Nov. 11, 1947. S. P. MOYER 2,430,778

DIFFERENTIAL FROTH FLOTATION OF CHALCOPYRITE-SPHALERITE ORES

Filed July 9, 1945

FIG. 2.

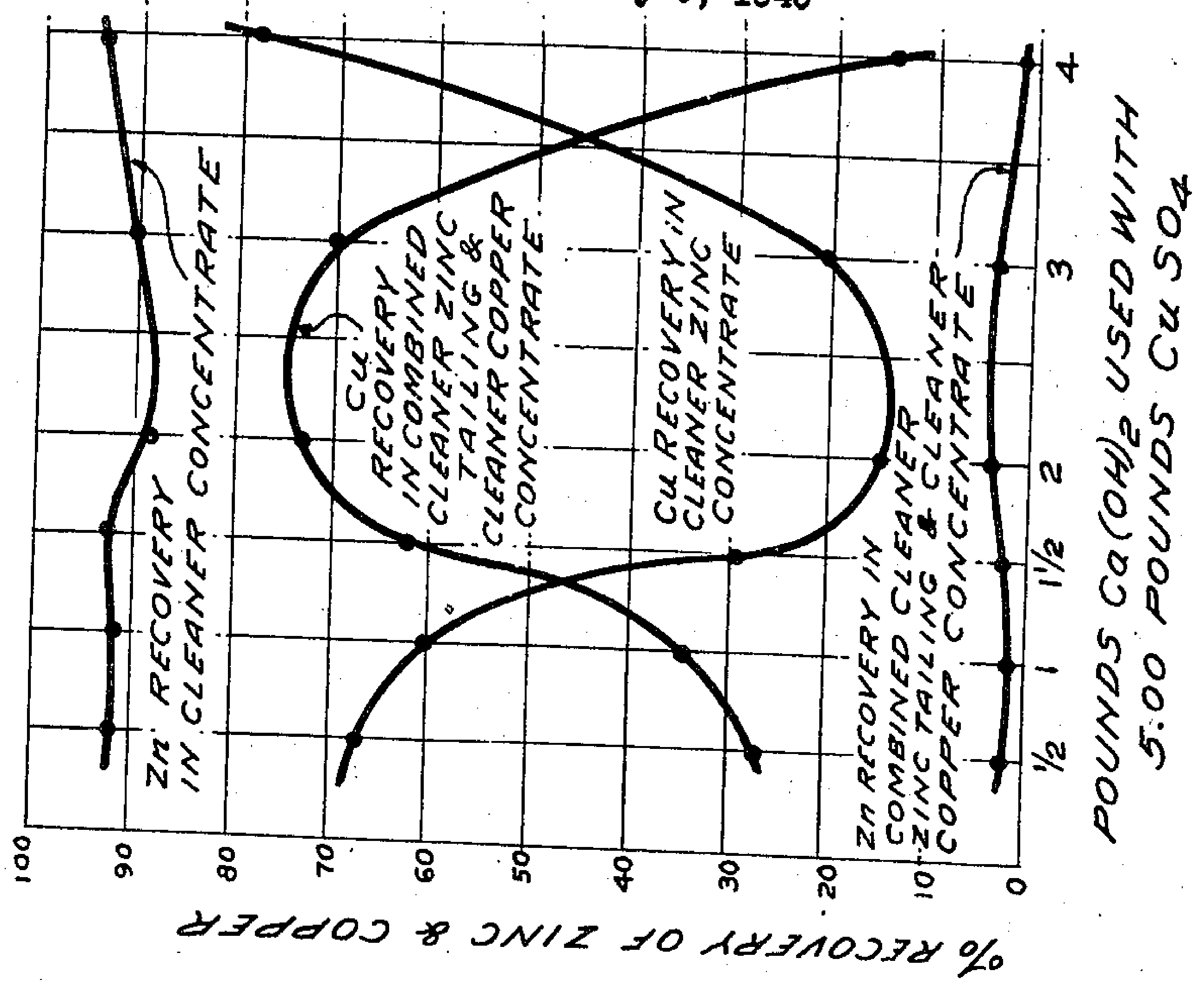
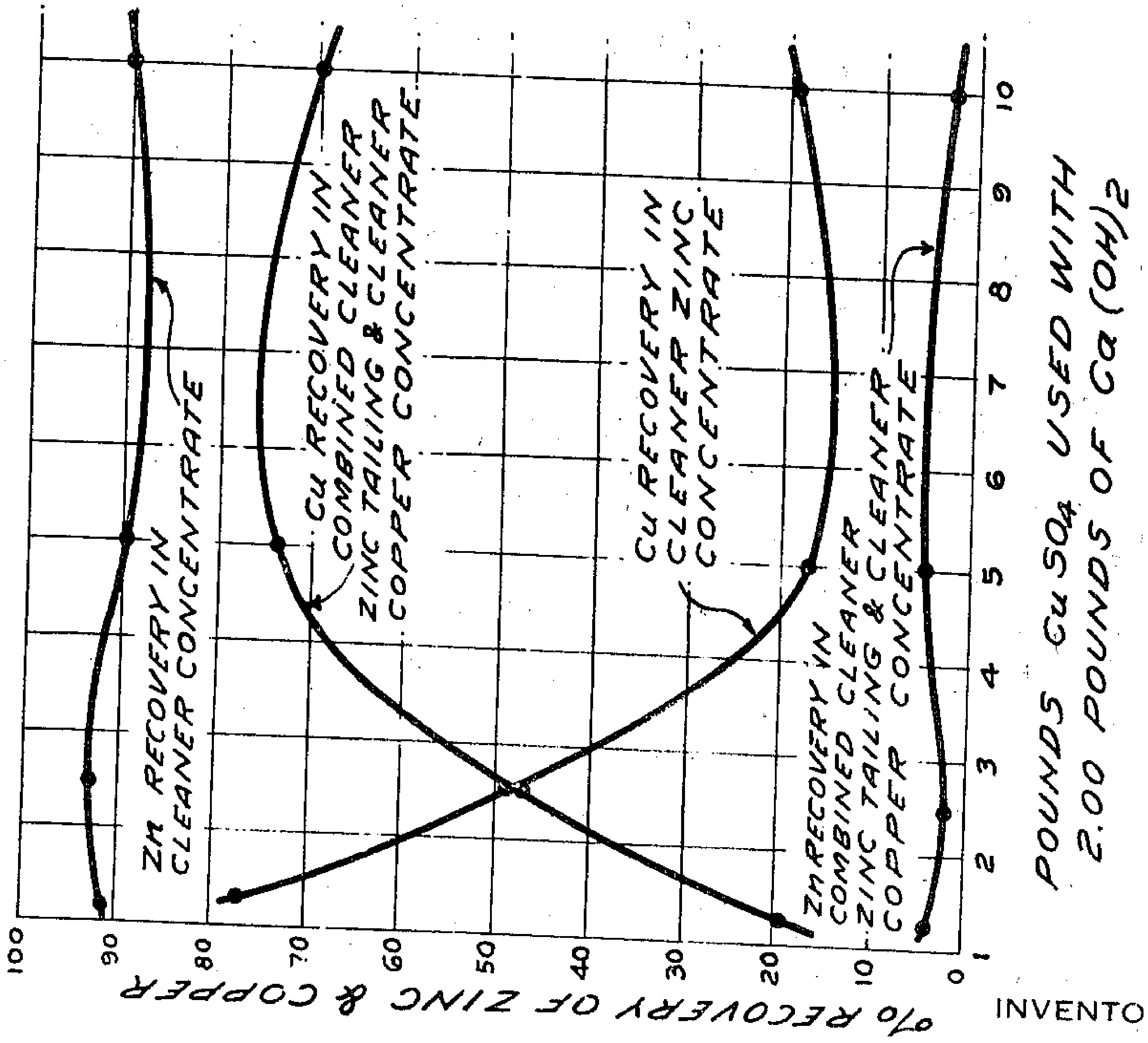


