed gear box, giving a cutter head speed range of 7 to 80 rpm. The feeding mechanism consists of an input and output

carriage on the respective sides of the cutter head. These carriages are hydraulically driven and equipped with hydraulic clamping devices. The maximum feeding rate of these carriages is 15 ft. per min. The rotating cutter head is equipped with 4 to 7 cutters depending on the diameter rod being turned. An 18% W - 4% Cr - 1% Va general purpose high speed steel, hardened to 62-64 Rc, is used for the cutters. The size of the cutter is 2" x 2" x 6". A cooling and lubricating solution consisting of 50% of soluble oil in water flows over the work during turning.

The hot rolled or forged rounds, after having one end sawed square to permit even cutting entrance and to minimize tool breakage, are turned to the desired diameter in one pass through the machine. The machined diameter is determined by the size of the extrusion container in which they will be used.

The operating data for the bar peeler are tabulated in Table VII.

T A B L E VII

Operating Data for Bar Peeler

Size before turning	Size after turning	No. cutters in Rotat- ing head	Feed		Speed	
			in.	per min.	ft. per min.	
7-1/16" dia.*	6.900"	4	7.5		55	
9-5/8" dia.	8.750"	5	5.0		45	
11-5/8" dia.	10.700"	6	3.2		40	
12-3/4" dia.	11.87"	7	3.2		36.5	

*The 7-1/16" dia. round is hot rolled, the larger sizes are forged.

Chipping

In the event that harmful surface defects exist after turning to size, such defects are removed by hand operated pneumatic chisels of conventional design operating on an air pressure of 90 psi. The chisel is a 2.75 W - 1.25 Cr - 0.50 C steel hardened to 59 Rc.

Sawing

After turning and chipping, the rods are sawed into short lengths suitable for use in the extrusion press, the length of the billet being determined by the weight of the tube to be produced therefrom.

The saws are of conventional design for cutting heavy metal sections. They are 38" in diameter and are tooled with high speed steel. The saws are driven by a fifteen hp motor through a variable speed gear box, the feed being maintained by a low pressure type hydraulic unit using 240# pressure. A cooling and lubricating solution consisting of 50% of soluble oil in water flows over the work during sawing. The speed of the saw is 43 ft. per min., and the feed is 0.50" to 1.2" per min.

Billet Heating

The billets are heated in a furnace which is 27 ft. diameter and has a 5 ft. wide rotating hearth. Forty-three hearth plates are set equidistant around the hearth to support the billets. The wall of the furnace is supported by means of water cooled boxes and a water seal is used between the moving hearth and the stationary wall of the furnace. Pneumatic tongs are used for charging and discharging the billets.

The burners are arranged in three zones, the temperature of each zone being independently controlled by means of a radiation type pyrometer. The fuel used is low sulphur natural gas. The furnace atmosphere is maintained reducing by controlling the air-gas ratio on the burners and by flue dampers which enable a positive gas pressure within the furnace and prevent infiltration of uncontrolled air. The furnace atmosphere is maintained at 3% to 4% CO equivalent to 6% to 8% total combustibles with no free oxygen present.

Table VIII indicates the usual heating time and temperature for various size billets.

T A B L E VIII

Billet Heating Times and Temperatures

<u>Billet Dia.</u>	<u>Time in</u>		<u>Billet Temp. Attained</u>
	<u>Furnace</u>		
6.900"	1½ hrs.		2060° F.
8.75"	2 "		2150° F.
10.7"	3 "		2150-2175° F.
11.87"	3 "		2175° F.

Extrusion

The production of tubing is effected by piercing and extruding solid billets, in the press, as parts of a single operation. The piercing mandrel is actuated by a separate hydraulic system, and moves coaxially with but independently of, the main extrusion ram within which it is partially withdrawn initially to allow the billet to be fed into the container. The piercer is driven through the billet, ejecting a small plug of metal. The main ram and piercer, the latter serving as a mandrel, advance together to extrude the tube. After the extrusion,

the die is unlocked from its position at the outlet end of the container and the unextruded portion of the billet ("discard") is forced from the container. The die and die holder assembly, bearing the tube and discard, is shifted axially to a hot saw where the discard is cut from the tube to facilitate removal of the tube from the die. The tube, after quenching in a solution of 2% alcohol in water, is cold sawed to the desired length and to square the ends.

The extrusion press is of the horizontal, four column type, developing 4,000 tons total force at 4,250 psi hydraulic pressure. The piercing cylinder develops 1,500 tons, working independently of the main ram which develops 2,500 tons.

The pressure system for activating the press is composed of two three-throw horizontal pumps driven at 120 rpm, through reduction gear sets connected to 720 rpm, 400 hp motors. The pumps each have a capacity of 95 U.S. gals. per min. at 4,250 psi.

The press has four sizes of containers permitting the use of four billet sizes as indicated in Table IX.

T A B L E IX

<u>Container and Billet Sizes</u>	
<u>Container Inside Diameter</u>	<u>Billet Diameter</u>
7-3/32"	6.900"
9"	8.750"
11"	10.700"
12-1/4"	11.87"

The tools which contact the metal during extrusion are of conventional design except as noted below. The tools are as follows:

1. A pressing disc bored to pass the mandrel is slipped over the mandrel and serves to protect the main ram from wear. The face of the pressing disc which contacts the billet is convex, being tapered at a 25° angle.
2. The solid concave die has a 25° taper on the face, parallel to that on the pressing disc, a 3/4" entrance radius which leads to a 3/4" long land with a 4° relief behind the land.
3. The mandrels have a 0.040" taper in their length, their leading end being shaped to provide a friction fit for the piercer point.
4. The hemispherical piercer point is placed on the leading end of the mandrel to protect the end of the mandrel from excessive wear during piercing. The piercing point is 1/4" to 3/4" larger in diameter than the mandrel, enabling the mandrel lubrication to remain intact during the piercing operation.
5. The container liners are of conventional design. The nominal composition and hardness of the commonly used tools are tabulated in Table X.

T A B L E X
Composition and Hardness of
Extrusion Tools

	Analysis					Hard- ness Rc
	C %	Cr %	Mo %	W %	Fe %	
Container Liner	0.35	5.0	2.25	1.25	bal.	35
Mandrel	0.28	3.25	-	9.0	"	46
Piercer Point	0.28	3.25	-	9.0	"	46
Pressing Disc	0.28	3.25	-	9.0	"	46
Die	(1) 0.28	3.25	-	9.0	"	46
	or (2) 0.35	4.75	1.5	1.2	"	46

The liners are uniformly preheated to 500° F. and all other tools to 700° F. prior to service to avoid cracking from thermal shock during the first few extrusions.

All the tools are thoroughly lubricated before each extrusion by swabbing with a suspension of graphite in tallow or heavy petroleum oil supplemented by another lubricant composed of an asphalt tar impregnated with flake mica.

The data for typical press operations are tabulated in Table XI.

T A B L E X I - Operating Data for Typical Tube Sizes

Unit Force**

tons per
sq. in.

Temp.

