(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 514 175 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92304365.7**

(51) Int. Cl.[5] : **C23C 2/36**

(22) Date of filing : **14.05.92**

(30) Priority : **17.05.91 GB 9110678**

(43) Date of publication of application :
19.11.92 Bulletin 92/47

(84) Designated Contracting States :
BE DE FR GB IT NL SE

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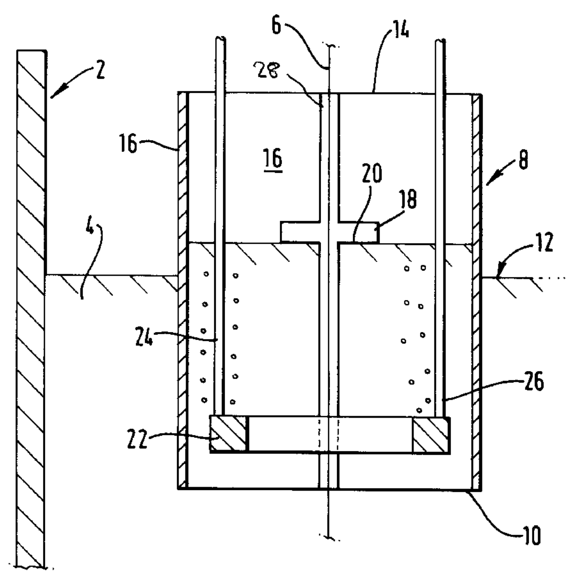
(54) Treatment of longitudinally extending members passing through a bath of molten metal.

(57) Metal wire 6 to be coated is passed through a tank 2 containing a volume 4 of molten zinc. The wire emerges from the bath through a refractory shroud 8 whose lower end 10 is submerged in the molten zinc. The shroud 8 has an elongate arcuate slot 18 formed therein at a level above that of the general level of the surface. In use, gas such as nitrogen is continuously bubbled into the molten zinc within the shroud 8. A gas lift pumping effect is thereby created which causes a continuous flow of molten metal over the lower edge of the slot 18. The surface of the molten zinc in the vicinity of the emerging wire is thus continuously renewed. The lift gas creates a non-oxidising atmosphere above the surface. Build up of oxide around the emerging wire is thus prevented.

FIG. 1



EP 0 514 175 A1

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This invention relates to the treatment of a longitudinally extending member or members. It is particularly concerned with treatment of a metallic wire or strip by passing it through a bath of an oxidisible metal. One example such a treatment is the galvanising of ferrous metal wire or strip.

Galvanising of wire is carried out commercially by passing the wire through a bath of molten zinc. The freshly galvanised wire is particularly susceptible to oxidation at the location where it breaks the surface of the molten zinc. In addition, there tends to be a build-up of zinc oxide particles on the surface, which particles tend to adhere to the wire. It is accordingly common practice to employ a layer of charcoal impregnated with oil at the location where the wire breaks the surface on leaving the molten zinc. This practice helps to clean the wire of any particles of zinc oxide "ash" loosely adhering to it and also helps to protect the freshly galvanised surface of the wire from oxidation. This practice does however have the drawbacks that the charcoal needs regular replenishment and that erosion of the charcoal tends to take place rendering less effective the protection given against pick-up of zinc oxide and against oxidation.

One alternative method of protecting the emerging freshly galvanised wire from oxidation is to form a shroud around the location where the wire leaves the surface of the molten zinc and to pass into the shroud a stream of nitrogen or argon, or other gas that does not react with the zinc to form zinc oxide, so as to maintain around the emerging galvanised wire an atmosphere which is in comparison with air relatively free of oxygen. Our experiments with such shrouds using nitrogen as the protective gas have shown that better quality wire can be produced for a short period of time. It has been found however that over prolonged periods of operation there is nonetheless still a build up of zinc oxide around the surface of the emerging galvanised wire which has a deleterious effect on the quality of the wire giving rise to coating weight variations and a rough surface finish. The build-up of zinc oxide may arise partly as a result of reaction between the molten zinc and what oxygen there is in the shrouding atmosphere and partly as a result of reaction between zinc and fluxing agent which is used to pre-treat the wire so as to facilitate the formation of a good bond between the zinc coating and the ferrous metal. Accordingly, we believe that the mere maintenance of a relatively non-oxidising atmosphere in the vicinity of the location where the wire leaves the surface of the molten zinc is inadequate to obtain the highest quality of finish to the galvanised wire.

According to the present invention there is provided a method of treating a longitudinally-extending member by passing it through a bath of oxidisible molten metal, comprising the step of repeatedly or continuously renewing the surface of the molten metal at a location where the longitudinally extending member leaves the surface.

The invention also provides apparatus for treating a longitudinally-extending member with oxidisible molten metal, comprising a bath for holding a volume of the molten metal, means for passing the longitudinally extending member through the molten metal, and means for repeatedly or continuously renewing the surface of the molten metal at a location where the longitudinally-extending member leaves the surface of the molten metal in use of the apparatus.

