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FULL NAME(S) OF APPLICANT(S)

71	MINTEK
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FULL NAME(S) OF INVENTOR(S)

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TITLE OF INVENTION

54	METHOD OF AND APPARATUS FOR REFINING ZINC
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## BACKGROUND OF THE INVENTION

[0001] This invention relates generally to the thermal refining of zinc and more particularly is concerned with the thermal refining of prime western grade (PWG) zinc to special high grade (SHG) zinc.

5 [0002] The New Jersey process is in widespread use for the thermal refining of PWG zinc to SHG zinc. One of the main input costs of the process is the energy required to boil the zinc. Typically use is made of fossil fuels as an energy source. It is found however that the overall energy efficiency in a conventional fossil fuel fired New Jersey column is poor and often of the order  
10 of 30% to 40%.

[0003] Zinc vapour produced in the boiler is distilled using conventional techniques. The New Jersey column size is dictated by energy transfer criteria and is subject to a constraint for the internal generation of reflux liquid. The size of the reflux section of the New Jersey column is determined by the  
15 energy removal requirement to internally generate the required quantity of reflux liquid. On the other hand the size of the New Jersey column is limited by the mechanical strength of the distillation plates which are structural members in the column.

[0004] The design of New Jersey columns is determined by energy transfer  
20 criteria in that the surface area required to transfer the necessary energy through the walls of the column into the zinc dictates the size of the boiler

section, and the surface area needed to dissipate the energy which must be removed to internally generate the required quantity of reflux liquid in the distillation step dictates the size of the reflux section.

**[0005]** New Jersey columns are constructed from silicon carbide because it is one of the few materials that offer:

- (a) adequate mechanical strength. This is necessary because each column tray is a load-bearing structural member;
- (b) chemical resistance to hot zinc-rich liquid and vapour; and
- (c) adequate thermal conductivity to permit energy transfer.

**[0006]** Silicon carbide is however expensive and, given its mechanical properties, it limits the size, and hence the maximum capacity, of New Jersey columns.

#### SUMMARY OF INVENTION

**[0007]** The present invention is concerned with a method of, and apparatus for, thermally refining zinc which is based on mass transfer criteria as opposed to energy transfer criteria.

**[0008]** The invention provides a method of refining zinc which includes the steps of boiling a zinc-bearing material to produce a vapour which contains zinc, refining the vapour to increase its zinc content, and condensing the refined zinc-containing vapour to produce a liquid, characterised in that at least a portion of the liquid is used as a reflux liquid to refine the vapour.

**[0009]** Preferably the boiling step is carried out in a boiler in which energy, required for boiling, is introduced internally into the boiler. In this regard use may be made of electrical energy. In a preferred form of the invention use is made of a DC arc boiler.

5 **[0010]** By internally introducing the energy for boiling, into the boiler, the energy transfer constraint that is encountered in the New Jersey process is eliminated.

**[0011]** The invention also provides apparatus for refining zinc which includes a boiler for boiling a zinc-bearing material to produce a vapour which contains  
10 zinc, a refiner for refining the vapour to increase its zinc content, and a condenser for condensing the refined zinc-containing vapour thereby to produce a liquid, the apparatus being characterised in that at least a portion of the liquid is used as a reflux liquid in the refiner to refine the vapour.

**[0012]** The boiler is preferably electrically operated. In one form of the  
15 invention the boiler is based on the use of an induction heating system but in a preferred form of the invention the boiler is a DC arc boiler.

**[0013]** The refiner may comprise any appropriate device. As the invention is based on mass transfer criteria, the refiner is preferably chosen taking into account its mass transfer performance. It is possible therefore to make use of  
20 a packed distillation column as the refiner.

5       **[0014]** Packing in the column does not comprise a structural component nor is it required to transfer energy to or from the liquid or vapour. Consequently the packing only has to be chemically resistant to zinc liquid and zinc vapour and must be capable of supporting its own weight at the operating temperature.

**[0015]** As the reflux liquid is predominantly generated externally to the packing, in the condenser, the full volume of reflux liquid is available across the whole length of the column. The design of the packed column allows for the use of a steel shell with a refractory lining.

