O T T A W A March 30th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1160.

Frothing Properties of Eight Samples of Low Boiling Fractions Obtained from Crude Douglas Fir Tar.

(Copy No. 23.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Shipment:

Eight samples of oils which are the low boiling fractions obtained from crude Douglas fir tar were received on January 5th, 1942, from the Forest Products Laboratories, Lands, Parks and Forests Branch, Department of Mines and Resources, Ottawa. The samples were submitted by T. A. McElhanney, Superintendent.

Purpose of the Investigation:

The investigation was made to determine the frothing properties of the various fractions and of the total low boiling oil obtained from crude Douglas fir tar, in comparison with Yarmor F. pine oil used in standard flotation practice.

Character of the Oils, and Other Data:

Excerpts from correspondence by T. A. McElhanney, Superintendent, Forest Products Laboratories, state:

"These low boiling fractions have to be removed in order that the residual tar may be of a suitable grade for use in the manufacture of rubber tires, and we are desirous of finding a market for part or all of these low boiling fractions as flotation agents."

"The samples were obtained as follows:
Crude Douglas fir tar, obtained by the destructive distillation of Douglas fir waste wood, was heated and all low boiling fractions distilling below 232° C. were collected. These low boiling oils were re-distilled and fractionated. The following samples were submitted.

(1) Total low boiling oil (225° to 232° C.)
(2) 170° to 180° C. fraction.
(3) 180° to 190° C. "
(4) 180° to 220° C. "
(5) 180° to 245° C. "
(6) 190° to 220° C. "
(7) 190° to 245° C. "
(8) 220° to 245° C. "

"According to the literature," Mr. McElhanney continues, "the best grade of pine oil is obtained by the steam and solvent process and has a boiling range mainly between 190° C. and 220° C. and a specific gravity at 15° C. from 0.933 to 0.937. Our fraction corresponding to this pine oil in boiling range has a specific gravity of 0.941 at 15° C. If the total low boiling oil or 'crude turps' could be used for ore flotation purposes,

(Character of the Oils, and Other Data, cont'd) -

it would be a great advantage because of the greater potential supply of this fraction. The 190° to 220° C. fraction represents only about 10 per cent of the total low boiling fraction."

EXPERIMENTAL TESTS:

Tests were made to determine the frothing properties of the various samples of oils and also their effects on recoveries and ratios of concentration compared to the results obtained with Yarmor F. pine oil.

The total low boiling fraction was used in combination with various amounts of pine oil and cresylic acid.

The total low boiling fraction was also added to the ball mill to note the results of adding the oil to various points in the circuit.

As these oils would be produced on the Pacific Coast, the outlet for these would naturally be the mills of British Columbia.

For this investigation a low-grade copper ore from the Granby Consolidated Mining, Smelting and Power Company Limited, Allenby, British Columbia, was chosen.

This ore assayed:

Gold	-	0.01 oz./ton.
Copper	-	0.85 per cent.
Iron	-	3.69 "
Sulphur	-	0.89 "

A second sample of the same ore, used for part of the tests, assayed:

Copper - 1.0 per cent.

Results of Experimental Tests:

The results of the tests indicated the following:

1. The characteristic pine oil froth was obtained with 0.10 pound of pine oil per ton.

2. Fractions No. 5 (180° to 245° C.), No. 6 (190° to 220° C.), and No. 7 (190° to 245° C.) produced a froth when the quantity of oil added averaged 0.30 pound per ton; indicating that three times as much of low boiling oil as of pine oil was required to give a froth. It was also noted that these oils did not give the same buoyant free froth as pine oil does but were rather more brittle. The froths did not rise from the same pulp level to overflow from the cell, indicating that a higher pulp level would be required to give an overflow of concentrates.

3. Fraction No. 4 (180° to 220° C.) produced a froth which was more brittle and of poorer quality than Nos. 5, 6 or 7.

4. Fraction No. 3 (180° to 190° C.) frothed very slowly and gave a poor froth.

5. Fractions No. 2 (170° to 180° C.) and No. 8 (220° to 245° C.) were of no use as frothers when added to the flotation cell. They produced a thick scum of floating sulphides.