Billet

Extrusion
Ratio*

Billet
Size

Container
Size

Tube Size

42.7	2060° F.	16.7	6.9" dia.	6.9" dia.	7-3/32"	2 1/2" OD x 5/16" Wall x 10'6" long
42.5	2060° F.	10.0	6.9" dia.	6.9" dia.	7-3/32"	3 1/4" OD x 3/4" Wall x 10'6" long
33.0	2060° F.	8.0	6.9" dia.	6.9" dia.	7-3/32"	3 1/4" OD x 1/2" Wall x 8' long
46.0	2150° F.	28.8	8.75" dia.	8.75" dia.	9"	2 1/2" OD x 5/16" Wall x 22' long
44.2	2150° F.	20.0	8.75" dia.	8.75" dia.	9"	3 1/4" OD x 3/4" Wall x 20' long
37.2	2150° F.	12.9	8.75" dia.	8.75" dia.	9"	4" OD x 3/4" Wall x 18' long
37.5	2175° F.	17.9	10.7" dia.	10.7" dia.	11"	5-9/16" OD x 3/4" Wall x 24'6" long
37.6	2175° F.	9.9	10.7" dia.	10.7" dia.	11"	5-9/16" OD x 1/2" Wall x 14'3" long
38.0	2175° F.	11.8	10.7" dia.	10.7" dia.	11"	6.625" OD x .280" Wall x 18' long
39.0	2175° F.	8.5	11.87" dia.	11.87" dia.	12"	8" OD x 3/4" Wall x 15'6" long
47.8	2175° F.	5.2	11.87" dia.	11.87" dia.	12"	9 1/4" OD x 7/16" Wall x 11' long

* = Ratio of pierced billet cross sectional area to gross sectional area of extruded tube.
** = Tons per sq. in. of pierced billet cross sectional area.

CHAPTER VII

PRODUCTION OF SHEET

Hot Rolling

The starting material for the production of sheet is sheet bar which is described in Chapter V on Merchant Mill Rolling. The size of hot rolled sheet bar ranges from 0.280" to 2¾" thick by approximately 11¾" wide, the length of the bar being the desired width of the sheet to be hot rolled. The cross-sectional area of the sheet bar is proportional to the thickness and length of the desired hot rolled sheet. For an extremely thick, long sheet an extra thick, forged sheet bar is used to furnish the required cross-sectional area.

The hot rolled sheet bar is inspected and hand chipped to remove any defects which might affect the quality of the finished sheet. The defects in the forged sheet bar are removed by grinding before being transferred to the sheet mill.

The heating is done in open, batch-type, gas-fired furnaces, which are operated at a positive pressure and a reducing atmosphere. The atmosphere contains less excess combustible gas than is the case in the heating furnaces for forging and merchant mill rolling. This is done to prevent excessive sticking of the sheets when they are rolled in packs.

The approximate atmospheres and temperatures used on the heating furnaces are:

<u>Furnace</u>	<u>% CO+H₂</u>	<u>Operating Temp. °F.</u>
Pair	4	2100
Reheat	4	2180
Sheet	1	2000-2080

The hot mills have capacity for rolling sheets from .018" to .270" thick, 20" to 60" wide, and a maximum length of 144" on light gauges and 177" on some heavier gauges.

The hot mills are driven by a single 1200 hp motor with two 10-ton flywheels. The motor speed is 353 rpm, which is geared down to operate the rolls at 25.5 rpm. A friction drag at the end of the roll train is used to reduce backlash.

Each mill consists of two stands of two-high 31" diameter rolls, a roughing stand and a finishing stand.

The roughing rolls are nickel chromium cast iron, and are 44" and 66" long. The top and bottom roughing rolls are both driven. The top roll is counterbalanced by a weight hanging in the pit to give sensitivity to the motor driven screwdown. The 44" rolls are ground with .005" crown, and the 66" rolls are ground with .020" crown. The roughing rolls are cooled intermittently with water and are kept in condition by an automatic polishing device which passes an 80 grit stone back and forth over the surface.

The finishing rolls are chill cast nickel molybdenum iron. Various length rolls are used depending upon the width of sheet to be rolled. It is desirable to use rolls only a little wider than the sheets being rolled. The top roll is friction driven by the bottom roll. The screwdown is hand operated. Rolls from 36" to 44", across the face, are ground with .020" concavity in the top roll and .015" in the bottom roll; 48" with .015" in the top and .010" in the bottom; 56" with .005" in both top and bottom; and 66" are ground flat. The rolls are warmed in electrical resistance heating jackets to 400° F. before use. During operations, the roll temperature

is maintained at approximately 650° F., using live steam. The roll surfaces are kept in proper condition while in the mill by means of an automatic polishing machine carrying an 80 grit stone.

The first step in hot rolling sheets after the sheet bars reach temperature in the pair furnace is to rough them down to $\frac{1}{4}$ " thick on the roughing stand. The bars are cross rolled, so that the length of the bar becomes the width of the sheet. Rolling is done by the hand method; each sheet is handled individually by hand tongs and is returned over the top roll for successive passes until the required reduction is obtained or until reheating is necessary. The reduction per pass usually runs 20-30%. During the roughing down operations, the temperature drops to the extent that reheating is necessary before further rolling.

When the $\frac{1}{4}$ " bars reach temperature in the reheat furnace, they are removed and given a few single passes to approximately 0.140" thick on the finishing mill. The maximum reduction per pass is 25%, decreasing as the temperature decreases. These intermediate sheets are then placed in the sheet furnace for reheating. Sheets over .098" are finished singly; over .050" to .098", in pairs, .040" to .050", in three sheets per pack; over .023" to .039", in pairs doubled; .023" and under, in packs of three doubled.

The hot rolled sheets are next trimmed roughly to size, leaving approximately $1\frac{1}{2}$ " extra width and 3" extra length.

Annealing

The hot rolled sheets are annealed in order to soften them for subsequent cold rolling and to reduce the oxide film to the metallic state for easier

pickling. This is done in a continuous annealing furnace. The hearth consists of discs mounted on revolving steel shafts, spaced on 12" centers. All the shafts in the hot zone and some of the shafts in the cooling zone are water cooled. The hot zone is 60 feet long, and the cooling zone is 110 feet long.

Heating is accomplished with direct fired natural gas through burners a few inches above the conveyor level. The air-gas ratio is regulated to yield an atmosphere containing approximately 9% CO+H₂. Heat is removed from the cooling chamber by trays of running water on the roof.

The furnace accommodates sheets up to 60 inches wide. The speed of the conveyor can be regulated from 8 to 26½ feet per minute. Furnace temperature and annealing speeds are discussed later in this chapter under the heading Annealing Cold Rolled Sheets.

Individual hot rolled sheets are loaded onto the conveyor manually from a stack of sheets. No carrier sheets are used; the sheets which are being annealed are carried directly on the rotating discs. As the annealed sheets emerge from the furnace, they are removed from the conveyor by hand and stacked, ready to be transferred to the pickle house.

Pickling

The pickling equipment consists of four steam operated Mesta machines with three tanks at each machine, for acid, rinse water, and neutralizer. Each machine has four arms to support four pickling crates so that one is always available for loading during the action of the solutions. Two of the machines have lifting capacities of 10,000 pounds; and the other two, 16,000 pounds. The tanks are built of

concrete, with a lining of dense vitreous acid proof brick (60% silica and 40% alumina) which is bonded with an acid proof cement made of silica flour in sodium silicate solution. The reciprocating vertical motion of the machine produces vertical and also some lateral motion of the sheets which stand on edge in the crates and are separated by spacers. The maximum width of sheet with standard loading is 55". The maximum length varies with the different tanks and ranges from 157" to 198".