10       **[0016]** To enhance the distribution of reflux liquid in the packed column, and thereby maximise its efficiency, distributor plates may be positioned at intervals inside the column. These distributor plates may also be used as structural members to support the weight of the packing.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15       **[0017]** The invention is further described by way of examples with reference to the accompanying drawings in which:  
Figure 1 is a schematic representation of prior art apparatus for refining zinc using the New Jersey Column method; and  
Figure 2 is a drawing which is similar to Figure 1 but illustrating apparatus for  
20       refining zinc in accordance with the principles of the invention.

## DISCUSSION OF PRIOR ART

[0018] Figure 1 illustrates a prior art New Jersey column-based system for refining zinc. The system includes a boiler 10 into which a lead/zinc material 12 is introduced. Typically the lead content is  $\pm 1\%$ .

5 [0019] The boiler is heated by means of energy 14 from a fossil fuel such as coal, oil or gas. The size of the boiler 10 is dictated by the surface area that is required to transfer the energy through the walls of the boiler into the material inside the boiler.

10 [0020] Zinc vapour 16 is produced by the boiler. The vapour is directed to a distillation column 18 which, as noted, is normally constructed from silicon carbide. In the column reflux liquid 20 is internally generated, and is returned to the boiler. The size of the reflux section of the New Jersey column is determined by the energy removal requirement to generate the required reflux liquid internally. The energy that is dissipated from the column is designated  
15 by the numeral 22.

[0021] So-called "dirty zinc" 26, containing elevated levels of lead (commonly 2,5% to 5% lead, but at times significantly higher), is tapped from the boiler for treatment in a different manner.

20 [0022] Vapour 30 from the distillation column 18 is directed to a condenser 32 that condenses the vapour into zinc 34 with a lead content as low as

30ppm. Energy 36 is extracted or dissipated from the condenser in a manner known in the art.

#### DESCRIPTION OF PREFERRED EMBODIMENT

5 [0023] The preceding description of the New Jersey process is not meant to be exhaustive and has been given merely to provide a background for a better understanding of the method of the invention which is described hereinafter with reference to Figure 2.

10 [0024] Figure 2 illustrates apparatus 50 for thermally refining zinc in accordance with the principles of the invention which includes a boiler 52, a refiner 54 and a condenser 56.

15 [0025] Energy costs are a significant proportion of the cost of processing the zinc. The refining process should therefore be as energy-efficient as possible. For this reason a DC arc boiler system is a preferred choice for the component 52. A commercial scale DC arc boiler is expected to have a thermal efficiency of above 85%. A significant advantage of a DC arc boiler system is that there are very few limits on scale-up and it is possible to construct a single DC arc boiler regardless of the size of the plant. This is largely because there is no energy transfer inward through the walls of the boiler and the equipment can therefore be of conventional design. In a preferred example the zinc is boiled in a steel shell 58 with a refractory lining 60. A DC arc unit can provide a high energy flux so that the energy source is not a size-limiting factor. It has been calculated that a single DC arc boiler

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can exhibit the same boiling capacity as 12 to 14 New Jersey lead columns for a 300 000 t/a capacity.

**[0026]** The refiner 54, in this example, is a packed column for the refining of the vapour.

5 **[0027]** Reflux liquid is predominantly generated externally to the packing and the constraint for internal generation of reflux liquid is removed.

**[0028]** The advantages of using a packed column include the following:

- 10 (a) the packed column has a 2 to 3 order of magnitude greater mass transfer surface area, when compared to a tray column of equivalent dimensions;
- (b) tests results have shown that the required zinc grade can be achieved in less than one metre of packing height;
- (c) the capacity of the column is primarily dictated by the column diameter 64 with the height 66 dictating the zinc grade;
- 15 (d) the packing, designated 68, is not part of the column structure. The packing is also not required to transfer energy to or from the liquid or vapour. Consequently the packing only has to be chemically resistant to zinc liquid and zinc vapour and must be capable of supporting its own weight at the operating temperature;
- 20 (e) the packing does not form part of the column structure and consequently the maximum dimensions of the column are more flexible;



(f) the design of the packed column 54 allows for the use of a steel shell 70 with a refractory lining 72. This is significantly cheaper than machined silicon carbide, a material that is used in a New Jersey column. It is also possible to replace the lining 72 without replacing the steelwork 70.

