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UNITED STATES PATENT OFFICE

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PROCESS OF ORE FLOTATION

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The present invention relates to the froth flotation of ores, including sulfid ores, and other metalliferous materials, by the use of certain classes of tri-thiocarbonate compounds as hereinafter discussed. The invention is based on the use of the mono-ester acids or their alkali or alkaline earth metal salts. Thus the salts of mono-ethyl tri-thiocarbonic acid (or of other mono-alkyl or mono-aryl tri-thiocarbonic acids) or the acids themselves constitute excellent collecting agents for use in flotation. These compounds can be prepared, for example, by reaction of mercaptans, carbon bisulfide, and caustic alkali or sodium sulfide.

We give the following classification of the "tri-thiocarbonate type" of compounds which can be conveniently employed in flotation in accordance with the present invention: (*a*) the acid esters of tri-thiocarbonic acid, including the alkyl and the aryl derivatives such as, for example, the mono-ethyl ester, the mono-propyl ester and the mono-phenyl derivative; (*b*) the metallic salts of the mono-ester acids of tri-thiocarbonic acid such as, for example, the sodium, potassium or barium salts of mono-ethyl tri-thiocarbonic acid; (*c*) the ammonium salts of the mono-ester acids of tri-thiocarbonic acid such as, for example, ammonium ethyl tri-thiocarbonate; (*d*) the salts of the mono-ester acids of tri-thiocarbonic acid formed with nitrogenous bases, such as, for example, the mono ethyl tri-thiocarbonate salts of hydroxylamine or pyridine. (In these salts the nitrogenous base, which is a substituted ammonia, may be considered as functioning somewhat like a metal in the compound, the reaction being analogous to the reaction of ammonia with an acid to form ammonium salts.)

The substances above referred to come within the generic formula

$$S=C\begin{matrix}SR\\SM\end{matrix},$$

in which R may represent an alkyl or aryl radical, and M may represent an inorganic radical (such as the ammonium radical), alkali or alkaline earth metal, hydrogen, or substituted ammonium complex (for example that obtained by the reaction of a nitrogenous base with a tri-thiocarbonic acid compound. The characters M and R are used in this sense hereinafter.

In order to make ourselves entirely clear, we will state that the tri-thiocarbonic acid is a well known substance having the formula $CS(SH)_2$. Ethyl tri-thiocarbonic acid (which can be called hydrogen mono-ethyl tri-thiocarbonate), is likewise a well known substance, having the formula $SC_2H_5—CS—SH$. While these substances are more or less well known, having been described in text books of chemistry for many years, they do not seem to have heretofore been employed or suggested for employment in the art of mineral flotation. According to our researches, these substances are active flotation agents, and the salts of the alkyl-tri-thiocarbonic acids are found to be especially active. An illustrative example would be $C_2H_5S—CS—SK$. While these substances have great selective action or collecting power for sulfid minerals, in the flotation operation, they do not have any substantial frothing properties, so that an appropriate frothing agent such as pine oil should be employed in conjunction therewith, in carrying out the froth flotation operation. In carrying out the flotation operation it is preferable to use either a neutral or alkaline circuit depending on the character of the ore. In an acid circuit the salts of the acid ester tri-thiocarbonate compounds are unstable, the degree of instability depending on the acidity of the circuit and on the particular compound used. A slightly acid circuit can be successfully used, however, if sufficient reagent is added to take care of the loss due to decomposition during the flotation operation, for example, an acidity of fifteen hundredths per cent (0.15%) of sulfuric acid was successfully used with sodium ethyl tri-thiocarbonate on a copper sulfide ore by doubling the amount of reagent employed with the same ore in a lime circuit.

As a specific example of the process, to which the invention of the present case is not restricted, the following is given:—

An ore containing copper sulfid was made into a pulp with water, and an amount of sodium ethyl tri-thiocarbonate was added

equivalent to one-tenth of a pound (0.1 lb.) of this material to a ton of the dry ore. An amount of pine oil was then added, as a frothing agent, equivalent to .22 lb. per ton of ore, and 4 lbs. of hydrated lime was added, and the mixture was then subjected to aeration flotation, in a Janney machine of the ordinary construction. We were able in this manner to separate a high grade concentrate, and to leave a tailing containing practically no copper.