The acid pickling solution for each tank is made up as follows:

Sodium Nitrate	1,700 lbs.
Sulphuric Acid, 60° Bé	5,000 lbs.
"Spent" Pickling Solution	1,000 gal.
Add water to make 4,300 gal. final solution.	

When no spent pickling solution is available, an equivalent volume of water is used instead, and 725 lbs. of blue vitriol ($\text{Cu SO}_4 \cdot 5 \text{ H}_2\text{O}$) are added in order to provide copper ions, which otherwise would have been available from the spent solution. The presence of a minimum of 5 g.p.l. of copper facilitates pickling.

The pickling solution is operated at a temperature of 180° to 190° F. and the average pickling time cycle approximates 2 hours. Heat is supplied by live steam introduced through a carbon pipe.

The rinse solution is plain water contained in the second tank of the circuit. The neutralizing solution is in the third tank and consists of approximately 8½% by volume of 26° Bé aqua ammonia. The neutralizing reaction is accelerated by air agitation in addition to the motion of the machine. Since all four arms of the machine have to move simultaneously, the time in the rinse and ammonia is the same as in the acid.

The acid solution is maintained at a minimum of 7% acid until the nickel and copper salts cause the solution to reach 40° Bé. During this time, when acid is added, sodium nitrate is added proportionately. When the solution reaches 40° Bé, no further additions of acid and sodium nitrate are made but pickling is continued until the concentration of free acid does not exceed 4%. The solution is then considered as "spent" and a new solution is made up as indicated above.

After the sheets have been pickled, rinsed and neutralized, they are scrubbed on both sides in a machine utilizing jets of water and steam together with rotating palmetto scrubbing brushes. The sheets are dried in passing through a hot air drier located at the exit end of the scrubber.

Cold Rolling

The hot rolled sheets after annealing and pickling are delivered to the cold mill for further processing.

Standard cold rolled sheets are cold rolled up to 20% reduction. They may be annealed after cold rolling to provide soft properties or finished as temper cold rolled; the latter type sheet may be furnished also with a ground finish. Tempered sheets receive 3 to 5% cold reduction and may be supplied with as-rolled surface or a ground surface.

The eight cold rolling mills have the bottom roll flat and the top roll crowned. The ends are relieved .002" for a distance of 2 inches to allow for expansion due to heating of the roll necks. The cold mills are equipped with "billey" rolls which are used to press the light gauge sheets against the top work-

ing roll for the prevention of pinches and whips. The bottom roll can be heated by means of soft gas flames at selected spots to control flatness in the sheets. The screwdowns are hand operated except on one cluster mill and the four high mill; on the latter two mills, the screwdowns are motor-driven.

One 31" x 66" two high mill is used for cold rolling all sheets over 48" wide which finish over .093" thick. The rolls are cast iron. The top roll is ground with .020" crown using a 60 grit wheel. The top roll is friction driven by the bottom roll which in turn is driven through the hot mill train.

One 26" x 66" two high mill is used for light reductions on wide sheet. The rolls are chill cast nickel chromium iron. The top roll is ground with .015" crown using an 80 grit wheel. The rolls are dressed in the stands when necessary with an 80 grit stone and 1½ grit cloth. Both rolls are driven. This mill is equipped with a mechanical conveyor to return the sheet over the top of the roll for successive passes.

One 26" x 56" two high mill is used for cold rolling sheets over .078" finished thickness and up to 48" wide. This mill is also used for temper rolling sheets up to 48" wide in finished thicknesses .021" and above. The rolls are forged and hardened steel. The top roll is ground with .010" crown using an 80 grit wheel. The rolls are dressed with 80 grit stone and 1½ grit cloth. Both rolls are driven. This mill is also equipped with a mechanical returning table.

One 26" x 56" two high mill is used for the same purpose as the mill mentioned in the preceding paragraph. This mill is like the preceding one except it has a crown of .004" on the top roll.

One 26" x 56" two high mill is used for skin passing sheets up to .078" and to 48" wide. This mill

is sometimes used for temper rolling thin sheets. The rolls are forged and hardened steel. The top roll is ground with .004" crown using a 120 grit wheel. The rolls are dressed with a 180 grit stone and 220 or 360 grit paper. Both rolls are driven. Sheets rolled on this mill receive only one pass and, therefore, there is no table for returning the sheets over the rolls.

Two cluster type mills with 14" diameter x 42" working rolls, each roll being backed up by two 24" x 42" rolls, are used for standard cold rolled sheet up to .078" in finished thickness and in widths up to 36". All the rolls are forged and hardened steel. The top working roll is ground with .004" crown using an 80 grit wheel. The working rolls are dressed with number one emery cloth for rolling finished thicknesses heavier than about .043", whereas they are dressed with number 1/2 to double nought emery cloth for finished thicknesses lighter than .043". Both working rolls are driven, with the back-up rolls idling against them.

A four high mill with 13" x 60" working rolls and 26" x 60" back-up rolls is used for 20% cold reduction of sheets up to .078" finished thickness in widths up to 56". All the rolls are made of forged and hardened steel. The top working roll is ground with .009" crown using an 80 grit wheel. The rolls are dressed the same as the cluster mills. Both working rolls are driven.

The four 26" mills described above are in a single train driven by a 300 hp motor, turning at 293 rpm. A gear reduces the speed to 25.5 rpm on the rolls.

Each cluster mill is driven by a 750 hp variable speed motor with a range of 300 to 600 rpm. The gear reduction results in a roll speed of 24 to 48 rpm.

The four high mill is driven by a 250 hp variable speed motor with a range of 700 to 1400 rpm. The gear reduction results in a roll speed of 20 to 40 rpm.

In the cold rolling of sheets, kerosene is used on the rolls for all passes with the exception of the first two passes on the cluster mills and the four high mill; in the latter instances, dry rolling assists in closing the surface pores of the sheets. Sheets which are rolled on the mills with mechanical returning devices are rolled individually to final thickness; whereas on the other mills each sheet in a lift is given one pass and then the entire lift is moved around the mill for the second pass on each sheet, and so on until the sheets reach the desired final thickness. The reduction per pass varies according to the mill and the dimensions and physical properties of the sheet. For any given sheet, the first pass receives the greatest reduction. As the sheet becomes harder, the reduction per pass decreases, even though the rolls are continually closed with the screwdown. The cluster mills and the four high mill, for example, usually give about 6% reduction in the thickness on the first pass.

The standard limits for cold rolling sheet are as follows: .018" to .250" gauge, 20" to 60" wide, and up to 144" long. Not every width and length can be furnished in every thickness. For example, extremely thin or extremely thick sheets cannot be rolled to 144" long.

