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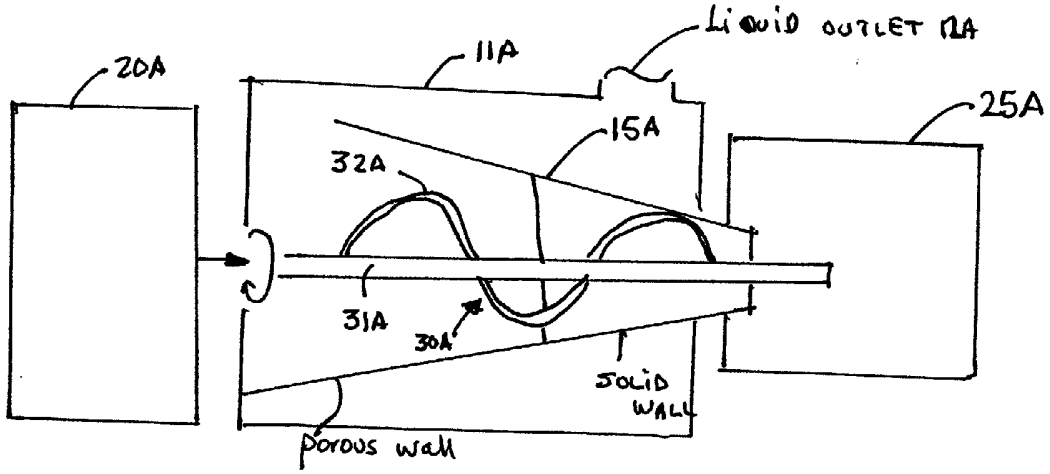
(54) Title: SCREW DEVICE FOR TRANSFER OF TI-CONTAINING REACTION SLURRY INTO A VACUUM VESSEL




(57) Abstract: A transfer mechanism between a first vessel containing a slurry of liquid and solids and a second vessel under vacuum. A housing is in communication with the first and second vessels and contains a screw in which the volume between adjacent screw threads and the housing diminishes between the first and the second vessels to form a plug sealing the second vessel from the first vessel. A method of forming the seal is also disclosed. The slurry typically may contain liquid alkaki metal, titanium metal particles and halide salt particles such as obtained in the production of titanium metal by reduction of Ti halide with alkali metal.

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# FILTER EXTRACTION MECHANISM

## RELATED APPLICATIONS

This application, pursuant to 37 C.F.R. 1.78(c), claims priority based on provisional application U.S. Provisional Application Serial No. 60/408,919 Filed September 7, 2002.

## BACKGROUND OF THE INVENTION

This invention relates to the Armstrong process as described in 5,779,761, 5,958,106 and 6,409,797, the disclosures of each of which is incorporated herein by reference. In the practice of the invention disclosed in the above referenced patents, there is produced in the reaction chamber a slurry consisting of excess reductant metal, salt particles produced and elemental material or alloy particles or powder produced. This slurry is thereafter treated by a variety of methods. However, all of the methods have in common the separation of excess liquid metal from the slurry and thereafter separating the remaining liquid metal and the produced salt from the desired product which is the elemental material or alloy. In the particular example disclosed in the three referenced patents, liquid sodium is used as a reductant for titanium tetrachloride to produce titanium powder.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a transfer mechanism and method for transferring a slurry of liquid and particles between two vessels or containers, at least one of which is under vacuum or inert atmosphere.

Yet another object of the present invention is to provide a transfer mechanism of the type set forth for the Armstrong Process in order to transfer slurry from an inerted vessel or container to a vacuum chamber for further processing wherein a seal is established in the transfer mechanism separating the vessels or containers.

Yet another object of the present invention is to provide a transfer mechanism between a first vessel containing a slurry of liquid and solids and a second vessel under vacuum, comprising a housing in communication with the first and the second vessels, a screw having a plurality of helical threads along a longitudinal shank within the housing for transferring material from the first vessel to the second vessel, the volume between adjacent screw threads and the housing diminishing between the first and the

second vessels, whereby slurry entering the housing from the first vessel has the solids therein concentrated as the slurry is transported by the screw toward the second vessel while liquid is expressed from the slurry as the solids are concentrated until the concentrated solids form a plug sealing the second vessel from the first vessel.