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**[0029]** The vapour 16 produced by the boiler is directed to the refiner 54 and a liquid zinc/lead mixture 20 is returned to the boiler from the refiner.

**[0030]** Zinc vapour 30 is directed to the condenser for condensation. In the process of the invention, liquid is generated in the condenser 56 and, if necessary, some of the zinc liquid is returned to the top of the refining column 54 as reflux liquid 80. This means that the requirement for internally generating reflux liquid in the distillation column, as is the case in the New Jersey process, is removed. Consequently the energy transfer limitation of the refiner, which in the New Jersey process is represented by the block 22 in Figure 1, is done away with.

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**[0031]** The reflux liquid 80, which is generated in the condenser, is allowed to pass through the full length of the column of the refiner 54 from the top to the bottom. By way of contrast in the New Jersey column there is very little reflux liquid at the top of the column because the liquid is generated across the height of the reflux section. In the apparatus of the invention the reflux liquid is predominantly generated externally to the packing, in the condenser,

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and consequently the full volume of the reflux liquid 80 is available across the whole height of the column.

5 **[0032]** To enhance the distribution of reflux liquid in the column and thereby increase the efficiency of the refining process, distributor plates 82 can be positioned at intervals inside the column. The plates can also be used as structural members to support the weight of the packing 68.

10 **[0033]** The principles of the invention have been tested on a pilot plant scale. The distributor plate system in the refiner 54 works well and provides an even distribution of liquid to the packing 68. The packing performed well with acceptable wetability. It is considered likely that the column throughput can be significantly increased by increasing the amount of reflux liquid with a consequent increase in column efficiency. The maximum capacity of the column will ultimately be determined when the vapour velocity exceeds the transport velocity of the reflux liquid.

15 **[0034]** Pressure drop tests across the pilot plant column indicate a pressure drop of about 0,5kPa per metre of packing. This suggests that pressure drop and pressure buildup should not create problems in a commercial plant.

20 **[0035]** The results from the pilot plant show that the lead content of the condensed zinc product can be lowered to below 10ppm using as little as 0,5 metre of packing. The results also show that the product grade is relatively unaffected by the operating conditions.

