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BIBLIOGRAPHY

ON THE CONTINUOUS CASTING OF STEEL

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On the Manufacture of Continuous Sheets of Malleable Iron and Steel, Direct from Fluid Metal. Sir Henry Bessemer, F.R.S. (Journal of the Iron and Steel Institute, 1891, 40, 23-41).

Continuous Casting of Steel Sections to Reduce Rolling. B. Sheynin. (Metallurgia, 1933, 8, July, 76). The author suggests a continuous method of casting billets. The essential features of the method are summarised.

Direct Rolling of Molten Steel. (Iron Coal Trades Rev., 1934, 129, Nov. 23, 812). An English summary of a paper by H. Bleckmann describing his method of rolling molten steel by passing it through water-cooled rolls. The original paper appeared in Stahl u. Eisen, 1934, 54, Nov. 15, 1177-1180).

Direct Rolling. T.W.Lippert. (Iron Age, 1935, 135, Mar. 21, 10-17). An illustrated description is given of machinery and methods for the direct rolling of molten metals. Brass and copper have been rolled successfully, and plants have been put down for the rolling of ferrous materials, including stainless steel. The principle of the method is similar to that described by H. Bleckmann.

Recent Progress in Steel Making Reported from Germany. S. Epstein. (Metals and Alloys, 1935, 6, Sept., 247-251). The developments reported in this article deal with slag control in open-hearth furnaces, the use of manganese in the open-hearth charge, slag tests (by judging the appearance of samples cast into flat discs), jolting ingots during solidification, and the direct rolling of molten steel.

Problems of High Quality Metallurgical Production During the Third Five-Year Plan. K. Grigorovich. (Stal', 1937, (9) IX-XIV). (In Russian). Application on the industrial scale of ingotless rolling is being developed. Plant is at present being constructed for the American (Hazelett) process and the liquid rolling process, developed by Professor Ulitovskii in Leningrad. It is intended to use the latter process particularly for the production of thin (0.1 mm.) transformer steel sheet.

Ingotless Rolling of Steel Sections. N.Groume-Grjimailo. (Stal', 1937, (9) 37-40). (In Russian). The steel to be rolled is cast into an "infinite" mould formed by thick metal plates carried on two endless chain conveyors situated opposite and parallel to one another. The metal leaves the "mould" with only an outer crust of solidified metal, the liquid core solidifying on the way to the rolling mills. The design of such a machine is illustrated. The calculated output capacity is 100 tons per hour.

Direct Rolling. F. A. Fox.(Machinery, 1938, 52, June 9, 290-291). The author reviews experiments which have been made in the production of brass and steel strip and plate by direct rolling from the molten metal without intermediate solidification. An experimental plant used to produce steel plate 0.3 in. thick consisted of two semi-cylinders 6 ft. 8 in. dia. These were of copper 4 in. thick and were water-cooled internally. The rolls were mounted side by side.

A controlled quantity of molten steel was poured between the rolls, at the ends of which there were retaining cheeks of refractory material. The process was intermittent in action and produced one plate at each downward movement of the semi-cylinders. The height of the liquid column was 2 ft. 8 in. For such plates, 20 in. wide, the production rate was about 100 tons per hour.

Ingotless Process of Rolling Molten Steel. Yu.Grdina and E.Frolov. (Stal', 1939, (4-5), 42-44). (In Russian). After brief reference to both Russian and foreign work on direct rolling of liquid metals, an examination of the heat-loss conditions in this type of process leads the authors to the conclusion that it is limited as regards the cross-section of the products which can be produced. Some experiments are described in which an attempt was made to overcome this difficulty by rolling sections using successive pairs of rolls with gradually widening passes, the section being built up by super-imposing successive layers of metal which were formed and cooled as the section passed through the different pairs of rolls. The chief difficulty was to obtain a satisfactory welding together of the superimposed layers, particularly in the case of aluminium, with which the first experiments were carried out. The maximum dimensions obtainable were also limited. In conclusion an apparatus for the continuous rolling of molten steel is suggested. In this, metal is poured between four vertical strip conveyors which are water-cooled internally. The metal issuing from between the conveyors is passed through rollers.

Direct and Continuous Casting - Production of Sheet and Bar from Molten Metal. E.R. Mort. (Metal Ind., 1939, 54, Jan. 13, 41-46). The author describes a number of processes for the direct rolling of liquid steel and non-ferrous metals which have had some success in America during the past few years. Of these processes, those of Hazelett and Eldred produce a saleable product direct from the molten metal, subject, of course, to the usual finishing processes, whilst that of Junghans produces in indefinite lengths something which is intermediate between the present raw material utilised by some manufacturers and the final product derived from that raw material. These three processes have been tried out, and have been given good results. Some other processes more briefly described because they are too new for much information to be available, are those of F.J. Kohlhaas, C.O. Evans and A.R. Walton.

Continuous Casting. T.W.Lippert. (Iron Age, 1940, 145, Apr. 4, 31-39; Apr. 11, 44-47). The author reviews the methods of continuous casting, both successful and unsuccessful, which have been tried in the United States and other countries for the production of billets, rod and strip of both ferrous and non-ferrous metals with special reference to those of Bessemer and Hazelett. One of the processes was described in detail in a paper on continuous casting by E.R. Williams.

Continuous Casting. E.R. Williams. (Steel, 1940, 106, Apr. 8, 48-49, 56-58, 81). The author describes a method of continuous casting applicable to both ferrous and non-ferrous metal ingots. It was developed in America and its principal feature is the water-cooled mould of high-conductivity material such as copper, around which the water passes at high velocity. The bottom of the mould is a plate with a number of removable lugs projecting upwards and this plate is attached to mechanism below, capable of drawing it downwards at a speed dependent upon the rate at which the metal enters the mould from a pouring box placed above it. The molten metal solidifies round the lugs in the bottom plate and a means of drawing the ingot down through the mould is thus provided. It is claimed that the mould wall is subject to remarkably little wear because, after the metal has solidified, it contracts away from the wall. It will be seen that while the ingot is being drawn down through the mould the solid-liquid interface forms an inverted pyramid which remains almost stationary relative to the mould, provided that the pouring rate and the downward movement of the bottom plate are correctly controlled. With this casting system the length of the ingot is limited only by the amount of molten metal available for pouring, for it can be cut in suitable lengths as the solidified metal emerges from the bottom of the mould. In the experimental plant illustrated, a 10-cwt., electric furnace was used, the pouring box was preheated to about 2700°F., the steel was teemed at 150-200°F., above its melting point and, using a 4-in x 4 in. mould, ingots were drawn through it at about 7 ft. per min. The author states that this system eliminates pipe and that the ingots were remarkably clean as all the impurities rose to the top and passed to the outer surface of the ingot.

<u>Continuous Casting of Metals</u>. (Steel, 1941, <u>108</u>, Feb. 17, 80-83). A description is given of the Goss method for the continuous casting of steel. The equipment for this method of casting consists of a feeder ladle with a heavy refractory lining surrounded by an induction coil to keep the steel molten. This ladle is fixed over a water-cooled, die-casting unit, the upper portion of which is lined with refractory bricks and the lower portion with a copper lining surrounded by the water-circulation system. The cooling is adjusted so that a thin skin forms by solidification as the metal enters the chamber, and this skin becomes thicker when the copper lining is reached. There are ports at intervals down the sides of the chamber through which graphite or some other suitable lubricant is injected. By the time the metal reaches the lower open end of the casting unit it is sufficiently solid to be pulled out by rolls. After passing through these rolls it is cut off into suitable lengths for hot-rolling. The dimensions of the equipment and the speed of casting are not stated.

