PATENT REQUEST: STANDARD PATENT / PATENT OF ADDITION

We, being the person(s) identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

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[54] Invention Title  
THE METHOD OF ACCELERATING THE LEACHING OF THE NON-FERROUS METAL ORES AND INCREASING THE LEACH RATE BY SOLAR ENERGY

[72] Name(s) of actual inventor(s)  
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ASSOCIATED PROVISIONAL APPLICATION(S) DETAILS

[60] Application Number(s) and Date(s)  
PK 3393 19 NOVEMBER 1990

BASIC CONVENTION APPLICATION(S) DETAILS

DIVISIONAL APPLICATION DETAILS

[62] Original application number

PARENT INVENTION DETAILS (Patent of Addition requests only)

[61] Application number

Patent number

TICK IF APPLICABLE

I am an eligible person described in Sections 33 - 36 of the Act.

Drawing number recommended to accompany the abstract  
2

Zhang Jiahao  
(Signature)  
17 November 1991  
(Date)
NOTICE OF ENTITLEMENT
(To be filed before acceptance)

I, ZHANG JIANHAO
of 5 FORBES STREET, HORNSBY, N.S.W. 2077,

being the applicant in respect of Application No. , state the following:-

Part 1 - Must be completed for all applications.

The person(s) nominated for the grant of the patent:

*is / *are the actual inventor(s)
or
*has entitlement from the actual inventor(s)

(eg by assignment, by mesne assignment, as legal representative of ......, etc)

Part 2 - Must be completed if the application is associated with one or more provisional applications.

The person(s) nominated for the grant of the patent:

*is / *are the applicant(s) of the provisional application(s) listed on the patent request form

or
*has entitlement to make a request under Section 113 in relation to the provisional application(s) listed on the patent request form

(eg by assignment, by agreement, etc)

Part 3 - Must be completed for all Convention applications.

The person(s) nominated for the grant of the patent:

*is / *are the applicant(s) of the basic application(s) listed on the patent request form

or
*has entitlement from the applicant(s) of the basic application(s) listed on the patent request form

(eg by assignment, by mesne assignment, by consent, etc)
*The basic application(s) listed on the request form:
  *is *are the first application(s) made in a Convention country in respect of the invention
  or
  *was/were not the first application(s) made in a Convention country in respect of the invention, and a
  request has been made under Section 96 of the Patents Act 1990 (or Section 142AA of the Patents Act
  1952) to disregard the following application(s) ..............................................................................

*Part 4—Must be completed for PCT applications:

The person(s) nominated for the grant of the patent:
  *is / *are the applicant(s) of the application(s) listed in the declaration under Article 8 of the PCT
  or
  *entitled to rely on the application(s) listed in the declaration under Article 8 of the PCT.

*Part 5—Must be completed if the application is a Divisional application:

The person(s) nominated for the grant of the patent *is / *are:
  *the applicant(s) / patentee(s) of the original application / patent
  or
  *entitled to make a request under Section 113 of the Act in relation to the original application / patent.

*Part 6—Must be completed if the application relates to a microorganism and relies on Section 6 of the
  Act:

The person(s) nominated for the grant of the patent *is / *are:
  ☐ the depositor(s) of the deposits listed hereafter (by number, depositary institution and date)
  or
  ☐ entitled to rely on the deposits listed hereafter (by number, depositary institution, date, and depositor's
    name and address) for the following reasons:
    ........................................................................................................................................................................

*Part 7—Must be completed if the application is a Convention application, or the application was made
under the PCT and the applicant made a declaration under Article 8 of the PCT in respect of the
basic application:

☐ Except as stated in the next paragraph, the basic application(s) *listed on the patent request form / *referred to in the declaration under Article 8 of the PCT *is / *are the application(s) first made in a
  Convention country in respect of the invention.

☐ A request has been made under Section 96 of the 1990 Act (or Section 142AA of the 1952 Act) to
disregard the following application.
Part 2—Must be completed if the applicant for a patent of addition is not the applicant or patentee of the main invention.