Annealing Cold Rolled Sheets

The cold rolled sheets are annealed in the same continuous bright annealing furnace that is used for the annealing of hot rolled sheets. The following

data are illustrative of the time-temperature cycles used:-

Thickness of Sheet. Inches	Temperature of Heating Zone. °F.	Time of Exposure in Heating Zone. Minutes
Up to .046	1800	2.3
.047 - .062	1800	2.4
.063 - .078	1800	2.9
.079 - .093	1800	3.7
.094 - .109	1800	4.4
.110 - .125	1800	5.7
.126 - .136	1800	6.6
.137 - .140	1800	7.3
Over .140	1800	7.4

Carrier sheets are used to prevent scratches and dents from the hearth discs. Spacer bars are also used on sheets up to .043" gauge to promote circulation of the hot gases under the sheet and to prevent sticking to the carrier sheets. The sheets emerge from the furnace bright and are unloaded carefully to prevent surface damage.

Finishing

Cold rolled annealed sheets up to .078" thick are skin passed to remove all kinks and dents and to prepare the sheet for flattening, except in the case of sheets intended for extremely difficult forming operations. The latter are shipped without skin passing and flattening. Skin passing causes a very slight reduction in the thickness of a sheet, not exceeding 1%.

Standard cold rolled sheets are flattened by means of an hydraulic stretcher leveler. The limits are from .018" to .250" in thickness, up to 60" in width, up to 179" in length. Sheets harder than 1/4 hard are not stretched.

Tempered sheets are flattened by means of two standard type roller levelers. The limits of the larger machine are 20 to 60 inches in width, .025" to .187" thick if soft but up to .093" if $\frac{1}{2}$ hard. The small machine limits are 20 to 48 inches in width, .021" to .050" thick if up to $\frac{1}{4}$ hard but .025" to .050" if $\frac{1}{2}$ hard.

The last step in the production of sheet is to shear to width and length. Three plate-type shears are used for this purpose. Two machines cut thicknesses up to .187" and lengths up to 156", while the third machine cuts up to .250" thick and up to 184" in length. Two rotary shears are also available for cutting circles from sheets. One machine has a capacity of from .031" to .250" in thickness in $11\frac{1}{4}$ " to 62" diameter circles; the other machine has a capacity up to .050" in thickness in 5" to 30" diameter circles.

CHAPTER VIII

PRODUCTION OF COLD ROLLED STRIP

First Annealing

The hot rolled strip coils from the Merchant Mill are open-annealed in a rotary hearth furnace, under reducing atmosphere containing about 7% CO+H₂, at a furnace temperature of 1700° F., for a total time of approximately 70 minutes. Coils are charged by means of a suitable lifting bar and are so placed in the furnace as to avoid direct flame impingement. When in the furnace, the strip is seated on rider bars, to prevent contact with the refractory hearth. When discharged, the metal is quenched by dropping into a 2% aqueous solution of denatured alcohol.

Pickling

The annealed and quenched coils are re-coiled loosely, and the strands separated by means of spacer hooks. Thus prepared, the coils are loaded on racks for subsequent pickling in the Cold Drawing Department, using the solutions described in Chapter IX.

After pickling, the strip-loaded racks are withdrawn, and rinsed over a suitable drain with water. They are then dipped for a few minutes in a 2% ammoniacal solution to neutralize any traces of acid which may remain.

Surface Conditioning

Any surface imperfections evident in the pickled strip which will not roll out in the subsequent processing are removed by spot grinding. For this pur-

pose, power driven abrasive coated cloth grinding wheels 16" diameter x 3" face are used; the abrasive is No. 60 emery grit.

Breakdown Rolling

For the breakdown or roughing operations, four stands of 2-high mills 16" x 22" are used either as a 4-set tandem or as two 2-set tandems depending upon the thickness of the strip involved and the cold rolling reduction desired. The delivery speed of the first stand is from 50 to 100 feet per minute; the second stand, 75 to 150 feet per minute; the third and fourth stands, 100 to 200 feet per minute. The top roll in each stand is ground with .003" crown, whereas the corresponding bottom rolls are flat across the barrel.

The overall reduction in roughing operations is of the order of 50 percent. In the case of operating all four mills in tandem, such reduction is accomplished by reducing approximately 20 percent with the first stand, 16 percent with the second, 10 percent with the third and 4 percent with the fourth.

Intermediate and Final Annealing

The intermediate and final annealing operations are carried out in five horizontal continuous type, electrically heated, controlled atmosphere bright annealing furnaces with variable speed drives. The controlled atmosphere is nitrogen containing 10 to 12 percent hydrogen dried to a dew point of about minus 60° F. The time-temperature cycle for any particular lot of strip depends upon the thickness of

material to be annealed. The following data are illustrative of the time-temperature cycles used:

Thickness of Strip	Temperature of Heating Zone-°F.	Speed of Travel Feet per Minute	Time of Exposure In Heating Zone Minutes
.005"	1650	7	3.3
.010"	1650	7	3.3
.015"	1700	7	3.3
.025"	1725	6	3.8
.034"	1800	4.5	5.1
.050"	1850	4	5.7
.070"	1925	3.5	6.6

Finishing Rolling

For finishing rolling, six mills of various types and sizes are used.

A single stand 2-high mill 16" x 22" is used for rolling strip in widths from 4" to 18" in thicknesses from .015" to .250". The top roll has .003" crown; the bottom roll is flat across the barrel. The delivery speed is from 125 to 250 feet per minute.

A single stand 2-high mill 12" x 18" is used for rolling strip in widths from 3" to 12", in thicknesses of .015" to .250". The top roll has .003" crown; the bottom roll is flat across the barrel. The delivery speed is from 75 to 150 feet per minute.

A single stand 2-high mill 10" x 13½" is used for rolling strip in widths from 1" to 8" in thicknesses from .005" to .093". The top roll has .003" crown; the bottom roll is flat across the barrel. The delivery speed is from 63 to 126 feet per minute.

A single stand 2-high mill 6" x 8" is used for rolling strip in widths of $\frac{1}{4}$ " to 4", in thicknesses of .005" to .093". The top roll has .003" crown; the bottom roll is flat across the barrel. The delivery speed is from 48 to 96 feet per minute.

For temper rolling on any of the above mills, the top roll is .002" - .003" concave and the bottom roll flat across the barrel.

A 4-high, reversing, "pull-through" or tension type mill, in which the rolls are not driven but rather the movement of the strip is accomplished entirely through power driven reels, is used for rolling strip in widths from 2" to 6 $\frac{1}{2}$ ", in thicknesses from .005" to .030". The working rolls are 3" x 8 $\frac{1}{2}$ " and both the top and bottom rolls are flat across the barrel. The delivery speed is variable from 95 to 508 feet per minute.

A larger 4-high mill similar to that described in the preceding paragraph is used for rolling .005" in widths from 8" to 12", .006" in widths from 7 $\frac{1}{4}$ " to 12", .007" in widths from 7 $\frac{1}{2}$ " to 12", .008" in widths from 7" to 12", .009" in widths from 6" to 12", and .010" to .030" in widths from 5 $\frac{1}{4}$ " to 12". Both the top and bottom rolls are ground flat across the barrel. Delivery speed is variable from 700 to 1,400 feet per minute.

All cold rolls are of forged steel heat treated to a hardness of approximately 100 Scleroscope. Rolls are ground in a conventional roll grinding machine to the required dimensions. The desired high surface polish on the rolls is accomplished after the rolls have been set up in the mills; this is done by hand lapping with No. 320 emery cloth.

