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(71) Applicant: Kvaerner Metals Continuous Casting Limited
Sheffield S9 4EX (GB)

(72) Inventors:
- Thomas, Philip Milroy
  West Moors, Ferndown, Dorset BH22 0EP (GB)
- Grocock, Peter George
  Walkeringham, Nr Doncaster DN10 4LF (GB)

(74) Representative: Harman, Michael Godfrey
Hillgate Patent Services,
No. 6 Aztec Row,
Berners Road
Islington, London N1 0PW (GB)

(54) A method for feeding roll casters and apparatus therefor

(57) A method of feeding molten metal into a roll caster by means of a nozzle passing the molten metal through a first channel arranged essentially parallel to the flow of the molten metal, characterised in that molten metal is then separated within the nozzle and passed through second and third channels also arranged essentially parallel to the flow of the molten metal before exiting the nozzle tip to enter the gap between casting rolls.

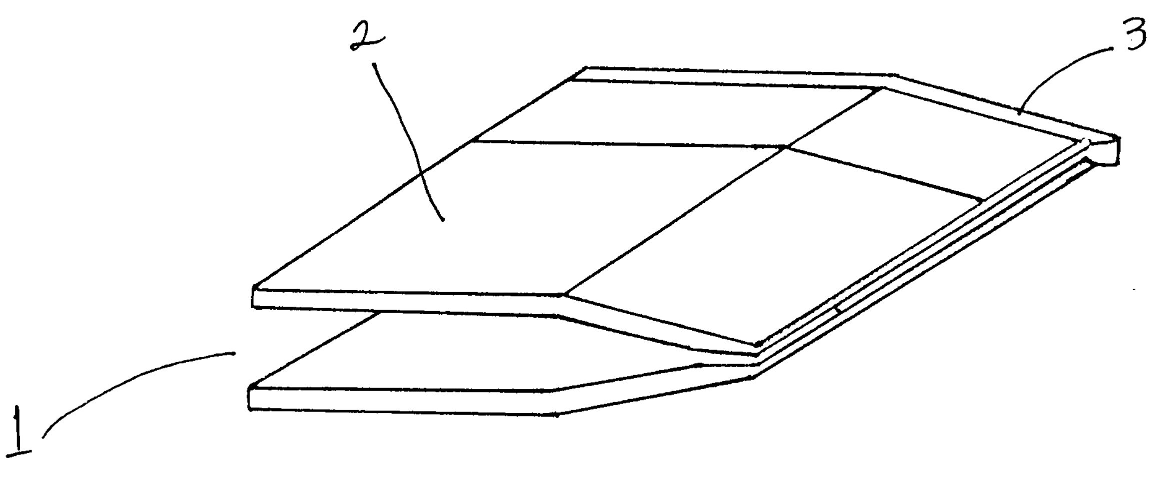

Fig. 1

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Description

[0001] This invention relates to roll casting and, in particular, to a method and apparatus for feeding molten metal into a roll caster such as a twin roll caster.

[0002] Twin roll casting is an established technology for the production of metal strip. In the case of aluminium alloys, it is usual for the thickness of the cast strip to be in the range 6 - 10 mm. In this casting process molten metal is fed into the bite of a pair of internally cooled, counter-rotating rolls. The molten metal solidifies in contact with the casting rolls and then undergoes a hot reduction before exiting the caster as solid strip.

[0003] Molten metal is fed into the caster by means of a refractory nozzle usually referred to as the feeder tip. Tips can be manufactured in a number of ways. They can be machined from solid or more normally fabricated from tip sections. Traditionally tip sections have been limited in width and as result multiple tip sections are joined together until the required width is achieved. These joined sections then form the top and bottom portions of the tip. The leading edge of the tip is profiled such that it approximates to the curvature of the casting rolls. A typical feeder tip is shown schematically in Figure 1.

[0004] The tip is closed at each end by a profiled refractory component referred to as an end dam. The end dam is profiled to accommodate the spreading of the molten metal that can occur before solidification is complete.

[0005] The interior of the tip can have one of two basic forms. Closed (baffled) tips are characterised by the presence of an array of baffles whereas open tips are generally free from baffles although it is usual to use spacers to maintain a parallel orifice at the exit of the tip.