I, ...........................................................................................................

the *applicant/*patentee for *application/*patent No. ...........................................

authorise ...........................................................................................................

to apply for a further patent for an improvement in, or modification of, the main invention.

Note: This MUST be signed by the applicant or patentee of the main invention.

...........................................................................................................

(Signature) ...........................................................................................................

(Date) ...........................................................................................................
The invention comprises a process for the leaching of non-ferrous metal ores and regeneration of the ferric ion solution by solar energy and a solar energy device for the regeneration of the ferric ion solution. Said process comprising heating the reactants containing the aqueous solution of ferrous ion in aid of solar energy device, oxidizing the ferrous ion by air, forming the ferric ion solution and leaching non-ferrous metal ore; said solar energy device comprising a transparent covering providing heat insulation for said solar energy device, formed from two layers or more of transparencies and the air between the transparencies through which solar light can pass, and a base.

Advantages of the invention compared with the common dump leaching of non-ferrous metal ores include higher leach rate and shorter leach period.
Invention Title: THE METHOD OF ACCELERATING THE LEACHING OF THE NON-FERROUS METAL ORES AND INCREASING THE LEACH RATE BY SOLAR ENERGY

The following statement is a full description of this invention, including the best method of performing it known to me:-
This invention relates to a method for leaching non-ferrous metal ores in ferric ion solution and the regeneration of the ferric ion solution by utilization of solar energy.

Some important non-ferrous metal ores, such as copper ore, nickel ore, uranium ore, etc., are often sulfide, acid insoluble and low-grade. For example, the major copper ores in nature are sulfide which is acid insoluble and often contains less than 1% copper. Copper sulfide with less than 0.4% copper is called low-grade or sub-mill-grade ore. The low copper content makes it impossible to be concentrated in flotation and, hence, difficult for industrial mining and utilization. Besides, the mining of high-grade sulfide mines will leave large quantities of low-grade copper material, tailings and spent ore. The low-grade ore, tailings, and spent ore, etc., make a considerable proportion of copper resources. There is similar case in other non-ferrous metal ores. If these low-grade sulfide ores can be fully utilized, not only will the production of these metals increase, but the waste of the present resources of these metals will become avoidable.

Because the ores are impossible to be concentrated in flotation, the only common method is leaching.

The leaching of copper sulfide, as a typical example, may serve to illustrate the common leach process of the non-ferrous metal ores. In the presence of sulfuric acid and air or other leaching agents, the copper is leached out from the ore, forming copper solution. Copper metal or its intermediate is then obtained from the solution by replacement with iron scrap or extraction-electrowinning. Until recently, the leaching of the ores can be categorized as follows.

1. **Bacteria leaching.** Thiobacteria are used to treat ferrous sulfate or pyrite. Sulfuric acid is added to adjust the pH value of the solution. Ferrous compounds will slowly be oxidized to form ferric sulfate due to the performance of the thiobacteria. A copper solution is then obtained from leaching crushed ores by the ferric sulfate solution. The process is extensively used to treat the ores. The leaching requires a long period and high air temperature.
(2) Dump leaching. Dilute sulfuric acid is directly sprinkled on crushed ore dumps. Affected by the oxygen in air and the sulfuric acid, the sulfide is slowly converted into sulfate of copper, which can be leached from the ores through dissolution into water or dilute acid. Of all the leaching processes, this is the simplest, but the leach period is too long, about quite a few months to one year, and the rate is low. The bacteria leaching and dump leaching are frequently applied together.

(3) Other lixiviant leaching. The sulfide ore are directly leached in lixiviants which can oxidize and dissolve sulfide, such as cupric chloride, ferric chloride, nitric acid, etc. The cost of these lixiviants is much higher than of sulfuric acid. If the sulfide ore is low-grade, there will be much waste of the lixiviant, hence, resulting in excessive production cost and the loss outweighs the gain.

