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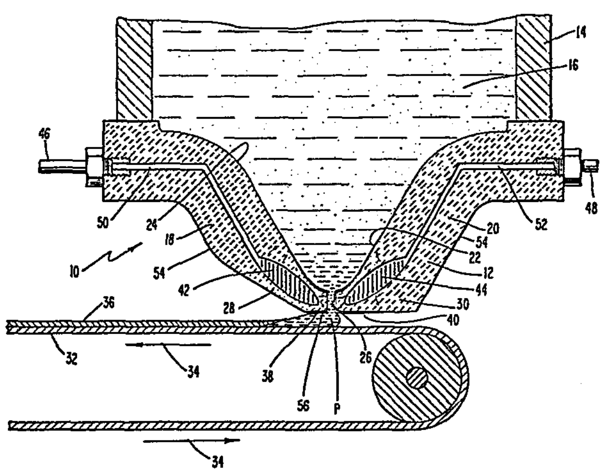
(54) Casting apparatus for controlling puddle stability and nozzle degradation.

(57) A casting assembly for controlling melt puddle stability and nozzle degradation in planar flow metal casting operations includes a casting nozzle for receiving and dispensing molten metal from a reservoir. The nozzle dispenses the molten metal through an elongated discharge slot onto a relatively moving chill body. The metal solidifies soon after deposit onto the chill body. The discharge slot is defined by a pair of spaced parallel lips. A manifold is provided in the lips for directing an inert gas through the nozzle to isolate the lips, including the exterior surfaces thereof adjacent to the chill body, from molten metal deposited onto the chill body. A surface glaze impermeable to the inert gas is applied to all external surfaces of the nozzle except the exterior lip surfaces to confine passage of the inert gas to critical areas of the nozzle.



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CASTING APPARATUS FOR CONTROLLING PUDDLE STABILITY AND NOZZLE DEGRADATION

Technical Field

The invention relates to casting of molten metal and more particularly concerns a casting assembly for controlling melt puddle stability and nozzle degradation in planar flow casting operations.

Background of the Invention

In the continuous planar flow casting of metal, it is conventional to dispense molten metal through a casting nozzle onto a relatively moving chill body. The casting nozzle may include a pair of lips extending transverse to the direction of substrate movement defining an elongated discharge orifice. Molten metal is discharged through the elongated orifice to form a melt puddle on the chill body. The metal quickly solidifies as it is transported on the relatively moving chill body to form a cast filament, such as a ribbon. A cast product having an amorphous molecular structure, in the form of a relatively thin elongated strip or ribbon, has proven to be effective for winding into highly efficient cores of electrical transformers, and other uses.

It has been observed that melt puddle stability will sometimes degenerate to an uncontrolled condition during the planar flow casting of amorphous metal alloys. Deterioration of puddle stability may be caused by several factors, including reactions between the molten metal alloy and the nozzle refractory material, nozzle geometry erosion, or slag wetting of exterior surfaces of the nozzle. Each of these factors results from contact between the molten metal alloy and the refractory material of the nozzle.

It has been suggested in the prior art that products of deoxidation of aluminum killed steel may be flushed from a nozzle bore to prevent nozzle clogging. For example, in U.S. Patent 3,838,798 to Voss, an annular manifold is disposed in concentric relationship to the bore of a tundish nozzle. An inert gas is directed into the manifold under pressure to form a gaseous blanket around the interior surface of the bore. The pressurized gas is inert and avoids adhesion of aluminum slag to the interior bore surface.

U.S. Patent 4,003,561 to Cudby also discloses a nozzle for the continuous pouring of molten steel wherein inert gas is supplied to prevent adhesion of deoxidized products. The inert gas, such as argon, is supplied through a permeable sidewall for diffusion into the nozzle passageway. The inert gas is used to form a separating film between the steel being poured and the passage sidewalls to minimize risk of nozzle blockage.

In U.S. Patent 4,102,386 to Hildebrandt et al, a casting apparatus for directing molten metal in a free-falling stream to a casting mold is disclosed. A curtain of inert gas surrounds the free-falling stream to prevent oxidation of the molten metal.

