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(54) **Continuous casting steel strip method**

Bandgiessverfahren

Möthode de coulée continue de bande méallique

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Description

TECHNICAL FIELD

[0001] This invention relates to the casting of steel strip.

[0002] It is known to cast metal strip by continuous casting in a twin roll caster. In this technique molten metal is introduced between a pair of contra-rotated horizontal casting rolls which are cooled so that metal shells solidify on the moving roll surfaces and are brought together at the nip between them to produce a solidified strip product delivered downwardly from the nip between the rolls. The term "nip" is used herein to refer to the general region at which the rolls are closest together. The molten metal may be poured from a ladle into a smaller vessel or series of vessels from which it flows through a metal delivery nozzle located above the nip so as to direct it into the nip between the rolls, so forming a casting pool of molten metal supported on the casting surfaces of the rolls immediately above the nip and extending along the length of the nip. This casting pool is usually confined between side plates or dams held in sliding engagement with end surfaces of the rolls so as to dam the two ends of the casting pool against outflow, although alternative means such as electromagnetic barriers have also been proposed.

[0003] Although twin roll casting has been applied with some success to non-ferrous metals which solidify rapidly on cooling, there have been problems in applying the technique to the casting of ferrous metals. One particular problem has been the achievement of sufficiently rapid and even cooling of metal over the casting surfaces of the rolls. In particular it has proved difficult to obtain sufficiently high cooling rates for solidification onto casting rolls with smooth casting surfaces and it has therefore been proposed to use rolls having casting surfaces which are deliberately textured by a regular pattern of projections and depressions to control heat transfer and so control the heat flux achieved at the casting surfaces during solidification.

[0004] Our United States Patent 5,701,948 discloses a casting roll texture formed by a series of parallel groove and ridge formations. More specifically, in a twin roll caster the casting surfaces of the casting rolls may be textured by the provision of circumferentially extending groove and ridge formations of essentially constant depth and pitch. This texture produces enhanced heat flux during metal solidification and can be optimised for casting of steel in order to achieve both high heat flux values and a fine microstructure in the as cast steel strip. Essentially when casting steel strip, the depth of the texture from ridge peak to groove root should be in the range 5 microns to 60 microns and the pitch of the texture should be in the range 100 to 250 microns for best results. For optimum results it is preferred that the depth of the texture be in the range 15 to 25 microns and that the pitch be between 150 and 200 microns.

[0005] Although rolls with the texture disclosed in United States Patent 5,701,948 have enabled achievement of high solidification rates in the casting of ferrous metal strip it has been found that they exhibit a marked sensitivity to the casting conditions which must be closely controlled to avoid two general kinds of strip defects known as "crocodile-skin" and "chatter" defects. More specifically it has been necessary to control crocodile-skin defects by the controlled addition of sulphur to the melt and to avoid chatter defects by operating the caster within a narrow range of casting speeds.

[0006] The crocodile-skin defect occurs when δ and γ iron phases solidify simultaneously in shells on the casting surfaces of the rolls in a twin roll caster under circumstances in which there are variations in heat flux through the solidifying shells. The δ and γ iron phases have differing hot strength characteristics and the heat flux variations then produce localised distortions in the solidifying shells which come together at the nip between the casting rolls and result in the crocodile-skin defects in the surfaces of the resulting strip.

[0007] A light oxide deposit on the rolls having a melting temperature below that of the metal being cast can be beneficial in ensuring a controlled even heat flux during metal solidification on to the casting roll surfaces. The oxide deposit melts as the roll surfaces enter the molten metal casting pool and assists in establishing a thin liquid interface layer between the casting surface and the molten metal of the casting pool to promote good heat flux. However, if there is too much oxide build up the melting of the oxides produces a very high initial heat flux but the oxides then resolidify with the result that the heat flux decreases rapidly. This problem has been addressed by endeavouring to keep the build up of oxides on the casting rolls within strict limits by roll cleaning devices. However, where roll cleaning is non-uniform there are variations in the amount of oxide build up with the resulting heat flux variations in the solidifying shells producing localised distortions leading to crocodile-skin surface defects.

[0008] Chatter defects are initiated at the meniscus level of the casting pool where initial metal solidification occurs. One form of chatter defect, called "low speed chatter", is produced at low casting speeds due to premature freezing of the metal high up on the casting rolls so as to produce a weak shell which subsequently deforms as it is drawn further into the casting pool. The other form of chatter defect, called "high speed chatter", occurs at higher casting speeds when the shell starts forming further down the casting roll so that there is liquid above the forming shell. This liquid which feeds the meniscus region, cannot keep up with the moving roll surface, resulting in slippage between the liquid and the roll in the upper part of the casting pool, thus giving rise to high speed chatter defects appearing as transverse deformation bands across the strip.

[0009] Moreover, to avoid low speed chatter on the one hand and high speed chatter on the other, it has been necessary to operate within a very narrow window of casting speeds. Typically it has been necessary to operate at a casting speed within a narrow range of 30 to 36 metres per minute. The specific speed range can vary from roll to roll but in general the casting speed must be well below 40 metres per minute to avoid high speed chatter.

[0010] The present invention enables significant suppression of the tendency for chatter defects by careful selection of the chemistry of the steel melt in association with a randomly textured casting surface. The invention enables the range of possible casting speeds to be greatly expanded. In particular, it enables significantly higher casting speeds to be achieved.

[0011] It has been found that a randomly textured casting surface enables a dramatic increase in casting speed to be achieved. At casting speeds above 60 metres/minute a new type of chatter defect, termed "high frequency" chatter is encountered but this can be alleviated by selection of the melt chemistry in accordance with the present invention.

DISCLOSURE OF THE INVENTION

[0012] According to the invention there is provided a method of continuously casting steel strip comprising supporting a casting pool of molten steel on one or more chilled casting surfaces and moving the chilled casting surface or surfaces to produce a solidified strip moving away from the casting pool, wherein the or each casting surface is textured by a random pattern of discrete projections having pointed peaks, the strip is moved away from the casting pool at a speed of more than 60 meters per minute, and the molten steel has a manganese content of no less than 0.60% by weight and a silicon content in the range 0.1 to 0.35% by weight.

[0013] The steel may have a carbon content of less than 0.07% by weight.

[0014] Preferably, said pointed peaks have a surface distribution of between 5 and 100 peaks per mm^2 and an average height of at least 10 microns.

[0015] Preferably, the average height of the discrete projections is at least 20 microns.

[0016] The strip may be moved away from the casting pool at a speed of at least 75 meters per minute. More specifically, it may be moved away from the casting pool as speed in the range 75 to 150 meters per minute.

[0017] The manganese content of the steel may be in the range 0.6 to 0.9% by weight.

[0018] The method of the present invention may be carried out in a twin roll caster.

[0019] Accordingly the invention further provides a method of continuously casting steel strip of the kind in which molten metal is introduced into the nip between a pair of parallel casting rolls via a metal delivery nozzle disposed above the nip to create a casting pool of molten steel supported on casting surfaces of the rolls immediately above the nip and the casting rolls are rotated to deliver a solidified steel strip downwardly from the nip, wherein the casting surfaces of the rolls are each textured by a random pattern of discrete projections having pointed peaks, the strip is moved away from the casting pool at a speed of more than 60 meters per minute, and the molten steel has a manganese content of no less than 0.6% by weight and a silicon content in the range 0.1 to 0.35% by weight.

[0020] The texture of the casting surface or surfaces can be achieved by grit blasting each casting surface or a metal substrate which is protected by a surface coating to produce the casting surface. For example the or each casting surface may be produced by grit blasting a copper substrate which is subsequently plated with a thin protective layer of chrome. Alternatively the casting surface may be formed of nickel in which case the nickel surface may be grit blasted and no protective coating applied.