It is known that sulfides of copper and some other non-ferrous metals can be directly oxidized by and dissolved in ferric ion solution; in the meantime the ferric ion is reduced to ferrous ion. The process is quite quick. The reaction of ferric ion to chalcopyrite and chalcocite are as follows.

\[
\text{CuFeS}_2 + 4\text{Fe}^{+3} = \text{Cu}^{+2} + 5\text{Fe}^{+2} + 2\text{S}
\]

\[
\text{Cu}_2\text{S} + 4\text{Fe}^{+3} = 2\text{Cu}^{+2} + 4\text{Fe}^{+2} + \text{S}
\]

When the reduced ferrous ion is permitted full contact with air in a certain pH value range, the ferrous ion will be oxidized by the oxygen in air and form ferric compound. The ferric ion can be regenerated from the ferric compound by adding acid into the solution and then recycles to the leaching of the sulfide of copper. The ferric ion is cycle uses, and the loss of ferric ion or ferrous ion can also be supplied by the leaching of the sulfide, so only one single leaching agent, sulfuric acid or hydrochloric acid, is needed. But the oxidation of the reduced ferrous ion in air is too slow at normal temperature, which makes a short cycle period difficult to achieve.

It is known that ferrous ion solution, such as the aqueous
solution of ferrous sulfate, is subject to oxidation in air, and the rate of oxidation increases with an increase in pH value, temperature and light. When there are adequate area of contact between the solution and the air, and the flow of the solution and the air phase are counter and complete turbulence, we may neglect the influence of diffusion of the air molecules through the solution-air interface to the solution. Thus, the rate of oxidation of ferrous ion depends on the pH value, temperature and light. When the range of pH value is limited, the effect of temperature becomes more important. van't Hoff's law is an approximate experimental equation to represent the relation between temperature and reaction velocity.

\[
\frac{K_{t+10}}{K_t} = 2 \sim 4
\]

where \(K_t\) is the reaction velocity constant when temperature is \(t^\circ C\), and \(K_{t+10}\) when \((t+10)^\circ C\). Thus the temperature increases 10\(^\circ\)C, the reaction velocity will increase by about 1~3 times. Arrhenius equation is a more accurate experimental equation.

\[
K = K_0 \exp\left(-\frac{E_a}{RT}\right)
\]

From reaction dynamics, we know that when the pH value of the reaction increases, the apparent activation energy of the reaction \(E_a\) decreases, and according to Arrhenius equation the reaction velocity will increase rapidly. In practical production, the pH value must be limited because of the cost of the reactants. When the pH value is fixed, the apparent activation energy of the reaction \(E_a\) is a fixed value, the reaction velocity constant \(K\) will increase with the increase of temperature \(T\). Thus, the oxidation rate of the ferrous ion will increase greatly and the cycle period shortens with the rise of temperature. If we want to raise the temperature in the reaction, the reactants, the solution of ferrous ion and air, have to be heated. The heat requirement will be tremendous on account of the tremendous amount of reactants. For instance, leaching one tonne of copper from sulfide ore containing 0.25% copper, the reactants will be more than four hundred tonnes. In addition, we will lose quite a lot of heat as the air continuously flows through the reaction. If fuel is used for heating the reactants, not only is the consumption of fuel tremendous, but the heating is difficult, so some other way of heating must be considered.
We know that solar radiant energy on a vertical plane towards the sun ray, at an average distance between the earth and the sun and without the effect of atmospheric air, that is, the solar constant, is \( 1353 \text{ w/m}^2 \). If the effect of atmospheric air, latitude, climatic conditions, etc., are considered, for example, on a vertical plane towards the sun ray, where latitude is \( 56° \) and atmospheric clearness is 1, from 8 a.m. to 4 p.m., in winter, the mean direct solar radiant energy is about \( 550 \text{ w/m}^2 \) and diffuse solar radiant energy \( 40 \text{ w/m}^2 \); in summer, the mean direct solar radiant energy is about \( 800 \text{ w/m}^2 \) and diffuse solar radiant energy is about \( 100 \text{ w/m}^2 \). Assuming that solar energy is available 250 days in a year from 8 a.m. to 4 p.m., then on a plane with an area of 1 hectare, the solar radiant energy of \( 1.4 \times 10^7 \text{ kilowatt-hour yearly} \) can be utilized, which is equal to the heat energy engendered by burning 1200 tonnes of oil. Hence, it is very beneficial to use solar energy heating the reactants and raising the temperature for the increase of the reaction velocity. For the above reason, this invention takes some special measures to use solar energy in the leaching process of the ore.