CLAIMS

1. A method of refining zinc which includes the steps of boiling a zinc-bearing material to produce a vapour which contains zinc, refining the vapour to increase its zinc content, and condensing the refined zinc-containing vapour to produce a liquid, characterized in that at least a portion of the liquid is used as a reflux liquid to refine the vapour.  
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2. A method according to claim 1 wherein the boiling step is carried out in a boiler in which energy, required for boiling, is introduced internally into the boiler.  
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3. A method according to claim 2 wherein the boiler is a DC arc boiler.
4. Apparatus for refining zinc which includes a boiler for boiling a zinc-bearing material to produce a vapour which contains zinc, a refiner for refining the vapour to increase its zinc content, and a condenser for condensing the refined zinc-containing vapour thereby to produce a liquid, the apparatus being characterized in that at least a portion of the liquid is used as a reflux liquid in the refiner to refine the vapour.  
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5. Apparatus according to claim 4 wherein the boiler is electrically operated.  
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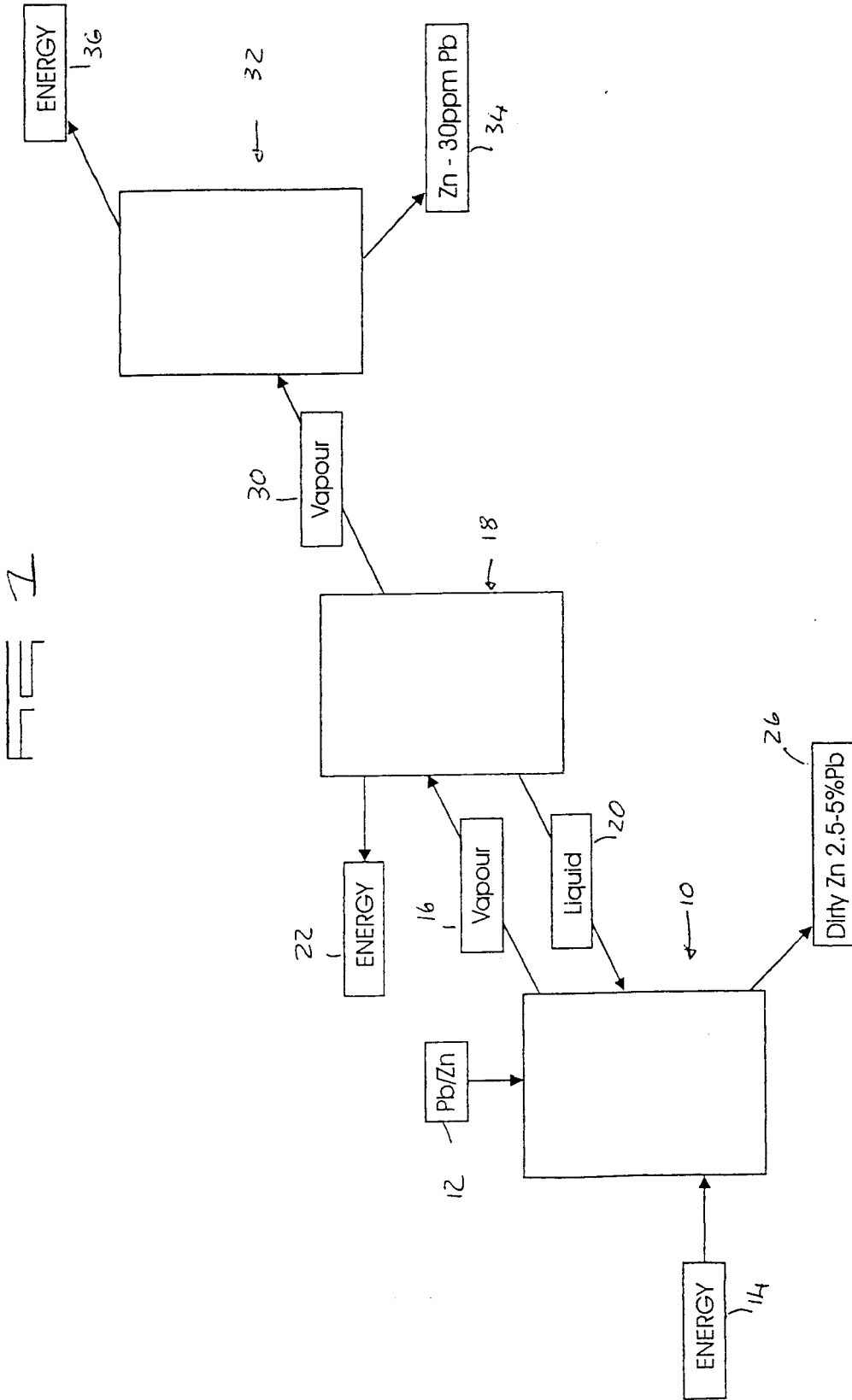
6. Apparatus according to claim 5 wherein the boiler is a DC arc boiler.
7. Apparatus according to any one of claims 4 to 6 wherein the refiner is a packed distillation column.
- 5 8. Apparatus according to any one of claims 4 to 7 wherein the reflux liquid is available across the length of the column.
9. Apparatus according to any one of claims 4 to 8 wherein the column includes a steel shell with a refractory lining.
- 10 10. Apparatus according to any one of claims 4 to 9 which includes a plurality of distributor plates positioned at intervals inside the column.
11. Apparatus according to claim 10 wherein the distributor plates are used as structural members to support the weight of packing in the column.
- 15 12. A method of refining zinc substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.
13. Apparatus for refining zinc substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

DATED this 17<sup>th</sup> day of February 2004.