The method and apparatus according to the invention are generally suited for the hot-dip coating of ferrous metal wire or strip. They may in particular be used to coat a ferrous metal wire or strip with zinc, an alloy of zinc, aluminium, an alloy of aluminium, lead or an alloy of lead, or with any other molten metal which has oxide forming characteristics. By continuously renewing the surface of the molten metal in the vicinity of where the longitudinally-extending member leaves the molten metal, the tendency for the surface of the finished member to be spoilt or disfigured by the build-up of oxide is reduced.

The longitudinally-extending member is preferably withdrawn from the bath of molten metal through an upwardly extending passage defining a weir, and the surface of the molten metal is renewed by pumping molten metal up the passage and over the weir. Although any pumping technique may be employed for this purpose, we prefer to employ gas-lift pumping. The gas is desirably one that does not react with the molten metal to form a metal oxide. A noble gas such as helium or argon may be used irrespective of the composition of the molten metal. Nitrogen is however preferred when it does not have any adverse metallurgical effect. In particular, we prefer to use nitrogen in the galvanising of ferrous wire or strip in accordance with the invention.

Gas lift pumping is advantageous in that it requires no moving parts to be brought into contact with the molten metal. Nor does it require the supply of electrical power in a potentially hazardous environment.

It is preferred to maintain an atmosphere depleted in oxygen above the region of the surface of the molten metal where the longitudinally extending member leaves the molten metal. Preferably, the oxygen-depleted atmosphere contains less than 5% by volume of oxygen, and more preferably less than 2.0% by volume of oxygen. It is nonetheless desirable that the atmosphere does contain some oxygen so as to prevent or keep down evolution of metal vapour from the apparatus according to the invention. Typically, in particular if the metal is zinc, there is preferably always a minimum of from 0.1 to 0.2% by volume of oxygen in the atmosphere. Preferably the passage continues upwards above the weir, and the oxygen-depleted atmosphere is created by displacing air from the passage with a noble gas such as helium or argon, or with nitrogen. The noble gas or nitrogen may include mixed with it sufficient oxygen impurity to ensure that the aforesaid minimum oxygen level is maintained in the atmosphere. Accordingly, if the atmosphere is to be based on nitrogen, it may be supplied at the desired purity level from a generator of the PSA (pressure swing adsorption) or membrane kind. Preferably, the gas employed for creating the oxygen-depleted atmosphere is solely the lift-pumping gas.

The lift pumping gas is preferably introduced into the molten metal in a portion of the passage situated beneath the normal level of the surface of the molten metal through one or more porous or perforate members, preferably formed of refractory material.

The method and apparatus according to the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic side elevation, partly in section, of a first apparatus for protecting from oxidation a single galvanised wire emerging from a galvanising bath;

Figure 2 is a schematic plan view of the apparatus shown in Figure 1;

Figure 3 is a schematic side elevation, partly in section, of a second apparatus according to the invention for protecting from oxidation a plurality of galvanised wires emerging from a galvanising bath;

Figure 4 is a plan view of the apparatus shown in Figure 3; and

Figure 5 is a section through the line V-V in Figure 4.

Figure 6 is a schematic side elevation, partly in section of a third apparatus according to the invention for protecting from oxidation a plurality of galvanised wires emerging from a galvanising bath

Figure 7 is a plan view of the apparatus shown in Figure 6.

The drawings are not to scale.

Referring to Figures 1 and 2 of the drawings, there is shown part of a bath or tank 2 containing a volume 4 of molten zinc through which a ferrous wire 6 is able to be passed so as to provide the wire 6 with a zinc coating which rapidly solidifies once the wire emerges from the bath 2. A system of pulleys (not shown) is provided such that the wire 6 emerges vertically from the bath 2. The emerging wire is surrounded by a hollow, open-ended, generally vertically disposed, right cylindrical shroud 8 of refractory material. A passage for the emerging wire 6 is defined by the shroud 8 whose lower end 10 is submerged typically up to 1m below the normal level of the surface 12 of the molten zinc and whose upper end 14 is located typically up to 1m above the level of the surface 12. The cylindrical wall 16 of the shroud 8 is formed with an elongate arcuate slot 18 whose lower transverse edge 20 is typically located from 11 to 20 cm above the normal level of the surface 12 of the molten zinc.

An annular porous plug 22, for example formed of sintered metal or graphite or other refractory material, is located near the bottom end 10 of the shroud 8 beneath the surface 12 of the molten zinc. The porous plug 22 may be of a kind commonly used in metallurgy to pass bubbles of gas into a volume of molten metal. The plug communicates with a pair of vertical gas supply pipes 24 and 26 which extend vertically downwards through the shroud 8 from above the surface 12 of the molten metal. The pipes 24 and 26 communicate with any convenient source (not shown) of nitrogen. The shroud 8 preferably has a narrow vertical slit 28 formed in its wall 16 which extends from the bottom 10 to the top 14 thereof. The presence of the slit 28 enables the shroud 8 to be positioned around a wire which is about to be galvanised. Owing to the buoyancy of the molten zinc, it is desirable to ensure that the shroud 8 is firmly anchored in position by providing a suitable support arm (not shown) for it. Such an arm may be fastened to the tank 4.