Briefly stated, the present method comprises a process for the leaching of non-ferrous metal ores and the regeneration of ferric ion solution by solar energy and a solar energy device for the regeneration of ferric ion solution which comprises:

- said process comprising heating the reactants containing the aqueous solution of ferrous ion in the said solar energy device, oxidizing the ferrous ion by air, forming the ferric ion solution and leaching non-ferrous metal ore;
- said solar energy device comprising a transparent covering providing heat insulation for said solar energy device, formed from two layers or more of transparencies and the air between the transparencies through which solar light can pass, and a base.

In one form of the invention, the aqueous solution of ferrous ion together with the air is heated in said solar energy device.
energy device; the base of said solar energy device may be an incline, where the aqueous solution of ferrous ion flows down along said incline and the air flows up along said incline, or a horizontal plane, where the air flows along said plane and the used air is exhausted through the exhaust passegway on said plane.

In another form of the invention, the aqueous solution of ferrous ion is alone heated in said solar energy device and then is oxidized by air.

The transparencies in said solar energy device are glass plates or plastic sheets or plastic films.

The aqueous solution of ferrous ion in said process is the aqueous solution containing ferrous sulfate or ferrous chloride.

The non-ferrous metal ores in said process is the copper-containing material or the nickel-containing material or the uranium-containing material.

To assist with understanding the invention, reference will now be made to the accompanying drawings which show the examples of the invention.

FIG.1, FIG.2 and FIG.3 show said solar energy device and the structure according to one form of the invention.

FIG.4 shows another form of the invention.

FIG.5 shows an applied process of the invention.

Example 1, as shown in FIG.1, a transparent covering covers the reactants, solar light passes through the transparent covering to heat the reactants. The transparent covering consists of two layers or more of glass plates or plastic films and the air between the glass plates or the plastic films. The role of supports 4 is to support the glass plates or plastic films. The air between the glass plates or the plastic films plays an important part in light transmission and heat preservation. But for the air there would be little effect in heat preservation only with the glass plates or the plastic films in themselves. We can
roughly estimate the effects of the heat preservation in two conditions, with an air layer between two plastic films and with only two plastic films.

Assume that the thickness of the plastic films is $b_1 = 0.1 \text{ mm}$, the thermal conductivity $\lambda_1 = 0.1 \text{ Kcal/m.hr.}^{\circ}\text{C}$, the thickness of the air layer is $b_2 = 20 \text{ mm}$, the thermal conductivity $\lambda_2 = 0.022 \text{ Kcal/m.hr.}^{\circ}\text{C}$, the temperature difference between the inside and surroundings $\Delta t = 30^{\circ}\text{C}$. If the convection of the air layer between the plastic films is not considered, the loss of heat from the inside to the surroundings through conduction on per square metre is:

with only two plastic films,

$$Q_1 = \frac{\Delta t}{2b_1/\lambda_1} = \frac{30}{2 \times 0.0001/0.1} = 15000 \text{ Kcal/hr}$$

with an air layer between the two plastic films,

$$Q_2 = \frac{\Delta t}{2b_1/\lambda_1 + b_2/\lambda_2} = \frac{30}{2 \times 0.0001/0.1 + 0.02/0.022} = 32.9 \text{ Kcal/hr}$$

As may be inferred from this, for the great loss of heat, there is little effect in heat preservation with only glass plates or plastic films. There must be the air 3 between the glass plates or the plastic films 2 as a heat insulation layer. When solar light 1 radiates to the reactants through the heat insulation layer, the radiant energy is absorbed in the solar energy device and is converted into heat energy, and thus the temperature of the reactants rises. The surface of the base 5 may be painted black so that the solar energy device has higher absorption rate of solar light. The reaction, which occurs in the solution containing ferrous ion and the oxygen in air, is accelerated with the rise of temperature. The higher the reaction velocity is, the faster the oxygen in the air consumes.