[0006] With this configuration of tip, the molten metal is fed from the reservoir of molten metal (referred to as the head box into the tip by means of a refractory tube). Traditionally tip designs have evolved by the modification of the size or position of baffles and it is accepted that a different design of tip will be required for different strip widths. In closed tips both the shape and the positioning of the baffles is critical and even small errors in tip manufacture can result in sheet defects.

[0007] In open tips, there is a complete absence of baffles, although it is usual for a number of "spacers" to be used. The purpose of the spacers is to hold the top and bottom sections of the tip apart and maintain a parallel orifice at the tip exit. The method of feeding metal into an open tip is different to that used for closed tips. In this case it is usual for the head box to be connected directly to the tip and for the width of the head box to be between 0.5 and 0.75 times the width of the tip.

[0008] It is an object of the invention to provide a casting method and apparatus which prevents sheet defects, the temperature of the molten metal as it contacts the casting rolls is uniform or has some predetermined temperature profile.

[0009] It is also an object of the invention to provide a method and apparatus for feeding a roll caster where the cast width exceeds 2 metres as well as a method for producing simultaneous multiple cast strips.

[0010] In this invention a tip design will be described that overcomes the problems of traditional "closed" (baffled) tips and allows a predetermined temperature and pressure profile to be established in the tip.

[0011] According to the invention there is provided a method of feeding molten metal into a roll caster by means of a nozzle passing the molten metal through a first channel arranged essentially parallel to the flow of the molten metal, characterised in that molten metal is then separated within the nozzle and passed through second and third channels also arranged essentially parallel to the flow of the molten metal before exiting the nozzle tip to enter the gap between casting rolls.

[0012] Preferably the molten metal enters a front tip chamber arranged at the front tip area of the nozzle, after exiting the second and third channels and before exiting the nozzle. Preferably the front tip area of the nozzle comprises a weir baffle arranged orthogonally to the flow of the molten metal.

[0013] According to the invention there is provided a casting nozzle apparatus for feeding molten metal into a roll caster comprising a first entry channel arranged essentially parallel to the flow of the molten metal, characterised in that the nozzle comprises second and third channels also arranged essentially parallel to the flow of the molten metal and through which the flow of molten metal is divided before exiting the nozzle tip to enter the gap between casting rolls and that the molten metal enters a front tip chamber arranged at the front of the nozzle, after exiting the second and third channels and before exiting the nozzle.

[0014] The nozzle may include additional channels to separate the flow of molten metal further, the second channel leading into fourth and fifth channel and the third channel leading into sixth and seventh channels before entering the front tip chamber.

[0015] The invention will now be described in more detail by means of exemplary embodiments described in the following description and appended figures in which:

Fig. 1 is a perspective view of a conventional nozzle type of the type with which the invention is concerned,

Fig. 2 is a first embodiment of the invention with a single entry point,

Fig. 3 is a second embodiment of the invention with a single entry point,

Fig. 4 is a third embodiment of the invention with a single entry point, and

Fig. 5 is a fourth embodiment of the invention with a double entry point.

[0016] As the molten metal contacts the casting rolls it starts to solidify and it is important from a process standpoint that solidification takes place uniformly across the full width of the strip being cast. In other words, a macroscopically planar solidification front develops across the full width of the strip. If this does not occur and local perturbations in the solidification front develop, it is likely that sheet defects will result.

[0017] To ensure a planar solidification front it is important that the rate of heat transfer between the rolls and the solidifying strip is uniform across the width of the sheet and to achieve this a number of conditions need to be satisfied:

1. The temperature of the casting roll needs to be uniform across the strip width
2. The parting layer applied to the casting rolls to prevent sticking of the cast strip to the casting rolls needs to be uniform
3. The molten metal being fed to the casting rolls needs to at a uniform temperature across the width of the feeder tip.

[0018] If the casting process is considered in detail it can be shown that as the molten metal contacts the casting roll surface there is a sudden increase in the roll temperature. Depending on the precise arrangement of the casting roll and particularly the thickness of the casting shell, the material of the casting shell and the cooling arrangement of the casting roll, the surface temperature of the shell can rise from ambient to a peak of several hundreds of degrees Celsius during the time the metal is in contact with the roll. Once the roll leaves this contact region the shell is cooled and the temperature falls. This cycle is repeated once every revolution of the caster roll. Once steady state casting conditions have been achieved, the return temperature of the casting rolls (i.e., the temperature of the casting roll immediately before the contact region) will be uniform.