<u>The Direct Rolling of Liquid Steel</u>. G.Naeser. (Stahl u. Eisen, 1941, <u>61</u>, Apr. 24, 409-416). After a brief discussion of the advantages of a satisfactory process for the continuous casting of steel, the author reviews some of the many attempts which have been made to solve this question from Bessemer's proposal in 1857 up to the present time. He gives brief descriptions and schematic diagrams of several processes (including some for copper and aluminium), concluding with recent attempts by Hazelett. In the Hazelett method the molten steel is poured on to the outer surface of a broad steel cylinder of very large diameter (up to 6m.); this ring is supported and revolved by a roller turning inside it. The molten steel is carried a short distance to a roller revolving above the ring, which rolls the almost solidified steel into a thin plate or strip. From the latest information available, steel strip up to 6.35 mm. thick has been satisfactorily rolled by this process at a speed of 150 m. per min.

<u>Progress in the Direct Rolling of Metal</u>. (Iron Steel, 1941, <u>15</u>, Oct., 3-7; Nov., 40-43). Difficulties experienced in the direct rolling of metal are discussed with particular reference to Russian investigations and to the results achieved at the Hammer and Sickle Works, where a mill was put in commission in 1939. This mill was designed for the direct rolling of steel strip 300-600 mm. wide and up to 10 mm. thick. Particulars are given of the equipment of this mill, including the ladles, pouring boxes, water-cooled rolls, guards and instruments for measuring roll pressures.

Continuous Casting. L.H. Day. (Metal Treatment, 1943, 10, Autumn Issue, 173-180). The author describes with diagrams the following continuous casting machines: (1) The Junghans; (2) the Williams; (3) the Eldred; (4) the Poland-Lindner; (5) the Hazelett "A"; (6) the Hazelett "B"; and (7) the Merle. The first four employ a stationary mould through which the metal is poured, whilst in the other three the metal is poured into the trough formed by two water-cooled turning rolls.

Continuous Casting. L.H. Day. (Metal Treatment, 1943, 10, Winter Issue, 233-238, 267). Supplementing a previous article the author describes how finished and semi-finished strip and sheet can be produced straight from milten metal, eliminating the ingot and re-rolling stages. Details are given of the process developed in 1891 by the Fluid Metal Rolling Co., Maywood, Illinois; for this the plant consisted of a melting cupola, a converter, a Bessemer ladle, a tilting ladle, a Bessemer-type continuous casting machine and a Teplitz finishing train. The steel strip casting unit at the Crown Cork and Seal Co.'s works at Baltimore is also described.

Continuous Casting. T.W.Lippert. (Iron Age, 1944, 153, Feb. 24, 48-63, 138-148). The development of the continuous casting of metals is reviewed, with descriptions of the Williams and the Goss processes for steel. The former has been the subject of an earlier paper. In the Goss machine the mould is made up of several sections each with separate cooling. As the metal skin freezes and pills away from the mould wall a finely divided solid material is introduced through many orifices in the wall. This material remains solid during the casting operation and accommodates itself to the interstices between the cast metal and the mould. This protects the latter from abrasion and helps to conduct away the heat. Provision is also made for sealing off the top of the mould and introducing an inert or reducing gas above the pool of metal. Sound metal with a smooth ingot skin has been cast at a fair speed by the Goss method, but it requires further investigation and development.

Continuous Casting of Metals. The Williams Process. E.R.Williams. (Amer. Inst. Min. Met. Eng: Steel, 1944, 114, Mar. 6, 140-141). In the Williams process of continuous casting the water-cooled vertical rectangular mould is of brass or copper up to 1/4 in. in thickness. The mould is long enough to permit the solidification of only sufficient ingot skin within the mould to prevent the pressure of the molten metal within from bursting the skin as the piece emerges from the bottom of the mould. The completion of solidification is controlled by water sprayed directly against the ingot surface. Pairs of rolls below the mould compress the descending ingot and squeeze out the skrinkage cavity.

Continuous Casting of Metals. The Goss Process. N.P.Goss (Amer. Inst. Min. Met. Eng.: Steel, 1944, 114, Mar. 6, 141-142, 174-178). A description is given of the Goss continuous casting process.

Continuous Casting. V.Kondic. (Metal Ind. 1944, 65, July 28, 56-58). Those aspects of the rapid abstraction of heat which concern continuous casting are discussed and some effects of the rapid rate of solidification on the properties of the metals and alloys cast are dealt with.

Symposium on Continuous Casting. (Amer. Inst. Min. Met. Eng. Tech. Publ. 1793: Metals Technology, 1945, 12, Feb.). Four papers were presented at the Symposium on Continuous Casting which was held in New York on February 23, 1944. The papers were:

Continuous Casting Yesterday and To-Day. T.W.Lippert. Continuous casting processes for ferrous and non-ferrous metals are reviewed.

The Continuous Casting of Molten Metals - History, Requirements, Metallurgy and Economics. N.P.Goss.American patents relating to continuous casting processes are reviewed and drawings of several of the machines used are presented. The author's own process is described in detal. It is designed for casting steel in 4 x 4 in. billets and has a preforming chamber and vertical moulding plates with devices for keeping the inner surfaces of the plates lubricated.

Improvements in the Direct Rolling of Strip Metal. C.W. Hazelett. Difficulties encountered in the direct rolling of ferrous and non-ferrous metals are reported with notes on how many of them have been overcome.

The Williams Process of Casting Metals. E.R. Williams. A brief account of the Williams continuous casting process is given. This has been described previously.

Continuous Casting. L.H. Day. (Metal Treatment, 1945, 12, Spring Issue, 43-48). Some machines for the continuous casting of ferrous and non-ferrous metal tubes are described; these include the Williams and the Auguste Jacquet machines.

Continuous Casting. L.H. Day. (Metal Treatment, 1945, 12, Autumn Issue, 193-199). The continuous-casting process developed by J.M.Merle is described. In this method molten metal is released in oblique streams from the bottom of a suitable container on to a rapidly rotating disc. The metal loses its latent heat by contact with the disc, and is whirled round in a kind of spiral to be flung off at the periphery of the disc in atomised particles. These particles fly through a circular slit in their path of travel and build up in a mould which surrounds the device. Details of machines for continuously producing strip, sheet and bar, both plain and composite, are also given. Ferrous and non-ferrous metals as well as alloy steels have been successfully cast in these machines.

Continuous Casting of Metals in Germany. (British Intelligence Objectives Sub-Committee, 1946, F.I.A.T. Final Report No. 876: H.M.Stationery Office). A brief account is given of the use in Germany of two continuous casting processes, the Junghans and the VLW (Vereinigte Leichtmetall Werke, Hanover). At the end of the war a Junghans plant for the continuous casting of steel was nearing completion; experiments had been made to cast steel by both processes, but difficulty was experienced in obtaining good surface finish.

Direct Rolling and Continuous Casting. Z.Wusatowski. (Hutnik, 1946, 13, Feb., 91-96: Mar., 165-171). (In Polish). The various methods used since Bessemer's original work on direct rolling are discussed. References are given to existing patents and technical papers.