A further object of the invention is to provide a transfer mechanism between a first vessel containing a slurry of liquid alkali or alkaline earth metal or mixtures thereof and metal or alloy or ceramic particles and halide salt particles and a second vessel under vacuum, comprising a housing in communication with the first and the second vessels, a screw having a plurality of helical threads along a longitudinal shank within the housing for transferring material from the first vessel to the second vessel, the volume between adjacent screw threads and said housing diminishing between said first and the second vessels, whereby slurry entering the housing from the first vessel has the particles therein concentrated as the slurry is transported by the screw toward the second vessel while liquid metal is expressed from the slurry as the particles are concentrated until the concentrated particles form a plug sealing the second vessel from the first vessel.

The invention consists of certain novel features and a combination of parts hereinafter fully described, illustrated in the accompanying drawings, and particularly pointed out in the appended claims, it being understood that various changes in the details may be made without departing from the spirit, or sacrificing any of the advantage of the present invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawings a preferred embodiment thereof, from an inspection of which, when considered in connection with the following description, the invention, its construction and operation, and many of its advantages should be readily understood and appreciated.

FIGURE 1 is a schematic diagram showing the two vessels and an embodiment of the transfer mechanism therebetween;

FIG. 2 is a schematic of an alternate embodiment of the present invention; and

FIG. 3 is a schematic illustration of yet another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1 of the drawings, there is shown a transfer mechanism 10 which includes a double walled conduit including an outer conduit wall 11 having a liquid outlet 12 and end walls 13, the wall 11 being preferably but not necessarily cylindrical. Interior of the cylindrical wall 11 is an inner tube or conduit 15 having a portion 16 which is solid and a portion 17 which is apertured and may be a mesh of any suitable size. The inner tube or conduit 15 may either be cylindrical as illustrated in Fig. 1 or conical as will be explained, the inner conduit 15 has a discharge end 18 thereof which opens into a vacuum chamber 25 and has an inlet end 19 thereof which opens into a container or vessel 20 in communication with the reactor as illustrated in the Armstrong patents previously referenced and incorporated herein.

A feed screw 30 is positioned within the inner conduit 15 and includes a rotatable shank 31 having a conical thread 32 positioned on the shank 31 as is well known in the art. The thread 32 may have a constant or a variable pitch. The pitch is the distance between adjacent threads and the variable pitch may preferably be a progressive pitch in which the pitch decreases from the vessel 20 toward the container or vessel 25, for a purpose hereinafter described.

In the preferred but not limiting embodiment of the present invention, the transfer mechanism 10 is used in conjunction with a material made by the Armstrong Process. More particularly, for purposes of illustration only, the slurry discussed herein will be a combination of liquid sodium, sodium chloride particles and particles of titanium and/or a titanium alloy. As set forth in the Armstrong patents, a variety of metal and non-metal products may be made thereby and it is intended that the present invention not be limited to any particular product made by the Armstrong Process and certainly not limited to the preferred product described herein.

In any event, the vessel or container 20 preferably operated under an inert atmosphere or under vacuum has therein a slurry of the particles previously described and as the slurry enters the portion 19 of the inner conduit or tube 15 and the feed screw 30 is rotated as illustrated in the drawings by rotation of the shank 31, the slurry is moved along the feed screw from left to right as illustrated in Fig. 1. Because of the progressive pitch of the feed screw 30 in Fig. 1, that is the threads 32 thereof are closer together so that the pitch decreases from left to right, the material is concentrated as

it is moved from the container or vessel 20 to the container or vessel 25. Moreover, because the portion 17 of the conduit or tube 15 is apertured or porous, liquid sodium drains therethrough and passes out of the outlet 12 for further processing. Therefore, the slurry as it is transported from container or vessel 20 to container or vessel 25 becomes more concentrated as liquid is drained therefrom and the density increases as the pitch between the adjacent threads diminishes.