In operation, before continuous translation of the wire 6 through the bath 4 of molten zinc is commenced, streams of nitrogen are passed into the porous plug 22 from the pipes 24 and 26. The nitrogen is distributed to the volume of molten zinc contained within the shroud 8 in the form of a multitude of fine bubbles. The effect of the bubbles is thus to reduce the buoyancy of the volume of molten zinc within the shroud 8 in comparison with the volume outside the shroud. Accordingly, this volume is raised above the normal level 12 of the molten zinc such that molten zinc within the shroud 8 flows over the lower edge 20 of the slot 18. Accordingly, a continuous flow of molten zinc over the edge 20 (which thus functions as the top edge of a weir) is established and thus the surface in the immediate vicinity of the wire 6 is continuously renewed by this gas lift pumping action. Thus, any zinc oxide "ash" forming or collecting on the surface of the molten zinc in the immediate vicinity of the wire 6 being galvanised is carried away by the molten zinc flowing over the edge 20 of the slot 18. The height of the edge 20 above the normal level 12 of the molten zinc determines the rate at which pumping gas needs to be supplied to the molten zinc. Preferably, the molten metal is therefore lifted no more than 5cm so as to keep down the overall demand for the lift gas. The bubbles of nitrogen lift gas continuously break the surface of the molten zinc within the shroud 8 and thus displace air from above this surface. After several minutes operation, the presence of oxygen in the atmosphere immediately above the surface can be reduced to a level at which the rate of oxide formation at the shrouded surface is substantially reduced, but is nonetheless adequate for the purposes of preventing any substantial evolution of zinc vapour or zinc dust (formed by condensation of zinc vapour). The nitrogen gas thus not only acts as a medium for pumping the molten zinc upwardly through the shroud 8, it also establishes a shrouding atmosphere above the surface in the vicinity of the wire 6.

Once such an atmosphere has been established, continuous translation of the wire 6 through the bath 2 may be commenced, so as to effect galvanising of a coil of ferrous wire. In practice, using a shroud 8 about 8cm in diameter, and generating nitrogen bubbles some 18cm beneath the surface level 12 of the molten zinc, we have been able to lift the molten zinc within the shroud 8 at least 7cm with a nitrogen supply pressure in the order of 200 to 300 kPa and a flow rate of less than 20 l/min.

Although we prefer to operate the apparatus shown in Figures 1 and 2 of the drawings with a continuous supply of nitrogen bubbles to the shroud 8, it is within the scope of the invention to supply such bubbles intermittently. In such operation, the gas lift pumping of the molten zinc is only intermittent and thus the surface of the molten zinc in the vicinity of the wire 6 is renewed repeatedly rather than continuously. If the nitrogen is substantially pure, and if the natural leakage of air into the shroud 8 is inadequate to maintain a desired oxygen concentration within the atmosphere therein during continuous gas lifting pumping then such pumping can be interrupted at intervals so as to ensure that the oxygen concentration does not fall below a chosen minimum.

Referring now to Figures 3 to 5 of the drawings, there is shown an apparatus generally similar to that shown in Figures 1 and 2, but adapted to be used in the simultaneous galvanising of several lengths of wire in parallel to one another. In this apparatus, a shroud 30 is in the form of a generally vertically disposed, cuboidal member 31 having an open bottom 32 and an open top 34. The bottom 32 is typically located up to 1m beneath the surface 36 of a volume 38 of molten zinc, while the top 34 is generally located up to 1m above the surface 36. In plan view (see Figure 4) the shroud 30 is of generally elongate shape having a longer pair of parallel sides 40 and 42 and a shorter pair of parallel sides 44 and 46. Located within the shroud 30 at its bottom are a pair of elongate porous blocks 48 which each extend from one of the shorter pair of sides 44 and 46 to the other. The porous blocks 48 are typically formed of sintered metal, or other refractory material, and are analogous to porous members that are used in other metallurgical processes to introduce a gas,in the form of a multitude of fine bubbles into a volume of metal. The porous blocks 48 each communicates with a nitrogen supply pipe 50. The pipes 50 extend from the blocks 48 through the molten metal to a source of nitrogen (not shown) outside the molten metal.

The side 40 of the shroud 30 has formed in it an elongate, horizontally extending slot located at a chosen height from 1 to 20 cm above the level of the surface 36 of the molten zinc. In use of the device, the lower horizontal edge 54 of the slot 52 forms the top of a weir over which molten zinc flows. The outer surface of the side 40 is provided with a hinged canopy 56 which extends from above the slot 52 of the shroud 30 to just below the surface 36 of the volume 38 of molten zinc.