The Development and Present Position of the Continuous Casting of Non-Ferrous Metals. H.Kästner. (Stahl u. Eisen, 1947, 67, Jan. 2, 10-19. Abridged English translation: Engineer, 1947, 183, June, 27, 562-563). Three German firms, by pooling their resources and patents, have brought the continuous-casting of copper, bronze, brass, zinc, and magnesium alloys, and more particularly aluminium alloys, to a high state of perfection, and their processes are used in several countries. A comprehensive review of these processes is given with drawings, and photographs of the equipment. Theoretical and practical considerations affecting the application of continuous-casting processes to iron and steel are discussed. Tables are given comparing the quantities of heat given up when cooling 1 kg. and 1 cu.m. of copper, aluminium, brass, pig iron, and steel through various temperature ranges. The practical difficulties in the case of steel include the prevention of slag formation due to the great affinity of molten iron for atmospheric oxygen, but it appears to be possible to overcome these by using closed vessels, protective atmospheres, short closed runners and slag traps. Tests lasting several months have been carried out at steelworks with promising results, but the nature of these is not stated.

The Production of High Speed and Other Special Alloys and Carbon Steels in Germany and Austria. (British Intelligence Objectives Sub-Committee, 1947, Final Report No. 1505: H.M.Stationery Office). A detailed summary is made of the products, output, equipment, and steelmaking practices of sixteen German and Austrian firms manufacturing special alloy and carbon steels. No confirmation of any successful method of continuous casting was obtained.

The Development and Present Condition of the Continuous Casting of Metal. I.Ya. Granat and V.M. Tageev. (Stal', 1948, (2), 160-166). (In Russian). A short note on the history of continuous casting is followed by descriptions of the various processes now in use.

Direct Rolling and Continuous Casting. E.Erni. (Von Roll Werkzeitung, 1948, 19, Mar., 64-68). The history of continuous casting and centrifugal casting is briefly reviewed with descriptions of machines developed by Bessemer, Hazelett, Trotz, Junghans and Eldred, for the former process, and that of Cammen for the latter.

Continuous Casting of Semi-Finished Steel at Babcock and Wilcox Beaver Falls Plant. (Industrial Heating, 1948, 15, Sept., 1478-1484, 1498). An illustrated description is given of the continuous casting plant for steel, which operates by the Williams patent process.

The Theory of Continuous Casting. A.N.Tikhonov and E.G.Shoidovski. (I. and S. I., 1949, Trans. Series No.384, 20-27). This is an English translation of a paper which appeared in J.Technical Physics, U.S.S.R, 1947, 17, (2), 161-176. The method of casting described comprises pouring the metal into a water-cooled mould the bottom of which is closed by a movable platform. As soon as a solid crust of metal has formed over the bottom this platform is slowly lowered and the metal is continuously cooled by the water on the outside of the mould walls. The paper is mainly mathematical, and its purpose is to calculate the stationary position of the solidification front for a constant rate of extension of the cast, and to analyse the factors determining the shape of the front.

Continuous Casting Processes for Production of Sheets and Billets from Ferrous and Non-Ferrous Metals. J.Chvojka. (Hutnicke Listy, 1949, 4, June, 175-182). (In Czech.). Continuous casting methods for ferrous and non-ferrous metals are briefly described, and the history of continuous casting is reviewed. The following methods are mentioned: Junghans, Junghans-Rossi, Williams, Eldred, Poland-Lindner-Betterton, Alcoa-Ennor, Vereinigte Leichtmetallwerke, Jacquet, Granville-Mellen, Ter-Akopoff, Dow Chemical Co., Reynolds Metals Co., United States Steel Co., International Nickel Co., and Bethlehem Steel Co. The above methods are all based on the casting of the metal in bottomless ingot moulds. A second group consists of those utilizing centrifugal force to obtain the desired shape of the metal. These are: The Bessemer, Hazelett, Merle, Novo-Krematorsk and Ulitovskii, and Swiss methods of centrifugal casting.

Annual Conference of the Association of Czechoslovak Foundrymen held between the 30th September and the 2nd October in Trencanska Teplice. (Rutnicke Listy, 1949, 4, Oct., 342-343). (In Czech). Among the papers read was:-

Problems of Centrifugal Casting, by V.Koutecky.

The Solidification of Steel in Continuous Casting. H.Krainer and B.Tarmann. (Stahl u. Eisen, 1949, 69, Nov.10, 813-819; Metal Treatment, 1950, 17, Spring, 3-10; I. and S.I., 1950, Trans. Series 397). The conditions governing the design of a water-cooled mould for the continuous casting of steel were worked out and compared with those applicable to non-ferrous metals. The following data for the continuous casting of steel rounds 80 mm. (3 1/8 in.) in dia. were determined; (a) The rate of heat transfer between steel and water-cooled mould does not exceed 1500 kg.cal/sq.m./hr. 1°C.; (b) the rate of heat transfer from mould to cooling water should exceed 20,000 kg.cal./sq.m./hr./1°C.; (c) for every kilogramme of steel poured into the mould 85-100 kg.cal. have to be removed; (d) the above bars can be cast at a speed of 1.2-2.0 m./min.; (e) to be economic several continuous casting units would have to be supplied by one furnace; (f) the metallographic structure of the bar is similar to that of a chill-cast ingot of slightly smaller size; and (g) the steel has excellent hot-working properties.

Continuous Casting. B.Wollmann. (Tecnica e Industria, 1950, 28, Sept., 971-976). (In Spanish). Bessemer's continuous casting scheme already possessed all the characteristics of more modern constructions. Some early developments in America and Russia are mentioned and several other types of continuous casting mechanism are described.

Properties of Continuously Cast Special Alloy Steels. H.Krainer, and B.Tarmann. (Stahl u. Eisen, 1950, 70, Nov.23, 1098-1106). A large number of casts of 19 different alloy steels were made with a continuous casting machine, having a mould 130 mm. in dia. The structures of these casts were compared with those of normal ingots prepared from the same melts, in the as-cast and in the hot-rolled states. The tensile strengths were determined. The results from the continuously cast bars were completely satisfactory. The degree of deformation in hot working necessary to break up the as-cast structure was less than that for the ingots; a four- to six-fold reduction proved satisfactory. No difference was noticed in the hardening properties of tool steels prepared by this method. The carbide distribution in ledeburitic tool steels was carefully investigated. The ledeburite network was finer with continuous than with ingot casting, so that the material required less deformation. Chemically resistant and chromium magnet steel could be satisfactorily cast continuously.

Babcock and Wilcox Tube Company Develops Continuous Casting. I. Harter, jun. (Iron Steel Eng. 1950, 27, Dec. 57-72). Association of Iron and Steel Engineers, Proc., 1950, 765-770; A.I.M.E. J. Met., 1951, 3, Mar. 223-226. This article describes the development and expansion of a number of Babcock and Wilcox works. Historical and statistical information on the plant is given as well as details of the tube mills and the hot-finishing department. Development work on the continuous casting of steel at the Beaver Falls plant is described. The equipment comprises a ladle, pinch (or withdrawal) rolls, a transfer car, instruments, and an inductively heated holding ladle designed and built by the Company and powered with a high-frequency generator of only 250 kW. capacity. Molten steel, melted in a 12-ft. electric arc furnace or in a 5000-lb. induction furnace in the steel plant, is hoisted to the casting floor and is there bottom-teemed into the holding ladle. The tilting of the ladle is governed by the manual operation of control rheostats and metal flows into a tundish (or slag-eliminating container) and thence into the mould. Over 200 heats have been cast in the tower, some of these as 4-in. rounds, some 6-in. rounds, a few in rather pointed ovals, and now a 9 x 4¼ in. oval mould has been developed. Approximately 130 tons of continuously cast steel have been supplied against trial orders. Present equipment does not permit casts of more than about 15 min. duration. The problems encountered in the process are briefly mentioned and the prospects of future development discussed.