6. The total low boiling fraction No. 1 (225° to 232° C.) would not produce a froth when added to the flotation cell but when added to the ball mill and ground with the charge resulted in producing a good froth when approximately 0.30 pound of the oil per ton was added. It also exhibited considerable collecting power. This test indicates that about three times as much total low boiling oil as pine oil would be required to produce a froth.

The use of the total low boiling oil as a frother and collector when added to the ball mill resulted in good froth,

(Results of Experimental Tests, cont'd) -

with a recovery of 77.5 per cent of the copper. Adding xanthates increased the recovery to 82.6 per cent of the copper.

7. The results of mixing the total low boiling fraction with pine oil or with cresylic acid and adding this mixture to the flotation cell indicated that sufficient of the mixture to produce a satisfactory froth contained the equivalent of pure pine oil or cresylic acid required when they are used separately.

8. The mixture containing 90 per cent total low boiling oil and 10 per cent Yarmor F. pine oil produced a froth which appeared to be as satisfactory as that made with pine oil. It was noted that a test using 0.294 pound of the mixture per ton (containing 0.03 pound of pine oil) gave practically the same recovery as the test using 0.10 pound of pure pine oil per ton. The frothers were added to the ball mill.

Raising the amount of this frother to 0.38 pound per ton produced a rather voluminous froth which raised considerable gangue slimes and produced a dirty concentrate.

Comparison of Results:

The following table of results shows a comparison of the various low boiling fractions with Yarmor F. pine oil, i.e., grade of concentrate, recovery, ratio of concentration, and consumption of frother when added to the flotation cell.

The type of froth is also indicated.

(Continued on next page)

(Comparison of Results, cont'd) -

Results:

Frothers Added to the Flotation Cell.

Test No.	FROTHER Used in test	Lb./ ton ore	Assays of flot. conc., copper, per cent	Recovery of copper, per cent	Ratio of concentration	Remarks on appearance of the froths
1	Yarmor F. pine oil	0.10	15.42	85.9	22.1:1.	Characteristic p.o. froth.
2	(1) Total low boiling oil	0.36	21.0	78.9	32.2:1.	Scum; no froth.
3	(2) 170° to 180° C.	0.28	13.19	82.6	18.3:1.	Scum; no froth.
4	(3) 180° to 190° C.	0.36	14.28	83.9	20.6:1.	Poor froth.
5	(4) 180° to 220° C.	0.28	14.30	86.4	21.4:1.	Fair froth.
6	(5) 180° to 245° C.	0.28	14.15	86.2	21.6:1.	Good froth.
7	(6) 190° to 220° C.	0.28	15.64	83.6	22.9:1.	Good froth.
8	(7) 190° to 245° C.	0.18	16.38	84.1	24.9:1.	Good froth.
9	(8) 220° to 245° C.	0.29	16.64	80.1	25.3:1.	Scum; no froth.

In the tests in which no froth was formed it was noted that the sulphides floated as a rather thick scum, which was scraped off.

Total Low Boiling Fraction Added to the Ball Mill.

Test No.	FROTHER Used in test	Lb./ ton ore	Assays of flot. conc., copper, per cent	Recovery of copper, per cent	Ratio of concentration	Remarks on appearance of the froths
10	T.L.B.F. (in ball mill)	0.20	17.34	76.2	28.0:1.	Good froth.
11	" (in B.M.) No xanthates	0.28	19.74	75.6	32.9:1.	" "
12	" "	0.36	18.24	77.5	27.5:1.	" "
13	" (in B.M.) With xanthates	0.36	14.0	82.6	20.6:1.	" "
	50% T.L.B.F. + 50% Pine Oil Added to the Cell.					
14		0.18	14.29	82.8	20.8:1.	Good froth.
	50% T.L.B.F. + 50% Cresylic Acid Added to the Cell.					
15		0.44	15.71	84.8	22.6:1.	Good froth.

(Continued on next page)

(Comparison of Results, cont'd) -

Total Low Boiling Fraction Added to the Ball Mill (cont'd).

Test No.	FROTHER Used in test	Lb./ ton ore	Assays of flot. conc., copper, per cent	Recovery of copper, per cent	Ratio of concentration	Remarks on appearance of the froths
	90% T.L.B.F. + 10% Pine Oil Added to the Ball Mill.					
16	"	0.08	13.70	79.0	17.5:1.	Good froth.
17	"	0.21	11.97	84.3	14.2:1.	" "
18	"	0.29	8.60	90.7	9.8:1.	" "
19	"	0.38	6.48	92.0	7.3:1.	Indicates too much frother.
20	100% pine oil	0.10	9.29	90.7	10.6:1.	Characteristic pine oil froth.