[0021] The required texture of the or each casting surface may alternatively be obtained by deposition of a coating onto a substrate. In this case the material of the coating may be chosen to control the heat flux during metal solidification. Said material may be a material which has a low affinity for the steel oxidation products so that wetting of the casting surfaces by those deposits is poor. More particularly the casting surface may be formed of an alloy of nickel chromium and molybdenum or alternatively an alloy of nickel molybdenum and cobalt, the alloy being deposited so as to produce the required texture.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In order that the invention may be more fully explained, results of trials carried out to date will be described with reference to the accompanying drawings in which:

Figure 1 is a plan view of a continuous strip caster which is operable in accordance with the invention;
Figure 2 is a side elevation of the strip caster shown in Figure 1;
Figure 3 is a vertical cross-section on the line 3-3 in Figure 1;
Figure 4 is a vertical cross-section on the line 4-4 in Figure 1;
Figure 5 is a vertical cross-section on the line 5-5 in Figure 1;
Figure 6 represent a typical casting surface texture used in the method of the present invention;
Figure 7 shows the results of trial casts using steels of varying compositions; and
Figure 8 shows the effect of manganese content on the generation of high speed chatter defects.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0023] United States Patent specification 5,701,948 describes how steel strip can be cast in a twin roll caster in which the casting rolls are provided with a regular texture of parallel groove and ridge formations. The present invention may employ a twin roll caster of the same kind as disclosed in that United States patent, but in which the casting rolls have randomly textured surfaces formed by grit blasting. A preferred form of apparatus is illustrated in Figures 1 to 5 of the accompanying drawings.

[0024] The caster illustrated in Figures 1 to 5 comprises a main machine frame 11 which stands up from the factory floor 12. Frame 11 supports a casting roll carriage 13 which is horizontally movable between an assembly station 14 and a casting station 15. Carriage 13 carries a pair of parallel casting rolls 16 to which molten metal is supplied during a casting operation from a ladle 17 via a distributor 18 and delivery nozzle 19 to create a casting pool 30. Casting rolls 16 are water cooled so that shells solidify on the moving roll surfaces 16A and are brought together at the nip 16B between them to produce a solidified strip product 20 at the roll outlet. This product is fed to a standard coiler 21 and may subsequently be transferred to a second coiler 22. A receptacle 23 is mounted on the machine frame adjacent the casting station and molten metal can be diverted into this receptacle via an overflow spout 24 on the distributor or by withdrawal of an emergency plug 25 at one side of the distributor if there is a severe malformation of product or other severe malfunction during a casting operation.

[0025] Roll carriage 13 comprises a carriage frame 31 mounted by wheels 32 on rails 33 extending along part of the main machine frame 11 whereby roll carriage 13 as a whole is mounted for movement along the rails 33. Carriage frame 31 carries a pair of roll cradles 34 in which the rolls 16 are rotatably mounted. Roll cradles 34 are mounted on the carriage frame 31 by interengaging complementary slide members 35, 36 to allow the cradles to be moved on the carriage under the influence of hydraulic cylinder units 37, 38 to adjust the nip between the casting rolls 16 and to enable the rolls to be rapidly moved apart for a short time interval when it is required to form a transverse line of weakness across the strip as will be explained in more detail below. The carriage is movable as a whole along the rails 33 by actuation of a double acting hydraulic piston and cylinder unit 39, connected between a drive bracket 40 on the roll carriage and the main machine frame so as to be actuable to move the roll carriage between the assembly station 14 and casting station 15 and vice versa.

[0026] Casting rolls 16 are contra rotated through drive shafts 41 from an electric motor and transmission mounted on carriage frame 31. Rolls 16 have copper peripheral walls formed with a series of longitudinally extending and circumferentially spaced water cooling passages supplied with cooling water through the roll ends from water supply ducts in the roll drive shafts 41 which are connected to water supply hoses 42 through rotary glands 43. The roll may typically be about 500 mm diameter and up to 2000 mm long in order to produce 2000 mm wide strip product.

[0027] Ladle 17 is of entirely conventional construction and is supported via a yoke 45 on an overhead crane whence it can be brought into position from a hot metal receiving station. The ladle is fitted with a stopper rod 46 actuable by a servo cylinder to allow molten metal to flow from the ladle through an outlet nozzle 47 and refractory shroud 48 into distributor 18.

[0028] Distributor 18 is formed as a wide dish made of a refractory material such as magnesium oxide (MgO). One side of the distributor receives molten metal from the ladle and is provided with the aforesaid overflow 24 and emergency plug 25. The other side of the distributor is provided with a series of longitudinally spaced metal outlet openings 52. The lower part of the distributor carries mounting brackets 53 for mounting the distributor onto the roll carriage frame 31 and provided with apertures to receive indexing pegs 54 on the carriage frame so as to accurately locate the distributor.

[0029] Delivery nozzle 19 is formed as an elongate body made of a refractory material such as alumina graphite. Its lower part is tapered so as to converge inwardly and downwardly so that it can project into the nip between casting rolls 16. It is provided with a mounting bracket 60 whereby to support it on the roll carriage frame and its upper part is formed with outwardly projecting side flanges 55 which locate on the mounting bracket.

[0030] Nozzle 19 may have a series of horizontally spaced generally vertically extending flow passages to produce a suitably low velocity discharge of metal throughout the width of the rolls and to deliver the molten metal into the nip between the rolls without direct impingement on the roll surfaces at which initial solidification occurs. Alternatively, the nozzle may have a single continuous slot outlet to deliver a low velocity curtain of molten metal directly into the nip between the rolls and/or it may be immersed in the molten metal pool.

[0031] The pool is confined at the ends of the rolls by a pair of side closure plates 56 which are held against stepped ends 57 of the rolls when the roll carriage is at the casting station. Side closure plates 56 are made of a strong refractory material, for example boron nitride, and have scalloped side edges 81 to match the curvature of the stepped ends 57 of the rolls. The side plates can be mounted in plate holders 82 which are movable at the casting station by actuation of a pair of hydraulic cylinder units 83 to bring the side plates into engagement with the stepped ends of the casting rolls to form end closures for the molten pool of metal formed on the casting rolls during a casting operation.

[0032] During a casting operation the ladle stopper rod 46 is actuated to allow molten metal to pour from the ladle to the distributor through the metal delivery nozzle whence it flows to the casting rolls. The clean head end of the strip product 20 is guided by actuation of an apron table 96 to the jaws of the coiler 21. Apron table 96 hangs from pivot mountings 97 on the main frame and can be swung toward the coiler by actuation of an hydraulic cylinder unit 98 after the clean head end has been formed. Table 96 may operate against an upper strip guide flap 99 actuated by a piston and a cylinder unit 101 and the strip product 20 may be confined between a pair of vertical side rollers 102. After the head end has been guided in to the jaws of the coiler, the coiler is rotated to coil the strip product 20 and the apron table is allowed to swing back to its inoperative position where it simply hangs from the machine frame clear of the product which is taken directly onto the coiler 21. The resulting strip product 20 may be subsequently transferred to coiler 22 to produce a final coil for transport away from the caster.

[0033] Full particulars of a twin roll caster of the kind illustrated in Figures 1 to 5 are more fully described in our United States Patents 5,184,668 and 5,277,243 and International Patent Application PCT/AU93/00593.

[0034] It has been found that a roll casting surface produced with a random pattern of discrete projections have pointed peaks, as produced by grit or shot blasting is much less prone to generation of chatter defects at casting speeds up to 60 metres/minute, although at higher casting speeds, high frequency chatter is encountered. It has been determined that the randomness of the texture is very important to achieving a microstructure which is homogenous and resistant to crack propagation.

[0035] An appropriate random texture can be imparted to a metal substrate by grit blasting with hard particulate materials such as alumina, silica, or silicon carbide having a particle size of the order of 0.7 to 1.4mm. For example, a copper roll surface may be grit blasted in this way to impose an appropriate texture and the textured surface protected with a thin chrome coating of the order of 50 microns thickness. Figure 6 illustrates a typical casting surface produced in this manner. Alternatively it would be possible to apply a textured surface directly to a nickel substrate with no additional protective coating.