Another way to express what occurs is that the volume between adjacent threads and the wall of the cylinder or tube 16 diminishes as material is moved by the feed screw 30 from container or vessel 20 to container or vessel 25. By the time the slurry is concentrated and reaches the portion 16, the solid portion 16 of the inner tube or conduit 15, a seal is established between the vessel 25 and the vessel 20 which houses the slurry from the reactor. The formation of a seal by the transfer mechanism 10 is a critical aspect of the present invention because separation of liquid sodium and salt from the desired particles of the ceramic or metal alloy, as described in the Armstrong patents may include distillation in a vacuum chamber or a vessel 25 and the Armstrong reactor itself may be an inerted vessel such as with argon. Accordingly, it is important for a seal to be formed between the two containers or vessels in order to permit continuous operation between the two vessels without the necessity of shutting down one of the vessels during transfer or destroying the protective atmosphere in the vessel 20 or the vacuum in vessel 25.

Referring to Figs. 2 and 3, there are disclosed alternate embodiments of the invention. Again with the principle feature that the volume between adjacent screw threads and the container or housing in which the feed screw is positioned diminishes from vessel 20A to vessel 25A. As seen in Fig. 2, the transfer mechanism 10A has a housing 15A conical in shape and the screw 30 therein may or may not be a progressive pitch screw. The screw threads in the embodiment illustrated in Fig. 2 may not need to be closer together, that is the pitch need not be diminished in order to reduce the volume of the material between adjacent threads and the housing wall as the material is moved from left to right or from vessel 20A to vessel 25A. However, it may be advantageous to use both the conical shaped inner housing 15A with or without a progressive screw 30A depending on engineering considerations.

Referring to Fig. 3, there is shown another embodiment of the present invention in which the shank 31B of the screw 30B is conical in shape with the larger end of the cone being adjacent the vessel 25B and with the pitch between adjacent threads 32B being constant or diminishing. In either case, the volume of the area between adjacent threads and the inner container 15B diminishes as the material is moved from the vessel 20B to the vessel 25B.

Although the invention has been described with respect to an inerted vessel and a vacuum vessel, the invention includes movement and concentration of material from one container to another without compromising the environment of either container. The containers may be connected pipes or vessels, and the environments may be vacuums, inerted atmospheres or otherwise. Central to the invention is concentration of solids in a slurry to transport solids from one environment to another while forming a seal therebetween so as to isolate the environments from each other.

While there has been disclosed what is considered to be the preferred embodiment of the present invention, it is understood that various changes in the details may be made without departing from the spirit, or sacrificing any of the advantages of the present invention.

**WHAT IS CLAIMED IS:**

1. A transfer mechanism between a first vessel containing a slurry of liquid and solids and a second vessel under vacuum, comprising a housing in communication with said first and said second vessels, a screw having a plurality of helical threads along a longitudinal shank within said housing for transferring material from said first vessel to said second vessel, the volume between adjacent screw threads and said housing diminishing between said first and said second vessels, whereby slurry entering said housing from said first vessel has the solids therein concentrated as the slurry is transported by said screw toward said second vessel while liquid is expressed from the slurry as the solids are concentrated until the concentrated solids form a plug sealing said second vessel from said first vessel.

2. The transfer mechanism of claim 1, wherein said screw is a variable pitch screw.

3. The transfer mechanism of claim 1, wherein said screw is a progressive pitch screw with the smallest pitch being nearest said second vessel.

4. The transfer mechanism of claim 1, wherein said housing is generally cylindrical.

5. The transfer mechanism of claim 1, wherein said housing is conical with the smallest end being nearest said second vessel.

6. The transfer mechanism of claim 1, and further including in said transfer mechanism slurry of liquid metal and salt particles and particles of a ceramic or a metal or an alloy.

7. The transfer mechanism of claim 6, wherein said liquid metal is Na or Mg.

8. The transfer mechanism of claim 7, wherein said particles of a ceramic or a metal or an alloy are Ti or an alloy thereof.