DETAILS OF TESTS NOS. 1 TO 9 (FROTHERS ADDED TO FLOTATION CELL).

A standard test was made as follows:

A sample of the ore was ground in water to 80 per cent minus 200 mesh with 1.2 pounds of lime and 0.1 pound of sodium cyanide per ton of ore. To the flotation cell, 0.04 pound of sodium ethyl xanthate (Z-4), 0.02 pound of Reagent No. 301, and 0.1 pound of pine oil per ton were added. The concentrates were removed for 7 minutes.

The concentrate was recleaned in a separate flotation cell with 10 pounds of lime per ton of concentrate. No other reagents were used for cleaning the final concentrate. The pH of the solution was 8.6.

The pulp level of this test was noted and the remaining tests were brought to the same level to note the lifting power of the frothers.

The following tests used the various low boiling fractions:

(Continued on next page)

Results of Flotation Tests:

(Frothing Reagents Added to Flotation Cell.)

Test No.	Product	Weight, per cent	Assays, copper, per cent	Distribution of copper, per cent		Ratio of concentration	Frother, lb./ton
1	Feed	100.00	0.81	100.0	100.0		
	Rough conc.	4.53	15.42	85.9		22.1:1.	(Pine oil,
	Cleaner conc.	2.13	28.82		75.5	46.9:1.	(0.10 lb./ton.
	Middling	2.40	3.53		10.4	41.7:1.	
	Tailing	95.47	0.12	14.1	14.1		
2	Feed	100.00	0.83	100.0	100.0		(Forest
	Rough conc.	3.11	21.0	78.9		32.2:1.	(Products
	Cleaner conc.	1.63	33.32		65.6	61.3:1.	(Laboratories
	Middling	1.48	7.43		13.3	67.6:1.	(total low
	Tailing	96.89	0.18	21.1	21.1		(boiling frac-
							(tion 225° -
							(232°C.,
							(0.36 lb./ton.
3	Feed	100.00	0.87	100.0	100.0		
	Rough conc.	5.46	13.19	82.6		18.3:1.	(F. P. L.
	Cleaner conc.	1.76	31.26		63.1	56.8:1.	(fraction,
	Middling	3.70	4.60		19.5	27.0:1.	(170°-180°C.,
	Tailing	94.54	0.16	17.4	17.4		(0.28 lb./ton.
4	Feed	100.00	0.83	100.0	100.0		
	Rough conc.	4.85	14.28	83.9		20.6:1.	(F. P. L.
	Cleaner conc.	1.77	30.86		66.1	56.5:1.	(fraction,
	Middling	3.08	4.76		17.8	32.5:1.	(180°-190°C.,
	Tailing	95.15	0.14	16.1	16.1		(0.36 lb./ton.
5	Feed	100.00	0.77	100.0	100.0		
	Rough conc.	4.68	14.30	86.4		21.4:1.	(F. P. L.
	Cleaner conc.	1.85	29.67		70.9	54.1:1.	(fraction,
	Middling	2.83	4.25		15.5	35.3:1.	(180°-220°C.,
	Tailing	95.32	0.11	13.6	13.6		(0.28 lb./ton.
6	Feed	100.00	0.76	100.0	100.0		
	Rough conc.	4.64	14.15	86.2		21.6:1.	(F. P. L.
	Cleaner conc.	2.02	27.40		72.7	49.5:1.	(fraction,
	Middling	2.62	3.93		13.5	38.2:1.	(180°-245°C.,
	Tailing	95.36	0.11	13.8	13.8		(0.28 lb./ton.
7	Feed	100.00	0.82	100.0	100.0		
	Rough conc.	4.37	15.64	83.6		22.9:1.	(F. P. L.
	Cleaner conc.	1.99	29.40		71.6	50.3:1.	(fraction,
	Middling	2.38	4.13		12.0	42.0:1.	(190°-220°C.,
	Tailing	95.63	0.14	16.4	16.4		(0.28 lb./ton.

(Continued on next page)

(Results of Flotation Tests, cont'd) -

(Frothing Reagents Added to Flotation Cell, cont'd.)