[0036] It is also possible to achieve an appropriate random texture by forming a coating by chemical deposition or electrodeposition. In this case the coating material may be chosen so as to contribute to high thermal conductivity and increased heat flux during solidification. It may also be chosen such that the oxidation products in the steel exhibit poor wettability on the coating material, with the steel melt itself having a greater affinity for the coating material and therefore wetting the coating in preference to the oxides. We have determined that two suitable materials are the alloy of nickel, chromium and molybdenum available commercially under the trade name "HASTALLOY C" and the alloy of nickel, molybdenum and cobalt available commercially under the trade name "T800". Our International Patent Application PCT/AU99/00641 describes the results of tests using randomly textured casting surfaces formed by coatings of HASTALLOY C and T800 showing that the solidified shells deposited on such surfaces are of remarkably even microstructure and of uniform thickness.

[0037] Casting trials have been carried out on a twin roll caster fitted with grit blasted textured rolls using low carbon steel having a range of manganese and silicon contents designed to test two hypotheses as to the cause of the high frequency chatter defects encountered as the casting speed is increased.

[0038] One hypothesis for high frequency chatter is that it is due to lack of wetting of the casting surfaces as the casting speed increases. On this hypothesis, the problem should be alleviated by controlling the steel chemistry so that oxidation products produce low temperature liquidus inclusions promoting wettability. This can be achieved by controlling the manganese and silicon contents of the steel.

[0039] A second hypothesis for the generation of high frequency chatter defects is that it is generated by the lack of cushioning effect of the mushy zone where the solidifying shells come together to form the strip. This hypothesis has been tested by varying the carbon content of the steel for the same manganese content so as to produce a thicker mushy zone. The results of these tests show that the effects of both hypotheses work together to contribute the high frequency chatter defects. The trials have shown that in order to eliminate high frequency chatter defects at high casting speeds, it is necessary to control the manganese content and the silicon content of the steel.

[0040] Figure 7 illustrates results of trials which demonstrate the effect of variation of inclusion liquidus temperatures due to varying manganese and silicon contents and Figure 8 shows the effect of varying manganese content on chatter severity. In these trials the carbon content was maintained below 0.07% by weight. The trials show that the variation of the manganese content is the predominant factor in controlling high frequency chatter defects. Varying the silicon content does not have the same effect, but it is necessary for the silicon content to be maintained within the range 0.1 to 0.35% by weight. If the silicon content is too high, castability problems are encountered because the strip becomes fragile and there are solid inclusions. If the silicon content is too low, the volume of oxides is increased.

[0041] It will be seen from Figure 8 that the content should be at least 0.6% to avoid the generation of chatter defects. As the casting speed is increased the manganese content of the steel must also be increased to avoid high speed chatter. Generally, the manganese content will be in the range 0.6 to 0.9% for casting speeds in the range 75 to 150 meters per minute.

Claims

1. A method of continuously casting steel strip comprising supporting a casting pool (30) of molten steel on one or more chilled casting surfaces and moving the chilled casting surface or surfaces (16A) to produce a solidified strip (20) moving away from the casting pool (30), **characterised in that** the or each casting surface (16A) is textured by a random pattern of dis-

crete projections having pointed peaks, the strip (20) is moved away from the casting pool (30) at a speed of more than 60 meters per minute, and the molten steel has a manganese content of no less than 0.6% by weight and a silicon content in the range 0.1 to 0.35% by weight.

2. A method as claimed in claim 1, further **characterised in that** the steel has a carbon content of less than 0.07% by weight.

3. A method as claimed in claim 1 or claim 2, further **characterised in that** said pointed peaks have a surface distribution of between 5 and 100 peaks per mm^2 and an average height of at least 10 microns.

4. A method as claimed in any one of claims 1 to 3, further **characterised in that** the average height of the discrete projections is at least 20 microns.

5. A method as claimed in any one of claims 1 to 4, further **characterised in that** the strip (20) is moved away from the casting pool (30) at a speed of at least 75 meters per minute.

6. A method as claimed in claim 5, further **characterised in that** the strip (20) is moved away from the casting pool (30) at a speed in the range 75 to 150 meters per minute.

7. A method as claimed in any one of claims 1 to 6, further **characterised in that** the manganese content of the steel is in the range 0.6 to 0.9% by weight

8. A method as claimed in any one of claims 1 to 7, further **characterised in that** there is a pair of said casting surfaces (16A) constituted by peripheral surfaces of a pair of parallel casting rolls (16) forming a nip (16B) between them, the molten steel is introduced into the nip (16B) between the casting rolls (16) to create the casting pool (30) supported on the casting surfaces (16A) of the rolls immediately above the nip (16B), and the casting rolls (16) are rotated to deliver the solidified strip (20) downwardly from the nip.

9. A method as claimed in claim 6, further **characterised in that** the molten steel is delivered into the nip (16B) between the casting rolls (16) via a metal delivery nozzle (19) disposed above the nip.

10. A method as claimed in any one of claims 1 to 9, further **characterised in that** the or each casting surface (16A) is defined by a grit blasted substrate covered by a protective coating.

11. A method as claimed in claim 10, further **characterised in that** the protective coating is an electroplated metal coating.

12. A method as claimed in claim 11, further **characterised in that** the substrate is copper and the plated coating is of chromium.

13. A method as claimed in any one of claims 1 to 9. further **characterised in that** the or each casting surface (16A) is a grit blasted surface.

14. A method as claimed in claim 13, further **characterised in that** the grit blasted surface is formed of nickel.

15. A method as claimed in any one of claims 1 to 9, further **characterised in that** the or each casting surface (16A) is defined by a coating deposited onto a substrate to produce the random texture of that surface.

16. A method as claimed in claim 15, further **characterised in that** the coating is formed by chemical deposition.

17. A method as claimed in claim 16, further **characterised in that** the coating is formed by electrode position.

18. A method as claimed in any one of claims 15 to 17, further **characterised in that** the coating is formed of a material which has a low affinity for the oxidation products in the molten steel such that the molten steel itself has greater affinity for the coating material and therefore wets the coating in preference to said oxidation products.

19. A method as claimed in any one of claims 15 to 18. further **characterised in that** the coating is formed of an alloy of nickel, chromium and molybdenum.

20. A method as claimed in any one of claims 15 to 18. further **characterised in that** the coating is formed of an alloy of nickel, molybdenum and cobalt.

Patentansprüche

1. Verfahren zum kontinuierlichen Gießen von Stahlband, das das Tragen eines Gießpools (30) aus geschmolzenem Stahl auf einer oder mehreren gekühlten Gießflächen und das Bewegen der gekühlten Gießfläche(n) (16A) zum Erzeugen eines erstarrten Bandes (20) beinhaltet, das sich von dem Gießpool (30) wegbewegt, **dadurch gekennzeichnet, dass** die oder jede Gießfläche (16A) mit einem zufälligen Muster von diskreten Vorsprüngen mit spitzen Erhebungen texturiert ist, wobei das Band (20) von dem Gießpool (30) mit einer Geschwindigkeit von mehr

als 60 Metern pro Minute wegbewegt wird und der geschmolzene Stahl einen Mangangehalt von nicht weniger als 0,6 Gew.-% und einen Siliziumgehalt im Bereich von 0,1 bis 0,35 Gew.-% hat.

2. Verfahren nach Anspruch 1, ferner **dadurch gekennzeichnet, dass** der Stahl einen Kohlenstoffgehalt von weniger als 0,07 Gew.-% hat.

3. Verfahren nach Anspruch 1 oder Anspruch 2, ferner **dadurch gekennzeichnet, dass** die genannten spitzen Erhebungen eine Oberflächenverteilung zwischen 5 und 100 Spitzen pro mm^2 und eine durchschnittliche Höhe von wenigstens 10 Mikron haben.

4. Verfahren nach einem der Ansprüche 1 bis 3, ferner **dadurch gekennzeichnet, dass** die durchschnittliche Höhe der diskreten Vorsprünge wenigstens 20 Mikron beträgt.