Faster Cooling Key to Jacquet Continuous Casting Method. (Steel, 1950, 127, Dec.4, 108-113). This article describes the Jacquet method of continuous casting of steel. The primary difference from other methods is in the use of multiple horizontal moulds to increase the cooling surface and permit the casting of steel without the necessity of reheating the charge and without exceeding the maximum stripping speed.

Interest in Continuous Steel Casting Gains Momentum. (Steel, 1950, 127, Dec. 4, 108-113). This article describes the Jacquet method of continuous casting of steel. The primary difference from other methods is in the use of multiple horizontal moulds to increase the cooling surface and permit the casting of steel without the necessity of reheating the charge and without exceeding the maximum stripping speed.

Interest in Continuous Steel Casting Gains Momentum. (Steel, 1950, 127, Dec. 25, 68-72). This article summarizes the technical session of the eighth annual conference of the Electric Furnace Committee, American Institute of Mining and Metallurgy, when the subject of continuous casting was discussed. A description of the plant of Babcock and Wilcox at Beaver Falls is given. A mould is now being constructed for casting a slab of 100 sq. in. for rolling to a width of 26 in. on a continuous strip mill.

Horizontal Continuous Casting Machine. (Iron Steel Eng. 1951, 28, Jan., 144-147). This article describes a new development in continuous casting recently patented by J.F. Jacquet, technical secretary of the Belgian Blast Furnace and Steel Works Association. The method produces small cross-section steel ingots which can be rolled directly by the finishing mills. The rapid cooling of ingots gives a fine and uniform crystalline structure; the method eliminates piping, reduces cracks and scratches on the ingot skin, and achieves the mechanization of the ingot-casting operation. The moulds are directly connected to the ladle and the ingots are cast in the horizontal position. The advantages claimed for the method are described and the main technical details outlined.

Some Observations on the Continuous Casting of Steel. (J.Met., 1951, 3, Mar., 227-228). This article describes the continuous casting machine built by Continuous Metalcast Corp., and gives details of the operation of these machines on a pilot plant basis at the Watervliet works of Allegheny Ludlum Steel Corp. The differences in the plant and practices at this works and at the Babcock and Wilcox Tube Co. works are pointed out. The adaptability of continuous casting to steel production is discussed.

Aspects of Continuous Casting. D.R. Wood. (J. B'ham. Met.Soc., 1951, 31, Mar., 25-30). The author considers the thermal equilibrium in the open-mould continuous casting process and examines conditions under which various metals and alloys may be cast by such a method. The heat contents and thermal diffusivities of magnesium, aluminium, copper, nickel, and iron are compared.

Continuous Billet Casting: Application to High-Melting Point Alloys. J.C. Wright. (Birmingham Metallurgical Society: Iron Coal Trades Rev. 1951, 162, June 8, 1319-1323). The author discusses some of the technical difficulties involved in producing continuously cast billets of high-melting-point alloys. Particular attention is given to the problems associated with the low thermal diffusivity and high heat content of the alloys and the high pouring temperatures required, and some of the methods employed to overcome these difficulties are discussed. The machines suitable for high-melting-point alloys are then considered, a description of the Babcock and Wilcox commercial plant being included. Finally, the economic aspects of continuous casting are discussed.

Continuous Steel Casting Pilot Plant Proves Successful. D.I.Brown. (Iron Age, 1951, 168, Sept. 20, 113-118). The Allegheny Ludlum Steel Corp. are installing a new unit working on the Rossi principle for casting slabs and ingots with a cross-section up to 150 sq.in. at a speed of 15 ft./min. A pilot plant has been successfully casting carbon, stainless, and other alloy steels, and operations with this machine are described. The distinguishing feature is the oscillatory motion of the copper mould which has a maximum travel of 2 in. Greater cooling rates are possible as the mould is in contact with the cast bar for a longer period and the upward motion helps to break the mould away from the thin solidified skin.

The Manufacture of Sheets Directly from Liquid Iron. E.G.Nikolajenko. (Selkhozmashina, 1951, (4): Przeglad Odlewnictwa, 1951, 1, Dec., 340-341). (In Polish). A process of producing sheet iron directly from liquid iron is described. The process consists of melting the metal in a cupola, formation of sheets by teeming on to water-cooled rolls, suitable heat-treatment, and finishing to obtain sheets of required size. The chemical composition of the metal was similar to grey iron with silicon up to 2.2% and phosphorus from 0.15 to 0.20%. Russian factories are at present producing by this method iron sheets 0.5 to 1.2 mm. thick, 300 mm. wide, and 750-1000 mm. long. The structure and the mechanical properties of the sheets are described. These can be modified according to requirements by the chemical composition of the metal and heat-treatment (graphitizing or decarburizing). The cost of cast iron sheets is 25-50% cheaper than steel sheets and in addition they are 8-9 times more resistant to corrosion.

The Possibilities of the Continuous Casting of Steel. M.Schneider and E.Zalsinski. (Hutnik, (Katowice), 1952, 19, (1) 1-6). (In Polish). A survey of literature concerning the continuous casting of steel is given, and various aspects of this process are discussed.

The Physical and Mathematical Basis for Calculations of the Cooling of Metal Rods Made by the Continuous Casting Process, with the Help of Differential Equations. H.Klein. (Giesserei Technisch-Wissenschaftliche Beihefte, 1952, Mar., 441-454). The physical characteristics used in mould and continuous casting are compared, and the mathematical methods available for the calculation of the cooling processes reviewed. The derivation of the differential equations for heat conduction is described and the characteristics of the thermal properties of casting metals discussed. The boundary conditions are described and from them the heat flow across the surface of the rod calculated.

Continuous Casting of Steel in the United States. (J.Four. Elect., 1952, 61, Mar-Apl., 51-53). Work carried out on a pilot plant at the Beaver Falls works of the Babcock and Wilcox Co. is reviewed. The results obtained have justified the construction of a further plant.

New Developments in Continuous Casting. O. Schaaber. (Z.Metallkunde, 1952, 43, May, 181-190). A survey of the principles involved in continuous casting, and a review of existing methods of casting non-ferrous metals and steels is given. The most important factors in the design of plants are discussed, and reference is made to the special features involved in casting steel by this method. Particular aspects of the Junghans, Rossi, and Babcock and Wilcox plants are mentioned.

Continuous Casting of Steel Bars. (Metalen, 1952, 7, July 15, 224-227). (In Dutch). This is a brief survey of some of the difficulties occurring at the Beaver Falls, Pennsylvania, plant erected by the Republic Steel Corp. in conjunction with the Babcock and Wilcox Tube Co.