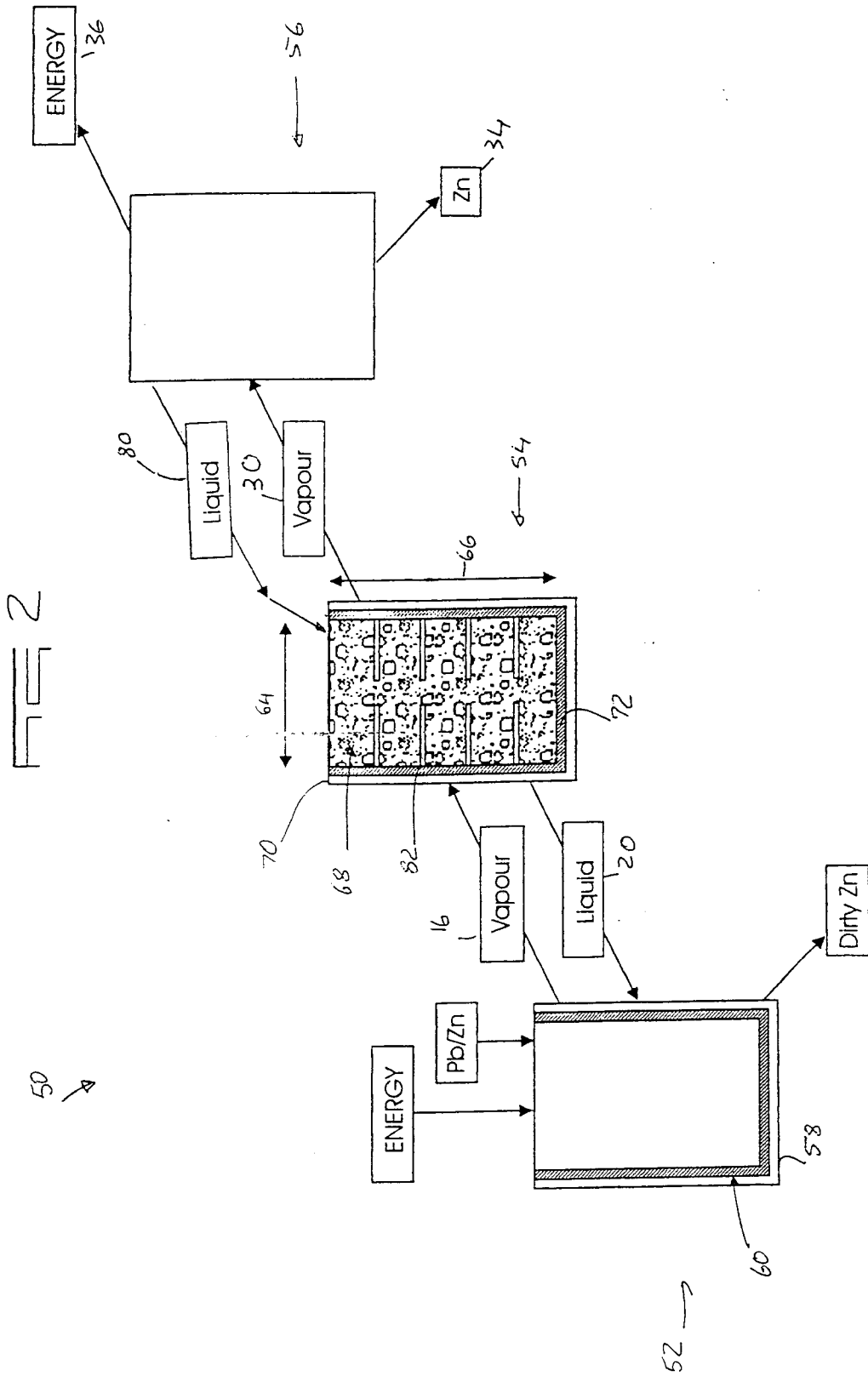
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