5. Verfahren nach einem der Ansprüche 1 bis 4, ferner **dadurch gekennzeichnet, dass** das Band (20) von dem Gießpool (30) mit einer Geschwindigkeit von wenigstens 75 Metern pro Minute wegbewegt wird.

6. Verfahren nach Anspruch 5, ferner **dadurch gekennzeichnet, dass** das Band (20) von dem Gießpool (30) mit einer Geschwindigkeit im Bereich von 75 bis 150 Metern pro Minute wegbewegt wird.

7. Verfahren nach einem der Ansprüche 1 bis 6, ferner **dadurch gekennzeichnet, dass** der Mangangehalt des Stahls im Bereich von 0,6 bis 0,9 Gew.-% liegt.

8. Verfahren nach einem der Ansprüche 1 bis 7, ferner **dadurch gekennzeichnet, dass** es ein Paar der genannten Gießflächen (16A) gibt, die durch periphere Flächen eines Paares von parallelen Gießwalzen (16) mit einem Spalt (16B) dazwischen gebildet wird, der geschmolzene Stahl in den Spalt (16B) zwischen den Gießwalzen (16) geleitet wird, um den auf den Gießflächen (16A) der Walzen unmittelbar über dem Spalt (16B) getragenen Gießpool (30) zu erzeugen, und die Gießwalzen (16) gedreht werden, um das erstarrte Band (20) stromabwärts von dem Spalt zuzuführen.

9. Verfahren nach Anspruch 8, ferner **dadurch gekennzeichnet, dass** der geschmolzene Stahl in den Spalt (16B) zwischen den Gießwalzen (16) über eine über dem Spalt angeordnete Metallzuführungsdüse (19) zugeführt wird.

10. Verfahren nach einem der Ansprüche 1 bis 9, ferner **dadurch gekennzeichnet, dass** die oder jede Gießfläche (16A) durch ein kugelgestrahltes Substrat definiert wird, das mit einem Schutzüberzug bedeckt ist.

11. Verfahren nach Anspruch 10, ferner **dadurch gekennzeichnet, dass** der Schutzüberzug ein galvanisierter Metallüberzug ist.

12. Verfahren nach Anspruch 11, ferner **dadurch gekennzeichnet, dass** das Substrat aus Kupfer ist und der galvanisierte Überzug aus Chrom ist.

13. Verfahren nach einem der Ansprüche 1 bis 9, ferner **dadurch gekennzeichnet, dass** die oder jede Gießfläche (16A) eine kugelgestrahlte Oberfläche ist.

14. Verfahren nach Anspruch 13, ferner **dadurch gekennzeichnet, dass** die kugelgestrahlte Oberfläche aus Nickel gebildet ist.

15. Verfahren nach einem der Ansprüche 1 bis 9, ferner **dadurch gekennzeichnet, dass** die oder jede Gießfläche (16A) durch einen Überzug definiert ist, der auf ein Substrat abgesetzt wird, um die zufällige Textur dieser Oberfläche zu erzeugen.

16. Verfahren nach Anspruch 15, ferner **dadurch gekennzeichnet, dass** der Überzug durch chemische Abscheidung gebildet wird.

17. Verfahren nach Anspruch 16, ferner **dadurch gekennzeichnet, dass** der Überzug durch Galvanisieren gebildet wird.

18. Verfahren nach einem der Ansprüche 15 bis 17, ferner **dadurch gekennzeichnet, dass** der Überzug aus einem Material gebildet wird, das eine niedrige Affinität für die Oxidationsprodukte in dem geschmolzenen Stahl hat, so dass der geschmolzene Stahl selbst eine höhere Affinität für das Überzugsmaterial hat und daher den Überzug bevorzugt gegenüber den genannten Oxidationsprodukten benetzt.

19. Verfahren nach einem der Ansprüche 15 bis 18, ferner **dadurch gekennzeichnet, dass** der Überzug aus einer Legierung von Nickel, Chrom und Molybdän gebildet ist.

20. Verfahren nach einem der Ansprüche 15 bis 18, ferner **dadurch gekennzeichnet, dass** der Überzug aus einer Legierung von Nickel, Molybdän und Kobalt gebildet ist.

Revendications

1. Procédé de coulée continue d'acier en bandes comportant l'étape consistant à supporter un bassin de coulée (30) d'acier en fusion sur une ou plusieurs surfaces de coulée refroidies et l'étape consistant à déplacer la surface de coulée refroidie ou les surfaces de coulée refroidies (16A) à des fins de production d'une bande solidifiée (20) s'éloignant du bassin de coulée (30), **caractérisé en ce que** la ou chaque surface de coulée (16A) est texturée selon un modèle aléatoire de parties saillantes discrètes ayant des crêtes pointues, la bande (20) est éloignée du bassin de coulée (30) à une vitesse de plus de 60 mètres par minute, et l'acier en fusion a une teneur en manganèse ne faisant pas moins de 0,6 % en poids et une teneur en silicium se trouvant dans la plage allant de 0,1 à 0,35 % en poids.

2. Procédé selon la revendication 1, **caractérisé par** ailleurs en ce que l'acier a une teneur en carbone de moins de 0,07 % en poids.

3. Procédé selon la revendication 1 ou la revendication 2, **caractérisé par** ailleurs en ce que lesdites crêtes pointues ont une répartition superficielle comprise entre 5 et 100 crêtes par mm^2 et une hauteur moyenne d'au moins 10 microns.

4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé par** ailleurs en ce que la hauteur moyenne des parties saillantes discrètes est au moins de 20 microns.

5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé par** ailleurs en ce que la bande (20) est éloignée du bassin de coulée (30) à une vitesse d'au moins 75 mètres par minute.

6. Procédé selon la revendication 5, **caractérisé par** ailleurs en ce que la bande (20) est éloignée du bassin de coulée (30) à une vitesse se trouvant dans la plage allant de 75 à 150 mètres par minute.

7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé par** ailleurs en ce que la teneur en manganèse de l'acier se trouve dans la plage allant de 0,6 à 0,9 % en poids.

8. Procédé selon l'une quelconque des revendications 1 à 7, **caractérisé par** ailleurs en ce qu'il y a une paire desdites surfaces de coulée (16A) constituées par des surfaces périphériques d'une paire de rouleaux lamineurs parallèles (16) formant un espace (16B) entre eux, l'acier en fusion est introduit dans l'espace (16B) entre les rouleaux lamineurs (16) pour créer le bassin de coulée (30) supporté sur les surfaces de coulée (16A) des rouleaux immédiatement au-dessus de l'espace (16B), et les rouleaux lamineurs (16) sont mis en rotation pour acheminer la bande solidifiée (20) vers le bas depuis l'espace.

9. Procédé selon la revendication 8, **caractérisé par** ailleurs en ce que l'acier en fusion est acheminé dans l'espace (16B) entre les rouleaux lamineurs (16) par le biais d'une buse de distribution de métal (19) disposée au-dessus de l'espace.

10. Procédé selon l'une quelconque des revendications 1 à 9, **caractérisé par** ailleurs en ce que la ou chaque surface de coulée (16A) est définie par un substrat décapé à l'abrasif recouvert d'un revêtement protecteur.

11. Procédé selon la revendication 10, **caractérisé par** ailleurs en ce que le revêtement protecteur est un revêtement métallique électroplaqué.

12. Procédé selon la revendication 11, **caractérisé par** ailleurs en ce que le substrat est du cuivre et le revêtement plaqué est du chrome.

13. Procédé selon l'une quelconque des revendications 1 à 9, **caractérisé par** ailleurs en ce que la ou chaque surface de coulée (16A) est une surface décapée à l'abrasif.

14. Procédé selon la revendication 13, **caractérisé par** ailleurs en ce que la surface décapée à l'abrasif est formée à partir de nickel.

15. Procédé selon l'une quelconque des revendications 1 à 9, **caractérisé par** ailleurs en ce que la ou chaque surface de coulée (16A) est définie par un revêtement déposé sur un substrat pour produire la texture aléatoire de cette surface.