Test No.	Product	Weight, per cent	Assays, copper, per cent	Distribution of copper, per cent	Ratio of concentration		Frother, lb./ton
8	Feed	100.00	0.78	100.0	100.0		
	Rough conc.	4.02	16.38	84.1	24.9	1.	(F. P. L.
	Cleaner conc.	1.69	31.28		67.5	59.2 1.	(fraction,
	Middling	2.33	5.58		16.6	42.9 1.	(190°-245°C.,
	Tailing	95.98	0.13	15.9	15.9		(0.18 lb./ton.
9	Feed	100.00	0.82	100.0	100.0		
	Rough conc.	3.95	16.64	80.1	25.3	1.	(F. P. L.
	Cleaner conc.	1.85	30.72		69.3	54.1 1.	(fraction,
	Middling	2.10	4.24		10.8	47.6 1.	(220°-245°C.,
	Tailing	96.05	0.17	19.9	19.9		(0.29 lb./ton.

Character of the Froths Observed in Tests Nos. 1 to 9.

Test No. 1. - Using Yarmor F. pine oil.

Characteristic pine oil froth, small to medium bubbles, well covered with sulphides, rising uniformly through the pulp.

Test No. 2. - Using total low boiling fraction oil. (Sample No. 1).

This oil was apparently more or less insoluble and took appreciable time to go into solution; produced a weak and brittle froth. The sulphide concentrate gathered on the surface of the pulp as a thick scum which did not rise to the lip of the cell but could be scraped off. This oil would not be satisfactory as a frother when added to the flotation machine, in comparison with pine oil.

Test No. 3. - Using the 170° - 180° C. fraction oil. (Sample No. 2).

This oil produced a poor, brittle froth, some large bubbles, sulphides mainly in a thick scum. This oil was not a suitable frothing oil in comparison with pine oil.

Test No. 4. - Using the 180° - 190° C. fraction oil. (Sample No. 3).

This oil required about 5 minutes' agitation to

(Test No. 4, cont'd) -

produce a brittle froth carrying sulphides on medium bubbles. The froth did not rise in the cell to flow over the lip. This oil did not produce a satisfactory froth.

Test No. 5. - Using the 180° - 220° C. fraction oil. (Sample No.4).

This oil produced a fairly strong froth with medium to large bubbles well covered by sulphides. The froth held up well during the flotation period. This froth did not raise the concentrate to the lip of the cell but it could be recovered by raising the pulp level.

Test No. 6. - Using the 180° - 245° C. fraction oil. (Sample No.5).

This oil would apparently be satisfactory as a frothing reagent. The bubbles were medium sized, well covered with sulphides, but appeared to be more brittle than pine oil. This froth did not rise to the pine oil level but the concentrate could be removed easily by raising the pulp level.

Test No. 7. - Using the 190° - 220° C. fraction oil. (Sample No.6).

This oil produced a tenacious froth of medium to large bubbles well covered with sulphides. The concentrate was easily recovered and the froth held up well. Except that this oil did not raise the concentrate to the same level, it appeared to give satisfactory results as a frother. This is the fraction that corresponds most closely to the boiling range of pine oil.

Test No. 8. - Using the 190° - 245° C. fraction oil. (Sample No.7).

This oil produced a tenacious froth of medium to large bubbles well covered with sulphides. This oil worked as well as that of Sample No. 6 (190° - 220° C.) and would likely prove satisfactory as a frother.

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(Character of the Froths Observed in Tests Nos. 1 to 9, cont'd) -

Test No. 9. - Using the 220° - 245° C. fraction oil. (Sample No.8).

This oil is apparently of no use as a frother. The froth appeared as large bubbles and the concentrate collected in a thick scum. The froth was very brittle. The oil appeared to be insoluble in the pulp. No real froth was obtained within the time of flotation. The thick scum was scraped off. It is apparent that this oil could not be used under the same conditions as pine oil.

TESTS NOS. 10 TO 20 (ADDING TOTAL LOW BOILING FRACTION TO BALL MILL).

Since the most satisfactory fractions included that fraction recovered from 190° to 220° C. and this fraction represents only about 10 per cent of the total low boiling fraction, further tests were made to determine whether the total low boiling fraction could be used.