Tolerances

General tolerances maintained on finished strip are as follows:

<u>Thickness (inches)</u>	<u>Tolerance (inches)</u>
.005 - .012	+ 0
.015 - .050	± .001
.056 - .078	+ .001
.093	± .0015
.109 - .125	± .0025
.130 - .156	± .003
.171 - .250	± .004

Cold reduction required to produce various tempers and the corresponding hardness values are as follows:

<u>Temper</u>	<u>% Cold Reduction</u>	<u>Hardness (Rb)</u>
Soft	0	61-68
Skin Hard	1 to 3	69-73
¼ Hard	3 to 7	74-82
½ Hard	7 to 12	83-89
¾ Hard	12 to 17	90-93
Hard	17 to 27	94-97
Full Hard	Above 27	98 min.

Protection of Surface in Final Cold Rolling

Every possible care is exercised to prevent scratching and other superficial damage to the surface of strip while cold rolling or otherwise processing the metal. Machine oil thinned with kerosene is introduced on the strip, which also passes through felt wipers before entering the finishing mills.

Rolls of wrapping paper cut to width are used in such a way as to introduce a layer of paper between each layer of metal in each operation requiring re-coiling. When it is necessary to move coils with the crane, brass tools are used to avoid scratching.

Finishing

After the rolling operations have been completed, the strip, other than that specified to be supplied in tempered condition, is annealed in the continuous furnaces previously mentioned.

The next operation after temper rolling or final annealing, as the case may be, is slitting the strip to the required width. Two conventional type rotary gang slitters are used. Coils are processed singly through each of these machines and the number of cuts per coil is limited to five for thicknesses up to .050" and to two for thicknesses from .050" to .250".

The resulting coils of strip are flattened and straightened using two conventional breakers which are not unlike roller levellers in design. Each has two interchangeable heads of different sizes. Strip is drawn through each machine by means of a power reel. The limitations in respect to width and thickness of strip handled by each head are as follows:

	<u>Large Head</u>	<u>Small Head</u>
Width	¼" to 12½"	¼" to 5½"
Thickness	.015" to .065"	.003" to .014"

Strip supplied in coils is boxed after the breaker operation. If straight lengths are desired, the coils are sent to the cut-off machines.

Two machines are used for cutting to specified lengths. One is an automatic machine wherein a pair of feeder rolls hands the metal to the knives; the other is a manually operated machine.

"Cut-to-length" strip is flattened by means of a hydraulic stretcher providing the temper is not over $\frac{1}{4}$ hard; tempered strip over $\frac{1}{4}$ hard is flattened in a multiple roll machine.

CHAPTER IX

PRODUCTION OF COLD DRAWN PRODUCTS

Cold Drawn Rods and Other Solid Sections

Cold drawn rounds are produced in sizes from $\frac{1}{2}$ " diameter to $1\frac{1}{4}$ " diameter, inclusive, in steps of $\frac{1}{32}$ "; from $1\frac{1}{4}$ " diameter to and including 3" diameter in steps of $\frac{1}{16}$ "; from 3" diameter to and including $3\frac{1}{2}$ " diameter in steps of $\frac{1}{8}$ "; and from $3\frac{1}{2}$ " diameter to and including 4" diameter in steps of $\frac{1}{4}$ ".

The hot rolled rounds for the production of finished sizes from $\frac{1}{2}$ " diameter to $2\text{-}7/16$ " diameter, inclusive, are hot rolled $3/32$ " to $7/32$ " oversize to allow sufficient stock for overhauling and for the proper amount of cold reduction; for finished sizes from $2\frac{1}{2}$ " diameter to 4" diameter, the oversize allowance is $11/32$ " to $13/32$ ".

The hot rolled rounds received from the Merchant Mill are first straightened in a conventional cross-roll straightening machine. This is followed by machining one end of each round to a size approximately $1/16$ " less than the finished diameter for a distance of 5" to 7" in order to enable the round to enter the dies in the subsequent drawing operation; this is known as "pointing."

Rounds to finish $\frac{1}{2}$ " diameter to $2\text{-}7/16$ ", inclusive, are then overhauled by removing approximately $1/32$ " on the diameter by centerless grinding; rounds to finish $2\frac{1}{2}$ " to 4", inclusive, are "skinned" or rough turned $\frac{1}{8}$ " to $3/16$ " on the diameter followed by centerless grinding a further $1/32$ " on the diameter.

The pointed rounds are then annealed in a continuous type, radiant tube, controlled atmosphere bright annealing furnace. The time-temperature cycles

are dependent upon the diameter of the rounds to be annealed. For example, 1" diameter rounds receive an overall exposure in the hot zone equivalent to approximately 30 minutes; for 2" diameter rounds, this time interval approximates 60 minutes. The heating zone is maintained at 1700° F. The controlled atmosphere is provided by an external gas producing unit using natural gas; the gas-air combustion in this unit is controlled so that the effluent gaseous mixture contains about 13 percent carbon monoxide plus hydrogen with no free oxygen present.

The annealed rounds are "flash" pickled in a solution made up as follows:

Sodium Chloride (Salt)	2500 lbs.
Sodium Nitrate	2400 lbs.
Sulphuric Acid - 60° Bé	5000 lbs.

Add water to make 5000 gallons of final solution.

As mentioned in the comments under Sheet Pickling, a minimum of 5 g.p.l. of copper is maintained in the solution for the purpose of facilitating pickling. The solution is operated at 180 - 200° F. When the acid content has decreased to about 2 percent by weight corresponding to about 30° Bé, it is discarded and a new solution is made up. The expression "flash" pickling denotes a short time immersion of the order of 10 to 15 minutes.

Any surface defects present in the rounds are removed by spot grinding with hand-operated, motor driven grinding wheels. This is followed by a second "flash" pickle and then the rounds are lime coated by dipping in a hot lime slurry. The purpose of the lime coating is to aid the cold drawing lubricant in maintaining a lubricating film on the surface of the rounds as they are passing through the drawing dies.

The rounds are next given one pass on the drawbench, the reduction being equivalent to about half the overall reduction in cross-sectional area required to produce the finished size desired. The overall cold reductions are from 15 percent to 30 percent, the smaller percentages being applicable to the larger diameters and the larger percentages being applicable to the smaller diameters. The rounds, as they enter the drawing dies are flooded with a lubricant made up of 50 percent wire drawing grease and 50 percent paraffine oil. The rounds are again "flash" pickled and lime coated, then drawn one pass to the finished size required.

Two drawbenches are used for these operations; one is of 50,000 lbs. capacity which handles sizes from $\frac{1}{2}$ " diameter to 2-15/32" diameter, inclusive, and the other is of 200,000 lbs. capacity which handles the larger sizes up to and including 4" diameter.

Drawing speeds vary according to the size of the work. The following table is illustrative of those normally used:

1/2" to 15/16" dia.	at 60 ft./min.
1" to 1-1/2" dia.	at 43 ft./min.
1-9/16" to 1-15/16" dia.	at 35 ft./min.
2" to 2-5/16" dia.	at 25 ft./min.
2-3/8" to 2-3/4" dia.	at 17 ft./min.
2-13/16" to 4" dia.	at 15 ft./min.