We know that besides temperature, the concentration of reactants is also a main factor which effects reaction velocity.

When the concentration of the oxygen in air decreases because of the consumption of the reaction, the reaction velocity will decrease. Thus, in the reaction, new air must be continuously drawn in and the used air exhausted out.
However, if the flow of air is too large, the heat in the reactants will be greatly lost with the exhaustion of the air, and the reaction will be affected by the temperature fall. Hence, we require some measures to ensure both a sufficient concentration of oxygen in air during the reaction and a well-controlled flow of air; thereby, the heat in the reactants can be retained as much as possible. As shown in FIG. 2, the reactants consist of the solution 6 containing ferrous ion and the air 7. The solution 6 flows along the incline 5, as a base for the solar energy device, from the top to the bottom; the air 7, because of the temperature difference, automatically enters the incline 5 from the bottom and is exhausted at the top. The role of the incline 5 and the counter flow between the solution 5 and the air 7 is exactly so. The angle of the incline 5 $\alpha$ may be selected according to the latitude, for example, for a solar energy device set up where the latitude is 35°, the angle of the incline 5 $\alpha$ may be selected in $30^\circ \sim 45^\circ$.

When the temperature of the reactants rises because of the absorption of solar energy, on the one hand the incoming air 7 reacts with the ferrous ion in the solution 6 and the oxygen in the air 7 is gradually consumed, on the other hand, with the temperature rise the air 7 continually flows along the incline 5 up. Because of the convection caused by temperature difference, new air continually enters the reactants from the bottom of the incline 5 and the used air is exhausted at the top. When the reactants are at a lower temperature, because of lower velocity of reaction between the solution 6 and the air 7, the consumption of the oxygen decreases, so the air 7 required for reaction decreases. Because the temperature of the air 7 in the reactants is lower, the convection is weak, the air 7 flows also slowly accordingly, the comparatively low flow accords with the requirement at this moment. When the reactants are at a higher temperature, because of higher velocity of reaction between the solution 6 and the air 7, the consumption of the oxygen increases, so the air required for reaction increases.
Because the temperature of the air 7 in the reactants is higher, the convection is strong, the air 7 flows fast accordingly, the comparatively high flow also accords with the requirement at this moment.

With this measure, not only can the air 7 flow automatically in the reactants without any mechanical energy, but the flow of the air 7 can change with the temperature variation of the reactants, that is, the flow of the air 7 is automatically regulated as the requirement for the reaction varies. The measure is effective as well as simple.

Besides the incline 5, the base 5 may be also the horizontal plane 5 as shown in FIG. 3. There is a vertical exhaust passageway 10 on the plane 5 that the used air can be exhausted through the passageway 10, thus achieving the entering of new air and the exhaustion of used air. To increase the flow of air 7, there may also be a vertical exhaust passageway 10 on the incline 5.

In the solar energy device there may be packing or netting 8 on the base 5, the surface of the base 5 may also be convex and concave. The packing or netting 8, or the convex and concave base, provides a large area of contact between the solution 6 and the air 7, and encourages intimate contact between the two phases. To increase the adsorption rate of solar light, the packing or netting 8 may be black or dark. To increase the insulating efficiency of said solar energy device, we may place insulating materials 9 in the base 5. The insulating materials 9 may be of various kinds, such as, air, foamed plastics, hollow concrete, asbestos, fibreglass, slag wool, etc.