This fraction did not produce a froth when added to the flotation machine. The following tests were made by adding various amounts to the ball mill and grinding with the charge. In several tests the xanthate collectors were omitted to discover the collecting power of the total low boiling fraction.

Some tests were made in which the total low boiling oil was mixed with cresylic acid and with pine oil.

Details of Tests Nos. 10 to 20.

Samples of ore were ground in water to 80 per cent minus 200 mesh, with 1.2 pounds of lime, 0.1 pound of sodium cyanide, 0.04 pound of sodium ethyl xanthate (Z-4), and 0.02 pound of Reagent No. 301 per ton. In addition, variable

(Details of Tests Nos. 10 to 20, cont'd) -

amounts of frothers were added to the several tests as indicated in the following tables.

Except where omitted from the test, the xanthates were added to the ball mill.

Results of Flotation Tests:

Test No.	Product	Weight, per cent	Assays, copper, per cent	Distribution of copper, per cent		Ratio of concentration		Frother, lb./ton
10	Feed	100.00	0.81	100.0	100.0			(F. P. L.
	Rough conc.	3.57	17.34	76.2		28.0	1.	(T.L.B.F.,
	Cleaner conc.	1.36	30.66		51.4	73.5	1.	(0.20 to
	Middling	2.21	9.14		24.8	45.3	1.	(ball mill.
	Tailing	96.43	0.20	23.8	23.8			
11	Feed	100.00	0.79	100.0	100.0			(F. P. L.
	Rough conc.	3.04	19.74	75.6		32.9	1.	(T.L.B.F.,
	Cleaner conc.	1.03	35.54		46.1	97.1	1.	(0.28 to
	Middling	2.01	11.64		29.5	49.8	1.	(ball mill.
	Tailing	96.96	0.20	24.4	24.4			(No xanthates.
12	Feed	100.00	0.86	100.0	100.0			(F. P. L.
	Rough conc.	3.64	18.24	77.5		27.5	1.	(T.L.B.F.,
	Cleaner conc.	1.30	34.94		53.0	76.9	1.	(0.36 to
	Middling	2.34	8.96		24.5	42.7	1.	(ball mill.
	Tailing	96.36	0.20	22.5	22.5			(No xanthates.
13	Feed	100.00	0.82	100.0	100.0			(F. P. L.
	Rough conc.	4.85	14.00	82.6		20.6	1.	(T.L.B.F.,
	Cleaner conc.	2.00	27.92		67.9	50	1.	(0.36 to
	Middling	2.85	4.24		14.7	35	1.	(ball mill,
	Tailing	95.15	0.15	17.4	17.4			(with xanthates.
14	Feed	100.00	0.83	100.0	100.0			(50% T.L.B.F.,
	Rough conc.	4.61	14.29	82.8		20.8	1.	(50% pine oil,
	Cleaner conc.	1.99	28.16		67.5	50.3	1.	(0.18 to
	Middling	2.82	4.50		15.3	35.5	1.	(flotation
	Tailing	95.19	0.15	17.2	17.2			(cell.

(Continued on next page)