Both carbon steel and tungsten carbide dies are used for drawing. The entry angle in the dies, or angle of approach, is 50° included; the entry angle to the working face of the dies is 22° included; the exit angle is 30° included. The working face or bearing for sizes under 1" diameter is $\frac{1}{4}$ "; for sizes 1" to 1½" diameter, it is $\frac{3}{8}$ "; for the larger sizes up to 4" diameter, it is $\frac{1}{2}$ ".

The cold drawn rounds are straightened using a conventional cross-roll straightening machine.

Rounds that are to be supplied in the stress-relieved condition are temper annealed for 18 hours at 575° F. in two electrically heated, car type furnaces. No special furnace atmosphere is provided. The rounds are then cut to the required length and prepared for shipment.

Rounds that are to be supplied in the annealed condition are annealed in the continuous, controlled atmosphere furnace previously mentioned and for the time-temperature cycles there indicated. After annealing, the rounds are again straightened, then cut to length and prepared for shipment.

The following are the standard diameter tolerances for cold drawn rounds:

<u>Size</u>	<u>Plus</u>	<u>Minus</u>
1/2" to 15/16" incl.	0	.002"
Over 15/16" to 1-15/16" incl.	0	.003"
Over 1-15/16" to 2 1/2" incl.	0	.004"
Over 2 1/2" to 3" incl.	0	.005"
Over 3" to 3 1/2" incl.	0	.006"
Over 3 1/2" to 4" incl.	0	.007"

The production procedures for cold drawn hexagons, squares and flats closely parallel the foregoing procedure for cold drawn rounds.

Cold Drawn Tubular Sections

Cold drawn seamless tubing is produced from extruded tube shells. The standard sizes are from 1/2" O.D. to 6" O.D. in steps of 1/16"; the wall thicknesses are from .020" to 1/8", the lower end of the range not

being applicable to the larger diameters and the upper end of the range not being applicable to the smaller diameters.

The cold reduction equipment for processing tubing comprises both conventional drawbenches and units known as tube reducing machines.

There are four drawbenches, viz., a single chain bench of 20,000 lbs. capacity, a double chain bench of 50,000 lbs. capacity for each chain, a single chain bench of 100,000 lbs. capacity, and a single chain bench of 200,000 lbs. capacity.

The 20,000 lbs. bench is used for drawing sizes 1-1/16" O.D. and smaller. For the size range 1 1/16" to 1-1/16" O.D., the drawing speeds are from 20 to 40 feet per minute; for sizes 3/4" O.D. and under, the drawing speeds are from 40 to 60 feet per minute.

The 50,000 lb. double chain bench is used for drawing sizes from 1 1/8" O.D. to 3" O.D. inclusive. For the size range 1 1/8" O.D. to 2" O.D., the drawing speeds are from 20 to 50 feet per minute; for the size range 2" O.D. to 3" O.D., the drawing speeds are from 15 to 30 feet per minute.

The 100,000 lbs. bench is presently not in use.

The 200,000 lbs. bench is used for drawing sizes over 3" O.D. The drawing speeds vary from 1 to 60 feet per minute depending upon the O.D., wall thickness and reduction for the particular drawing operation involved.

There are two tube reducers, viz., one 3 1/2" machine and one 1 1/2" machine. These are used not only for the production of certain sizes of finished tubing but also as roughers in combination with drawbenches for finishing.

Finished tube sizes above 2½" O.D. are produced by conventional drawbench practice only; sizes 2½" O.D. and under are produced either directly on the tube reducers or by conventional drawbench practice or by a combination of tube reducers and drawbenches for finishing.

To illustrate the production of tubing by conventional drawbench practice and by tube reducer practice, the production of 2" O.D. - 16 ga. using each of these procedures is described below.

For the conventional drawbench practice, the extruded tube shell size is 3¼" O.D. x ¼" wall. The shells, as received from the Extrusion Department, are first pickled in the same solution as used for the solid sections previously described.

Any surface defects present are removed by hand grinding with power driven grinding wheels. This is followed by "flash" pickling after which one end of each tube is pointed by hot forging on a power driven hammer equipped with swedging dies; the points are 6" to 8" long.

The shells are then drawn on the 50,000 lbs. double chain bench one pass to 3" O.D. x .203" wall and a second pass to 2½" O.D. x .165" wall. The drawing lubricant is dry wire drawing soap.

The resulting tubes are washed in a steam heated solution made up of 350 lbs. of tri-sodium phosphate in 3000 gallons of water.

The tubes are then annealed in the previously described continuous furnace using a temperature of 1700° F. and time exposure equivalent to about 30 minutes.

After re-pointing and washing, the tubes are drawn two additional passes on the same drawbench as before, the first to $2\frac{1}{2}$ " O.D. x .134" wall and the second to $2\frac{3}{4}$ " O.D. x .109" wall. The lubricant, as before, is dry wire drawing soap.

The operations of washing, annealing and re-pointing are repeated.

Following these operations, the tubes are drawn two more passes, on the same drawbench as before, the first to $2\frac{1}{4}$ " O.D. x .083" wall and the second to $2\frac{1}{2}$ " O.D. x .065" wall. The lubricant, as before, is dry wire drawing soap.

The operations of washing, annealing and pickling are repeated.

The tubes are then drawn the final pass to 2" O.D. x 16 ga. using a mixture of 10 parts prime western beef tallow and 1 part castor oil as the lubricant instead of soap in order to improve the surface finish.

The finished tubes after washing are annealed at 1700° F. using a time exposure of about 20 minutes. They are then straightened in a cross-roll straightener, cut to length and prepared for shipment.

Both heat treated high carbon steel and tungsten carbide dies are used. The entry angle in the dies is 30° included; the entry angle to the working face is 22° included; the exit angle is 30° included. The working face, or bearing, is $\frac{1}{8}$ " for sizes up to $2\frac{1}{2}$ " O.D.; it is $\frac{3}{16}$ " for sizes $2\frac{1}{2}$ " to 4" O.D.; and it is $\frac{1}{4}$ " for sizes over 4" O.D.

Mandrels are likewise heat treated high carbon steel.

All dies and mandrels are chromium plated; the thickness of deposit used is from .004" to .006".

The tube reducer practice for 2" O.D. - 16 ga. commences with the same size of pickled and ground extruded tube shell, 3 1/4" O.D. x 1/4" wall. The first reduction is to 2 3/8" O.D. x .165" wall. The tubes are then washed and annealed as above. An added operation of straightening is required before the next reducing operation. The second reduction is to the finished size 2" O.D. x 16 ga. The lubricant used on the outside of the tubes for both reducing operations is in reality a coolant. It is a mixture of 1 part "Purosol" to 5 parts of water and is flooded on the tubes by means of a recirculating pump. The inside lubricant is Standard #5214 drawing compound which is pumped through the hollow mandrel rod. Following the final reduction the tubes receive the same finishing operations as indicated above for the conventional drawbench practice.

CHAPTER X

POLISHING

Abrasives

A synthetic aluminum oxide is the abrasive used in the initial fine grinding and rough polishing in grit size numbers ranging from 80 to 240. This abrasive is used for both built-up cloth wheels and cloth or paper belts.

