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DEPARTMENT OF MINES

SOUTH AUSTRALIA.

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METALLURGICAL REPORT.

NO. 50.

THE TREATMENT OF CROCKER'S WELL ORE.

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METALLURGICAL ENGINEER.

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DEPARTMENT OF MINES.

SOUTH AUSTRALIA.

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CONTENTS.

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1. CHOICE OF THE SAMPLE INVESTIGATED.

At the beginning of this investigation the available geological information indicated a possible richer ore zone having values of 4 lbs. U_3O_8/long ton upwards, but that this zone might provide only limited tonnages. The presence of the major uranium bearing mineral, designated 'absite', in several places in the country rocks over a large area outside the richer zone did, however, suggest that a large low grade deposit might be a possibility.

For this investigation it was thought that a sample approximating to a low grade ore would be a more realistic feed and that a grade of 1 lb. or 1½ lb./long ton would be the lowest value worthy of consideration.

Such a sample was obtained by mixing equal amounts of six samples originating from the five shafts at the ore occurrence. The samples used were lettered A, B, C, C1, D and E, and the value of the composite sample, calculated from assays of the six components, was 0.97 lb./long ton by chemical methods and 1.41 lb./long ton by radiometric methods.

2. REVIEW OF PREVIOUS WORK.

The types of reagents used on Radium Hill ore had been tested on Crocker's Well ore of 4 lb. grade with promising results. Principally, the previous work had indicated that Whitcol and Fuel Oil combinations gave the best performance, that the ratio of Whitcol to Fuel Oil used was important and, that it might not be necessary to employ fine grinding to liberate the uraniferous components. Further indications had been that it was probably necessary to add the reagents to the mill.

The exact composition of Whitcol was not known but it was a proprietary mixture of various ingredients which could include fuel oil, cresylic acid and a collecting agent;

the latter might be either a long chain sulphonate or a fatty acid salt such as oleate. Some tests on controlled mixtures of such ingredients, one with a sulphonate as the active element and the other with oleate, had tended to show that the oleate mixture was the best.

In formulating a programme of work these points were taken into account and it was concluded that the first points to be established were:-

(a) Conditions for a roughing circuit based on Whitcol and fuel oil since these gave promise of a successful outcome.

(b) A further investigation of the use of sodium oleate or other oleates since the elimination of a proprietary reagent, of uncertain and possibly varying composition, would give greater control of any circuit and might lead to reagent economy.

(c) The use of other reagent combinations, particularly those previously applied with a measure of success to a granitic type of ore.

A second stage programme would investigate the cleaning of rougher concentrates up to products suitable for chemical treatment.

In carrying out the primary programme some points established for (a) above would be required for (b) and (c) and some information would be obtained which would be of use in the second stage programme.

3. CONDITIONS FOR A ROUGHING CIRCUIT BASED ON WHITCOL - FUEL OIL MIXTURES.

A few preliminary tests confirmed that Whitcol - Fuel Oil mixtures would give roughing recoveries of over 90% and that poor recoveries were obtained unless the reagents were added to the mill. This latter point was repeatedly brought out in subsequent work; even with other circuits giving poor results, the recoveries were always improved by adding reagents to the mill.

Throughout the roughing programme all tests were evaluated on radiometric assays in order to relieve pressure on chemical analysis; for comparative purposes these analyses would be satisfactory.

3.1 Whitcol - Fuel Oil Ratio.

A series of flotation tests were carried out on 560 gm. charges of ore to determine the optimum Whitcol - Fuel Oil ratio to be used. In all tests the charge was ground wet at 61.5% solids for 45 minutes in a ball mill to give a product containing approximately 48% -200 mesh (-76 μ), the flotation reagents being added to the mill. In each case the Whitcol addition was 10 lbs/long ton of ore and the Fuel Oil was varied to give different ratios. Flotation was carried out in a laboratory size Fagergren cell without conditioning. A rough concentrate was collected in four minutes flotation and this was refloated for one minute, to give three test products for assay, a concentrate, a cleaner tailing and a primary rougher tailing. No further reagents were added to either the roughing or cleaning cell.