In order to enable the apparatus shown in Figures 3 to 5 to be fitted about ferrous wires to be galvanised, it may be formed in two parts which may be clamped or otherwise fastened in position about several parallel ferrous wires 58 to be galvanised. Supply of nitrogen to the box 48 may then be commenced so as to begin gas lift pumping of the molten zinc within the shroud 30 over the edge 54 of the slot 52. The surface of the molten metal in the vicinity of the wires 58 is thus continuously renewed. The nitrogen lift gas also creates a suitable mildly oxidising atmosphere above the level of the molten zinc within the shroud 30 and in the space that is defined between the canopy 56 and the outside of the wall 40 of the shroud 30. The canopy 56 thus helps to limit the oxidation of the molten zinc as it flows over the edge 54 of the slot 52. Once an adequate mildly oxidising atmosphere has been created above the surface of the molten zinc within the shroud 30 (typically after nitrogen has been supplied for several minutes to the shroud 30), continuous translation of the wires 58 may begin and thus a series of lengths of wire may be galvanised. From time to time during the galvanising operation, the canopy 56 may be lifted to allow any accumulation of zinc oxide therebeneath to be cleared.

Various changes and-modifications may be made to the apparatuses shown in Figures 1 and 2 and Figures 3 to 5 respectively. For example, instead of using a porous block or blocks to introduce bubbles of lift pumping gas into the molten zinc, one or more perforate refractory pipes may be used instead.

In addition, it is also possible to introduce nitrogen or noble gas directly into the atmosphere above the surface of molten metal in the shroud without passing through the molten metal, if the rate of flow of lift pumping gas is inadequate to maintain the level of oxygen at or below a chosen maximum. If desired, the oxygen concentration may be intermittently or continuously monitored in the atmosphere within the shroud.

Referring now to Figures 6 and 7 of the drawings, a shroud assembly 60 includes a hollow, right cylindrical member 62 open at its top 64 and its bottom 66. An annular distribution chamber 68 is circumjacent the bottom 66 of the member 62, a bottom region 70 of the member 62 forming the inner wall of the chamber. The bottom region 70 has a ring of gas distribution orifices 72 formed therethrough. The chamber 68 communicates with a vertically-extending gas supply pipe 74. In use, the bottom 70 of the member 62 is located say up to 10 cm below the surface 76 of a bath

78 of molten metal. A pair of circular apertures whose axis are at right angles to one another are formed in the member 62 at a location which when the assembly 60 is located in a desired position relative the bath 78 is, say, up to 20 cm above the general level of the surface 76. In use, a lift gas is passed continuously from a source thereof (not shown) into the gas distribution chamber 68 and a multitude of small bubbles is formed in the molten metal within the member 62 by the passage of gas through the orifices 72. These gas bubbles reduce the effective density of the molten metal within the member 62 and create a gas lift pumping effect which raises the level of that part 82 of the surface 76 within the member 62 to that of the apertures 80 so that there is a continuous flow of molten metal through the apertures 80. The gas bubbles break through the surface of the molten metal and form a shrouding atmosphere within the member 62 above the part 82 of the surface 76. Accordingly, the lift gas is selected so that it is inert under the prevailing conditions to the molten metal. It typically comprises nitrogen or argon.

The apertures 80 communicate with a surrounding chamber 84 which extends from about the general level of the surface 76 to therebelow. A pipe 86 extends from a source of the shrouding gas to a region of the chamber proximate the surface 76. In use, continuous supply of shrouding gas (for example nitrogen) through the pipe 86 is able to create in the region of the molten metal flowing from the apertures 80 into the secondary chamber 84 a shrouding atmosphere which is effective to prevent significant oxidation of this molten metal.

Those parts of the assembly 60 which come into contact with molten metal are desirably made of refractory material. If desired, the assembly 60 may be provided with a handle 88 to enable it to be lifted into and out of the bath 78. Anchoring means (not shown) may also be provided to enable the shroud assembly 60 to be secured in a chosen position. Once the shroud assembly 60 is secured in position, one or more wires or other longitudinally extending members to be galvanised may be threaded therethrough. A conventional system is used for continuously passing the wire or wires through the shrouding device from underneath it and lift gas and shrouding gas are supplied respectively to the pipes 74 and 86. As described above, the lift gas creates a continuous flow of molten metal through the apertures 80 and thus the surface of the molten metal is continuously renewed in that region where the wire or wires break the surface. Build-up of metal oxide in this vicinity is therefore avoided.

Claims

1. A method of treating a longitudinally-extending member by passing it through a bath of oxidisible molten metal, comprising a step of repeatedly or continuously renewing the surface of the molten metal at a location where the longitudinally-extending member leaves the surface.

2. A method as claimed in claim 1, in which the longitudinally-extending member is withdrawn from the bath of molten metal through an upwardly extending passage defining a weir, and the surface of the molten metal is renewed by pumping molten metal up the passage and over the weir.

3. A method as claimed in claim 2, in which gas-lift pumping is employed.

4. A method as claimed in claim 3, in which the gas is one that does not react with the molten metal to form a metal oxide.

5. A method as claimed in any one of the preceding claims, in which an atmosphere depleted in oxygen is maintained above the region of the surface of the molten metal where the longitudinally-extending member leaves the molten metal.

6. A method as claimed in claim 5, in which the oxygen-depleted atmosphere contains less than 5% by volume of oxygen.

7. A method as claimed in claim 5 or claim 6, in which there is a minimum of from 0.1 to 0.2% by volume of oxygen in the oxygen-depleted atmosphere.