FIG. 1.



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DIFFERENTIAL FROTH FLOTATION OF CHALCOPYRITE-SPHALERITE ORES

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This invention relates to a process of separating sphalerite from chalcopyrite in ores containing both minerals by means of a selective or froth flotation process.

The differential separation of copper and zinc from ores which contain both minerals is a common procedure in ore dressing. In general the process used is a two-step froth flotation process in which the first step constitutes a copper float, commonly using depressants for zinc minerals, such as cyanides. The tailing from the rougher float is then activated with copper sulfate and the zinc floated in the form of a zinc concentrate. In other words, the standard flotation process operates by reason of the fact that in many ores the copper minerals float more readily than the zinc minerals and can be separated from them by a differential flotation procedure.

Some copper zinc ores, notably certain ores occurring in Canada and the United States, which contain copper in the form of chalcopyrite and zinc in the form of sphalerite, have not proved to be very amenable to the ordinary differential float, the selectivity of the two steps being inadequate and there being excessive zinc in the copper concentrate and copper in the zinc concentrate.

According to the present invention I have found that under certain very sharply restricted conditions it is possible to treat ores containing copper largely in the form of chalcopyrite and zinc in the form of sphalerite by differential flotation process in which the results are exactly the reverse of the ordinary procedure. In other words, by the process of the present invention it is possible to float sphalerite and leave behind chalcopyrite. By means of the present invention it is possible to effectively beneficiate copper zinc ores which were not readily amenable to the ordinary process.