Fine polishing is done with Turkish emery, a natural abrasive, in grit size number 180 used either as a cloth wheel or as applied to cloth or paper belts.

Finishes

Polished sheet is normally given a satin finish, which is a fine grind with a good lustre.

Polished tubing and rod may be given either a satin finish, or a mirror finish.

Polished flats, angles, half-rounds and other related shapes are given a satin finish.

Procedure

A satin finish is applied to sheets up to 0.093" x 60" x 186". Sheets up to 48" x 168" are polished on belt type Mattison machines. The cloth or paper-backed abrasive belts are 50" wide x 22' 6" long and travel at speeds of 2200 to 3200 ft./min. lengthwise of the sheet, while the table reciprocates parallel to the direction of belt travel at a speed of 30 ft./min. The sheets are given 3 passes on 80 grit (dry), 2 passes on 120 grit (dry), 2 passes on 150 grit (dry), and 3 passes on 150 grit using cottonseed oil.

If necessary, the sheets are spot ground between the 80 and the 120 grit dry grind, using 120 grit paper belts 4" x 46', travelling 4200 ft./min. to remove slight localized surface imperfections remaining after the 80 grit grinding passes.

Sheets wider than 48" or longer than 168" are polished on wheel-type machines. In this type machine, a table feeds the sheets past a revolving wheel which grinds a wavy pattern lengthwise of the sheet by virtue of a slight transverse oscillation built into the wheel machine. The table below lists the abrasives, speeds and number of passes used to produce a satin finish with the wheel type machines.

Grit No.	Abrasive	Type Wheel	Peripheral Speed of wheel-		Table Speed	No.
			fpm.	-fpm.		

80	Aluminum oxide	Cloth-dry	3800-7500	60	4
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-(Spot grinding as required to remove surface imperfections)-

180	Turkish emery	Cloth-dry	3300	60	4
180	"	Cloth-tallow	1900	60	4
180	"	Brush-oil	2600	100	½
180	"	"	2600	60	1½
180	"	"	1900	100	2½
180	"	"	1900	40	½

Tubing which is to be given a satin finish on the outside surface is first ground circumferentially on a conventional belt grinding machine. On this machine the tube is pressed against the belt and advanced past it by means of leather rolls, which also serve to keep the tube rotating. The belt travels at 6000 fpm., while the tube is fed across the belt face at the rate of 16 fpm. The tubing is first ground using three passes with 80, 120 and 240 grit cloth belts. It is then polished longitudinally on the wheel type sheet machines using 180 grit Turkish emery and tallow on a built-up cloth wheel. The tubes must be rotated by hand to expose the surface for this final polishing step. The 18" diameter by 45" wide wheel rotates at a peripheral speed of 2600 fpm., while the table travels back and forth at 40 fpm. A wavy pattern is produced by the oscillating action of the wheel. The tube size limitations are from 3/16" to 5" OD in lengths from 5' to 32' long.

A satin finish on the inside surface of tubing is produced on a belt-type inside tube grinding machine. This machine has a set of rolls to support and rotate the tube being ground. A narrow cloth abrasive belt is passed through the tube and made endless with a splicing patch. The belt is pressed against the inside surface of the tube by means of a rubber boot inflated with air. Pressure control is obtained by varying air pressures. The steps in grinding to a satin finish require passing the boot back and forth through the rotating tube while using 80 grit and 100 grit belts traveling at 6400 fpm. and a final 180 grit belt moving at 4000 fpm. Tubing between 3/8" ID and 4 1/2" ID up to 25' in length is within the capacity of the inside tube grinding machine.

Tubing with a mirror finish on the outside is produced by grinding with 80, 120 and 240 grit cloth belts on the belt grinding machine, and then finishing longitudinally on the wheel type sheet machine with

No. 180 emery cake on a Triplex cloth wheel followed by passes using No. 4 green stainless rouge on a canton flannel buffing wheel. The 18" diameter by 45" wide wheel used rotates at a peripheral speed of 8500 fpm., while the table travels back and forth at 40 fpm. Tubes from 3/16" OD to 4" OD and from 5 to 22 feet long up to 150 pounds are given this finish.

Rod is finished with a satin or mirror surface in a manner similar to that described for the outside surface of tubing. Flats, angles, half-rounds and other related shapes are given a satin finish using the wheel-type polishing machines.

CHAPTER XI

MACHINING

In the machining operations the important factors are:

1. The use of sturdy machines to facilitate a rigid setup of tools and work.
2. The use of accurately ground and smoothly finished tools.
3. The use of cooling or cutting compounds in amounts sufficient to keep the work well flooded.

Machining Stock

Forgings are generally of round or rectangular cross section and may be tapered longitudinally. Hot rolled products are of a variety of cross sections such as round, rectangular, angular and hexagonal.

The oversize allowances for machining are given below:

Allowance for Finished Machining of Hot Rolled Products

Size in.	Flats, Squares and Hexagons	
	<u>Rounds</u>	<u>Hexagons</u>
Up to $\frac{1}{8}$ incl.	$\frac{1}{8}$ in. dia. over	$\frac{1}{8}$ in. on each side
1 to $1\frac{1}{8}$ incl.	$\frac{1}{8}$ in. dia. over	$\frac{3}{16}$ in. on each side
2 to $2\frac{1}{8}$ incl.	$\frac{1}{8}$ in. dia. over	$\frac{3}{16}$ in. on each side
3 to $4\frac{1}{2}$ incl.	$\frac{3}{8}$ in. dia. over	$\frac{3}{16}$ in. on each side

The oversize allowance for finished machining of forgings is from $\frac{1}{8}$ in. to 1 in. on the diameter

for rounds, $\frac{3}{8}$ in. to $\frac{1}{2}$ in. on each side for rectangular cross sections, and for other shapes is dependent, in addition to the above, on the finished cross section.

Tool Selection

Three types of tools are used in the various machining operations performed in the machine shop:

1. Cemented carbide tipped tools are used in machining operations permitting high cutting speeds.
2. Cast non-ferrous, high speed steel, or super high speed steel tipped tools are used in machining operations run at intermediate cutting speeds.
3. Forged tools of high speed steel are used in general purpose machining at low speeds and heavy feeds.

Tool Design

The cutting tools used are, in general, the same as for other tough metals having comparable mechanical properties. The important differences are that true-rake angles are ground slightly larger back from the cutting edge and clearance angles are ground smaller to provide maximum support for the cutting edge. Tools are ground with a fine finish or are honed to obtain maximum tool life between grinds.

Cooling and Cutting Compounds

Two central reservoir systems are available with delivery and return lines to each machine. One system delivers a coolant made up with 1 part soluble oil to 50 parts of water; the second system delivers a solution made up of 1 part used machine oil to 1 part sulphurized cutting oil.

The sulphurized cutting compound is used in most tapping operations. It is thoroughly removed from machined pieces and from all chips in order to avoid contamination of the metal in subsequent exposure to heating to elevated temperatures in fabrication, in service, or in remelting as process scrap. Removal is accomplished by soaking for 20-30 minutes in a cold 10% solution of sodium cyanide.

Turning and Boring

Heavy cuts with fine feeds are used in preference to light cuts and heavy feeds. Speeds are reduced for boring as distinct from turning operations because of lower cooling and lubricating efficiencies, and limitations on size and rigidity of the tool.