9. The transfer mechanism of claim 1, wherein said housing is cylindrical and said screw is a progressive pitch screw with the smallest pitch being nearest said second vessel.

10. The transfer mechanism of claim 1, wherein said housing is conical with the smallest end being nearest said second vessel and said screw has threads of constant pitch.

11. The transfer mechanism of claim 1, wherein said shank has an increasing diameter toward said second vessel.

12. The transfer mechanism of claim 1, wherein at least a part of said housing in liquid communication with said first vessel has a plurality of apertures therein.

13. The transfer mechanism of claim 12, wherein the plurality of apertures is a mesh.

14. The transfer mechanism of claim 1, and further comprising an outlet in said housing for separating liquid flowing through said apertures from the slurry.

15. A transfer mechanism between a first vessel containing a slurry of liquid alkali or alkaline earth metal or mixtures thereof and metal or alloy or ceramic particles and halide salt particles and a second vessel under vacuum, comprising a housing in communication with said first and said second vessels, a screw having a plurality of helical threads along a longitudinal shank within said housing for transferring material from said first vessel to said second vessel, the volume between adjacent screw threads and said housing diminishing between said first and said second vessels, whereby slurry entering said housing from said first vessel has the particles therein concentrated as the slurry is transported by said screw toward said second vessel while liquid metal is expressed from the slurry as the particles are concentrated until the concentrated particles form a plug sealing said second vessel from said first vessel.

16. The transfer mechanism of claim 15, wherein said screw is a progressive pitch screw with the smallest pitch being nearest said second vessel.

17. The transfer mechanism of claim 15, wherein said housing is generally cylindrical.

18. The transfer mechanism of claim 15, wherein said housing is conical with the smallest end being nearest said second vessel.

19. The transfer mechanism of claim 15, wherein said housing is cylindrical and said screw is a progressive pitch screw with the smallest pitch being nearest said second vessel.

20. The transfer mechanism of claim 15, wherein said housing is conical with the smallest end being nearest said second vessel and said screw has threads of constant pitch.

21. The transfer mechanism of claim 20, wherein said shank has an increasing diameter toward said second vessel.

22. The transfer mechanism of claim 15, wherein at least a part of said housing in liquid communication with said first vessel has a plurality of apertures therein.

23. The transfer mechanism of claim 22, wherein the plurality of apertures is a mesh.

24. The transfer mechanism of claim 15, and further comprising an outlet in said housing for separating liquid flowing through said apertures from the slurry.

25. The transfer mechanism of claim 24, and further including a slurry of liquid Na, particles of NaCl and particles of Ti or an alloy thereof.

26. The transfer mechanism of claim 24, wherein a double wall housing is provided wherein the inner wall has a portion thereof apertured and a portion thereof solid and the outer wall has said outlet therein, said screw being positioned within said inner wall.

27. A method of concentrating and transferring a slurry from one container to another while sealing the containers, comprising providing communication between the containers, transporting slurry from one container toward another container while expressing liquid from the slurry thereby increasing the solids concentration thereof until a plug is formed between two containers while solids from the plug are transferred to the another container.