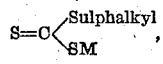
The quantity of tri-thiocarbonate compound to be used in the flotation operation may be varied, depending upon the specific ore under treatment and other factors. We find that from five hundredths (0.05 lb.) pound to two pounds (2 lbs.) or more of tri-thiocarbonate compound per ton of dry ore can be used successfully in floating ores of this character.

It will be understood that the tri-thiocarbonate compound can be used as the sole or essential selecting or collecting agent, or it can be used in conjunction with various oily materials, such as are shown in the art for this purpose. The tri-thiocarbonate compound, either alone or with other flotation agents can be incorporated with the ore while the same is being wet-ground, for example in a tube mill. In other modifications, the ore can be ground without the addition of the tri-thiocarbonate or oily flotation or frothing agents, and these can subsequently be dissolved or emulsified and added to the water with which the pulp is to be formed, or the tri-thiocarbonate can be added to the pulp of ore and water and dissolved or emulsified therewith. The order of adding the ore, water and flotation agent and frothing agent, accordingly can be varied to suit the particular ore under treatment or to suit the conditions of the plant in which the operation is to be conducted.

What is claimed is:

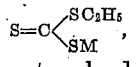
1. A process which comprises subjecting metalliferous material to a froth flotation treatment while associated with a tri-thiocarbonate substance containing one hydrocarbon radical only replacing a hydrogen atom of the tri-thiocarbonic acid.

2. Froth flotation of material in the presence of an agent including a tri-thiocarbonate of the type



in which M represents hydrogen or a metal or an inorganic radical acting as a metal or a substituted ammonium complex.

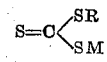
3. The step of froth flotation of material in the presence of an agent including a tri-thiocarbonate of the type



in which M represents a hydrogen or a metal or an inorganic radical acting as a metal or a substituted ammonium complex.

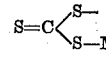
4. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of an alkali metal salt of monoethyl tri-thiocarbonic acid.

5. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a derivative of tri-thiocarbonate having the following structural formula:



in which R is an alkyl or aryl group and M is an alkali metal.

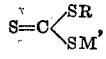
6. In the art of concentrating ores, the herein described step which comprises subjecting the ore to froth flotation in the presence of a compound containing the radical



in which M represents hydrogen or metal or an inorganic radical acting as a metal or a substituted ammonium complex.

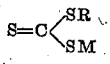
7. In the process of concentrating ores and minerals by froth flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of an organic tri-thiocarbonate compound of a substance selected from the group consisting of metals, hydrogen, and radicals functioning as a metal.

8. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the material to be concentrated in the form of a pulp to a froth flotation operation in the presence of an organic-inorganic derivative of tri-thiocarbonic acid having the structural formula:



in which R is an alkyl or aryl group and M represents hydrogen or a metal or an inorganic radical acting as a metal or a substituted ammonium complex.

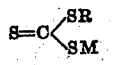
9. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of an organic-inorganic derivative of tri-thiocarbonic acid having the following structural formula:



where R represents a hydrocarbon radical and M represents metal, hydrogen, or a radical functioning like a metal.

10. In the process of concentrating ores and minerals by flotation, the step which com-

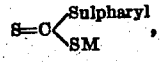
prises subjecting the same in the form of a pulp to a froth flotation operation in the presence of a derivative of tri-thiocarbonic acid having the following structural formula:



in which R is an alkyl or aryl group and M is a metal hydrogen or an inorganic radical

11. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of an alkali metal salt of monoethyl tri-thiocarbonic acid.

12. A process of flotation in the presence of an agent including a tri-thiocarbonate of the type



in which M represents hydrogen or a metal or an inorganic radical acting as a metal or a substituted ammonium complex.

13. In the process of concentrating ores and minerals by flotation, the step, which comprises subjecting the same in the form of a pulp to a froth flotation operation in the presence of a nitrogenous base salt of a monoester of a tri-thiocarbonic acid.

14. In the process of concentrating ores and minerals by flotation, the step, which comprises subjecting the same in the form of pulp to a froth flotation operation in the presence of a pyridine base salt of a monoester of tri-thiocarbonic acid.

In testimony whereof we have signed our names to this specification.

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