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[54] RECOVERY OF METAL VALUES FROM NICKEL-COPPER MATTES

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[51] **Int. Cl.** **C01g 1/10**, C22b 3/00

[58] **Field of Search** 23/125, 117; 75/117, 119

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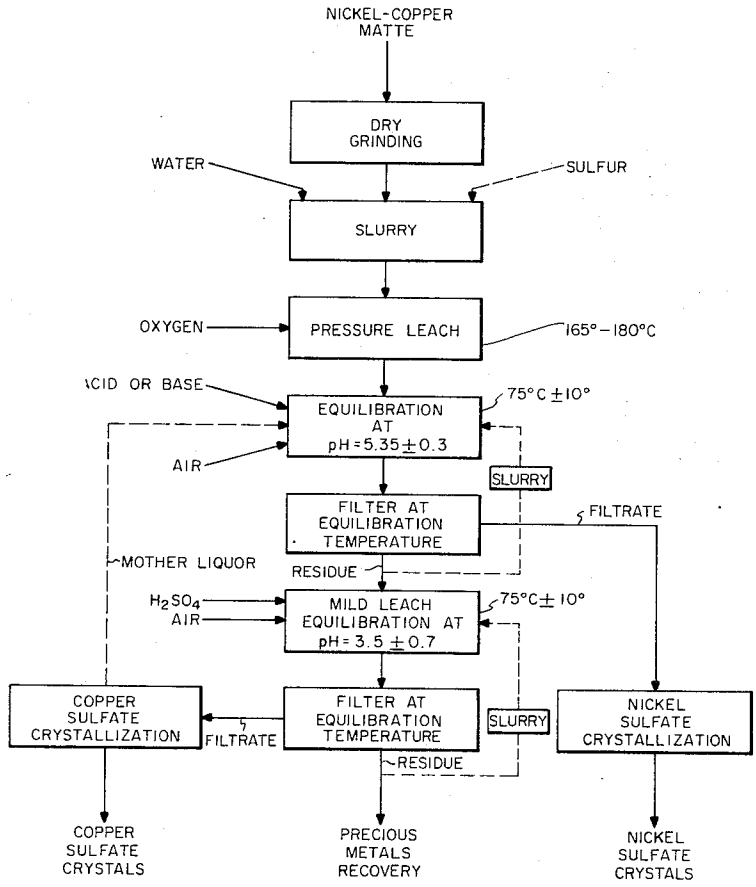
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[57] **ABSTRACT**

A process for recovering nonferrous metal values from nickel-copper mattes includes the selective separation of nickel from the mattes by oxidative pressure leach of the matte and equilibration of the pressure leached material to a pH of preferably 5.35 ± 0.3. Thereafter copper is leached from the resultant nickel depleted residue under relatively mild conditions. Precious metals are recovered from the mild leach residue.

