

# UNITED STATES PATENT OFFICE.

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PROCESS FOR THE TREATMENT AND SEPARATION OF COMPLEX SULFID ORES.

1,078,779.

Specification of Letters Patent.

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No Drawing.

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To all whom it may concern:

Be it known that I, TORMOD REINERT FORLAND, B. Sc., subject of the King of Norway, residing at Broken Hill, in the State of New South Wales, Australia, have invented certain new and useful Improvements in Processes for the Treatment and Separation of Complex Sulfid Ores; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention has been devised to provide an improved process of obtaining the valuable constituents from that class of ores known as complex sulfid ores; I would also have it understood that the process and means employed therein are of course applicable with economy and efficiency to sulfid ores of a simple nature.

I have discovered that if finely crushed sulfid ores are treated with chlorine gas in a sufficiently heated furnace it is possible to separate practically the whole of the sulfids from the gangue as chlorids and that these distil off at comparatively low temperatures and are collected. On the other hand if a lower temperature is used in the furnace some kind of chlorids may be distilled off while others are retained with the gangue for further treatment as may be wanted. I also discovered that the vaporized chlorids could be practically separated from each other in a molten state by condensing in fractions. Having separated the chlorids from each other the metals can be obtained by electrolysis or otherwise, and the chlorine is recovered for use upon further amounts of ore.

Some of the chemical reactions which take place in the furnace are represented by the following equations, viz:—

A. Zinc ores (concentrates, slimes, etc.)

Content: ZnS, PbS, FeS<sub>2</sub>, Ag<sub>2</sub>S and gangue.

1.  $2\text{ZnS} + 6\text{Cl} = 2\text{ZnCl}_2 + \text{S}_2\text{Cl}_2$ .
2.  $2\text{PbS} + 6\text{Cl} = 2\text{PbCl}_2 + \text{S}_2\text{Cl}_2$ .
3.  $2\text{FeS}_2 + 10\text{Cl} = \text{Fe}_2\text{Cl}_6 + 2\text{S}_2\text{Cl}_2$ .
4.  $2\text{Ag}_2\text{S} + 2\text{Cl} = 4\text{Ag} + \text{S}_2\text{Cl}_2$ .

Some of the iron sulfid however will also

react after the following equation when the temperature is above 500° C.



This combination will when cooled in the condenser if in contact with Cl or S<sub>2</sub>Cl<sub>2</sub> take up more chlorine and form Fe<sub>2</sub>Cl<sub>6</sub>.

B. Complex copper-nickel ore.

Content: CuS, NiS, ZnS, PbS, FeS<sub>2</sub>, and gangue.

1.  $2\text{CuS} + 4\text{Cl} = \text{Cu}_2\text{Cl}_2 + \text{S}_2\text{Cl}_2$ .
2.  $2\text{NiS} + 6\text{Cl} = 2\text{NiCl}_2 + \text{S}_2\text{Cl}_2$ .

(For zinc, lead and iron, see above.)

The boiling points for the above chlorids are:—

|                                       |               |
|---------------------------------------|---------------|
| ZnCl <sub>2</sub> -----               | 730° C.       |
| PbCl <sub>2</sub> -----               | about 900° C. |
| Fe <sub>2</sub> Cl <sub>6</sub> ----- | 280° C.       |
| Cu <sub>2</sub> Cl <sub>2</sub> ----- | about 900° C. |
| NiCl <sub>2</sub> -----               | about 800° C. |

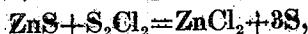
The sulfids referred to in this specification may be crude ores, concentrates, slimes, or tailings and they may contain one or more sulfids, and the term "ores" in the appended claims is intended to cover the same.

Chlorin is preferably used in my process for reacting on the sulfids but I may use any suitable halogen.

The degree of fineness to which the sulfid ores, etc., have to be crushed depends upon the nature of the ore. The fineness should be that which will secure the most complete chlorination.

It is not necessary but preferably the sulfid ores, etc., should be free from moisture. The distillation can also be complete even if a small proportion of the sulfids have previously been oxidized to oxids or sulfates.