16. Procédé selon la revendication 15, **caractérisé par** ailleurs en ce que le revêtement est formé par déposition chimique.

17. Procédé selon la revendication 16, **caractérisé par** ailleurs en ce que le revêtement est formé par dépôt électrolytique.

18. Procédé selon l'une quelconque des revendications 15 à 17, **caractérisé par** ailleurs en ce que le revêtement est formé à partir d'un matériau qui a une faible affinité pour les produits d'oxydation dans l'acier en fusion de telle sorte que l'acier en fusion lui-même a une plus grande affinité pour le matériau de revêtement et par conséquent mouille le revêtement de préférence auxdits produits d'oxydation.

19. Procédé selon l'une quelconque des revendications 15 à 18, **caractérisé par** ailleurs en ce que le revêtement est formé à partir d'un alliage de nickel, de chrome et de molybdène.

20. Procédé selon l'une quelconque des revendications 15 à 18, **caractérisé par** ailleurs en ce que le revêtement est formé à partir d'un alliage de nickel, de molybdène et de cobalt.

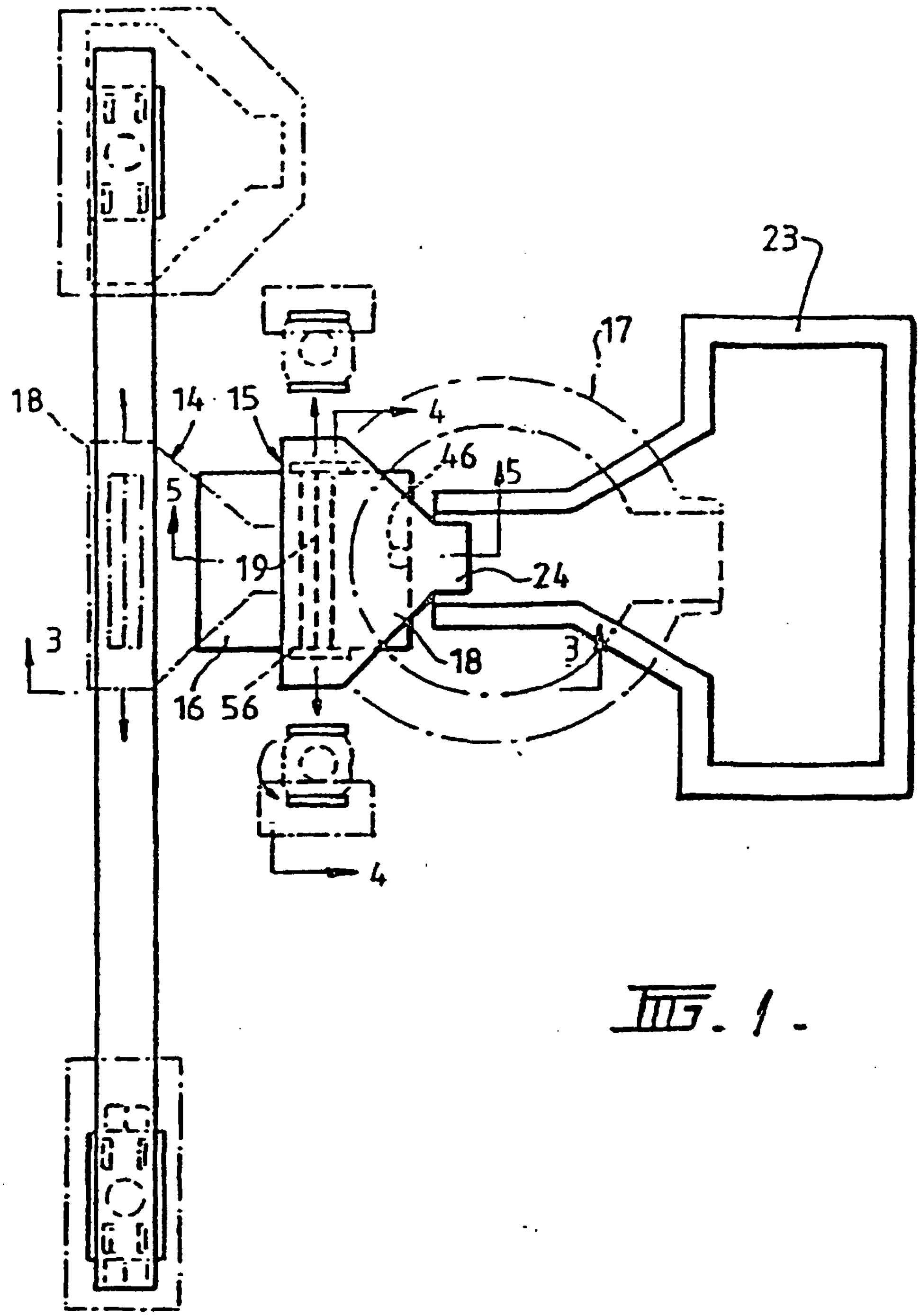
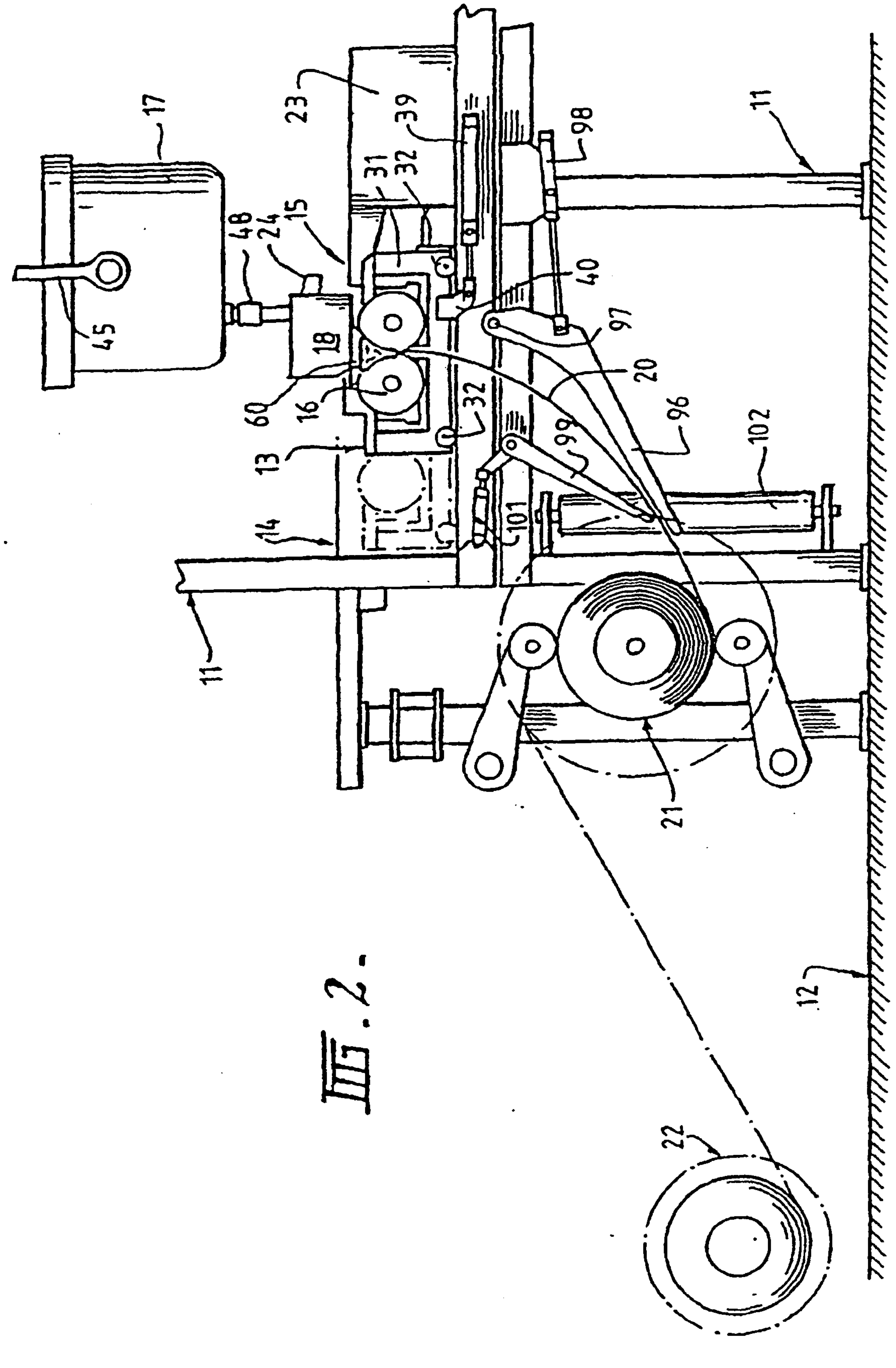