12 Claims, 3 Drawing Figures



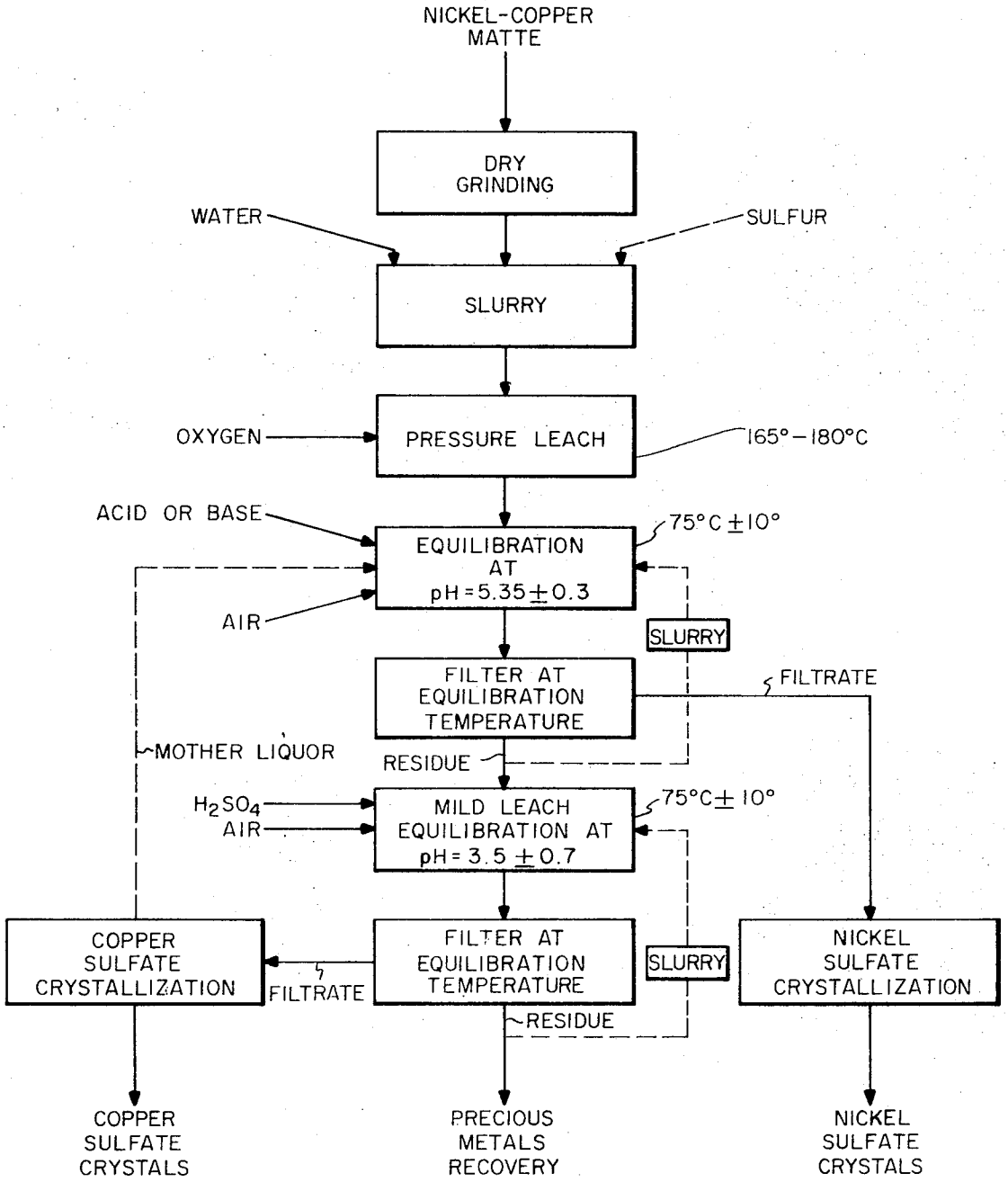


FIG. 1

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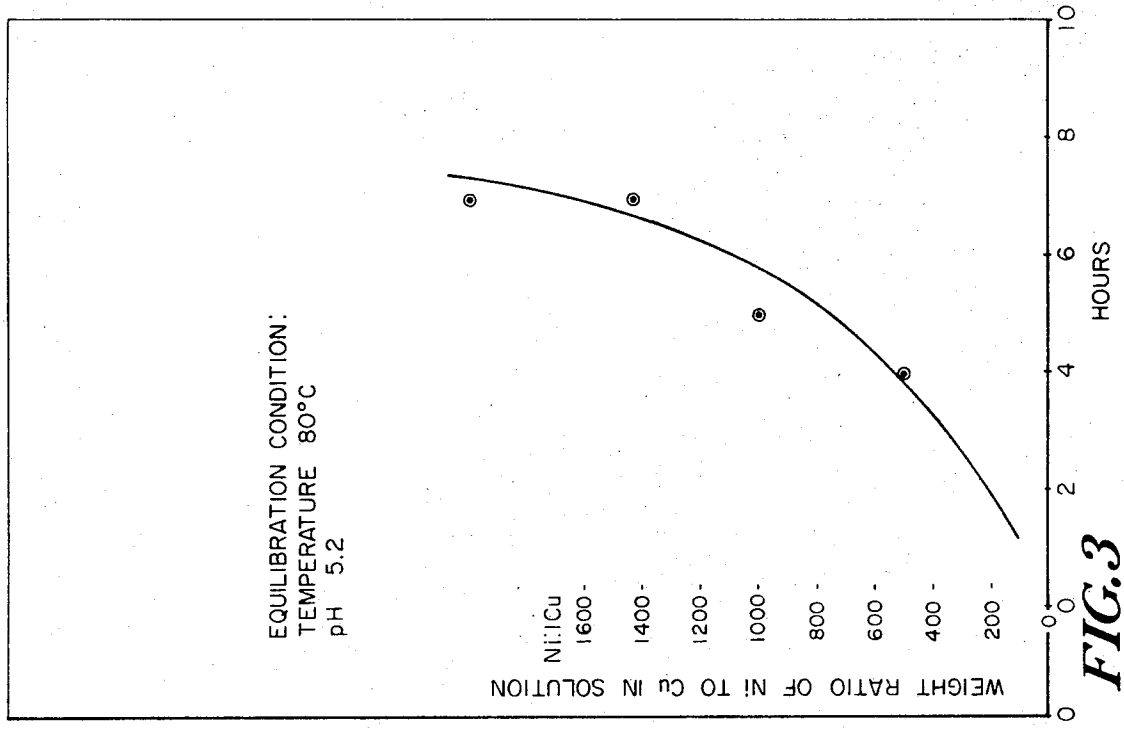