[0019] Fig. 1 shows a prior art caster tip 1, with one end dam 2 removed, including a conventional tip section 3.

[0020] Fig. 2 shows a first embodiment of the invention in its simplest form of a nozzle 1 with a single entry channel 11 which divides into two separate exit channels 12 which exit into a front tip chamber 13 . The front tip chamber comprises an overflow weir 14. The two exit channels 12 are spaced an equal distance from the entry channel 11 such that the flow of metal is divided evenly into the two exit channels 12 and ensures an even flow profile across the nozzle tip.

[0021] Fig. 3 shows a second embodiment of the invention in which there are four exit channels 22 which are fed by two intermediate channels 23 which are in turn fed by a single entry channel 11. Similarly to the embodiment in figure 2, the four exit channels 22 are spaced an equal distance from the intermediate channels entry 23 which are spaced an equal distance from the entry channel 11 such that the flow of metal is divided evenly into the four exit channels 22. It could, in some circumstances, be desirable to space the exit channels 22 at different distances to produce a different flow profile across the nozzle tip.

[0022] Fig. 4 shows an embodiment with eight exit channels 32 which are fed by a first set of four intermediate channels 33 which in turn are fed by a second set of two intermediate channels 34 which in turn is fed by a single entry port 11.

[0023] Fig. 5 shows an embodiment with two entry ports 11 each leading into eight exit channels via intermediate channels as is the case in figure 4.

[0024] In the present invention the method and tip construction described ensures that the metal leaving the tip is at a uniform temperature across the whole of the tip width. The principle adopted is one of multiple bifurcation. In the simplest case, metal is fed into the tip at a single point. The metal flow is divided into two by a refractory baffle and the two streams of metal feed the left and right hand sides of the tip respectively. When these secondary streams reach the quartile positions the flow is again split using refractory baffles. This process is repeated, the total number of bifurcations being governed by the size of the refractory baffles and the overall length of the tip from front to back. After the final bifurcation the metal is allowed to flow over a weir to minimise the risk of non uniformities in temperature.

[0025] This method of construction has a number of advantages over existing designs of closed tips:

1. The metal temperature profile across the width of the strip is uniform

2. The design is independent of cast width and casting speed

3. The design is relatively insensitive to inaccuracies during construction

[0026] It has been found that as a result considerable improvements have been achieved in the resulting end quality of the final strip.

[0027] For wide cast material, the single point entry can be replaced by twin point entry, as shown in fig. 5, with the entry points being arranged at the quartile positions. For material greater than 2 metres, additional entry points can be employed. In this case multiple headboxes can be used and it is possible that metal of a different temperature could be fed to the extreme edges of the tip. This embodiment is described in detail later.

[0028] As an alternative to point feeds a slot feed can be employed.

[0029] During roll casting it is usual for the material to "spread", i.e. the cast strip is wider than the orifice of the feeder tip and the amount of spread is a function of the freezing range of the alloy and the casting conditions. Whereas the bulk of the strip undergoes an extrusion effect, i.e. the strip moves faster than the casting rolls, the material at the extreme edges of the strip spreads sideways. Due to the extra cooling at the strip edges, material at the edge of the strip tend to be thicker than the bulk of the strip. This material cracks as it attempts to deform along with the bulk of the strip. One method of overcoming this problem would be to locally reduce the cooling effect of the casting rolls in the vicinity of the strip edges. A more convenient method is to control the flow of metal in the feed tip such that the temperature of metal at the edges of the strip is hotter than the bulk material.

[0030] As has been explained, this is extremely difficult with both traditional closed (baffled) tips and with open tips, but is readily achieved with the design of tip described in this invention. The flow rate of metal through the tip (and hence the temperature distribution across the tip) is governed by the dimensions of the flow passages. Consequently, if there is a requirement to increase the temperature of the metal at the edges of the strip, the channels feeding the extreme edges of the tip can be increased in size in order to reduce the resistance to flow.