All of the above prior art teachings are directed to protecting either the molten metal or the interior surface of a bore extending through a nozzle. However, it is primarily the exterior surface of the nozzle lips which defines the shape of the melt puddle and the resulting cast product, in planar flow casting operations. Thus, melt puddle stability is largely dependent upon contact between the molten alloy and the exterior surfaces of the casting nozzle, particularly the exterior lip surfaces.

Summary of the Invention

It is accordingly an object of the invention to improve melt puddle stability in a planar casting assembly.

It is another object of the invention to provide a planar casting assembly for producing a cast filament of uniform thickness and improved quality.

It is a further object of the invention to prevent reactions between a casting nozzle and molten metal cast therethrough.

It is yet another object of the invention to provide a planar casting assembly which reduces the erosion of a casting nozzle geometry.

It is still another object of the invention to provide a planar casting assembly which reduces slag wetting of exterior surfaces of a casting nozzle.

Another object of the invention is to provide a casting nozzle of increased life for planar casting operations.

A further object of the invention is to provide a planar casting assembly which reduces the downtime necessary for changing a casting nozzle.

Additional objects, advantages and other novel features of the invention will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following or may be learned with the practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the foregoing and other objects, and in accordance with the purposes of the present invention as described herein, an improved casting assembly is provided for controlling melt puddle stability and nozzle degradation in planar flow metal casting operations. The casting assembly includes a reservoir for molten metal. A casting nozzle is in fluid communication with the reservoir for receiving and dispensing molten metal from the reservoir. A relatively moving chill body positioned proximal to the nozzle receives and quenches the dispensed metal.

In accordance with the broad aspects of the invention, means are provided for forming a continuous gas barrier to isolate the nozzle from dispensed molten metal on the chill body and to thereby improve the stability of a melt puddle dispensed from the nozzle.

In accordance with a further aspect of the invention, the gas barrier forming means includes at least one manifold in the nozzle for directing an inert gas through the nozzle to isolate the nozzle from molten metal on the chill body.

According to a further aspect of the invention, the nozzle is formed of porous refractory ceramic, and the manifold is formed of refractory ceramic more porous than the nozzle.

In accordance with a further aspect of the invention, the casting nozzle includes an elongated discharge slot defined by a pair of spaced parallel lips for dispensing the molten metal.

In a still further aspect of the invention, the molten metal forms a melt puddle beneath the nozzle, and the casting assembly provides an inert gas barrier isolating all exterior surfaces of the lips from molten metal on the chill body.

Yet another aspect of the invention relates to a casting assembly wherein the nozzle defines an internal melt cavity and a continuous inert gas barrier from the lower portion of the melt cavity to the exterior lip surfaces for totally isolating the lips from molten metal.

In accordance with another aspect of the invention, a casting assembly is provided wherein all exterior surfaces of the nozzle, except the exterior lip surfaces, are covered with a surface glaze impermeable to the inert gas.

Still other objects of the present invention will become readily apparent to those skilled in this art from the following description wherein there is shown and described a preferred embodiment of this invention, simply by way of illustration of one of the best modes contemplated for carrying out the invention. As it will be realized, the invention is capable of other different embodiments, and its several details are capable of modifications in various, obvious aspects all without departing from the invention. Accordingly, the drawings and descriptions will be regarded as illustrative in nature and not as restrictive.

Brief Description of the Drawings

The accompanying drawings incorporated in and forming a part of the specification, illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

Fig. 1 is a side elevational view, partially in cross section, of a casting assembly constructed according to the present invention.

Fig. 2 is an enlarged view of the lower portion of the casting nozzle in Fig. 1 more clearly depicting a melt puddle dispensed upon a chill body through a pair of spaced lips.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

Detailed Description of the Preferred Embodiment

Reference is now made to Fig. 1 depicting a planar flow casting assembly 10 constructed in accordance with the present invention. The casting assembly 10 includes a nozzle 12 secured to the lower portion of a crucible 14. The crucible 14 is heated by an induction coil or the like (not shown) and provides a reservoir for a molten amorphous metal 16.