The first step in the process of the present invention, i. e. the zinc float which is, of course, the critical step, depends on the use of relatively large amounts of copper sulfate, at least about 5 lbs./ton of ore associated with rigidly restricted ranges of lime. When the effective lime is in the range between a minimum of about 1¾ lbs./ton and a maximum of about 3 lbs./ton the sphalerite floats in a zinc concentrate having but little copper and the tailing can then be treated with additional lime, preferably bringing the amount of lime up to 4 lbs./ton or more, and a high grade copper concentrate can then be floated.

The water in which the lime and copper sulfate are added to the ore during conditioning is important. I have found that it is necessary for best results to condition the ore with a lime first and then to add the copper sulfate. If the copper sulfate is added first optimum results are not

obtained. This may be due to the fact that the copper sulfate might react with lime to use up a portion of it and decrease the amount available for actual conditioning of the ore particles.

The present invention is not limited to a particular sulfide promoter combination. However, by far the best results are obtained by the use of reagents of the dithiophosphate type, preferably dialkyl dithiophosphate, such as sodium diethyl dithiophosphate. Other sulfide promoters may be used but it is difficult to obtain satisfactory control of the first step under practical operating conditions. Therefore, the dithiophosphates constitute the preferred reagents. In the second step, the copper float, any suitable promoter for chalcopyrite may be used. As the pulp already contains dithiophosphate from the zinc float, it is convenient, although not necessary, to add further amounts of dithiophosphates for the second, or copper float.

It is an advantage of the present invention that operating conditions are not critical except that the lime concentration must be rigidly maintained within the limits set and generally good flotation practice may be employed. In line with common flotation practice, it is thus desirable although not essential, with all ores, to clean both zinc and copper concentrates. As is common in flotation operations the optimum time of conditioning with the various reagents will vary from ore to ore. It is an advantage of the present invention that the conditioning time is not critical, and it is only necessary to condition thoroughly for a sufficient time to permit the reagents used in conditioning to act on the mineral particles to produce the surface alteration thereof on which the present process depends.

The invention will be described in greater detail in conjunction with the following examples. In these examples the sulfide copper was chalcopyrite and the sulfide zinc sphalerite.

Example I

An ore having approximately the following analysis:

Total copper	3.39% Cu
Non-sulfide copper	0.11% Cu
Total zinc	4.91% Zn
Non-sulfide zinc	0.15% Zn
Iron	4.82% Fe
Insoluble	66.10% insol.
Specific gravity	3.29 sp. gr.

was ground to approximately 50%-325 mesh. It was then conditioned in a flotation cell with 2 lbs./ton of hydrated lime, followed by thorough conditioning with 5 lbs./ton copper sulfate. The pulp was then subjected to a rougher zinc float using sodium diethyl dithiophosphate as a promoter and pine oil as a frother. The tailing was conditioned for a short time with an additional 2 lbs./ton of hydrated lime, a small amount of sodium disecondary butyl dithiophosphate added during conditioning and a copper concentrate floated off using a small amount of additional pine oil. Each concentrate was cleaned once by reflotation. The operations and conditions, as well as the metallurgical results, are shown in the following tables, the symbols NaAF being used for diethyl dithiophosphate and 238 for disecondary butyl dithiophosphate, respectively.

Point of Addition	Time, mins.	Conditions, per cent Solids	pH	Reagents, pounds per ton				
				Ca (OH)$_2$	Cu SO$_4$	Na AF	Pine Oil	238
Grind	6	60	------	------	------	------	------	------
Condition	5	22	10.4	2.00	------	------	------	------
Condition	60	------	------	------	5.00	------	------	------
Zn Float	3	22	------	------	------	0.03	0.08	------
Condition	2	------	------	2.00	------	------	------	0.10
Cu Float	2	------	------	------	------	------	0.04	------
Cl. Zn Float	2	------	------	------	------	------	0.04	------
Cl. Cu Float	2	------	------	------	------	------	0.04	------

Product	Per cent Weight	Assays		Per cent Distribution	
		Per cent Zn	Per cent Cu	Zn	Cu
Calc. Head	100.00	4.92	3.29	100.00	100.00
Cl. Zn Conc	8.64	50.38	3.83	88.5	10.1
Cl. Zn Tailing	2.88	6.37	18.29	3.7	16.0
Cl. Cu Conc	7.30	1.56	28.68	2.3	63.6
Cl. Cu Tailing	1.52	3.08	5.04	1.0	2.3
Rgh. Tailing	79.66	0.28	0.33	4.5	8.0
Calc. Rgh Zn Ct	11.52	39.38	7.45	92.2	26.1
Calc. Rgh Cu. Ct	8.82	1.83	24.61	3.3	65.9

It will be apparent that a remarkably good recovery of zinc was obtained with little contamination of the concentrate by copper and a good recovery of copper obtained in a high grade concentrate. Overall losses in the final rougher tailing for the copper float amounted to only 4½% of the zinc and 8% of the copper.