FIG.3

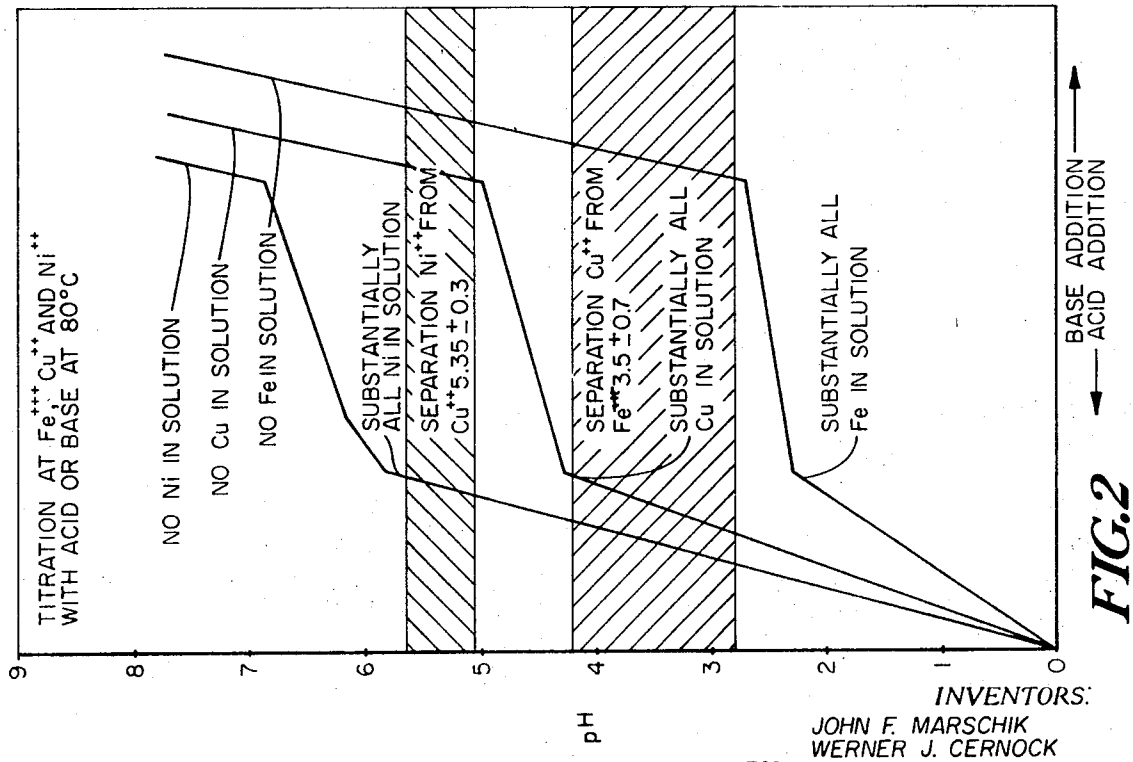


FIG.2

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RECOVERY OF METAL VALUES FROM NICKEL-COPPER MATTES

This invention relates to a process for the recovery of nonferrous metal values from nickel-copper mattes. More specifically it relates to a hydro-metallurgical process for treating nickel-copper mattes to selectively recover a high grade nickel product. It also relates to the recovery of other metal values, especially copper and precious metals from such mattes.

The term "nickel-copper matte" applies to an impure metallic sulfide product containing nickel and copper values obtained by the smelting of mineral sulfide containing ores and concentrates. These mattes have a wide range of metal concentrations with respect to nickel, copper, and other metals. However, the mattes which are of particular concern in the present process are those which have or can be adjusted to have a nickel content which is equal to or greater than the total sulfur content, on a molar basis. In addition to nickel and copper the mattes may contain varying amounts of other metals, e.g., cobalt, iron, and precious metals. It is well known to form such mattes to recover metal values from ores and many routes have been taken to effect the recovery of the metals from the mattes.

The separation of nickel from copper in the nickel-copper mattes has long been a problem. Among the reported processes are those which utilize mechanical, magnetic, and chemical treatment as a means of separating the nickel and copper. The recovery of precious metals from such mattes further complicates the problem. One method in general use where previous metals are to be recovered as well as the nickel and copper is to cast the matte directly into anodes for electrofining. Although effective for the recovery of the precious metals, this method has many unattractive aspects. For example, the anodes are difficult to cast and handle, and care must be taken that such anodes corrode smoothly in operation. Moreover, the various metal values, e.g., nickel, copper, and precious metals are not separated effectively and not only must each of the resulting products at the anode, cathode and in the electrolyte be subjected to many expensive recovery steps, but also a sizable portion of the precious metal values are lost because of the high cost to recover them from the electrolyte. Also, the power requirements are high and the process is very slow, tying up a considerable amount of valuable metals in the electrolyte and the anode and cathode slimes. In addition, during the process considerable quantities of waste sulfur is formed and disposal of such waste without causing environmental pollution is a major problem.