28. The method of claim 27, wherein one container is operated under an inert atmosphere.

29. The method of claim 27, wherein one container is operated under vacuum.

30. The method of claim 27, wherein the slurry contains liquid metal and metal particles.

31. The method of claim 30, wherein the slurry contains liquid alkali or alkaline earth metal.

32. The method of claim 27, wherein slurry contains liquid sodium metal and particles of Ti or an alloy thereof.

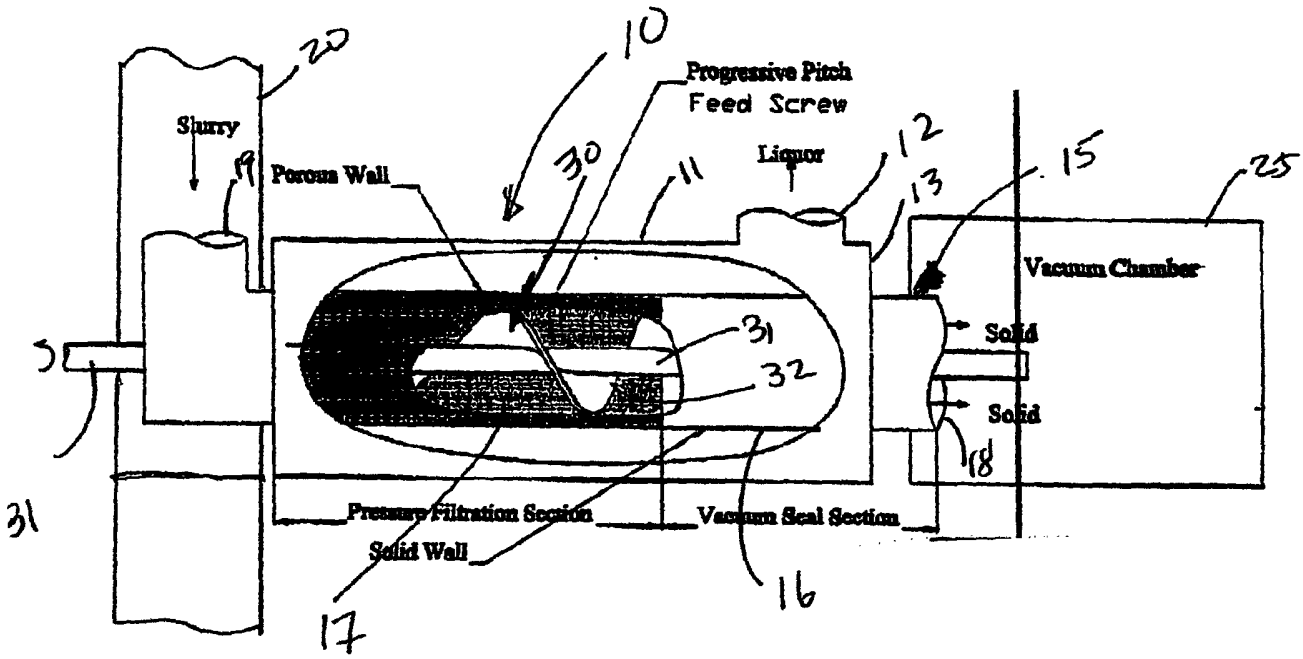
20
10
Progressive Pitch
Feed Screw
Slurry
19
Porous Wall
30
11
Liquor
12
13
15
25
Vacuum Chamber
31
32
Solid
Solid
18
Pressure Filtration Section
Vacuum Seal Section
Solid Wall
17
16
31

Fig 1

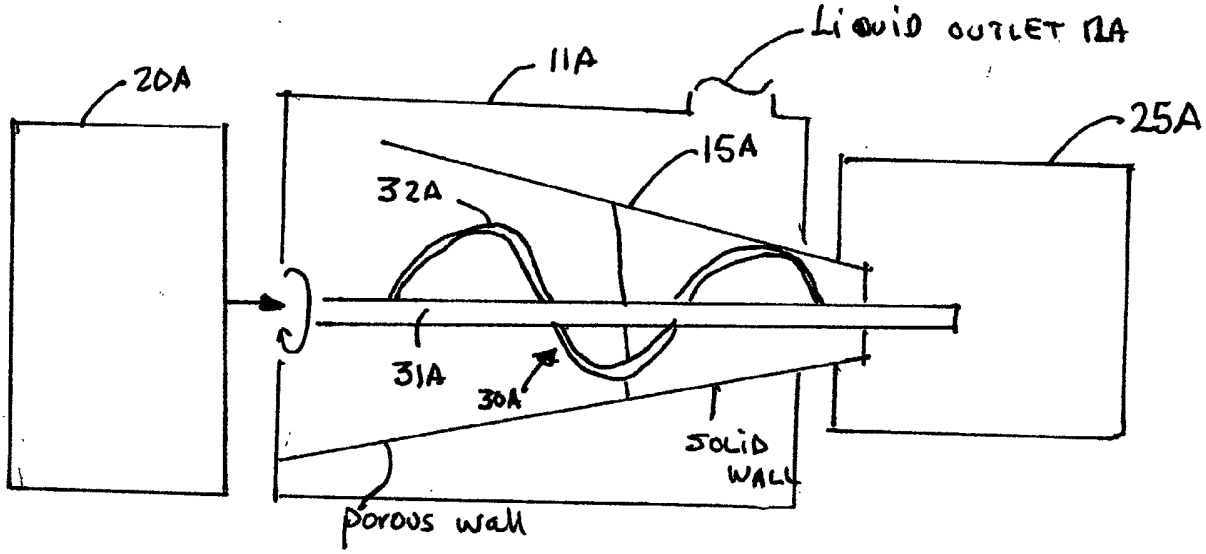
LIQUID OUTLET 11A
20A
11A
25A
15A
32A
31A
30A
SOLID WALL
porous wall