8. Apparatus for treating a longitudinally-extending member with oxidisible molten metal, comprising a bath for holding a volume of the molten metal, means for passing the longitudinally-extending member through the molten metal, and means for repeatedly or continuously renewing the surface of the molten metal at a location where the longitudinally-extending member leaves the surface of the molten metal in use of the apparatus.

9. Apparatus as claimed in claim 8, in which the surface renewing means comprises a pump.

10. Apparatus as claimed in claim 9, in which the pump is of the gas lift kind, and means are provided beneath the surface of the molten metal to introduce a multiplicity of bubbles into an upwardly extending passage defining a weir, whereby the bubbles cause the molten metal to ascend the passage and flow over the weir.

11. Apparatus as claimed in claim 10, in which the passage is defined by a shroud which extends

from above the surface of the molten metal to therebeneath, whereby, in use, gas bubbles pass out of the molten metal within the passage and create an oxygen depleted atmosphere above that part of the surface through which the longitudinally extending member leaves.

12. Apparatus as claimed in claim 11 including a chamber communicating with the outlet side of said weir, and means for creating a non-oxidising atmosphere within said chamber.

FIG. 1

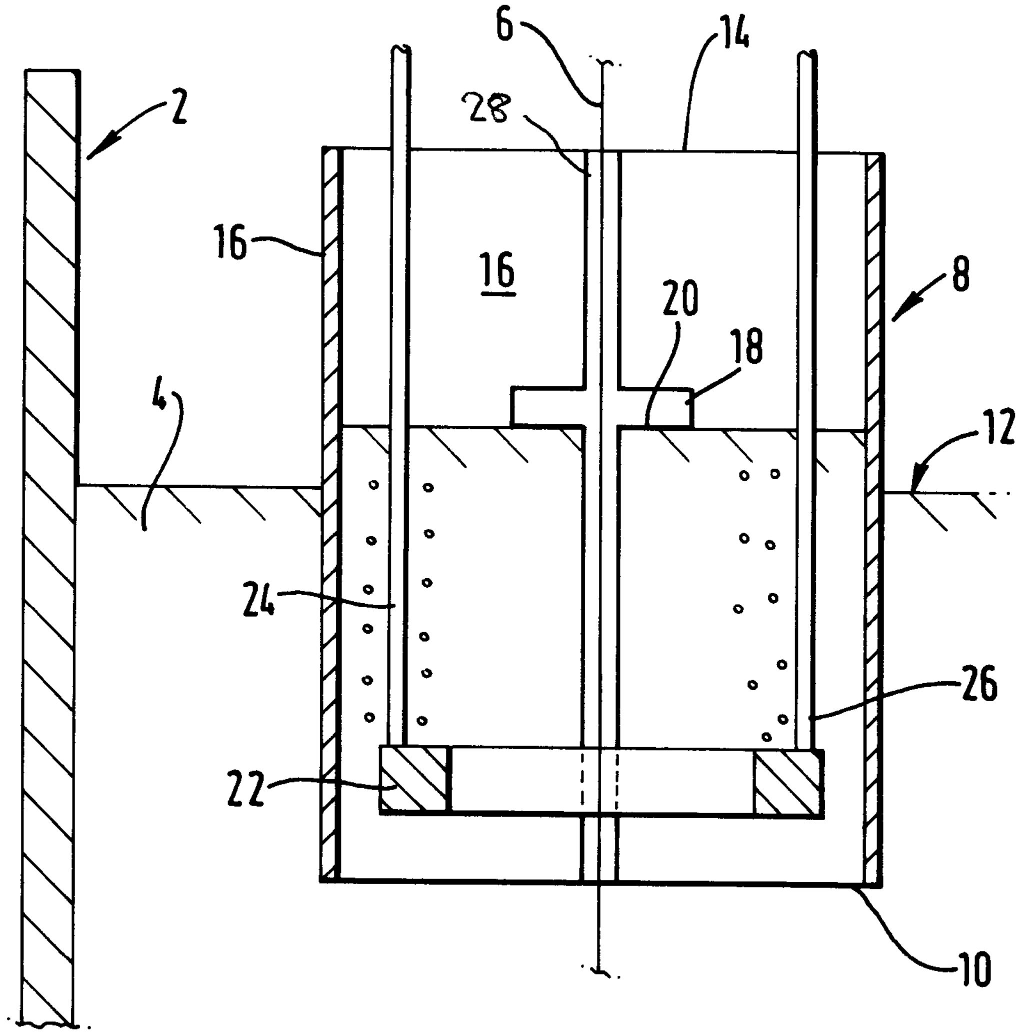

FIG. 2

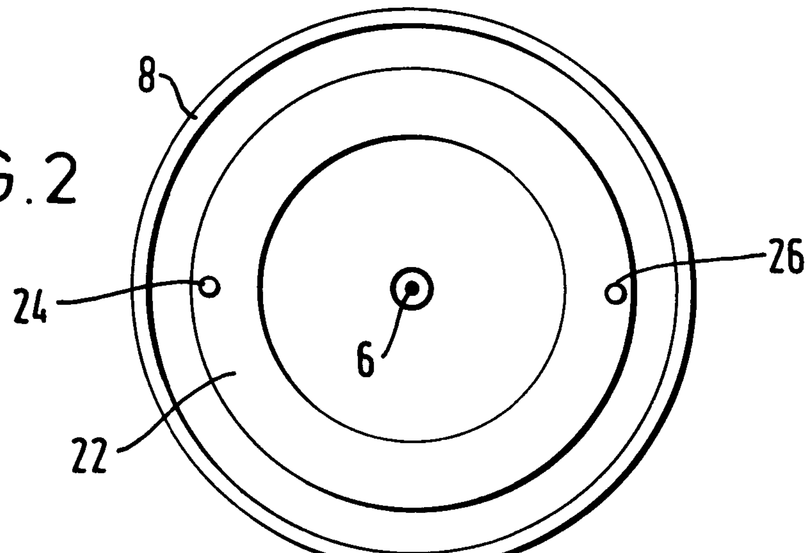

FIG.3

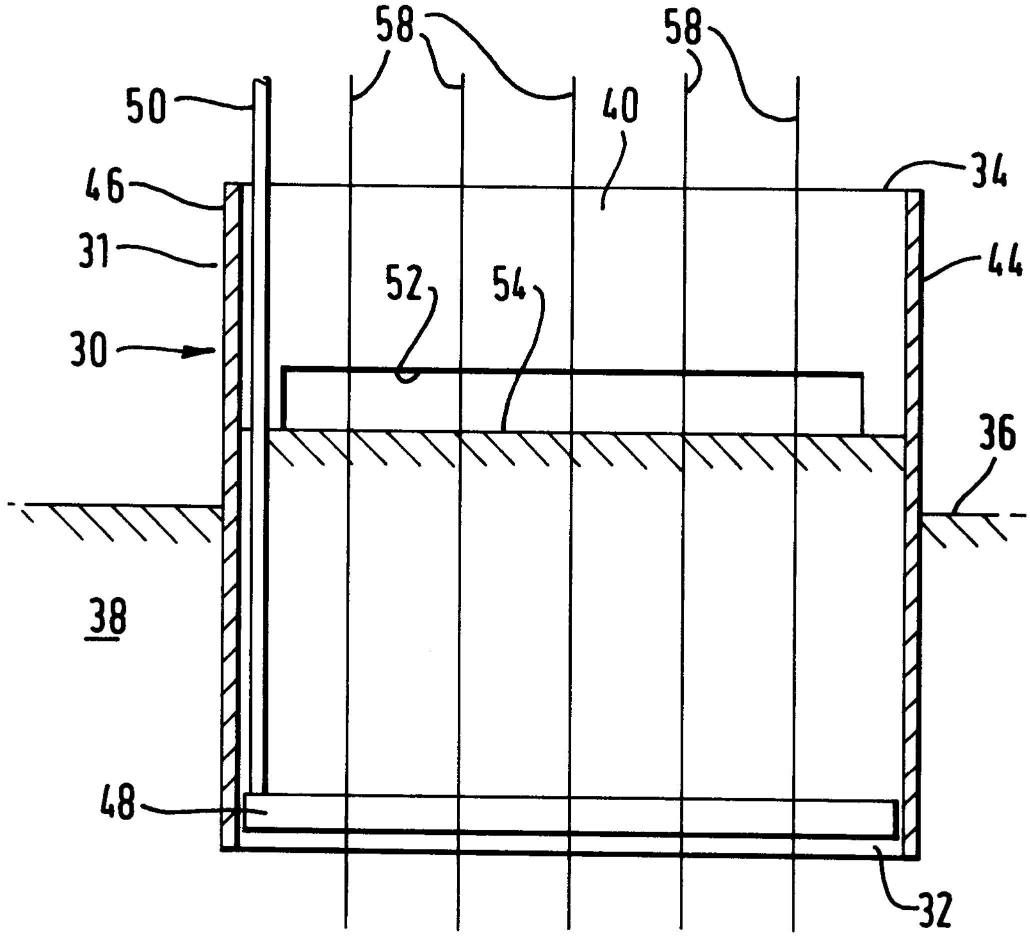
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FIG.4