It has been suggested that hydrometallurgical processes can be used for recovery of nonferrous metals. Hydrometallurgical processes involve the extraction of nonferrous metals by chemical dissolution from mineral bearing materials. Generally, the methods known in the art involve converting the nonprecious metals into a mixture of readily soluble salts, e.g., sulfates, in one or more oxidative pressure leach steps. Where precious metals are present and are to be recovered, considerable amounts of the precious metals have to be recovered from acidic leach solutions. Although hydrometallurgical processes for the recovery of metals are well known and have been applied commercially, none of the known processes are satisfactory for the selective separation of nickel from nickel-copper mattes. Generally, nickel-copper mattes are sulfur deficient relative to their metal content and heretofore it has been the practice to add sufficient sulfur, especially as sulfuric acid to get both nickel and copper values immediately into solution. Not only is such initial highly acidic leach highly corrosive, requiring a low pH under oxidizing conditions, and also requiring a long time, but in addition no satisfactory way has been developed to separate the nickel and copper sulfate. Moreover, to rid the leach solution of iron, usually an iron cake is formed and, in precipitating the iron, nickel and copper values are absorbed which are especially difficult to recover. In fact, considerable nickel and copper values are lost because it is not economically feasible to recover them from the iron cake.

It is the object of this invention to separate and recover the nonferrous metals from nickel-copper mattes. It is another object to recover nickel from such mattes by a process which has a high degree of nickel extraction efficiency. It is another object to isolate nickel from such mattes in a form of a high quality product suitable for industrial use with minimal additional purification steps. It is a further object to recover precious metals from nickel-copper mattes by an economical process. It is an additional object to provide a hydrometallurgical process for the recovery of metals from nickel-copper mattes which is improved in that it avoids the problem of waste sulfur disposal. It is still an additional object to provide a hydrometallurgical process for the recovery of metal values which avoids the problem of loss of nickel values in an iron cake, formed for the purpose of removing iron from the leach solution.

These and other objects are accomplished in the process of the present invention by the steps which include the oxidative leach of the matte under noncorrosive conditions and equilibration of the oxidative leach material under conditions for effective selective separation of the nickel and copper.

THE INVENTION

Briefly, in accordance with this invention the nickel-copper matte is first treated to effect the selective separation of nickel from the matte by a method comprising slurrying the matte in finely divided form in water, subjecting the matte to an oxidative pressure leach, equilibrating the pressure leached solution at a pH of 5.35 ± 0.3, and separating such equilibrated solution from the residue.

At the indicated pH of 5.35 ± 0.3 the equilibrated liquid product withdrawn is a high quality nickel product in the form of nickel sulfate. Not only is the nickel product of sufficiently high grade to be directly marketable with minimal additional treatment, but the nickel is recovered from the matte with exceptionally high efficiency. Because of the effective removal of the nickel, the treatment of the resultant nickel depleted residue for the recovery of other metal values is made relatively simple.

It is therefore a further embodiment of the present invention to selectively separate the nickel from the matte and then to separate copper from iron and precious metals by a treatment comprising subjecting the resultant nickel depleted residue to an acid leach at a pH of preferably 3.5 ± 0.7 under mild conditions. Under these conditions copper goes into solution, and iron and precious metals remain in the residue.

The resultant mild leach solution, which has an enriched copper content (relative to the matte), and the resultant mild leach residue, which has an enriched precious metal content (relative to the matte), can be treated for the recovery of these values using any one of a number of well-known techniques. For example, the copper may now be recovered by an electrofining technique or crystallized as copper sulfate. It will be noted, however, that for some purposes no additional purification steps of the copper product are required. The precious metals include Ag, Au, Pt, Pd, Rh, Ru, Ir, and Os. These metal values may be recovered, for example, by subjecting the residue to a strong acidic leach, separating the bulk of the insoluble precious metals from the iron solution and recovering any soluble values by cementation.

As noted above, it is an essential feature of the present invention that nickel is first separated from the matte by a sequence of steps including the oxidative pressure leach of the slurry followed by an equilibration of the resultant pressure leached solution at a pH of 5.35 ± 0.3. This method achieves by a simple, rapid, and economically sound method the objective of efficient and rapid recovery of a high-quality nickel product in a form that is suitable for producing a marketable product with, at most only minimal purification required. It has been found, for example, that in accordance with this process nickel can be extracted from the matte with about 85 percent efficiency and greater. It will be further noted that the

sulfur content of the matte is adjusted to a level equivalent to that required for obtaining nickel sulfate, with substantially no other sulfur product remaining. Thus, in addition to obtaining the high-purity product, there is the additional advantage of avoiding the difficult problem of disposal of waste sulfur. A further advantage, previously pointed out is that the selective removal of the nickel from the matte simplifies the recovery of metal values other than nickel.

As an additional aspect of this invention the sulfur content of the matte is adjusted as an initial step, before the pressure leach, so that the total sulfur content is equivalent to just the nickel content on a molar basis.