FIG. 2

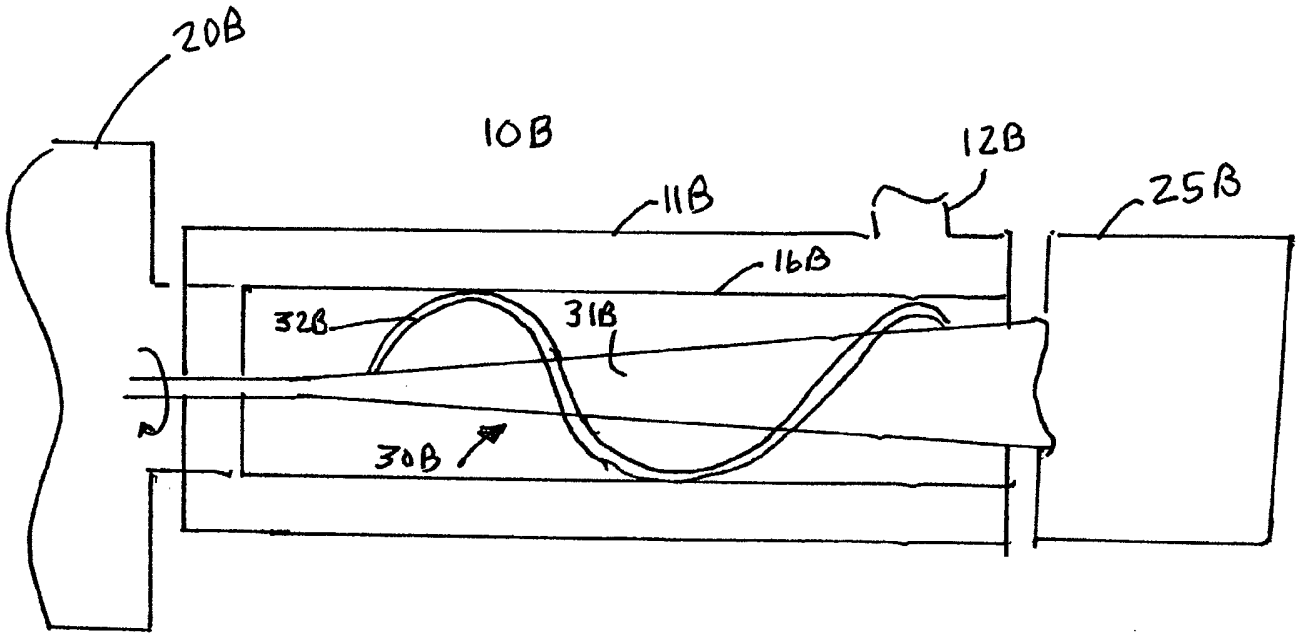


FIG. 3

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/27647

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C22B34/12 C22B5/04 B30B9/14 B30B9/12 B29C47/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C22B B30B B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 9 January 2004 | 16/01/2004 |

| Name and mailing address of the ISA | Authorized officer |
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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Bombeke, M |

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International Application No
PCT/US 03/27647

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