Rods up to $4\frac{1}{2}$ " in diameter are rough machined in a bar peeler, over $4\frac{1}{2}$ " are rough turned in engine lathes. In first operation work, where subsequent machining is to be done, a semi-smooth finish is furnished with an oversize allowance of between $1/16$ " and $\frac{1}{8}$ " on the diameter. Where straightness is a factor, the run-out over the length is controlled by "whipping" the rod, an operation performed by machining on centers with light to medium cuts at heavy feeds, with a reversal of the rod in the lathe after each pass of the tool over the length, repeating until down to size.

Rods are finish machined by making the last pass at a maximum feed of 0.015" per revolution with a tool having a nose radius less than the feed. This finish pass produces a "phonograph record" surface which is readily filed smooth and to size.

Lathes used in turning products such as valve stems and pinion shafts are 22" x 8' to 30" x 41' driven by 15 HP to 30 HP motors and 42" x 27' with a 40 HP drive motor.

The cuts, feeds and speeds tabulated below are based on cutting dry. Speeds are increased 20-25% when using coolant or cutting compound.

Cuts, Feeds and Speeds for Lathe Turning
with High Speed Steel Tools

Depth of Cut (inches)	$\frac{1}{32}$			$\frac{1}{16}$		
Feed (inches)	.008	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$
Speed (Ft. per min.)	168	139	118	121	104	60

Depth of Cut (inches)	$\frac{1}{8}$			$\frac{1}{4}$		
Feed (inches)	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{16}$
Speed (Ft. per min.)	110	68	48	34	57	29

Depth of Cut (inches)	$\frac{3}{8}$			$\frac{1}{2}$		
Feed (inches)	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$
Speed (Ft. per min.)	52	34	24	49	31	21

Increase speed 25-35 per cent when using cast non-ferrous tools.

Drilling

Standard twist drills as furnished by drill manufacturers are used for general purpose drilling. This type of drill has an included angle of 118° and a clearance angle of 12° to 15°. Drills with polished flutes are preferred. For maximum cutting speeds, heavy duty high speed steel drills are used for holes under ½ in. diameter, for ½" and up to 3" super high speed steel is used. Drills are kept sharp. The approximate feeds and speeds for various size drills are given in the table below:

Feeds and Speeds for Drilling

Drill Size in.	Speed		Feed	
	Ft. per min.	RPM	Per Rev.	in.
1/16	50	3055	0.0015	
3/32	50	2100	0.0020	
1/8	50	1525	0.0025	
3/16	50	1020	0.003	
1/4	60	920	0.0035	
5/16	60	735	0.004	
3/8	60	610	0.0045	
7/16	60	525	0.005	
1/2	60	460	0.0055	
9/16	60	405	0.006	
5/8	60	365	0.007	
11/16	60	335	0.008	
3/4	60	305	0.009	
13/16	40	190	0.010	
7/8	40	175	0.011	
15/16	40	165	0.012	

Feeds and Speeds for Drilling - (continued)

<u>Drill Size in.</u>	<u>Speed Ft. per min.</u>	<u>RPM</u>	<u>Feed Per Rev. in.</u>
1	40	150	0.013
1 1/4	40	135	0.014
1 1/2	40	120	0.015
1 3/4	40	115	0.015
1 7/8	40	102	0.015
2	40	100	0.016
2 1/4	40	85	0.016
2 1/2	40	80	0.016
2 3/4	40	75	0.016
3	40	65	0.016
	40	60	0.016
	40	55	0.016
	40	50	0.016

Holes larger in diameter than 3 in. are drilled with flat drills. Flat drills are ground with a 132° included angle, 12° to 15° clearance with chip breakers in the cutting edge. Flat drills are generally used with 0.005 in. feed at 80 ft. per min. speed. Coolant is supplied at the cutting edge of the drill.

A radial drill press with spindle speeds from 14 to 1010 rpm. and a 20 HP motor drive is used, in addition to the lathes, for drilling operations.

Reaming

Reaming operations are performed when a high finish and accurate size are required. Spiral fluted, high-speed steel reamers with narrow lands and well

polished flutes are used. The reamers are kept sharp at all times. Flat reamers are used for holes larger than 2 in. diameter. Reaming feed is approximately twice the drilling feed for the same hole size; reaming speed is approximately one-half drilling speed. The table below gives approximate feeds and speeds for reaming.

Feeds and Speed for Reaming

Speed Ft. per min.	Hole Diameter in.	Feed in per Rev.	Metal to be removed in. dia.
25-35	$\frac{1}{8}$ to $\frac{1}{4}$	0.003-0.005	to 0.005
25-35	$\frac{1}{4}$ to $\frac{1}{2}$	0.005-0.009	to 0.008
20-30	$\frac{1}{2}$ to 1	0.009-0.020	to 0.012
15-20	1 to 2	1/32	1/64 to 1/32

Tapping

National standard, four-fluted, high-speed steel plug taps, with ground threads and 7° spiral flutes, and four fluted, spiral-pointed plug taps are used in machine tapping. The flutes are ground to give approximately a 15° lip angle and the tap is "backed off."

Tapping is done at a speed of 15 to 25 ft. per min. The taps are kept sharp so that clean, smooth threads are obtained.

Planing and Shaping

The setup for planing or shaping is the same as that for mild steel. Both roughing and finishing operations may be dry but an improved finish is obtained by use of the water soluble coolant. The goose

neck type of planer tool is preferred for finishing cuts because the cutting edge is in line with, or behind the center line of, the clapper-box pin resulting in smoother cuts. The table below gives feeds and speeds used in production work.

Feeds and Speeds for Planing Heavy Work

Roughing Tool

Depth of Cut, in.	1/16	1/8	1/4	3/8
Feed, in.	3/32	1/16	5/64	3/64
Speed, Ft. per min.	25	25	25	25

Finishing Tool

Depth of Cut, in.	0.020	0.014	0.010
Feed, in.	11/32	5/32	3/8
Speed, Ft. per min.	25	35	30

Parting Tool

Depth of Cut, in.	0.005 to 0.010
Feed, in.	-
Speed, Ft. per min.	30

Milling

Milling chips tend to curl rather than to break up to fine shreds or powder. To facilitate the removal of the curling type of chip, milling cutters are ground with a back-rake angle of 10° to 15°. Coarse tooth cutters are preferred. Plain or barrel milling cutters are of the heavy-duty, spiral-fluted type. Alternate tooth or interlocking side millers are

used for milling deep holes or for slitting. For narrow slitting, high-speed steel slitting saws with alternate teeth chamfered are most satisfactory. This type of circular saw is ground concave on the sides for clearance.

The surface speeds and feeds that are used in milling depend to a large extent upon the power and rigidity of the milling machine. For general purpose milling, cutting speeds of 50 to 65 ft. per minute, and feeds of 0.005 to 0.010 in. per tooth (depending on the depth of cut) are employed.

Since the essential purpose of the milling operation is usually extreme accuracy and smooth finish, it is necessary to sharpen cutters carefully and as frequently as may be required to keep the cutting edges sharp. The work is also kept flooded with a stream of coolant or cutting compound.