After reacting for a period of time, the ferrous ion in the solution 6 have been mostly converted to ferric ion and compound. The oxidation reaction of the ferrous ion and the formation of the ferric compound are as follows.

\[
4\text{Fe}^{2+} + \text{O}_2 + 4\text{H}^+ = 4\text{Fe}^{3+} + 2\text{H}_2\text{O}
\]

\[
\text{Fe}^{3+} + (n+1)\text{H}_2\text{O} + \text{SO}_4^{-2} = \text{Fe(OH)}\text{SO}_4 \cdot n\text{H}_2\text{O} + \text{H}^+
\]

\[
2\text{Fe}^{3+} + (n+4)\text{H}_2\text{O} + \text{SO}_4^{-2} = \{\text{Fe(OH)}_2\} \cdot 2\text{SO}_4 \cdot n\text{H}_2\text{O} + 4\text{H}^+
\]
$$\text{Fe}^{3+} + (n+3)\text{H}_2\text{O} = \text{Fe(OH)}_{3} \cdot n\text{H}_2\text{O} + 3\text{H}^+$$

Then sulfuric acid or hydrochloric acid is added to the ferric compound or the solution and form ferric sulfate or ferric chloride, thus achieving the regeneration of the ferric ion solution. The reaction is as follows.

$$\text{Fe(OH)}_{3} \cdot n\text{H}_2\text{O} + 2\text{H}^+ = \text{Fe}^{3+} + (n+3)\text{H}_2\text{O}$$

$$\{\text{Fe(OH)}_2\}_2\text{SO}_4 \cdot n\text{H}_2\text{O} + 4\text{H}^+ = 2\text{Fe}^{3+} + (n+4)\text{H}_2\text{O} + 3\text{SO}_4^{2-}$$

$$\text{Fe(OH)SO}_4 \cdot n\text{H}_2\text{O} + \text{H}^+ = \text{Fe}^{3+} \cdot (n+1)\text{H}_2\text{O} + 3\text{SO}_4^{2-}$$

The solution of the ferric ion is used for leaching the non-ferrous metal ores. The non-ferrous metal ores may be various ores containing sulfide of copper, sulfide of nickel, sulfide of uranium, pitchblende. The non-ferrous metal ores also may be the material containing copper or nickel, such as tailings, spent ore, reverberatory furnace slag, converter slag, etc. When the solution of ferric sulfate or ferric chloride reacts with the non-ferrous metal ores, the non-ferrous metal ores dissolve or decompose in the solution and form the soluble non-ferrous metal compounds. In the meantime the ferric ion is reduced to ferrous ion. For example:

$$\text{CuS} + 2\text{Fe}^{3+} = \text{Cu}^{2+} + 2\text{Fe}^{2+} + \text{S}$$

$$\text{NiS} + 2\text{Fe}^{3+} = \text{Ni}^{2+} + 2\text{Fe}^{2+} + \text{S}$$

$$\text{UO}_2^+ + 2\text{Fe}^{3+} = \text{UO}_2^{2+} + 2\text{Fe}^{2+}$$

$$\text{Cu} + 2\text{Fe}^{3+} = \text{Cu}^{2+} + 2\text{Fe}^{2+}$$

The non-ferrous metal or the compounds are obtained from the solution by extraction or replace. The copper compounds also may be obtained by precipitation adding flotation waste water to the solution. Then the pH value of the solution containing ferrous ion may be adjusted to the suitable range, for example, pH > 2, and the solution cycles to reoxidation, and then next cycle begins. A process of the invention is shown in FIG. 5.

There may be still other forms of the process in the invention. For example, because of the precipitation of the ferric compound, it may be separated from the solution in the oxidation. The process may be as follows.

The solution containing ferrous ion and copper is heated and
oxidized in said solar energy device. The ferrous ion is oxidized to form the precipitate of the ferric compound and the ferric compound is separated from the solution. Then copper or the compound of copper is obtained from the solution by extraction or replace. Sulfuric acid or hydrochloric acid is added to the separated ferric compound and form the ferric ion solution. The ferric ion solution is used for leaching copper ore. The copper in the ore dissolves in the solution; in the meantime the ferric ion is reduced to ferrous ion.