Example II

A different ore having an analysis approximately as follows:

Total copper	2.53% Cu
Non-sulfide copper	0.02% Cu
Total zinc	6.24% Zn
Non-sulfide zinc	0.21% Zn
Iron	4.82% Fe
Insoluble	59.28% insol.
Specific gravity	3.22 sp. gr.

but containing fair amounts of indium and gallium, together with some molybdenum, were subjected to flotation following a similar procedure as in Example 1, the conditioning, grinding and

reagent consumption, as well as the metallurgical results, appearing in the following tables:

Point of Addition	Time, mins.	Per cent Solids	pH	Ca (OH)$_2$	Cu SO$_4$	Na AF	Pine Oil	238
Grind	6	60	------	2.00	------	------	------	------
Condition	10	22	6.9	------	5.00	------	------	------
Zn Float	7	22	------	------	------	0.05	0.04	------
Condition	2	------	------	2.00	------	------	------	0.10
Cu Float	4	------	------	------	------	------	0.04	------
Cl. Zn Float	2	------	------	------	------	------	0.04	------
Cl. Cu Float	2	------	------	------	------	------	0.04	------

Product	Per cent Weight	Assays				Per cent distribution			
		Per cent Zn	Per cent Cu	Per cent In	Per cent Ga	Zn	Cu	In	Ga
Calc. Head	100.00	6.60	2.67	0.004	0.081	100.00	100.00	100.00	100.00
Cl. Zn Conc	13.83	44.34	7.39	0.02	0.005	92.9	38.3	64.9	0.8
Cl. Zn Tail	4.83	3.56	13.02	0.01	0.05	2.6	23.6	11.2	3.0
Cl. Cu Conc	3.53	1.10	24.33	0.005	0.01	0.6	32.2	4.2	0.4
Cl. Cu Tail	2.08	1.56	2.52	0.004	0.10	0.5	2.0	1.9	2.6
Rgh. Tailing	75.73	0.30	0.14	0.001	0.10	3.4	3.9	17.8	93.2
Calc. Rgh. Zn Ct	18.66	33.78	8.85	0.017	0.017	95.5	61.9	76.1	3.8
Calc. Rgh. Cu Ct	5.61	1.27	16.24	0.005	0.043	1.1	34.2	6.1	3.0

It will be noted that even in the case of such an ore where conditions were chosen to obtain maximum recovery of indium, a high grade sphalerite concentrate was obtainable, although the separation between zinc and copper was not sharp as under the most advantageous conditions represented in Example 1.

The procedure of Example II was followed on the ore of Example I with varying amounts of copper sulfate for a fixed amount of lime, and varying amounts of lime for a fixed amount of copper sulfate. The results are shown in the drawings, in which:

Fig. 1 is a series of curves giving zinc recovery and copper distribution in the zinc and copper concentrate for various amounts of copper sulfate;

Fig. 2 is a similar set of curves for various amounts of lime.

The individual tests are shown as points on the curves, and it will be apparent that while the copper sulfate may be used in amounts above 5 lbs./ton without material falling off in selectivity and recoveries even when it is doubled, the lime shows a very sharply defined range within which optimum results are obtained.

The amounts of lime given in the specific examples above relate to effective lime, which is free to act on the surfaces of the minerals in the conditioning step. With some ores containing large amounts of soluble salts capable of reacting with lime some of the lime may be neutralized and somewhat larger amounts of lime will be needed in order to obtain the requisite amount in a state free to act on the mineral particles.

I claim:

1. A method of separating sphalerite from chalcopyrite in ores containing the same, which comprises conditioning the ore with an amount of effective lime from 1.75 to 3 lbs./ton, then conditioning with copper sulfate in amounts at least about 5 lbs./ton to 10 lbs./ton, subjecting the conditioned ore, at flotation pulp density, to froth flotation with a dithiophosphate sulfide promoter, whereby a concentrate is produced rich in sphalerite and poor in chalcopyrite and a tailing poor in sphalerite and rich in chalcopyrite, conditioning such tailing with additional lime in amounts such that the total amount of effective

lime in the two conditioning steps is in excess of 3 lbs./ton and subjecting the conditioned tailing to froth flotation in the presence of a dithiophosphate sulfide promoter to produce a concentrate rich in chalcopyrite and a tailing poor in chalcopyrite.

2. A method according to claim 1 in which the dithiophosphate promoter is a dialkyl dithiophosphate.

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