FIG. 1.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60
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32
96
102
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101
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FIG. 2

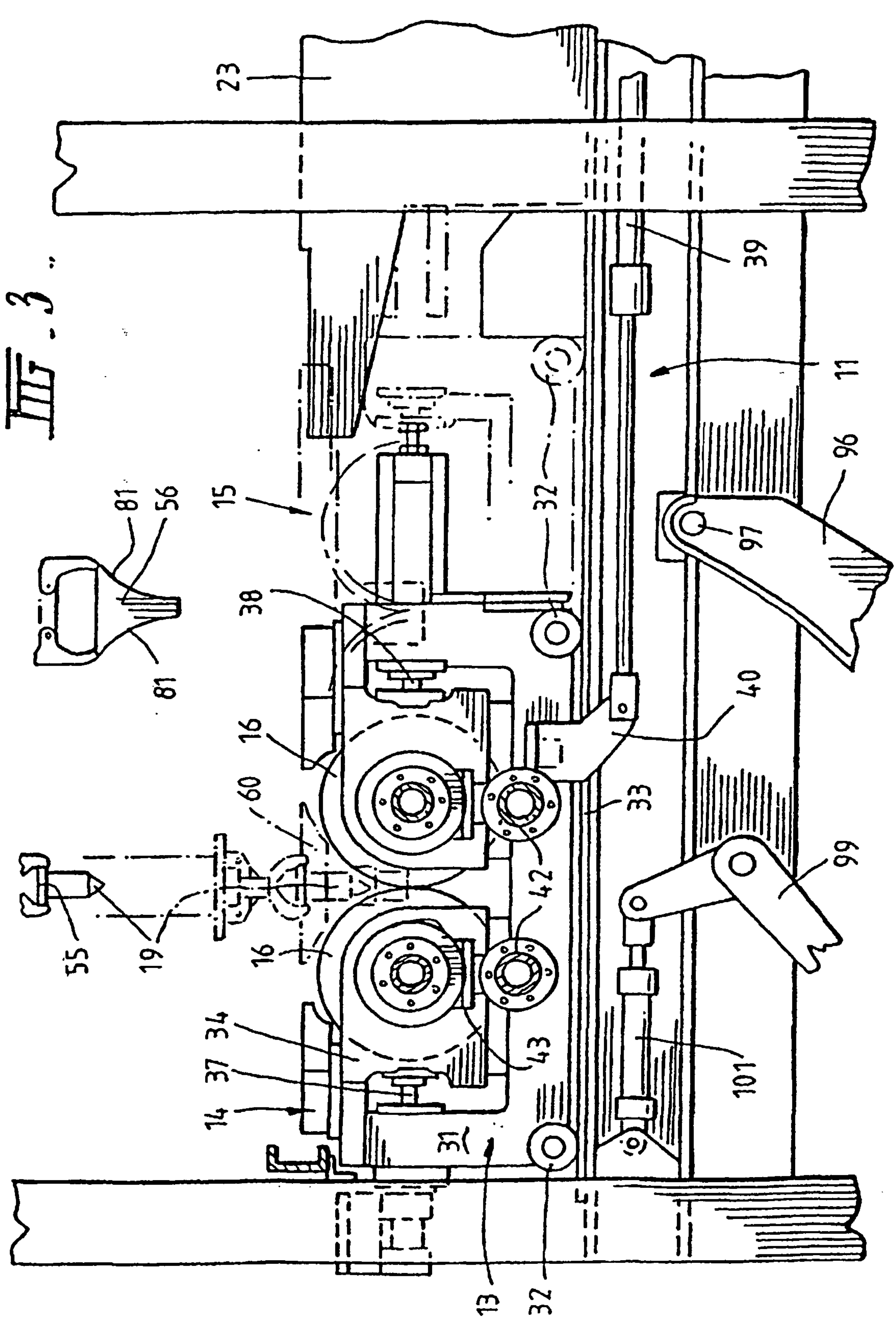
Fig. 3
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81
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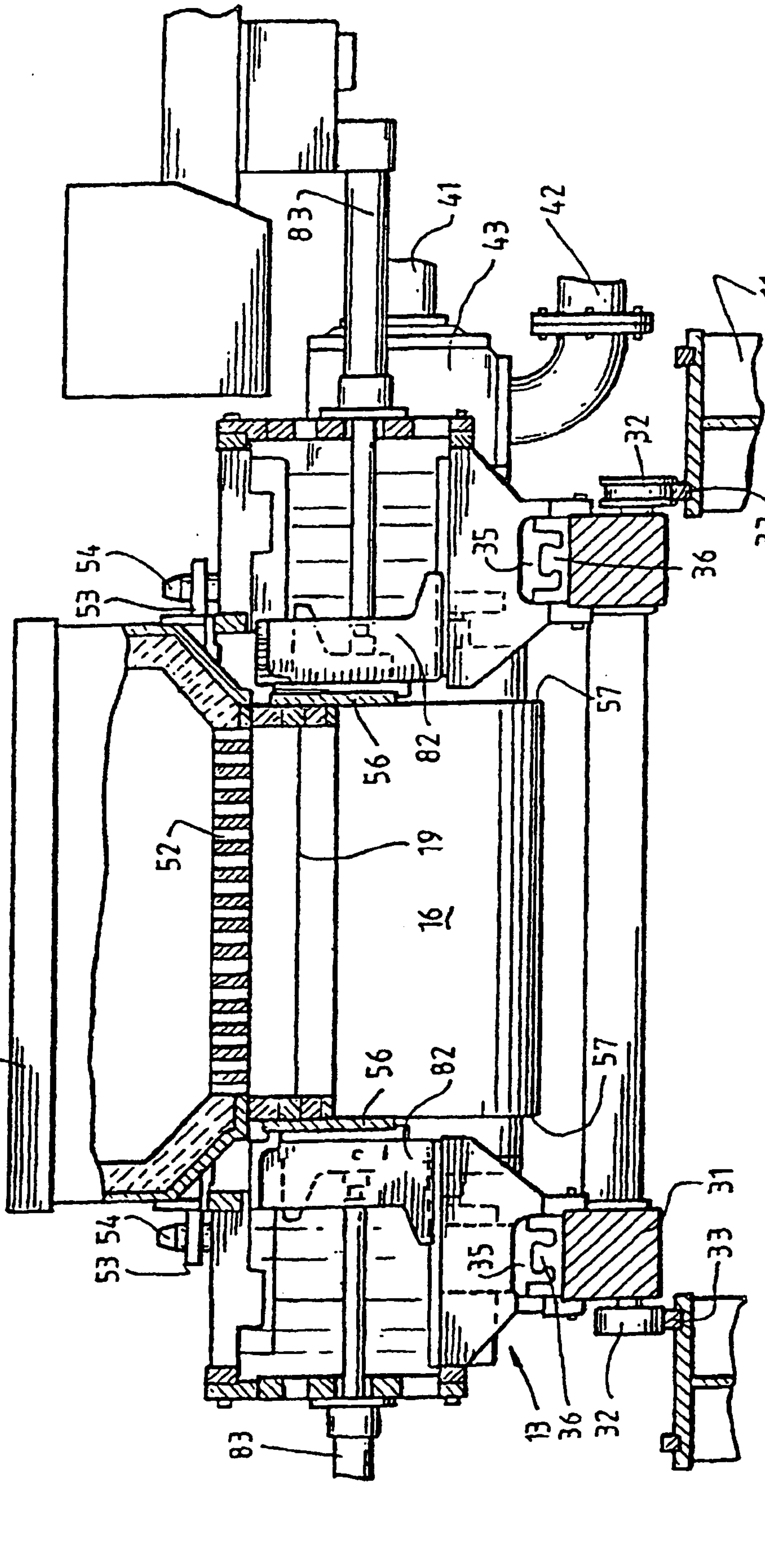
FIG. 4.