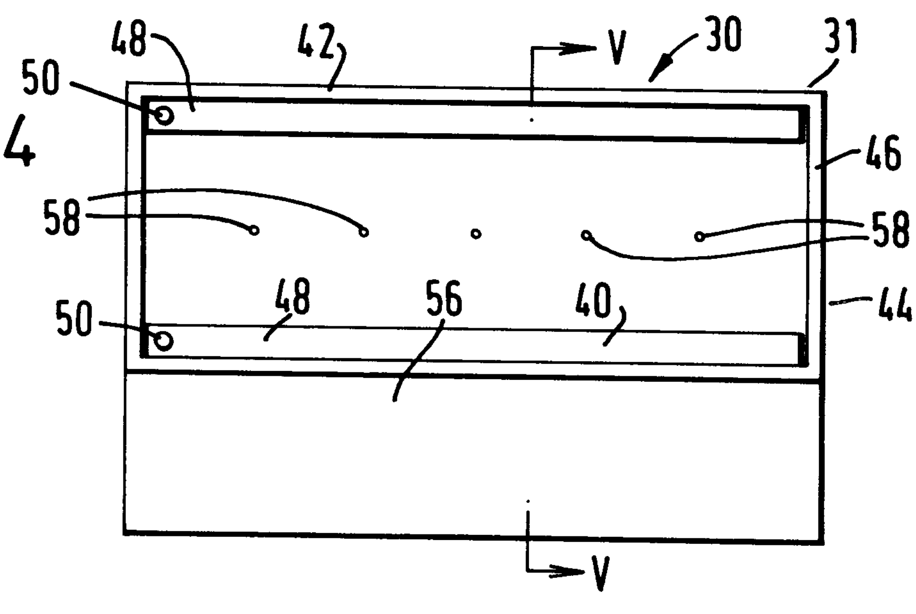
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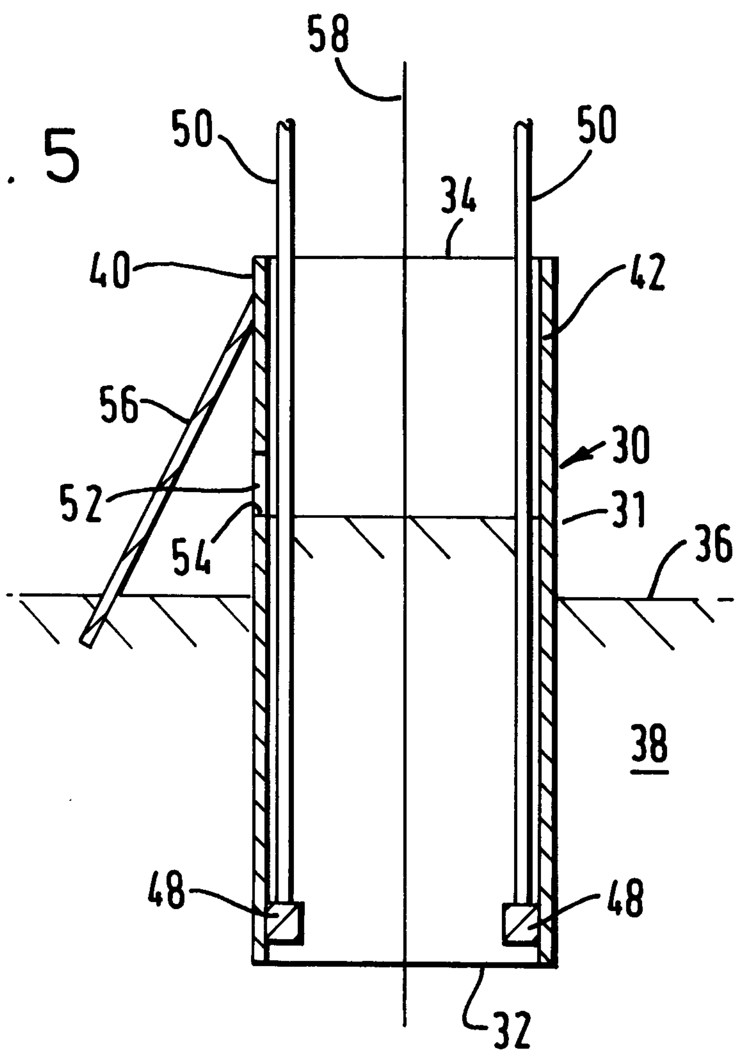
FIG. 5