The nozzle 12 is preferably formed of porous ceramic material and includes a pair of converging sidewalls 18 and 20. The sidewalls 18 and 20 are joined by a pair of end walls (not shown) perpendicularly disposed with respect to the sidewalls 18 and 20 to define an internal melt cavity 22. The internal melt cavity has a relatively wide upper mouth 24 communicating with the crucible 14 for receiving molten metal 16 therefrom. A relatively narrow elongated discharge orifice 26 is provided in the lower portion of the nozzle 12 for dispensing the molten metal 16. The discharge orifice 26 is formed by a pair of spaced lips 28 and 30 extending into the plane of the Fig. 1 illustration.

A chill body 32 is positioned in close proximity to the discharge orifice 26 for receiving and quenching molten metal 16 dispensed from the nozzle 12. The chill body 32 is movable relative to the nozzle 12. In Fig. 1, the chill body 32 is specifically illustrated as an endless belt continuously moving in the direction identified by arrows 34. It will be appreciated, however, that the chill body 32 may take other forms, such an an annular chill roll.

As illustrated, chill body 32 is positioned subjacent to the nozzle 12, and molten metal flow through the nozzle 12 is gravity assisted. Molten metal flow through the nozzle 12 is also enhanced and regulated by a pressure system (not shown) as is conventional in the art. Specific flow rates of the molten metal 16, travel speeds for the relatively moving chill body 32 and chill rates applied to the chill body 32 are known in the art and may be selected to produce a particular desired casting result in accordance with conventional practice.

Molten metal 16 is continuously discharged through the elongated discharge orifice 26 to form a melt puddle P on the surface of the chill body 32 immediately below the nozzle 12. The relatively moving chill body 32 carries the molten metal 16 from the melt puddle P with the molten metal solidifying on the chill body surface adjacent to and downstream of the nozzle 12. A cast filament in the form of a continuous strip or ribbon 36 results in the preferred embodiment.

The exterior surfaces 38 and 40, of lips 28 and 30 respectively, define the shape of melt puddle P and are critical in the formation of the resulting cast ribbon 36. In prior art nozzles of this type, the lips 28 and 30, especially the exterior lip surfaces 38 and 40 adjacent the chill body 32, are continuously in contact with the melt puddle P. Such contact leads to deterioration in shape of the exterior lip surfaces 38 and 40 and results in instability of the melt puddle P. A cast ribbon 36 of lesser quality results

Specifically, the relative movement between the exterior lip surfaces 38 and 40 and the dispensed molten metal 16 develops frictional forces tending to erode lip geometry. Moreover, many molten metal alloys, such as the metallic glass alloys of the preferred embodiment, react with the ceramic nozzle material when subjected to ambient air and result in further lip geometry deterioration. Lip geometry is also effected by slag wetting on the exterior lip surfaces 38 and 40. Consequently, it is necessary to frequently remove and replace casting nozzle 12 necessitating costly downtime for the casting assembly 10.

As seen more clearly in Fig. 2, manifolds 42 and 44, preferably formed of very high porous refractory ceramic, are disposed in the lips 28 and 30 in accordance with the broad aspects of the present invention. The manifolds 42 and 44 are on opposite sides of the discharge orifice 26, manifold 42 being disposed in the downstream lip 28 and manifold 44 being disposed in the upstream lip 30. Inlet ports 46 and 48 communicate through ducts or passageways 50 and 52 respectively to the manifolds 42 and 44.

Pressurized inert gas is supplied through the inlet ports 46 and 48 to the manifolds 42 and 44. The inert gas permeates the porous ceramic material of nozzle 12 and is directed interiorly to the lower portion of the melt cavity 22 and into the discharge orifice 26. Additionally, the pressurized inert gas is directed through the lower exterior lip surfaces 38 and 40 adjacent the chill body 32.

A surface glaze 54 is applied to all exterior surfaces of the nozzle 12 with the exception of the exterior lip surfaces 38 and 40 adjacent the chill body 32. The surface glaze 54 is impermeable to the inert gas and confines passage of the gas through the nozzle 12 to critical areas adjacent the discharge orifice 26, including the exterior lip surfaces 38 and 40.