Then the pH value of the solution containing ferrous ion and copper is adjusted to the suitable range and the solution cycles to reoxidation. The process is shown in FIG. 6.

In the invention the solar energy device with an area of 1 hectare at latitude $30^\circ$ to $35^\circ$, in the spring, summer, or autumn, will be able to heat and oxidize about 1000 tonnes of the solution of ferrous ion which can be used for leaching about 1000 to 1500 tonnes of the non-ferrous metal ore everyday.

The regeneration of the solution of ferric ion depends on the oxidation rate of the solution of ferrous ion, depending on the following factors. These factors are: the pH value of the solution of ferrous ion; the intensity of solar radiation; the structure of the solar energy device; the quantity of the solution of ferrous ion; the concentration of the ferrous ion in the solution.

Example 2, as another form of the invention, as shown in FIG. 4, the transparent covering with similar structure in example 1, covers the solution 6 containing ferrous ion, solar light 1 passes through the transparent covering to heat the solution 6. After the solution 6 is heated, air bubbles are blown in to oxidize the ferrous ion in the solution 6. Because the solution 6 is heated, the oxidation rate of the ferrous ion is comparatively fast. The ferrous ion is oxidized to ferric compound. The following process is similar to that of example 1.

Example 1 may be combined with example 2 for the regeneration of the ferric ion solution, that is, a combination of both forms of the invention may be effective. The structure and
place of the solar energy device may utilize natural terrain, such as, slope, waste heap, etc.

In the mining of non-ferrous metal ores, considerable quantities of non-ferrous metal are transported to waste dumps with the large quantities of overburden or waste rock which must be removed to reach ore-grade material suitable for treatment in flotation circuits. Since mine waste has been accumulating for many years, large quantities of low-grade non-ferrous metal material are in existing dumps. Methods for managing these existing dumps to maximize the non-ferrous metal recovery are being pursued actively by major non-ferrous metal producers. Additionally, leaching process is now being studied extensively for treatment of sulfide of non-ferrous metal because it offers an alternative to smelting which presents problems associated with sulfur dioxide and environmental controls. The application of the invention will benefit environmental controls, because advantages of the invention compared with the common dump leaching include higher leach rate and shorter leach period.

The copper ore and some other non-ferrous metal ores can be fully utilized, the waste of the resources will be avoidable.
The claims defining the invention are as follows:

1. The method comprises a process for the leaching of non-ferrous metal ores and regeneration of the ferric ion solution by solar energy and a solar energy device for the regeneration of the ferric ion solution, which comprises:
said process comprising heating the reactants containing the aqueous solution of ferrous ion in said solar energy device, oxidizing the ferrous ion by air, forming the ferric ion solution and leaching non-ferrous metal ore;
said solar energy device comprising a transparent covering providing heat insulation for said solar energy device, formed from two layers or more of transparencies and the air between the transparencies through which solar light can pass, and a base.

2. The solar energy device according to claim 1 wherein the aqueous solution of ferrous ion together with the air is heated.

3. The solar energy device according to claim 1 wherein the aqueous solution of ferrous ion is alone heated.

4. The solar energy device according to claim 1 wherein the transparencies are glass plates or plastic sheets or plastic films.

5. The process according to claim 1 wherein the aqueous solution of ferrous ion is the aqueous solution containing ferrous sulfate or ferrous chloride.

6. The process according to claim 1 wherein the non-ferrous metal ore is the copper-containing material or the nickel-containing material or the uranium-containing material.

7. The solar energy device according to claim 1 and claim 2 wherein the base is incline, where the aqueous solution of ferrous ion flows along said incline down and the air flows along said incline up.

8. The solar energy device according to claim 1 and
claim 2 wherein the base is a horizontal plane, where the
air flows along said plane and the used air is exhausted
through the exhaust passageway on said plane.

9. The method substantially as herein described with
reference to the examples.

Dated this 17 day of November 1991

Zhang Jianhao

Yu Qiang

(Name of Applicant)
(BLOCK LETTERS)