[0031] If there is a requirement to cast wide sheet (for example wider than 2 metres) it is possible for more than one head box to be used to feed the tip. Moreover the tip can be made up from a number of sections with the baffling arranged to optimise the temperature distribution. With this configuration it is possible, for example, to arrange the temperature profile of the metal leaving the tip and contacting the roll such that the metal at the extreme edges of the tip are hotter than the bulk of the strip width. This is achieved by arranging for the head boxes feeding the edges of the strip to be heated so that the temperature of metal was higher than that used for the central regions. Each of the head boxes feeding this composite tip would have its own dedicated level control device that would allow different metallostatic heads to be employed at the edges of the strip compared to the bulk of the strip.

[0032] An alternative approach is to use a single head box that is connected to the feeder tip by a plurality of feed tubes. Using this approach flow to various regions of the tip can be controlled by regulating the flow through each of the feed tubes.

Claims

1. A method of feeding molten metal into a roll caster, by means of a nozzle, passing the molten metal through a first channel (11) arranged essentially parallel to the flow of the molten metal, characterised in that molten metal is then separated within the nozzle and passed through second and third channels (12, 23, 34) also arranged essentially parallel to the flow of the molten metal before exiting the nozzle.

2. A method according to claim 1, characterised in that the molten metal enters a front tip chamber (13) arranged at the front tip area of the nozzle, after exiting the second and third channels (12, 23, 34) and before exiting the nozzle.

3. A casting nozzle apparatus for feeding molten metal into a roll caster comprising a first entry channel (11) arranged essentially parallel to the flow of the molten metal, characterised in that the nozzle comprises second and third channels (12, 23, 34) also arranged essentially parallel to the flow of the molten metal and through which the flow of molten metal is divided before exiting the nozzle tip and that the molten metal enters a front tip chamber (13) arranged at the front of the nozzle, after exiting the second and third channels and before exiting the nozzle.

4. A casting nozzle according to claim 3, characterised in that the front tip chamber of the nozzle comprises a weir baffle (14) arranged orthogonally to the flow of the molten metal.

5. A casting nozzle according to claim 3, characterised in that the nozzle includes additional channels (22, 33, 32) to separate the flow of molten metal further.

6. A casting nozzle according to claim 5, characterised in that the second channel leads into a fourth and a fifth channel (22) and the third channel leads into a sixth and a seventh channel (22) before entering the front tip chamber (13).

7. A casting nozzle according to claim 3, characterised in that the nozzle comprises two or more entry channels (11).

8. A casting nozzle according to claim 3, characterised in that the channels are of different sizes to produce different flow rates of molten metal.

9. A casting nozzle according to claim 8, characterised in that the channels on the outside edges of the nozzles are larger than those at the centre of the nozzle to induce a greater flow rate at the edges of the strip than at the centre.