After passing through the nonglazed portions of the nozzle 12, the inert gas forms a gas barrier 56 isolating the lower portion of the nozzle 12 from the molten metal 16. With the manifolds 42 and 44 positioned in the lips 28 and 30 as described, the inert gas barrier 56 is continuous from the lower portion of the melt cavity 22 to the exterior nozzle surfaces. More particularly, the entire lip structures, including the exterior lip surfaces 38 and 40 defining the melt puddle P, are shielded and protected from the molten metal 16 by the barrier of inert gas 56.

Isolating the lips 28 and 30, especially the exterior lip surfaces 38 and 40 defining the melt puddle P shape from the molten metal 16, eliminates many of the degrading mechanisms causing puddle instability. Any reaction between the molten metal 16 and the nozzle 12 is avoided. Similarly, slag wetting of the exterior lip surfaces 38 and 40 is prevented. A higher quality cast ribbon 36 results.

In summary, numerous benefits have been described which result from employing the concepts of the invention. The casting apparatus of the invention provides an inert gas barrier between the casting nozzle and molten metal dispensed onto a chill body. In particular, the exterior surfaces of the lips forming the discharge orifice in the nozzle are isolated from contact with the molten metal. As a result, deterioration of the lip geometry from frictional wear and reactions with the molten metal are avoided. Furthermore, slag wetting of the exterior nozzle surfaces is avoided. The stability of the melt puddle is thus increased and the quality of a resulting filament improved. Moreover, the frequency at which the casting nozzle must be changed is reduced.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described in order to best illustrate the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

Claims

1. A planar casting assembly for controlling puddle stability and nozzle degradation in planar flow metal casting operations, comprising:

a) a reservoir for molten metal;

b) a casting nozzle in fluid communication with the reservoir for receiving and dispensing molten metal from the reservoir;

c) a chill body positioned proximal to the nozzle for receiving and quenching the dispensed molten metal, said substrate being relatively movable with respect to the nozzle; and

d) means for forming a continuous gas barrier to isolate the nozzle from molten metal on the chill body.

2. A planar casting assembly as recited in claim 1 wherein the continuous gas barrier forming means includes at least one manifold provided in the nozzle for directing an inert gas through the nozzle to isolate the nozzle from molten metal on the chill body.

3. A planar casting assembly as recited in claim 2 further including a passageway through the nozzle for supplying inert gas to the manifold from an external source.

4. A planar casting assembly as recited in claim 2 wherein said nozzle is formed of porous refractory ceramic and said manifold is formed of refractory ceramic

more porous than the nozzle.