According to still another aspect of this invention, the nickel can be recovered from matte in even greater yield by subjecting the nickel depleted residue, formed on pH adjustment of the product of the pressure leach, to a further treatment before the mild leach step, which treatment comprises slurrying the nickel depleted residue in water, equilibrating the slurry at a pH of about 5.35 ± 0.3 and separating the resultant residue from the liquid. Such liquid contains in solution additional nickel product which was carried into the residue. It will be appreciated that while this step improves the yield of the nickel product and further separates nickel from copper, its use is optional, depending not only on the desired nickel recovery, but also on the desired purity and further treatment of the copper enriched residue. Using this technique, recovery of the nickel from the matte can be effected with an efficiency of 90 percent and greater. Up to 99 percent nickel recovery can be achieved by crystallization of copper sulfate from the mild leach solution and returning the mother liquor to the equilibration step.

It will be noted with respect to the precious metals that the nickel copper matte used to illustrate this invention contained 0.16 percent precious metals. The nickel and copper depleted residue resulting from the pH 5.35 ± 0.3 and the mild leach contains the precious metals in a concentration about 4 percent. That means that the precious metals are about 25 times enriched. Thus, in accordance with this invention, the precious metals can be recovered from nickel-copper mattes by a more economical method than heretofore known.

The present invention will be more fully understood by reference to the flow sheet and the detailed examples, which illustrate certain preferred embodiments of the present invention.

THE DRAWINGS

FIG. 1 is a schematic flow diagram, illustrating the various steps of an embodiment of this invention.

FIG. 2 is a graphical representation of titration experiments performed at a temperature of 80° C. The curves show the pH ranges at which nickel, copper, and iron are separated from each other most effectively in accordance with the present invention.

FIG. 3 is a graph showing the ratio of nickel to copper in solution plotted against hours at a pH of 5.2 at 80° C., in the process of this invention. It illustrates the progress of the equilibration step for separating the nickel and copper.

It will be noted that the diagram of FIG. 1 is a detailed representation of steps carried out generally in a preferred embodiment of this invention, without reference to the equipment used for performing such steps. Referring to the diagram:

DRY GRINDING

The nickel-copper matte is dry ground to a size not larger than 100 mesh. Preferably it is ground to minus 325 mesh, the finer particles providing more surface area for reaction with a sulfur adjusting agent. This slurry may be immediately subjected to a pressure leach or, optionally, may have an initial sulfur adjustment step as described below.

SULFUR ADJUSTMENT

In the embodiment of this process including an initial sulfur adjustment, the finely ground matte is dispersed in water to form a slurry and sulfur is added in an amount required to give a total sulfur content equivalent to just the nickel content on a molar basis. That is, the total sulfur content is adjusted such that the molar ratio of nickel to sulfur is 1:1. Generally the nickel-copper mattes are sulfur deficient so that sulfur must be added to adjust the ratio to the nickel content. As indicated, only so much sulfur is added so that the sulfur content is equal to the nickel content alone, mole per mole. However, variations in this ratio can be tolerated since such variations can be cured in a later step in the process, as explained below. In any case, caution should be taken not to add so much sulfur that the pH falls below about 3 in the pressure leach step which follows. In such case, not only will some of the precious metals go into solution but the environment will be corrosive.

It will be noted that the source of added sulfur may be elemental sulfur or a sulfur bearing material. In a preferred embodiment the sulfur content is adjusted with finely divided elemental sulfur. By either subjecting the matte directly to an oxidative leach or by treating the matte directly with elemental sulfur before performing the oxidative pressure leach, the problem of a highly corrosive environment which must be contended with in prior processes is avoided.

The sulfur adjusted slurry is agitated for a period of time sufficient for the sulfur to react with the metals. The reaction time depends on the particle size of the matte and the temperature. Suitably, temperatures in the range of 75° C. ± 10° are used. A preferred temperature range from the point of view of reaction time and convenience is about 75°–80° C. In this range the reaction will go to completion in about 3 to 5 hours.

PRESSURE LEACH

The finely divided matte dispersed in water, and with or without an initial sulfur adjustment is subjected to an oxidative pressure leach step, e.g., in an autoclave. It will be appreciated that the time for the reaction to go to completion, i.e., for sulfides to be converted to sulfates, will depend on the conditions, the length of time decreasing with the increase of oxygen partial pressure and with increase in temperature. Generally the oxidative leach step is conducted at a temperature within the range of about 120° to 250° C. under an oxygen partial pressure in the range of 10 to 600 p.s.i. Under such conditions the reaction will be completed in about 2 to 48 hours. Higher temperature and pressures may be used, resulting in a faster reaction time, however, the severer conditions require more expensive equipment. Typically at a pressure of about 200 p.s.i., the 0_2 partial pressure being about 100 p.s.i., and a temperature of 165° C., the time for reacting matte in a concentration of about 1 pound of matte per gallon is about 20 to 22 hours. At 300 p.s.i., 150 p.s.i., 0_2 pressure, and 180° C. the time is about 10 hours.