Continuous Casting of Steel by the Junghans Process. K.G. Speith and A.Bungeroth. (Stahl u. Eisen, 1952, 72, July 17, 869-885). Difficulties inherent in the continuous casting of steel, improvements in quality and yield, and reduction in costs to be gained by the successful operation of the process are discussed. The structure of continuously cast bars and induction stirring of the still molten core to improve internal structure are described. Experiments at Huckingen have demonstrated the effects of steel composition and casting temperature on maximum casting speed; the results are presented diagrammatically. The connections between bar diameter, solidification time and withdrawal speed, and the output rate of a plant have been clarified. The practical possibilities of the continuous casting process in modern steel-works are considered to be favourable.

Continuous Casting Machine Will Soon be in Operation at Welland. (Blast.Furn. Steel Plant, 1952, 40, Dec., 1456, 1468). Atlas to Continuously Cast Steel Billets, Slabs. (Canad. Metals, 1952, 15, Dec., 16-19). A short description of a continuous casting machine for use with tool, stainless, and other high-grade steels which is to be erected at Welland, Canada, is given.

Continuous Casting Makes Steady Progress. (Steel, 1952, 131, Dec.22, 79-82). The fundamental factors involved in continuous casting plant are set out, and the experience of Republic Steel Corp., and Babcock and Wilcox Co., in operating a pilot plant is briefly described. Erection of production plant for stainless steel may be started by the end of 1953, with carbon steel plants to follow.

Results Obtained in the Field of Continuous Casting of Steel. J.Gouzou. (Publication de l'Association des Ingenieurs de la Faculte Polytechnique de Mons, 1953, (4), 5-11; (5), 10-22). A comprehensive account of continuous casting of steel up to 1952 is presented. Details of the design and operation of a number of plants in the U.S.A., Germany, Canada, Great Britain and Austria are given. A number of recent patents on this subject are considered. The majority of methods use vertical casting methods to produce billets but a method in which casting is carried out horizontally (Jacquet process) and a method for continuous production of steel in sheet form are also described. Twenty diagrams of continuous casting plants are given. (94 references).

Continuous Casting Comes to Canada. H.W. Perry. (Brit. Steelmaker, 1953, 19, Mar. 148-149). The continuous casting machine now being installed at the Welland (Ontario) works of Atlas Steels Ltd. will produce billets of $4\frac{1}{2}$ x $4\frac{1}{2}$ in. and $5\frac{1}{2}$ x $7\frac{1}{2}$ in. cross-section, and slabs of $5\frac{1}{2}$ x $21\frac{1}{2}$ in. cross-section, at speeds up to 100 in./min. The operation of the machine is outlined, and a brief account is given of the development of continuous casting in the United States.

Metal Casting Methods. J.B.McIntyre. (Metallurgia, 1953, 47, Apr., 179-182; May, 231-236; June, 292-294, 48; July 21-26; Aug., 63-68; Sept., 123-129; Oct., 165-168; Nov., 241-246; Dec., 273-276). In the first part a general review of casting methods for ferrous and non-ferrous metals is made. The second part is concerned with centrifugal casting. In the third part the use of continuous casting methods is considered.

The Junghans Method of Continuous Casting of Steel. K.G.Speith and A.Bungeroth. (Metal Treatment Drop Forg., 1953, 20, May, 197-204; June, 268-272). Details are given of experimental work carried out by the authors in conjunction with Dr. Junghans at the Mannesmann-Hüttenwerke A.G., Huckingen, Germany. Billets up to 10.4 in. dia. and 11.8 in. square have been continuously cast in plain carbon, rimmed, tool and stainless steels. The process of solidification and the influence of temperature on casting speed are discussed. The importance of solidification time, its influence on the necessary height of the casting unit, and the furnace capacity to ensure an adequate supply of molten metal are also considered.

Status Report on Continuous Casting. W.B. Pierce. (Steel, 1953, 133, Oct. 12, 256-272; Blast Furn. Steel Plant, 1953, 41, Nov., 1301-1306.) A report is presented on the experience gained by the Allegheny Ludlum Steel Corp. in continuously casting stainless steel sections in a pilot plant. The process has reached the stage of commercial machines being prepared for production in 1954. The present plant comprises a reservoir, refractory tundish, oscillating water-cooled mould, cooling sprays, withdrawing rolls, and cut-off torch. Subsequent rolling must reduce the section 4 to 1 to give desired physical properties. Grades of steel that have been cast are specified; most sections have been $3\frac{3}{4}$ in. square or $5\frac{1}{2}$ in. round. The method gives a yield 10% higher than casting in hot-topped ingot moulds and rolling. The first cost and manpower requirement of a commercial machine are quoted. Suggested specifications are: 150 sq.in. capacity, 120 in./min. casting speed, and up to 20 tons/hr. production, for a single strand caster.

The Development of Continuous Casting and Direct Rolling of Steel. Z.Wusatowski. (Hutnik, 1954, 21, (11), 370-375). (In Polish). A survey of the literature of the Eastern and Western countries is given (36 references).

Industrial Application of the Process of Continuous Casting to Special Steels. J. Seloron. (Centre Doc. Sid. Circ. Inform. Tech., 1954, (7), 1341-1353). Foreign trials of continuous casting are briefly reviewed, after which results at the Jacob Holtzer steelworks in France are described. In spite of the small output (1 ton/hr.) the process is economically justified for special steels owing to the reduction in metal wastage and savings in cost.

Recent Research Projects in the Iron and Steel Industry: Post-War Expansion in Research and Development at the United Steel Companies, Limited. F.H. Saniter. (Sheffield Metallurgical Assoc.: Iron Coal Trades Rev., 1954, 166, Feb. 5, 319-323.) Research Work of the United Steel Companies. F.H. Saniter. (Engineering, 1954, 177, Feb.12, 213-213). A brief review is given of current research projects under investigation in the Research and Development Department of the United Steel Companies Ltd. These include continuous casting experiments.

Continuous Casting of Steel in Canada: New Plant Installed at Atlas Steels, Limited. (Iron Coal Trades Rev., 1954, 168, Feb.12, 397-398). A brief description is given of the continuous casting plant erected at Atlas Steels Ltd., Welland, Ontario. It is of the Junghans-Rossi type, with oscillating mould, and is expected to produce 134-150 tons of alloy steel billets per day. Mould sizes are $4\frac{1}{4}$ in.sq., $5\frac{1}{2}$ in. x $7\frac{1}{2}$ in., and $5\frac{1}{2}$ x $2\frac{1}{2}$ in.

The Continuous Casting of Metals. Metallurgical and Mechanical Problems. (Usine Nouvelle, 1954, 10, Mar. 25, 63-67). Techniques available for the continuous casting of metals are listed. The choice of method is discussed in relation to engineering, metallurgical and economic factors. Finally, processes suitable for various non-ferrous metals and for steel are described.

Application of the Process of Continuous Casting to Special Steels. J.Seleron. (Doc.Met., 1954, Apr.-May, 65-77). A review of continuous casting methods which are now in use is made and a description of the Jacob Holtzer plant in France is given. The output of the plant is only 1 ton/hr. but this is satisfactory as high-alloy steels are cast. Tool, stainless, and heat-resisting steels, and special high-alloy steels having magnetic properties are handled.

Continuous Casting of Steel on an Industrial Scale. (Aciers Fins Spec. Franç., 1954, June, 60-63). A brief description is given of the development of continuous casting of steel at the Unieux works of the Compagnie des Ateliers et Forges de la Loire, where the first industrial plant was started up in 1953. The capacity of the plant is 25 tons/day, and it is intended to produce a wide range of special and alloy steels.