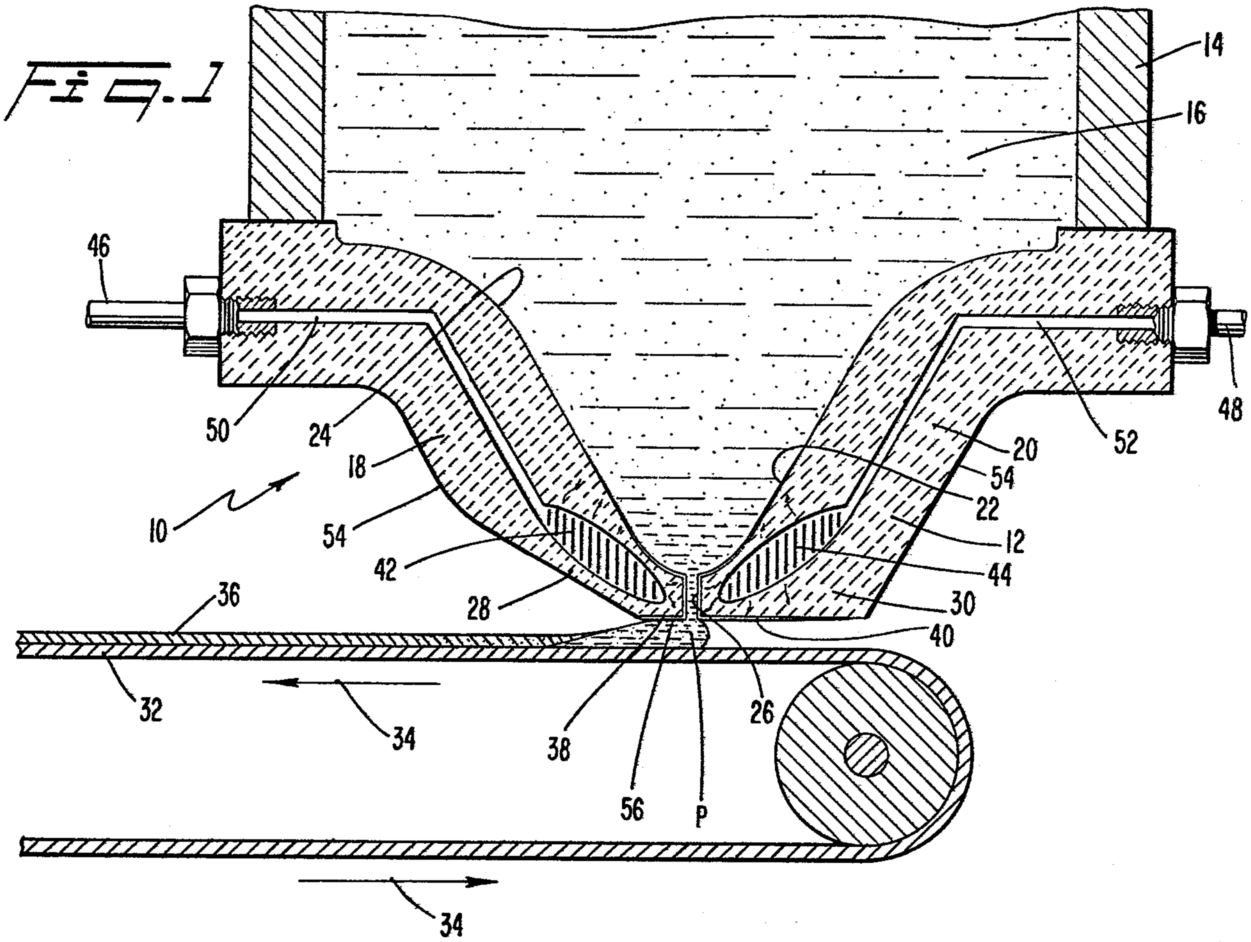
5. A planar casting assembly as recited in claim 1 wherein said casting nozzle includes an elongated discharge slot for dispensing the molten metal, said discharge slot being defined by a pair of spaced parallel lips.

6. A planar casting assembly as recited in claim 5 wherein said molten metal forms a melt puddle beneath the nozzle as the molten metal is dispensed from the nozzle, said gas barrier forming means being operative to isolate all exterior surfaces of the lips from molten metal on the chill body.

7. A planar casting assembly as recited in claim 5 wherein the nozzle defines an interior melt cavity for supplying molten metal to the discharge slot, the continuous gas barrier forming means providing a continuous gaseous blanket from the lower portion of the melt cavity to the exterior lip surfaces for totally isolating said lips from molten metal.

8. A planar casting assembly as recited in claim 7 wherein all exterior surfaces of the nozzle, except the exterior lip surfaces, are covered with a surface glaze impermeable to the inert gas.