An important feature of this pressure leach step, however, is that the time is not a critical factor. It will be noted that, in contrast to known processes, the pH of the pressure leach medium in this present process does not fall to a corrosive level even when there is an initial sulfur adjustment of the matte level. Where elemental sulfur is used as the sulfur adjusting reagent, the initial pH of the feed to the autoclave is about 7, the terminal pH of the leached slurry will be roughly about 3 to 6. Ideally for effective separation of the nickel and copper the pH should be about 5.35 and in the next step the pH is adjusted to 5.35 ± 0.3. This will be evident by reference to FIG. 2 which will be explained below.

EQUILIBRATION & pH ADJUSTMENT FOR NICKEL-COPPER SEPARATION

The variation in pH is caused by variations in the molar ratio of Ni to S, which ideally is 1:1. This variation can be cor-

rected with an acid or base depending on whether the pH must be lowered or raised. If for example, too much sulfur is added the pH will be too low, in such case, the pH is raised, for example, with nickel carbonate, lime, an alkali metal hydroxide, calcium carbonate, or sodium carbonate. The choice of base will depend on the ultimate use of the nickel product. Nickel carbonate is preferred where the high purity is a factor. If too little sulfur is added the pH will be too high, the pH is lowered with, for example, sulfuric acid. It will be appreciated that when there is an initial sulfur adjustment it will be of great advantage to adjust the nickel to sulfur ratio as close as possible to 1:1 initially. Indeed it is one aspect of this invention that the ratio is adjusted substantially at 1:1. Heretofore the advantage of using such sulfur ratio, based on nickel alone, had not been recognized.

In the oxidative pressure leach stage the sulfur values in the matte are oxidized to sulfates and the metallic values are converted to oxyhydrates. As shown in FIG. 2, the copper and nickel can be effectively separated at a pH of about 5.35 ± 0.3. At this pH the copper precipitates out from the aqueous medium as hydrates of copper oxide and nickel goes into solution as nickel sulfate. However, an essential factor for achieving effective separation of the nickel and copper is that the pH adjusted slurry must be maintained at the given separating conditions for a period of time sufficient to permit it to reach equilibrium. At the optimum pH the greatest separation of nickel and copper can be achieved and at equilibrium, the separation of nickel and copper will be substantially complete. The pH adjustment is performed at an elevated temperature, in order to decrease the time to equilibrium, preferably in the range of 75° C. ± 10°. The slurry is held at this temperature and pH until an equilibrium is reached, i.e., until the separation of copper and nickel is substantially complete. Reference to FIG. 3 shows, for example, after maintaining a pH of 5.2 at 85° C. for 6 hours the ratio of nickel to copper in solution is over 1,000:1, parts by weight.

NICKEL RECOVERY

The pH adjusted pressure leached solution is then separated from the residue, e.g., by filtration, at the equilibration temperature. The solution contains, generally, at this point about 85 weight percent of the nickel content of the matte as a high grade nickel sulfate solution.

Optionally, for even greater efficiency in the recovery of nickel, the nickel-depleted residue is reslurried in water and then the pH is adjusted to 5.35 ± 0.3 by the addition of sulfuric acid. In the diagram, the residue is filtered from the aqueous slurry and the filtrate recycled back for pH adjustment with the pressure leached effluent. The ratio of nickel to copper in the solution recovered from the residue is again dependent on the equilibration time, as shown in FIG. 3, and the total recovery of over 90 weight percent nickel can be achieved. This step can be repeated, if desired. The nickel sulfate is crystallized from solution and can be marketed directly without further purification.

MILD LEACH

The nickel depleted residue, which contains hydrated copper oxides, iron hydroxide, and precious metals is then subjected to an acid leach under relatively mild conditions to separate the copper and precious metal values. The mild leach is conducted at a pH of preferably 3.5 ± 0.7 and a temperature of about 75° C. ± 10° C. The pH is adjusted with an acid, preferably sulfuric. As in the previous pH adjustment step, the pH adjusted slurry is equilibrated, i.e., the pH and temperature are maintained for the period of time required for the separation of the copper from iron and precious metals to be substantially complete. The time required will depend on the temperature, generally the time decreasing with temperature increase.

REMOVAL OF IRON

Usually there is little iron in the copper-nickel mattes, but some of the iron present will appear in the solution as Fe^{++}. The Fe^{++} may be removed by conversion to Fe^{+++}, which will precipitate out in each leach residue under the given conditions. The conversion to the trivalent iron can be achieved by well-known techniques such as by the use of oxygen in the pressure leach stage and by bubbling air through the solution during the mild leach step or by adding hydrogen peroxide. The iron precipitates out as $Fe(OH)_3$ with the leach residues, as shown in FIG. 2.

RECOVERY OF COPPER

The mild leach solution is filtered at the equilibration temperature to separate the copper sulfate, when H_2SO_4 is the reagent, in solution from the residue containing iron and the precious metals.

The copper sulfate is then recovered from the mild acid leach solution. Generally about 85 weight percent of the copper sulfate can be crystallized out of the solution. This copper sulfate precipitate contains about 85 weight percent of the copper content of the matte and generally a maximum of only about 5 weight percent of the metal value of this product is nickel. Thus the copper sulfate may be used as is, or further refined, e.g., electrolytically, as desired.