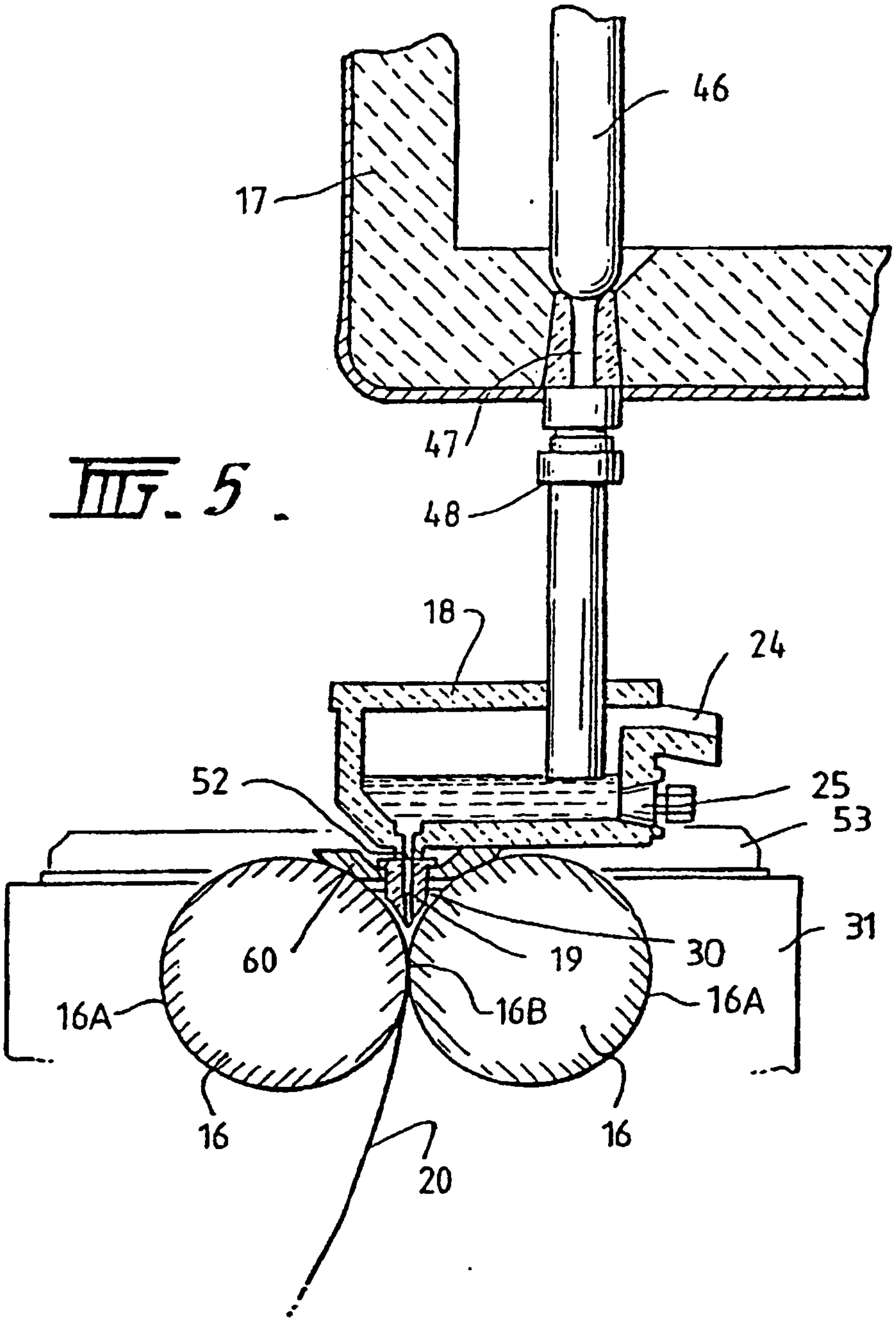


Fig. 5

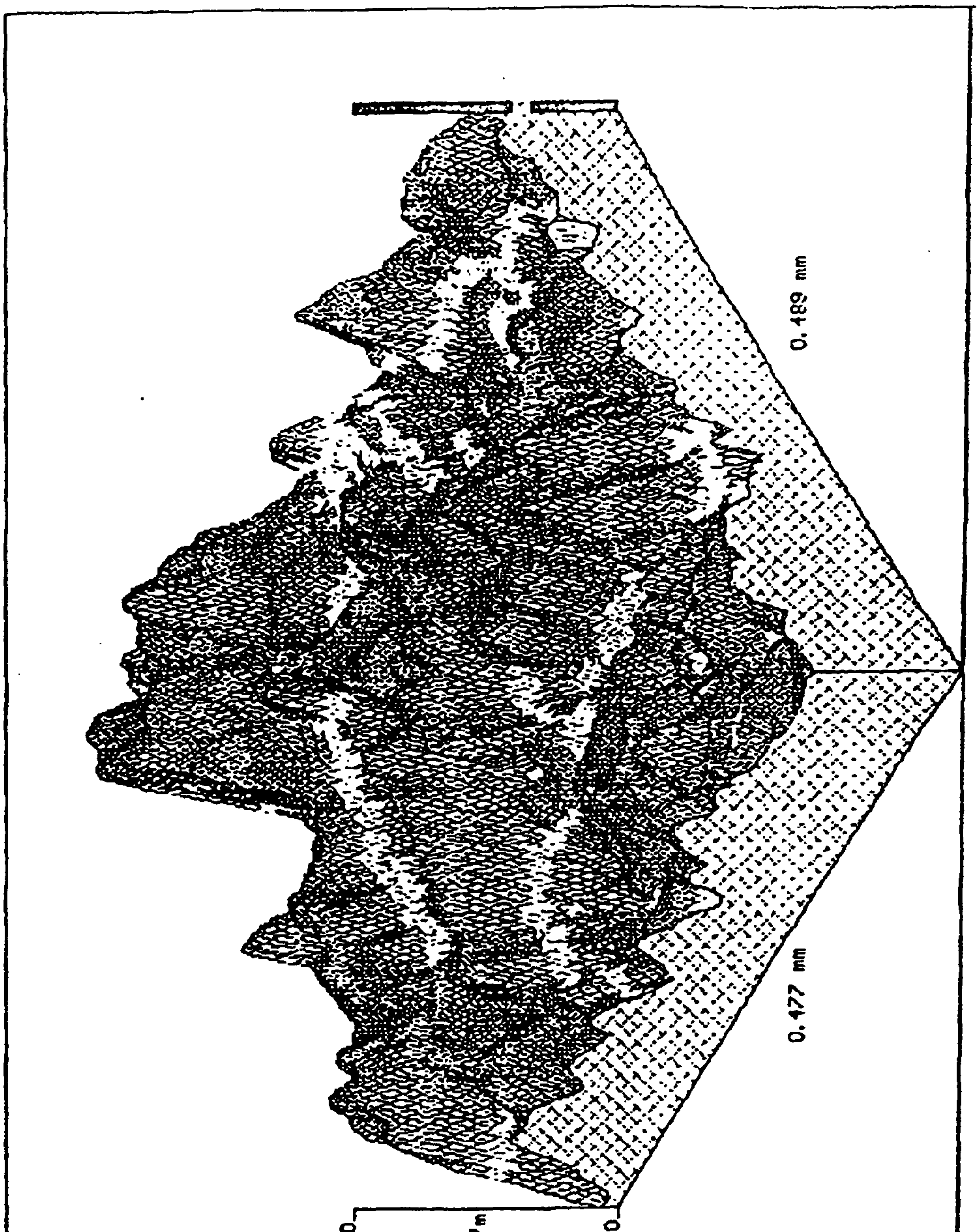


Fig. 6.