Continuous Casting - Progress in America. J.S.Smart. (Aust. Inst. Met. Conference; Australasian Eng., 1954, July 7, 57-71). The various processes now in operation for the continuous casting of aluminium, magnesium, copper, and other non-ferrous metals are described. A review of the difficulties and developments in the continuous casting of steel is then presented. The Babcock and Wilcox practice and the Hazelett process are both described, and possible future trends are indicated. (41 references).

The Problem of Rupture of the Billet in the Continuous Casting of Steel. J.Savage and W.H.Pritchard. (J.I. and S.I., 1954, 178, Nov., 269-277; Discussion, Ibid, 1955, 181, Sept., 55-59). Rupturing of the billet skin in the mould is a long-standing problem in the continuous casting of steel. It is caused by a combination of high frictional forces between the billet and the mould surfaces and the relatively low tensile strength of the billet skin. Measurements of the friction between the billet and the mould wall, which are described in this paper, have led to a method for preventing rupture which has already been employed successfully on an industrial continuous-casting plant.

Development of Continuous Casting of Steel. M.P.Newby. (Metal Treatment and Drop Forg., 1954, 21, Nov., 506-508). A very brief outline is given of the early development work on continuous casting carried out by the physics department of B.I.S.R.A. at Battersea, and more recently in the Sheffield laboratories. Problems associated with billet breaks are discussed, and the culmination of this work in the jointly sponsored full-scale pilot plant trials at Wm.Jessop and Sons's Sheffield works is outlined.

Continuous Casting Process now in Commercial Production. C.Longenecker. (Blast. Furn. Steel Plant, 1954, 42, Nov., 1292-1294). A brief illustrated account is given of a machine at Atlas Steels Ltd., Welland, Canada, which uses the Rossi-Junghans principle. The ingots are either forged or rolled into tool or special steels.

Casting Steel by the Mile. (Canad. Metals, 1954, 17, Nov., 18-20); Continuous Casting Installation for Stainless and Alloy Steels. (Engineer, 1954, 198, Dec. 31, 926-928); Modern Steel Plant Teams Continuous Casting with Planetary Mill. E.C. Beaudet. (Iron Age, 1954, 174, Nov.4, 113-120). Recently installed equipment for processing stainless steel, at the Welland (Ontario) plant of Atlas Steels Ltd. is described. A Rossi-Junghans machine, designed and installed by Koppers Co. for casting alloy steel slabs and billets up to 6 x 24 in. is operating. The quality of the steels produced is said to be comparable to that of conventionally produced materials; $5\frac{1}{2}$ x $7\frac{1}{2}$ in. billets have been cast at up to 75 in./min. and $5\frac{1}{2}$ x $21\frac{1}{2}$ in slabs up to 40 in./min.

Continuous Casting of Alloy Steel Billets. T.H.Adair. (Canad. Min.Met. Bull., 1954, 47, Nov., 740-747; Trans. Canad. Min. Met. 1954, 67, 475-485). Some of the devices developed for the continuous casting of metals are briefly described, beginning with the Bessemer machine, designed in 1842, and continuing with the Poland-Lindner, Williams, Ennor, and Junghans machines. The Rossi-Junghans machine, recently installed at Atlas Steels Limited, Welland, Ont., by Freyn Engineering of Chicago, is described in some detail.

Production of Steel by Direct Working of Liquid Metal. E.Weigl. (Kohaszati Lapok, 1954, 87, May, 207-216). (In Hungarian).

Direct Rolling. F.Arkos. (Kohaszati Lapok), 1955, 88, Jan., 4-7. (In Hungarian).

Semi-Continuous Casting of Steel in the German Democratic Republic. I.P.Bardin. (Stal' 1955, (5), 472-473). (In Russian). An account is given of a semi-continuous steel-casting process developed by Baake of Leipzig, the ingots obtained and sections through them being illustrated.

Continuous Casting of Steel. (Usine Nouvelle, 1955, 11, Jan.27, 33-35). After a brief general introduction, continuous casting installations in the U.S.A., Germany, Austria, and the U.K. are mentioned. The only French plant is that of the Compagnie des Ateliers et Forges de la Loire at Unieux.

Continuously Cast Wide Range of Alloy Steels. J.Seloron. (Iron Age, 1955, 175, Feb. 24, 88-90). A brief description is given of continuous casting at the Jacob Holzer Works of Compagnie des Ateliers et Forges de la Loire, Unieux, France. Highly alloyed steels, including stainless, heat-resisting, electrical, and tool steel grades, are being economically cast into sound oval-shaped billets on a limited production basis (1 ton/hr.).

Continuous Casting of Steel. J.S.Morton. (South Wales Inst.Eng.,Advance Copy, Mar.17, 1955). Conventional and continuous casting processes are compared. The development of continuous casting processes is outlined and the problems involved are discussed. The B.I.S.R.A. process is shown to be scientifically sound and technically superior to those developed by purely empirical methods. The pilot plant at the works of William Jessop and Sons Ltd., Sheffield, is described. This plant produces $2\frac{1}{2}$-4-in. square billets of high-speed, stainless, and special alloy steels, which are the most difficult to cast continuously.

The First French Industrial Plant for the Continuous Casting of Special Steels. J.Seloron. (Met.Constr.Mecan. 1955, __, May 361-367). A description is given of the development and operation of a continuous-casting plant at the Unieux works of C.A.F.L., France. The plant is capable of casting 25 tonnes/dy. Comparison is made between the operation of this plant and those in the U.S.A. Only special steels are cast and they include steels of the tool, stainless, high-temperature, magnetic, and non-forgeable types. The plant has been in satisfactory operation for two years.

On Several Improvements Related to The Continuous Casting of Light and Heavy Metals and Alloys. G.Befayt. (Usine Neuvelle, 1955, 11, May 26, 31-33). Continuous casting of iron, copper, aluminium, and their alloys is discussed, and suggestions are made. Points examined are the cooling system, the means of withdrawing the ingot, and direct rolling.

Continuous Casting of Steel at the "Anciens Etablissements Cail" at Denain (Nord). (Usine Nouvelle 1955, 11, May 12, 31-32). The installation was put into use in Dec. 1954. A brief history of continuous casting is given, and overseas plants are mentioned. The Cail plant has a capacity at 45 tons/h and has been used for a variety of steels. Some details of plant practice, quality of the products, and output are given.

Continuous Casting of High-Alloy Steels: Production Plant at Jacob Heltzer, Unieux, France. (Iron Coal Trades Nov., 1955, 170, May 27, 1221-1225). The Jacob Holtzer Works has developed a technique for continuously casting austenitic and other high-alloy steels. Details are given of the plant and its operation, and some of the difficulties overcome in the early experiments are described.

One Solution to the Problem of Rupture of the Billet Skin in Continuous Casting. J.Savage. (Centenary Congress of the Societe de l'Industrie Minerale, 1955, June, Sd.8, 1-5). The problem of billet skin rupture is discussed and a description is given of the design and method of operation of the mould evolved by B.I.S.R.A. to overcome skin rupture.

Special Problems in the Continuous Casting of Alloy Steels. R.Chouvel and J.Seloron. (Centenary Congress of the Societe de l'Industrie Minerale, 1955, June Sd.9, 1-15). An account is given of problems of billet quality, including internal defects and metal properties, as well as of problems of production and productivity. The rolling of continuously cast billets is also considered.