The remaining solution contains nickel and copper in a ratio of 2 to 1. This solution may be adjusted to a pH of 5.35 ± 0.3 e.g., in a recycle step, and additional nickel values recovered. In this way the total nickel recovery can be up to 99 percent.

RECOVERY OF PRECIOUS METALS

The mild leach residue which contains the precious metals and iron is treated for the recovery of the precious metals by well-known techniques, as indicated above. It will be noted that the precious metal content of the mild leach residue is generally greatly increased over the precious metal content of the original matte, thus making the precious metal recovery more economical.

Referring now to FIG. 2: The curves show the pH at which Ni^{++}, Cu^{++}, and Fe^{+++} go into solution as the sulfates in accordance with this invention, as determined by titration at a temperature of 80° C. In the titration experiments measured amounts of $Ni(OH)_2$, $Cu(OH)_2$ and $Fe(OH)_3$ were slurried in water. A 0.2N H_2SO_4 solution was used for the titration. The values of Ni, Cu and Fe in the solution were assayed by atomic absorption. At a pH above 6.9, there is virtually no nickel, copper or iron in solution. As sulfuric acid is added and the pH falls below about 6.9, nickel begins to go into solution as nickel sulfate, and at about 5.6 substantially all the nickel is in solution. Copper starts to go into solution as the sulfate at a pH of about 5.05. Therefore, to separate the nickel from the copper, the pH should be maintained between the limits of about 5.35 ± 0.3. Similarly Cu^{++} can be separated from Fe^{+++} at a pH of about 3.5 ± 0.7.

EXAMPLE 1A

A nickel-copper matte, having the following typical assay (by weight): 47.10 percent Ni, 27.55 percent Cu, 2.25 percent Fe, 0.0988 percent Pt, 0.0545 percent Pd, 0.00436 percent Au, and 19 percent S, is dry ground to a particle size of minus 325-mesh Standard Tyler Screen. A 300 gram sample of the finely ground matte and 20.8 grams of elemental sulfur in powder form is slurried in 1 liter of water for 5 hours at a temperature of 80° C. The slurry is then pressure leached in an autoclave with 100 p.s.i. oxygen overpressure at 165° C. for 22 hours. The reacted slurry, which has a pH of 4.4 at 20° C., is adjusted with NaOH to a pH of 5.1 at 80° C. and the slurry is maintained at these conditions for 6 hours. (It will be noted that the alkali used for the purpose of this test is NaOH. Where purity is a factor, a reagent such as $NiCO_3$ is preferred.) The resultant material is filtered at 80° C. and the

filtrate found to have the following composition: 117.1 grams Ni, 0.1 grams Cu, and no iron or precious metals. The nickel recovered in solution corresponds to about 83 percent of the total nickel content and the nickel to copper ratio in solution is approximately 1,171:1, parts by weight.

EXAMPLE 1B

The residue from Example 1A is subjected to a mild leach with H_2SO_4 at 80° C. for 4 hours at a pH of 3.1. A small amount of H_2O_2 is added to this slurry one-half hour before filtration. The resultant material is filtered at 80° C. This procedure is repeated with the mild leach residue and the filtrates are combined.

The combined filtrate is concentrated at 65° C. under a vacuum and $CuSO_4.5H_2O$ crystallizes out of solution. Thereafter the crystals are filtered from the mother liquor. The crystals are dried at 180° C. to obtain the anhydrous sulfate. The total amount of sulfate is 188.5 grams. Assay of the sulfate shows: 71.1 grams Cu in the form of $CuSO_4$, 3.96 grams Ni in the form of $NiSO_4$, and no iron.

Assay of the mother liquor shows: 18.2 grams Ni, 10.2 grams Cu, and 0.3 grams Fe. This result demonstrates that copper sulfate can be crystallized until the ratio of nickel to copper in the mother liquor is equal to about 2:1. In the process of this invention this mother liquor will be returned to the equilibration step (as shown in Example 1A) at a pH of 5.35 ± 0.3 for further recovery of nickel values.

EXAMPLE 2A

The nickel-copper matte having the same composition as that used in Example 1A is dry ground as described in Example 1A and a 300 gram sample of the finely ground matte is slurried in 1 liter of water. In this example, however, no sulfur is added. This slurry is pressure leached in an autoclave at a total pressure of 200 p.s.i. at 180° C. for 12 hours. The reacted slurry, which has a pH of 5.8 at 80° C. is adjusted with sulfuric acid to a pH of 5.2 at 80° C. The slurry is maintained at these conditions for 16 hours. The resultant material is filtered at 80° C. The resultant nickel depleted residue is reslurried in water, the slurry is adjusted to a pH of 5.2 at 80° C. and the slurry is maintained at these conditions for 16 hours. The resultant material is filtered at 80° C. and the filter solutions of both equilibration steps are combined. The filtrate is found to have the following values: 128.1 grams Ni, no Fe, no Cu, and no precious metals. The nickel recovered in solution corresponds to 90.5 percent of the total nickel content.