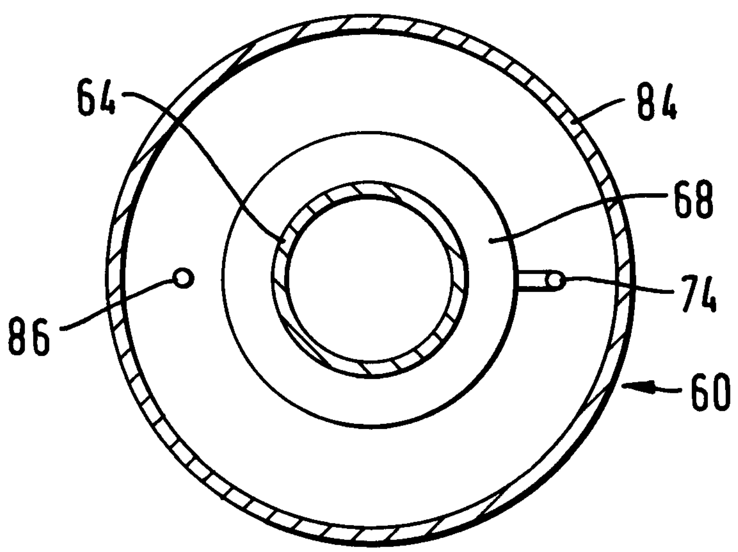
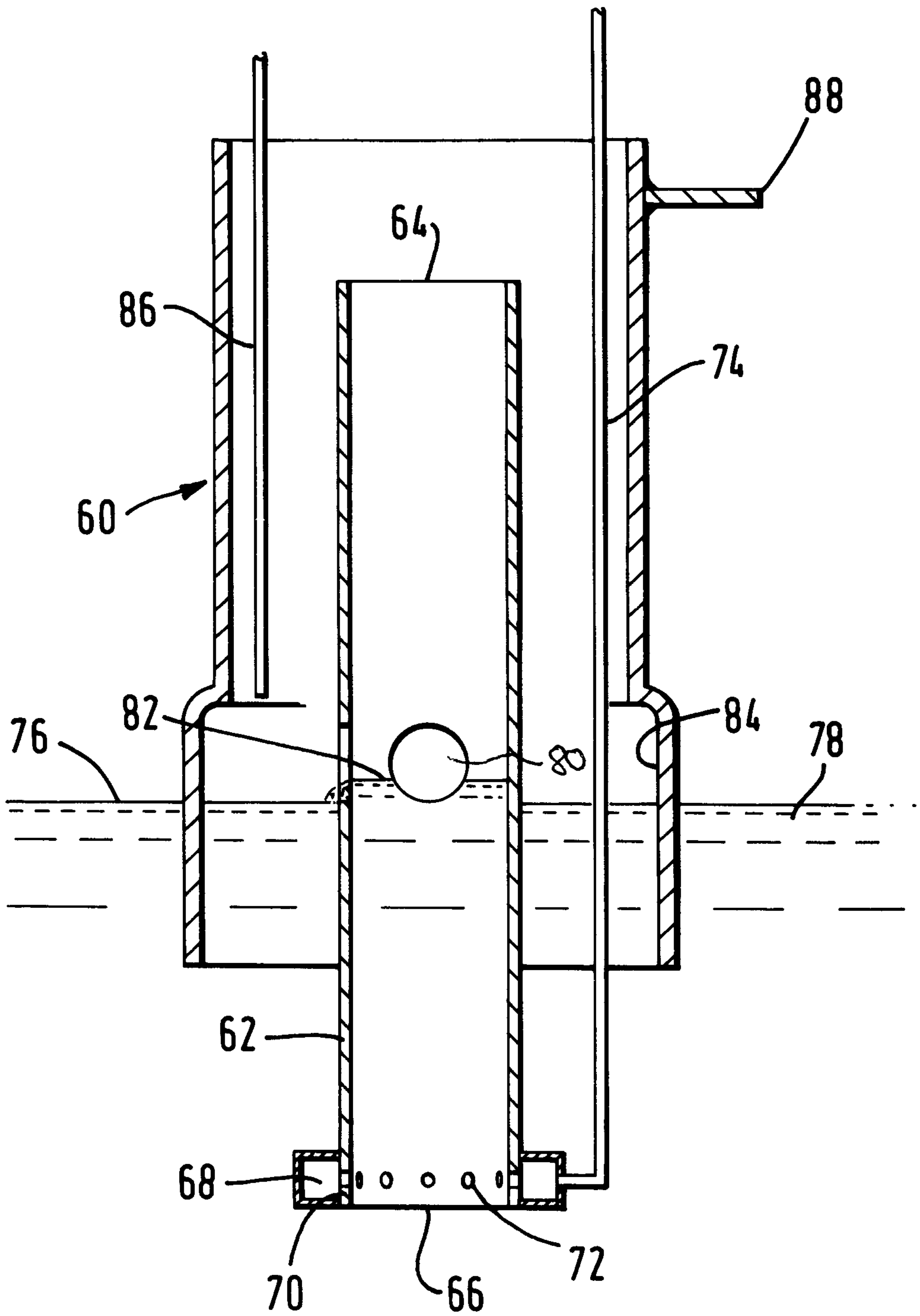


FIG. 7

FIG . 6



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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 4365

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.5)
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 228 (C-303)(1951) 13 September 1985 & JP-A-60 089 556 (SUMITOMO DENKI KOGYO) 20 May 1985 * abstract *	1,2,5,6, 8,9	C23C2/36
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 228 (C-303)(1951) 13 September 1985 & JP-A-60 086 258 (SUMITOMO DENKI KOGYO) 15 May 1985 * abstract *	1,2,8,9	
X	GB-A-486 584 (JOSEPH L. HERMAN) * page 7, line 91 - line 116; claims 1,2,3,7,8,12,13,16; figures 2-5 *	1,2,5,6, 8,9	
X	US-A-2 702 525 (MARSHALL G. WHITFIELD) * column 2, line 1 - line 10; figures 1-7 *	1,2,8	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 37 (C-473)(2884) 4 February 1988 & JP-A-62 185 863 (NIPPON STEEL CORP) 14 August 1987 * abstract *	2,3,4,9, 10	TECHNICAL FIELDS SEARCHED (Int. Cl.5) C23C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07 AUGUST 1992	ELSEN D.B.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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