(Results of Flotation Tests, cont'd) -

Test No.	Product	Weight, per cent	Assays, copper, per cent	Distribution, of copper, per cent		Ratio of concentration	Frother, lb./ton
15	Feed	100.00	0.82	100.0	100.0		(50% T.L.B.F.,
	Rough conc.	4.42	15.71	84.8		22.6:1.	(50% cresylic
	Cleaner conc.	2.03	28.82		71.5	49.3:1.	(acid, 0.44 to
	Middling	2.39	4.67		13.3	41.8:1.	(flotation
	Tailing	95.58	0.13	15.2	15.2		(cell.
16	Feed	100.00	0.98	100.0	100.0		(90% T.L.B.F.,
	Rough conc.	5.70	13.70	79.0		17.5:1.	(10% pine oil,
	Cleaner conc.	1.95	32.00		63.1	51.3:1.	(0.08 to
	Middling	3.75	4.18		15.9	26.7:1.	(ball mill.
	Tailing	94.30	0.22	21.0	21.0		
17	Feed	100.00	1.00	100.0	100.0		(90% T.L.B.F.,
	Rough conc.	7.06	11.97	84.3		14.2:1.	(10% pine oil
	Cleaner conc.	3.23	23.44		75.5	31.0:1.	(0.21 to
	Middling	3.83	2.30		8.8	26.1:1.	(ball mill.
	Tailing	92.94	0.17	15.7	15.7		
18	Feed	100.00	0.96	100.0	100.0		(90% T.L.B.F.,
	Rough conc.	10.18	8.60	90.7		9.8:1.	(10% pine oil,
	Cleaner conc.	3.77	20.32		79.4	26.5:1.	(0.29 to
	Middling	6.41	1.70		11.3	15.6:1.	(ball mill.
	Tailing	89.82	0.10	9.3	9.3		
20	Feed	100.00	0.97	100.0	100.0		(100% pine oil,
	Rough conc.	9.48	9.29	90.7		10.6:1.	(0.10 to
	Cleaner conc.	5.41	20.12		70.7	29.3:1.	(ball mill.
	Middling	6.07	3.20		20.0	16.5:1.	
	Tailing	90.52	0.10	9.3	9.3		
19	Feed	100.00	0.97	100.0	100.0		(90% T.L.B.F.,
	Rough conc.	13.76	6.48	92.0		7.3:1.	(10% pine oil,
	Cleaner conc.	4.51	17.80		82.8	22.2:1.	(0.38 to
	Middling	9.25	0.96		9.2	10.8:1.	(ball mill.
	Tailing	86.24	0.09	8.0	8.0		

The results of Test No. 19 indicate that too much frother was used. The froth was voluminous and considerable slime gangue was floated.

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Character of the Froths Observed in Tests Nos. 10 to 20.

Test No. 10. - Using total low boiling fraction oil. (Sample No.1).

Adding this oil to the ball mill resulted in the formation of a froth in the flotation machine carrying bubbles well covered with sulphides. This froth did not rise as high as the pine oil froth and the pulp level was raised. As no conditioning time was required, the froth formed rapidly and the flotation time was shorter.

This froth appeared at first as a thick mass of small bubbles which broke down rapidly as the concentrate was removed, becoming more brittle, until after approximately 4 minutes very little froth was left on the pulp.

Test No. 11. - Using total low boiling fraction oil.

This test was one in which no xanthates were added to the pulp. The amount of frother (T.L.B.F.) was increased to 0.28 pound per ton added to the ball mill.

The pulp frothed well and floated the sulphides in 2 minutes; the froth appeared clean of sulphides within 4 minutes. This froth was stronger than that of Test No. 10 and persisted for the required flotation period.

Test No. 12. - Using total low boiling fraction oil.

No xanthates were added to the pulp and the frother (T.L.B.F.) was increased to 0.56 pound per ton. This test gave a strong tenacious froth which floated the sulphides rapidly. The froth held up well during the flotation period. There was no difficulty in cleaning the froth, which was not noticeably brittle. The bubbles were medium sized and resembled a pine oil froth. The froth differs from a pine oil froth in that it appears less buoyant and does not lift the same amount.

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(Character of the Froths Observed in Tests Nos. 10 to 20, cont'd) -

Test No. 13. - Using total low boiling fraction oil.

In this test, xanthates were added to the pulp and the same amount of frother was used, 0.36 pound per ton. The froth appeared approximately the same as that of Test No. 12 except that it was more brittle and did not hold up so well. The overall recovery of copper was higher by about 5 per cent.

Test No. 14. - Using a mixture of 50% total low boiling fraction with 50% of pine oil (by weight).

This frother was added to the flotation cell and it was noted that the amount required to produce the froth contained approximately 0.10 pound of pine oil. This indicates that pine oil is producing the froth and the T.L.B.F. oil was not beneficial when added to the cell.

Test No. 15. - Using a mixture of 50% total low boiling fraction with 50% cresylic acid (by weight).

This frother was added to the flotation cell and the amount required to produce a froth indicates that the cresylic acid was producing the froth and, as in the case of Test No. 14, the total low boiling fraction has no effect.

Test No. 16. - Using a mixture of 90% total low boiling fraction with 10% of pine oil (by weight).

The frother was added to the ball mill at the rate of 0.08 pound per ton. The froth was medium-sized bubbles well covered with sulphides. The frothing was steady and held up for the flotation period. The froth rose about one-half the height of the froth produced by 0.1 pound of pure pine oil per ton.

Test No. 17. - Using 90% T.L.B.F., 10% pine oil mixture (by weight).