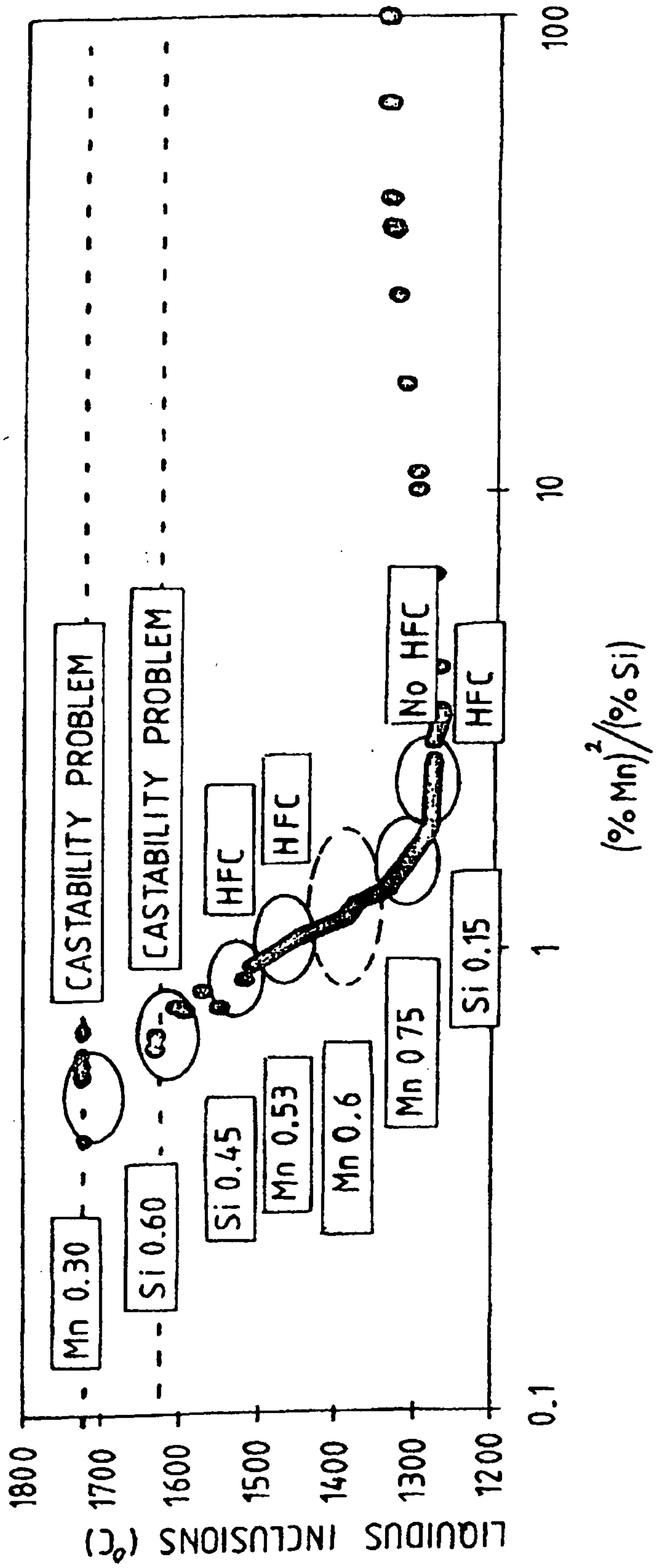

CASTABILITY PROBLEM
CASTABILITY PROBLEM
Mn 0.30
Si 0.60
Si 0.45
Mn 0.53
Mn 0.6
Mn 0.75
Si 0.15
HFC
HFC
No HFC
HFC
1800
1700
1600
1500
1400
1300
1200
0.1
1
10
100
LIQUIDUS INCLUSIONS (°C)
(% Mn)^2/(% Si)

FIG. 7.

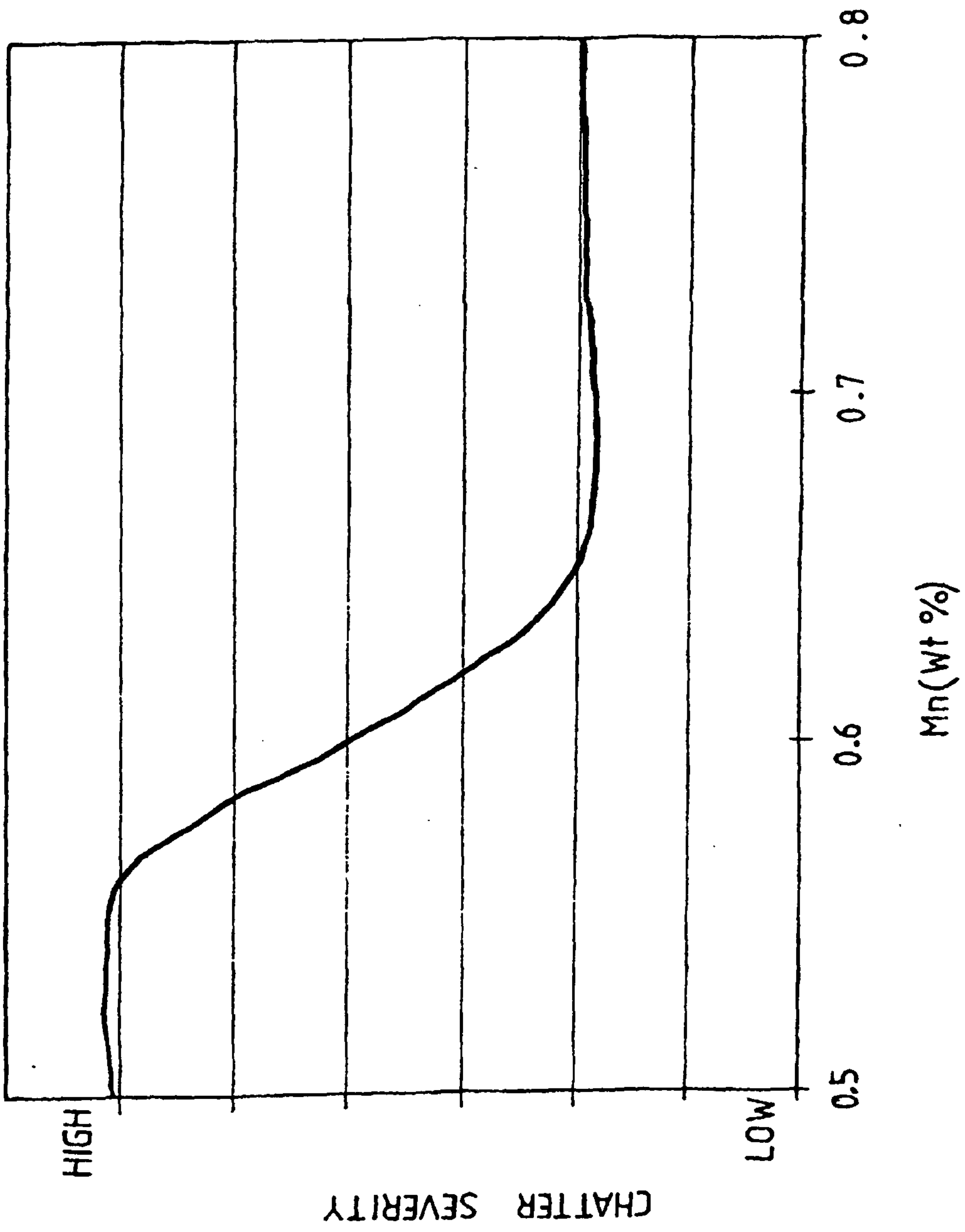


FIG. 8.

REFERENCES CITED IN THE DESCRIPTION

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