The quantity of chlorine required depends mainly upon the percentage and nature of sulfids present and should be so regulated to insure complete chlorination without waste. In practice it is found that a smaller quantity of chlorine than what is required to saturate the sulfids may be used with advantage. This is due to S<sub>2</sub>Cl<sub>2</sub> acting upon the sulfids as free chlorine forming metal chlorids and free sulfur, for example:—



so that all the formed S<sub>2</sub>Cl<sub>2</sub> can be reduced

to free sulfur simply by returning it to the furnace. From this it will be seen that the quantity of chlorin to be used for certain classes of ores will correspond to the quantity of metals present.

The temperature in the furnace is regulated by the object in view. If complete volatilization of all the chlorids is wanted, then the furnace must be heated to the boiling of the least volatile chlorid. The length of time necessary for the reaction between the chlorin and the sulfids depends upon many factors such as the fineness of the ore, the method of contact, the temperature, etc. The necessary temperature can be obtained and maintained solely by the formation heat of the chlorids or by exterior artificial heating, or by both. As the formation heat of the chlorids is very high, it will be possible also with a comparatively low grade ore to obtain the required temperature from the heat of the reactions.

To work my process the sulfid ores, etc., are crushed to a suitable degree of fineness and fed into a furnace which may be of a converter type or any other suitable form. The chlorin gas is passed or forced through the charge in such a way that a good contact will be effected and at such a temperature that a distillation takes place. The vaporized chlorids can if wanted be first passed through a dust collector and therefrom into a condensing arrangement where they are condensed into one or more fractions as are desired. As an example supposing I wanted to separate the chlorids of lead, zinc and iron. The first condenser would be maintained at a temperature just below the boiling point of  $PbCl_2$ , i. e.  $900^{\circ} C.$ , the second condenser would be under  $730^{\circ} C.$ , and the third condenser would be maintained under  $280^{\circ} C.$ , and so on. Also they may be separated in two fractions, one under  $730^{\circ} C.$ , thus obtaining a mixture of lead and zinc chlorids, and the second under  $280^{\circ} C.$ , thus obtaining iron chlorid and sulfur. The spent ores, etc., or residues which may be discharged continuously or periodically will if a complete distillation were effected practically only contain the gold and silver from the original ore as the chlorids of these metals do not distil but disassociate into metals and chlorin at a comparatively low temperature. These metals may be extracted from the residues by the cyanid or other well known processes. The fraction or fractions collect in a molten state or sublimate in the respective condenser or condensers and are tapped therefrom for further treatment for example electrolyzing whereby the end products will be metals and free chlorin which latter can be used over and over again with some losses which are

made up as required. On the other hand a partial distillation could be effected, for example for an ore containing lead, zinc and iron, or copper and iron, if the temperature in the furnace were kept at about  $500^{\circ} C.$  the residue would still contain the chlorids of lead and zinc or copper, but would be free from chlorids of iron and other chlorids of low boiling point (lead would be free from antimony). In this case these residues could easily be treated for the recovery of these metals. It would seem that by varying the temperature of the furnace I have an easy method of distilling off any objectionable chlorids which I may wish to remove and keep others which it would be profitable to utilize.

I claim:—

1. A method of chloridizing sulfid ores, of zinc, lead, iron, copper, nickel, arsenic, silver and the like, which comprises treating said ore with chlorin gas, at a temperature at which said metals, with the exception of silver, are converted into chlorids, and certain of said chlorids are volatilized, and chlorid of sulfur is formed and volatilized; passing said volatilized chlorids, together with any remaining chlorin and chlorid of sulfur, and other gases into contact with a further amount of said ore, at a temperature at which the chlorid of sulfur will attack said metal sulfids, and form chlorids of said metals except silver, and free sulfur and at which temperature certain only, of said chlorids are volatile.

2. A method of producing halogen compounds from sulfid ores of zinc, lead, iron, copper, nickel, arsenic, silver and the like, which comprises treating said ore with a halogen reagent in the form of a gas, at a temperature at which said metals, except silver, are converted into halogen compounds and certain of said compounds are volatilized, and a halogen compound of sulfur is formed and volatilized; passing said volatilized halogen compounds of sulfur and metals, together with any unchanged halogen reagent remaining, and other gases present, into contact with a further amount of sulfid ore, at a temperature at which the sulfid-halogen compound and free halogen will attack said sulfid ore, and form halogen compounds of said metals except silver, and free sulfur, at which temperature certain only of said metal-halogen compounds are volatile.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

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Witnesses:

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