The frother was increased to 0.21 pound per ton in this test. This produced a good steady froth which overflowed

(Test No. 17, cont'd) -

from the cell. The pine oil present in the frother amounts to about 0.02 pound per ton and produces a beneficial effect upon the character of the froth, making it less brittle and more buoyant.

Test No. 18. - Using 90% T.L.B.F., 10% pine oil mixture.

The frother was increased to 0.29 pound per ton in test. This produced a strong buoyant froth with small to medium bubbles. It did not appear brittle at any stage and floated the sulphides well. More gangue was floated, as indicated by the lower ratio of concentration. Pine oil present is approximately 0.029 pound per ton. This test compares with Test No. 20 in which 0.10 pound of pure pine oil was used. The overall recoveries were the same.

Test No. 19. - Using 90% T.L.B.F., 10% pine oil mixture.

The frother was increased to 0.38 pound per ton. The results indicate that too much frother was used. Considerable gangue floated. The froth was very strong and consisted of medium bubbles, carrying sulphides mixed with gangue slimes. These conditions were unsatisfactory for obtaining comparable results. The test indicates that too much of this frother is not satisfactory.

Test No. 20. - Using 100% pine oil.

This test was made to form a comparative test for those using the pine oil mixture. 0.10 pound of pine oil per ton was added to the ball mill. It was noted that this test compared very closely with the results obtained in Test No. 18.

CONCLUSIONS:

With Reference to the Eight Different Samples of Low Boiling Fractions Included in the First Nine Tests.

It was noted that the fraction No. 5, temperature range 180° to 245° C., appeared to be satisfactory as a frother when added in quantities approximately three times greater than pine oil.

The fraction No. 2 (170° to 180° C.) was unsatisfactory as a frother.

Several fractions within the range of No. 5 (180° to 245° C.) were not satisfactory as frothers, i.e., the No. 3 (180° to 190° C.) and the No. 8 (220° to 245° C.) fractions.

It was noted that the fractions No. 3 (180° to 190° C.) and No. 8 (220° to 245° C.), when combined in the fraction No. 5 (180° to 245° C.), did not appear to prevent the formation of a satisfactory froth.

The total low boiling fraction could not be used as a frother when added to the flotation machine.

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With Reference to the Properties of the Total Low Boiling Fraction Shown in Tests Nos. 10 to 20.

The oil froths well when ground with the charge and acts as a collector, producing a clean concentrate with a high ratio of concentration.

It is apparent that this oil could not be added to various points of a circuit as a secondary frother.

The addition of 10 per cent of pine oil to the total low boiling fraction indicates an improvement of the character of the froth, making it less brittle and more buoyant. It prolongs the time of frothing before the froth begins to break down.

(Continued on next page)

(Conclusions, cont'd) -

The addition of too much of this mixture indicates a tendency to produce a dirty concentrate by lifting slimes.

The addition of a 50:50 mixture of pine oil and total low boiling fraction to the flotation machine is not beneficial, since the amount of oil required to produce the froth contains the amount of pine oil used in the pure form.

The lifting power of the total low boiling fraction appears to be less than that of pine oil, as indicated by a difference in level of the pulp which will overflow the frothed concentrate.

The apparent advantages of this oil over pine oil are that it produces a clean, high-grade concentrate with a high ratio of concentration and acts as a collector.

The disadvantages of this oil are: (1) that apparently approximately 3 times as much total low boiling fraction oil is required to produce a froth comparative to pine oil, and (2) that this amount of oil gives a less buoyant and more brittle froth which breaks down more quickly. It does not produce a froth when added to the conditioner and cannot be used as a secondary frother by adding it to various flotation cells to increase the froth. It has to be added to the ball mill to produce the results noted in the investigation.

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It is apparent that the total low boiling fraction oil can only replace pine oil where it could be used as a primary frother and the addition of pine oil to it does not appear to change this property.

This total low boiling fraction can be used as a

(Conclusions, cont'd) -

frother when added to the grinding mill in quantities approximately 3 times greater than that required of pine oil.

20 per cent of this low boiling fraction can be fractionated (180° to 245° C.) and used as a frother in quantities equal to that of the total low boiling fraction.

It is evident then that this product in the crude form can be used to replace pine oil, the essential differences being that it must be added to the grinding mill and in quantities substantially greater than those of pine oil.

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