EXAMPLE 2B

The residue from Example 2A is subjected to a mild leach with H_2SO_4 at 80° C. for 16 hours at a pH of 3.1. During this period air is continuously bubbled through the slurry. The resultant material is filtered at 80° C. This procedure is repeated with the mild leach residue and the filtrates are combined.

The combined filtrates are concentrated at 65° C. under a vacuum and $CuSO_4.5H_2O$ crystallizes out of the solution. The crystals are filtered from the mother liquor and then dried at 180° C. to obtain the anhydrous sulfate. The total amount of dry sulfate is 201.5 grams. Assay of this sulfate shows: 76.8 grams Cu in the form of $CuSO_4$, 3.2 grams Ni in the form of $NISO_4$ and no Fe.

The mother liquor, on assay, shows 8.1 grams Ni, 4.4 grams Cu, 0.1 grams Fe. The result shows that $CuSO_4.5H_2O$ can be crystallized until the ratio of nickel to copper in the mother liquor is equal to 2:1. In the process of this invention the mother liquor will be returned to the equilibration step (shown in Example 2A) at a pH of 5.35 ± 0.3 for further recovery of nickel values.

I claim:

1. A process for selectively recovering nickel from a nickel-copper matte consisting essentially of nickel, copper, sulfur and minor amounts of iron and precious metals and containing a molar ratio of nickel to sulfur in excess of 1:1, which process comprises:
   a. dispersing the matte in finely divided form in water to form an aqueous slurry, and adding sufficient sulfur-bearing material to adjust the Ni:S molar ratio to about 1:1,
   b. subjecting the slurry to an oxidative pressure leach at an elevated temperature,
   c. equilibrating the resultant pressure leached slurry at a pH of 5.35 ± 0.3 to selectively separate nickel values from the slurry, and
   d. separating at the equilibration conditions the pH adjusted nickel containing solution from the insoluble nickel depleted residue.

2. The process of claim 1 wherein the oxidative pressure leach is effected at a temperature in the range of about 120° to 250° C. and under oxygen partial pressure in the range of about 10–600 pounds per square inch for a period of 2–48 hours.

3. The process of claim 1 wherein the pH of the resultant pressure leached slurry is less than 5.35 at 80° C. and the reagent to raise the pH to the optimum pH for separation of nickel and copper is nickel carbonate.

4. The process of claim 1 wherein the pH of the resultant pressure leached slurry is greater than 5.35 at 80° C. and the reagent to lower the pH to the optimum pH for separation of nickel and copper is sulfuric acid.

5. The process of claim 1 wherein the insoluble nickel depleted residue separated from the pH adjusted oxidative leach solution is treated for further recovery of nickel values by the steps comprising, slurrying such residue in water, equilibrating such slurry at a pH of 5.35 ± 0.3, and separating the solution containing additional nickel values from the residue.

6. The process of claim 1 wherein the sulfur content of the matte dispersed in the water is adjusted by the addition of elemental sulfur powder as the sulfur-bearing material and the slurry is heated to a temperature in the range of about 75° C. ± 10°.

7. A process for extracting nickel and copper metal values from a matte consisting essentially of nickel, copper, sulfur and minor amounts of iron and precious metals and containing a molar ratio of nickel to sulfur in excess of 1:1, which process comprises:
   a. dispersing the matte in finely divided form in water to form an aqueous slurry, and adding sufficient sulfur-bearing material to adjust the Ni:S molar ratio to about 1:1,
   b. subjecting the slurry to an oxidative pressure leach, at an elevated temperature,
   c. equilibrating the resultant pressure leached slurry at a pH of 5.35 ± 0.3 to selectively separate nickel values from the slurry,
   d. separating at the equilibration conditions the pH adjusted nickel containing solution from the nickel depleted insoluble residue,
   e. subjecting the insoluble nickel depleted residue to a mild acid leach and equilibration at a pH of 3.5 ± 0.7 to dissolve the copper values therefrom, and
   f. separating at the equilibration conditions the mild acid leach solution containing the copper values from the residue containing the precious metals.

8. The process of claim 7 wherein the mild acid leach is effected at a temperature in the range of 75° C. ± 10°.

9. The process of claim 7 wherein the pH of the mild leach solution is adjusted with sulfuric acid.

10. The process of claim 8 wherein the mild acid leach solution is subjected to mild oxidation conditions to oxidize Fe^{++} to Fe^{+++}.

11. The process of claim 9 wherein the separated mild acid leach solution is further treated for the recovery of additional nickel values by concentrating said solution to effect crystallization of copper sulfate therefrom, and recycling the mother liquor to the pressure leached slurry.

12. The process of claim 7 wherein the residue containing precious metals is treated for the recovery of precious metals.