Continuous Casting at Atlas Steels, Ltd. J.F.Black and F.W.Rys. (Iron Steel Eng. 1955, 32, June 78-87). The commercial continuous casting machine recently put into operation at Atlas Steels Ltd., is described in detail.

Application of Continuous Casting in Steel. J.Savage. (Metal Treatment and Drop Forg., 1955, 22, July, 277-287). The present range of application of continuous casting to steel, either commercially or experimentally, is reviewed for eleven plants known to be operating on a wide range of steels. The basic differences between the three principal continuous casting processes so far applied are discussed from the point of view of preventing rupture of the billet skin in the mould. These processes are the Junghans-Rossi reciprocating mould, the Babcock and Wilcox intermittent billet withdrawal from a fixed mould, and the flexibly mounted mould developed by B.I.S.R.A. The possible uses of automatic methods for controlling the flow of steel into the mould and the withdrawal of the billet are outlined. (17 references).

Pioneering in New Developments in a Speciality Steel Mill. H.C.de Young. (Iron Steel Eng., 1955, 32, July, 114-118); Continuous Casting Installation for Stainless and Alloy Steels. (Engineer, 1955, 200, Sept.9,383-384). Details are given of the revolutionary steel-mill plant installed at the Welland Works of Atlas Steels Ltd., in Ontario, which has now been in operation for six months. The equipment includes a Rossi-Junghans continuous slab casting machine, a Linde powder scarfing machine, a hot Sendzimir mill, and an electrolytic salt descaling line.

Continuous Casting of Steel. (Metal Bull., 1955, July 5, 12-13, 16-17). The advantage and problems of this method of casting are discussed. A description of the plant at Welland, Ontario, is given. A list of continuous-casting plants in operation is presented.

Continuous Casting. J.S.Smart. (Metal Progress, 1955, 68, Oct.117-125). A review is made of the practical application of continuous casting. Experience gained with aluminium and copper alloys has helped to develop continuous casting of steel to a practical production technique. Examples of commercial plants are described.

Continuous Casting of Steel in Austria; New Plant at Breitenfeld. F.Leitner. (Iron Coal Trades Rev., 1955, 171, Nov.18, 1241-1244). Details are given of the continuous casting unit which has been in production at the Breitenfeld steelworks in Austria since 1953. Operating results are given, and the effects of casting conditions on metal structure and quality are discussed.

Continuous Casting of Steel at the"Anciens Etablissements Cail" at Denain. R.Fievet. (Bull. Soc.Ing.Civils de France, 1956 (6) 161-164; discussion, 164-168). After summarizing the history and principles of continuous casting, and describing plants in other parts of the world, the author describes briefly the plant, constructed to Junghans' patents, at Denain. Squares of 240 x 240 mm. have been satisfactorily produced in mild steels, mid- and high carbon steels, and in chromium-molybdenum, chromium-nickel-molybdenum and low-carbon silicon steels.

The Continuous Casting of Steel. I.Luca. (Metalürgia si Constr. Mas., 1956, 8, (1) 94-96) (In Rumanian). A short account of the principles and advantages of the continuous casting of steel is given, with the names of establishments where the process is carried out, among them the "Hammer and Sickle" works in the U.S.S.R.

Determination of the Depth of the Liquid Phase during the Continuous Casting of Steel. V.S.Rutes and A.G. Il'in. (Zavodskaya Laboratoriya, 1956, 22,(1), 49-52). By the use of small quantities of lead, and of radioactive phosphorus, the position of the solidification front during the continuous casting of steel has been studied.

The Continuous Casting of Steel. M.S.Boichenko and V.S.Rutes. (Liteinoe Proizvodstvo, 1956, (3), 1-4). Work on the continuous casting of steel in the U.S.S.R. is being carried out in vertical and in inclined installations. The greater part of this article deals with the former type, which the authors consider to be superior. The material discussed includes the selection of billet shape, the special features of continuously cast billets, and billet quality. Installations described and illustrated include the original large-scale experimental plant at the "Red October" works, the later installation at the Novo-Tula works and the recent one at Krasnoe-Sormovo, all of the vertical type. Two inclined installations are briefly described. Some advantage of continuous casting are enumerated.

The Development of the Process of Continuous Casting of Steel. M.S.Boichenko, V.S.Rutes and V.V.Fulmakht. (Metallurg, 1955, (2), 7-11). (In Russian). Members of the Central Scientific Research Institute of Ferrous Metallurgy in co-operation with two metallurgical works have carried out experiments of continuous casting of steel. In the Novo-Tula works the underground installation was designed for the production of steel slabs 150 x 500 mm. in cross section, with a velocity of 0.5 to 1.5 m/min. and an output of 16 to 53 tons/hour. The casting was done from a ladle of 10 tons capacity. The primary cooling was done in a water-cooled mould from which the steel band passed, supported on the sides by a roller, into a secondary open air cooler containing water sprays. This method of cooling prevented the formation of internal cracks. Between levels 8 m. and 14 m. the steel band was cut by oxy-acetylene cutters and at a lower level the slabs were raised by a lift. A different plant was designed at the "Krasnoe Sormovo" works, where the casting was simultaneously produced in two bands, 175 mm. x 420 mm. in section and 1920 mm. in length cast from a 50 tons ladle and a total capacity 45-55 tons/hour. The lifts were arranged in a "V" fashion and the work was automatically controlled from remote control panels. The internal structure of the metal during casting was studied by means of radioactive isotopes of phosphorus and sulphur.

<u>Conference on Continuous Steel Casting</u>. (Stal', 1956, (3), 263-265). (V.S.Rutes). The depth of liquid phase in the billet is proportional to the rate of withdrawal from the mould and the skin thicknesses are proportional to the cross-sectional dimensions. A direct water quenching method has been developed, and autoradiographic studies of P and S have been made. (N.A. Nikolaev). Studies on ingot shape, quality, rate of solidification and amount of cooling are reported. St.3 steel cast at 500-700 mm./min. had a good surface and rolled to good strip. Crack formation was avoided by water mist sprays and special roll design. (A.V.Khripkov). A new double strand plant at Krasnoe Sormovo was described. (N.L.Komandin). Quality of normal and continuously cast rolled billets is the same. (V.P.Druzhinin). Constant level and speed, temperature and viscosity control keep a fluid meniscus. Viscous steels require high speed and lubrication and vibration of the mould. Cooling conditions are also considered. (A.Z.Kononov). Semi-continuous casting of 18/8 Ti-stabilized steel was described. (M.S.Boichenko). Problems remaining were mentioned. (G.A.Garbuz). A plant inclined at 10° to the horizontal and producing two billets simultaneously was described. The capacity was 63 tons/hr. Certain disadvantages were mentioned. (V.V.Fulmakht). Plans for a new installation were discussed. (A.S.Nikiforov). Continuous casting of light sections with immediate cross rolling was outlined. (M.F.Goldobin). A conveyor for a continuous casting plant was described. Also economics and yields were given, 1950-1955. (V.I.Yavoiskii). Non-metallic inclusions were examined, including gases. (A.P.Pronov). Studies on crystallization were reported, also viscosity measurements and the effects of aluminium and the presence of oxides. (L.M. Postnov and B.B. Gulyaev). Rate of solidification and mechanical properties were reported. (B.G.Gruzin). Effect of temperature on hot cracking was studied and found to be due to non-uniform heat loss over the surface. (Only abstracts are given).