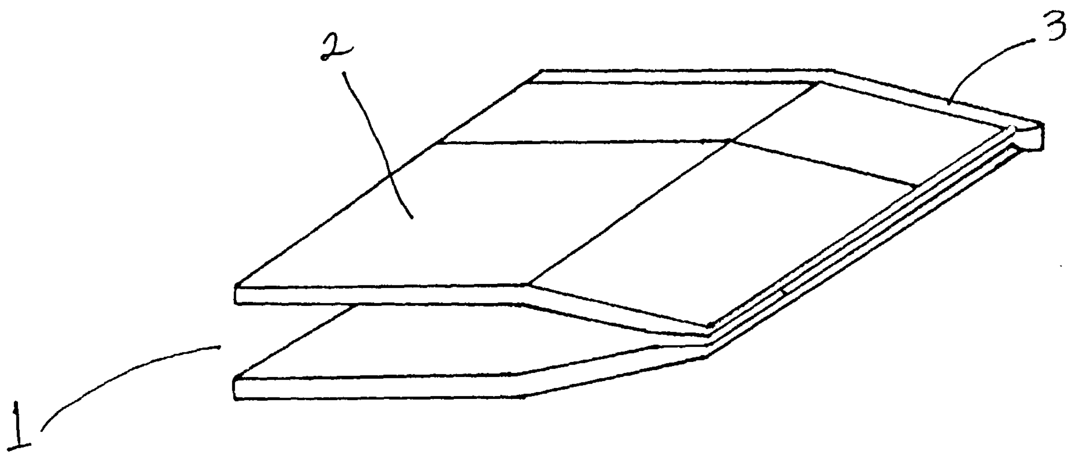

Fig. 1

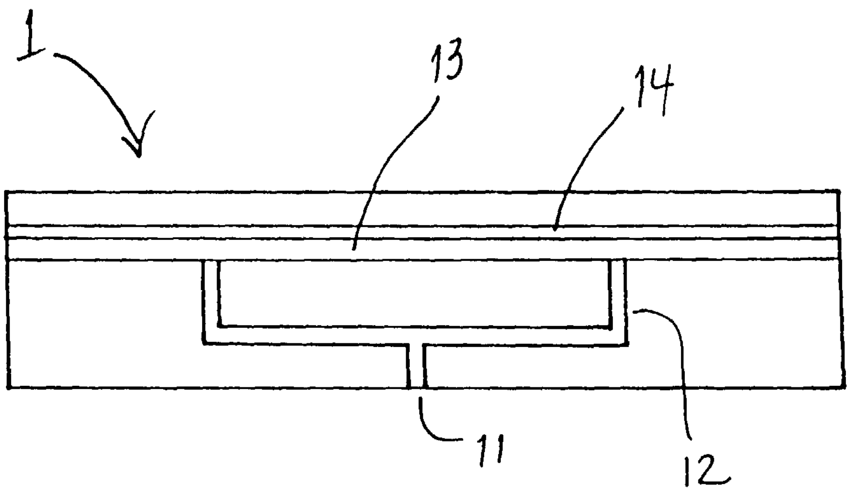

Fig. 2

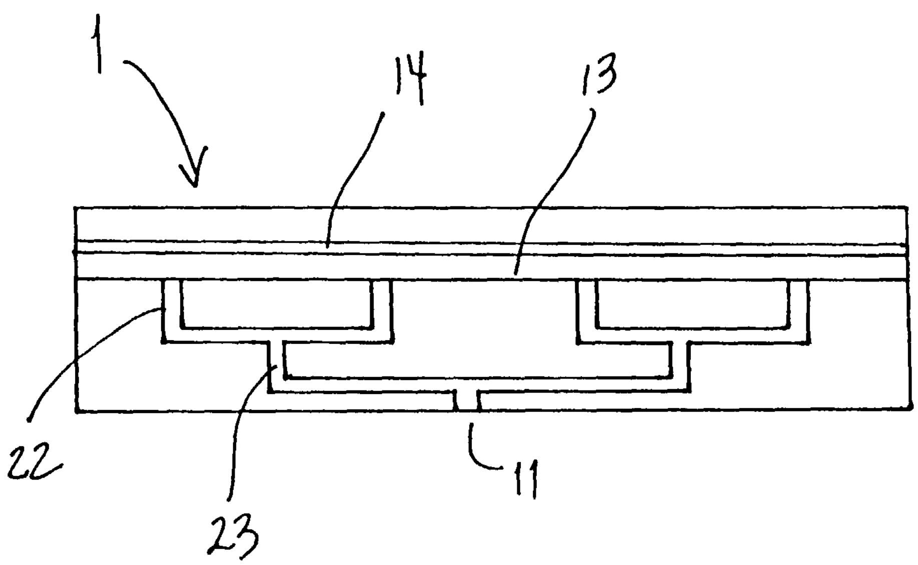

Fig. 3

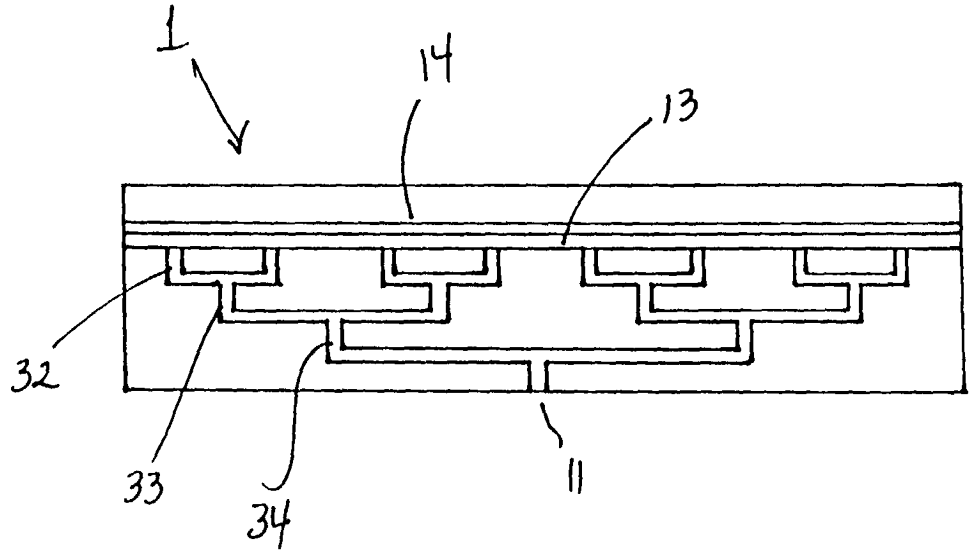

Fig. 4

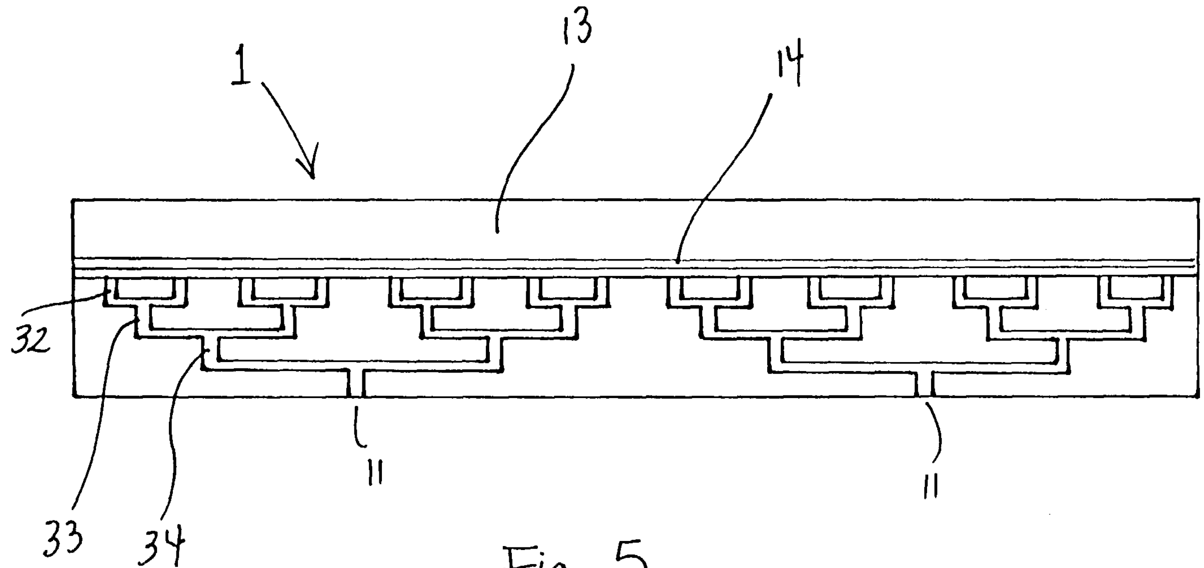

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 1998

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	ANONYMUS: "Roll Caster Nozzle" RESEARCH DISCLOSURE., no. 290, June 1988, page 409 XP002107783 HAVANT GB	1-3,5,6	B22D11/06
Y	* the whole document *	4,8,9	
Y	DE 38 42 789 A (ISHIKAWAJIMA HARIMA HEAVY IND) 6 July 1989 * figure 5 *	4	
Y	PATENT ABSTRACTS OF JAPAN vol. 006, no. 196 (M-161), 5 October 1982 & JP 57 103761 A (MATSUSHITA ELECTRIC IND CO LTD), 28 June 1982 * abstract *	8,9	
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			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B22D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	30 June 1999	Kesten, W

CATEGORY OF CITED DOCUMENTS

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30-06-1999

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