Fig. 1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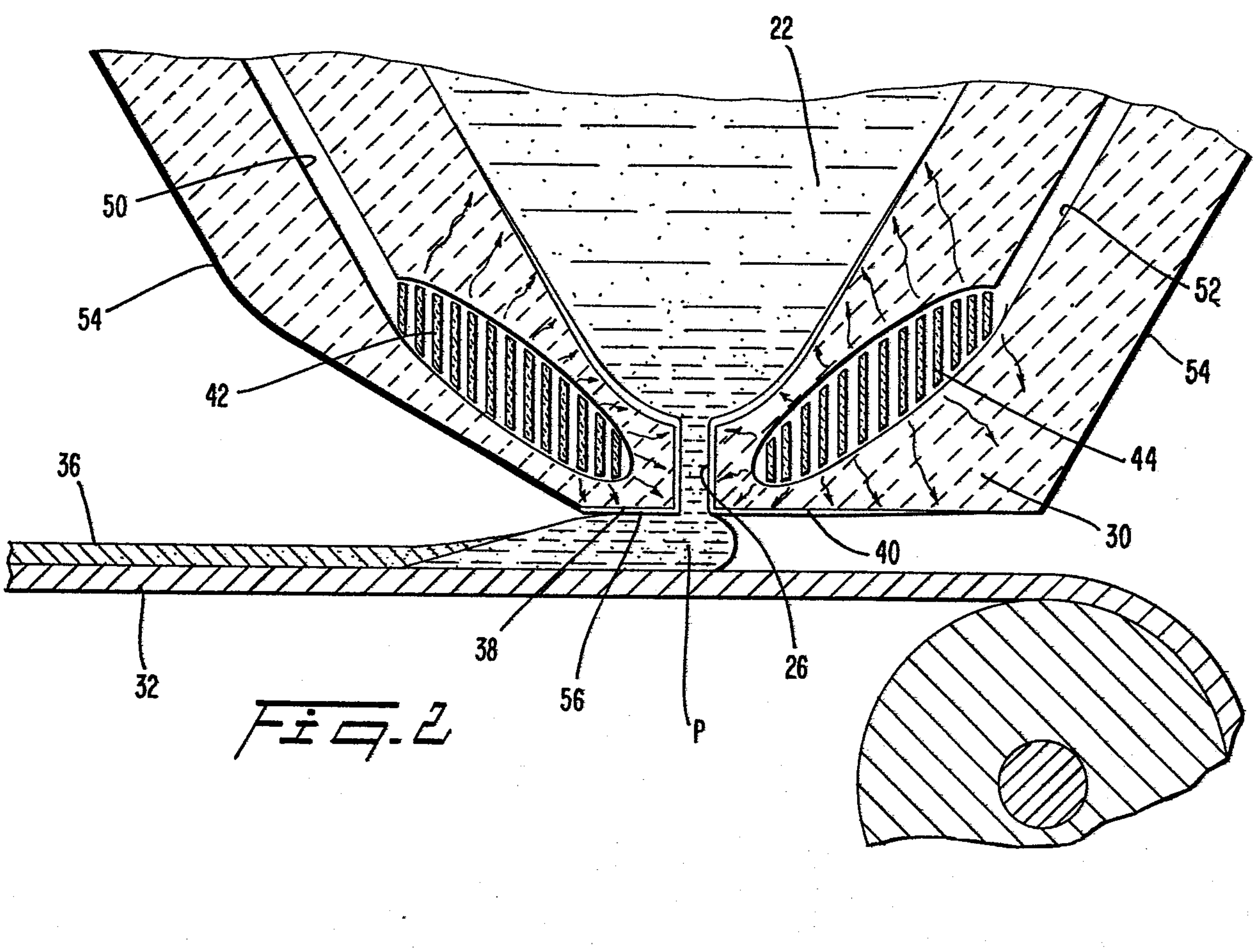
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Fig. 2

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EUROPEAN SEARCH REPORT

0126267

Application number

EP 84 10 4003

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. 3)
			B 22 D 11/06
X	PATENTS ABSTRACTS OF JAPAN, vol. 7, no. 163(M-229)(1308), 16th July 1983; & JP - A - 58 68455 (TAKAOKA KOGYO K.K.) 23-04-1983 ---	1-3,5, 6	
A	FR-A-2 167 284 (IRSID) * Page 2, line 31 - page 3, line 14 * ---	4	
A	FR-A-2 268 583 (SOCIETE CIVILE D'ETUDES DE CENTRIFUGATION) * Page 5, paragraph 1 * -----		

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

B 22 D 11/06
B 22 D 11/00
B 22 D 11/10
B 22 D 41/08

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-08-1984	SCHIMBERG J.F.M.

CATEGORY OF CITED DOCUMENTS

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