<u>Development and Adoption of the Continuous-Casting Process for Steel.</u> M.S.Boichenko, V.S.Rutes and N.A.Nikolaev. (Stal', 1956, (6), 505-513). (In Russian). An account is given of continuous casting process installations developed with the aid of the Central Research Institute for Iron and Steel of the U.S.S.R. After a general description of the process, mould design is dealt with, data showing the influence of taper on heat transfer between billet and mould are presented and the billet macro-structure is discussed. Details are given of the installation at the Novo-Tula works, which has dealt with about 10,000 tons of steel, the casting rate being about 10 tons in 20-25 min., and of the more recent plant at the Krasnoe Sormovo works where 15,000 tons of carbon steel were cast in the first ten months of operation. The quality of continuously-cast steel is discussed.

Economics of Continuous Casting of Steel. L.G.Degtyarev. (Stal', 1956, (6), 558-559). (In Russian). The simplification which can be effected by using continuous casting and the corresponding economics are discussed, and its influence on various cost items are considered. This method is economically especially advantageous when incorporated in the layout of new works.

The Principles of Continuous Casting of Metals. D.M.Lewis and J.Savage. (Met.Rev., 1956, 1, (1) 65-116). A review of steel and non-ferrous metal casting with sections on control of pouring, heat transfer and solidification, cooling, rupture of the ingot skin, temperature distribution in ingots and metallurgical effects.

Experiences of Continuous Casting and Subsequent Hot Working of Ingots. F. Leitner. (Inst. Hierro Acero, 1956, 9, Jan.-Mar., 258-266). (In Spanish). Details are given of the continuous casting equipment at Breitenfeld, Austria. A fixed mould is used with an oscillating stream, to produce billets (up to 130 mm. dia.) and slabs (275 mm x 65 mm) in various carbon steels. Casting conditions are discussed with reference to structure and segregation and examples are given of the structure, quality, and type of hot-worked product. The advantages of such plant for works which do not desire heavy equipment for hot-working are emphasized.

The Technology of Multiple Continuous Casting. R.Baake and H.Rosahl. (Neue Hutte, 1956, 1, Mar., 293-303). Development of the Freital continuous casting plant, where 3 billets of 6 m. length are cast. Cooling and casting control depending on the surface temperature of the billet, steel distribution, the correlation between flow velocity, steel quantity, vent diameter in the distributor, bath level, mould capacity, and ladle charge are described.

Observations on the Thermal Conditions of a Continuous Casting Ingot Mould. J.Tischendorf. (Neue Hutte, 1956, 1, Mar., 303-307). In the upper part of the mould heat flow is largely determined by water velocity, the thickness of the walls, and the material of which the mould is made. But these factors become insignficant when the gas layer between ingot and mould exceeds 0.1 mm. in thickness. The object of vibrating the mould is to reduce the insulating effect of the gas layer. Pulsation cooling has been shown to be most effective. Circular motion will double the cooling effect; vibration will increase it by 50%.

Continuous Casting of Steel. I. Harter, Jun. (Iron Steel Eng., 1956, 33, April, 58-61). This article describes the continuous casting process developed jointly by Republic Steel Corp. and the Babcock and Wilcox Co. Details are given of the mould, automatic pouring control, cooling devices, the cross section of the billet, and the possible yields.

Automatic Control of Continuous Casting of Steel in Russia. L.K. Tatochenko. (Instrument Practice, 1956, 10, June, 518-519). A number of devices have been developed under the auspices of the Russian Central Research Institute of Ferrous Metallurgy, by which the level of liquid metal in the mould is indicated or maintained automatically by the use of gamma radiation. A gamma radiator and counter are located in opposite sides of the mould, and due to absorption of radiation by the metal, a strong signal is obtained only when the metal falls below the level of the counter. By fitting counters at different levels, a visual or aural signal can be installed for manual control, or a servo-mechanism for automatic level control. Various modifications of the principle are described.

Electronic Recorders Lead Way to Better Continuous Casting. (Steel, 1955, 139, Oct. 22, 86-89). The recorders and controllers installed on the continuous casting machine at Atlas Steel Ltd., Ont. are described.

A Contribution to Continuous Casting Technology. J.Czikel. (Neue Hütte, 1956, 1, Nov., 561-562). The sinking velocity of the casting is inversely proportional to its diameter. Formulae are presented to enable sinking velocity and casting capacity to be predicted for any material and profile.

Development of Continuous Casting at Atlas Steels, Ltd. W.W.Jacobs. (Iron Steel Eng., 1956, 33, Dec., 92-97). An account is given of the development of continuous casting, with a description of the plant at Atlas Steels and of recent improvements in control, etc.

The Rational Design of the Mould for Continuous Casting of Steel. G.I. Kozlitin and L.N.Kolybalov. (Stal', 1957, (3), 209-213). The use of a mould with a reciprocating motion eliminates sticking of the billet, increases the stability of the operation, and improves the quality of the product. Experiments at the "Red October" works with a mould of a new design prepared by the Central Research Institute for Ferrous Metallurgy have shown that considerable reduction in the weight of the mould is possible.

Continuous Casting of Rolling-Mill and Forging Stock. J.Hofmaier. (Stahl u. Eisen, 1957, 77, Jan. 24, 69-78). The author describes methods of continuous casting of steel ranging from 0.9 to 35.5 tons/hr. and discusses factors affecting the surface quality and the structure in the interior of the bar. The working properties of continuous cast bars are enumerated and the economics of the process compared with conventional methods.

A Pneumatic Level Indicator for the Continuous Casting Process. A.G.Grimshaw and B.O.Smith. (J.I. & S.I., 1957, 185, Feb.,235-237). The pneumatic gauging principle is applied to a level indicator suitable for the continuous casting process for steel. Indication is obtained over a 6-in. length of the mould with an accuracy of better than $\frac{1}{8}$ in. The level indicator provides an electrical output signal which could be used to control either the rate of pouring from the tundish, or the rate of withdrawal of the ingot.

Russian Developments in (Continuous) Steel Casting. T.Margerison. (New Scientist, 1957, Feb. 14, 29-31). A diagrammatic account.

Russian Research on Continuous Casting of Steel. R.Sewell. (Iron Coal Trades Rev., 1957, 174, Feb.15, 391-394). An account based on the report by V.S.Rutes, N.A. Nikolayev, D.P. Evtyeyev, and V.P.Druzhinin in Stal', 1956, (1), 62-66. A formula for depth of liquid phase is quoted and tested by observations at the Novo-Tula Works on continuous and semi-continuous machines and depth of liquid phase was measured by temperature observations or by use of radioisotopes of P or S. Thickness of ingot skin is computed and the thermal processes investigated. Conclusions are drawn on the above topics, on the zone of contact and effects of increase of speed or increase of water consumption.

The Mechanical Properties of Steel Sheet Rolled from Continuously Cast Ingot. N.L. Komandin. (Sheet Metal Ind., 1957, 34, Apr., 289-290; from Metallovedenyi i Obrabodka Metallov, 1956, (5), 12). A two strand vertical continuous casting machine started in June 1955 supplied ingots and from the same ladle conventional ingots were cast. These were rolled into sheet, sampled, and examined. The sheet from the continuous casting machine was more uniform, more ductile and more impact-resistant, and the hot cracks were found to weld up during rolling.

AUTHOR INDEX

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