The results of these tests are given in Table 1. and are shown graphically in Figure 1.

From these results it is apparent that mixtures containing Whitcol in ratios of less than 2 to 1 are less effective and, especially, that ratios containing an excess of Fuel Oil over Whitcol result in an appreciable decrease in recovery. For subsequent test series it was decided to use 3:1 ratios in a standard mixture although it was recognised that 2:1 and 4:1 ratios might require trial eventually.

3.2 Addition of Cresylic Acid to the Whitcol-Fuel Oil Mixture.

In the use of reagents of this type in previous work it had been suggested that cresylic acid in small amounts was a useful adjunct to flotation.

A series of tests was carried out, using a technique similar to that described in section 3.1, but adding 6 lbs. Whitcol and 2 lbs. Fuel Oil per ton to the mill in each test together with a varying amount of Cresylic Acid.

The test results are given in Table 2 and shown graphically in Figure 2.

The results of TP 10 (see Table 1.) are plotted in Figure 2 to provide the points for no cresylic acid addition.

There appear to be no conspicuous advantages from adding cresylic acid, in fact there is a slight tendency for recoveries to decrease with increase in cresylic acid addition. There also appears to be some bad effect on the cleaning operation; although this improves with the greatest additions of cresylic acid it is still slightly less efficient than the cleaning operation in TP 10 when no cresylic acid was used. As indicated by the concentrate assays however, there could be some advantages in selectivity by adding a little cresylic acid and, from observation, the froth so obtained appeared to be improved in quality.

For subsequent tests it was decided to use a reagent (Reagent 'P') having Whitcol, Fuel Oil and cresylic acid in the proportions 3:1:0.1.

3.3 Minimum Addition of Reagent 'P' for Optimum Results.

A procedure similar to that described in section 3.1 was again used but the quantity of reagent 'P' added was varied.

Results of tests are given in Table 3 and shown graphically in Figure 3.

It is clear that a specific quantity of reagent is required to achieve a satisfactory recovery and, for the size of ore feed used, this would appear to be of the order of 8 lbs./long ton; for subsequent tests for other variables an addition of 8 lbs./long ton was used.

3.4 Pulp Density Effects.

All flotation had, hitherto, been conducted at the usual 5:1 W/S ratio, but in view of the small valuable mineral burden of the ore it was desirable to test the effect of thicker flotation pulps, since a greater burden of valuable mineral per unit of frothing area might, if that mineral reached the froth surface first, assist selectivity.

Two single charges, each of 560 gms. were ground as described in section 3.1 with 8 lbs./long ton of reagent 'P' and floated together at a pulp ratio of 2.5:1 approximately; a rougher concentrate was collected in 4 minutes and refloated for 1 minute to produce a cleaner concentrate.

A further test using 4 lbs./long ton of reagent 'P' was carried out to check the reagent usage required on thicker pulps. The results of these tests are given in Table 4 together with the results on normal pulp density (TP 28 and TP 32) for comparison.

These results show that there is no advantage in using thicker pulps and again emphasize that a reagent addition of less than 8 lbs./long ton is inadequate for this size of feed.

3.5 Variation in Grinding.

In section 2 it was remarked that previous work had suggested the possibility of mineral being released adequately by coarse grinding. This was checked by a series of tests on feeds ground for different periods. In all tests 8 lbs./long ton of reagent 'P' was used and the procedure was as described in section 3.1. Test results are given in Table 5 and shown graphically in Figure 4.

It will be noted that there is a remarkable consistency in the roughing recovery for grinding periods down to 10 minutes; there is a small decrease for 7 minutes grind and a considerable decrease for 5 minutes grind. Further there is a general tendency for greater amounts of material to be floated in the rougher concentrate as the grinding period increases, i.e. as the fineness of the ore increases; this results in a poorer grade concentrate. As the cleaning recoveries indicate, there is little evidence that reducing the grinding time to 10 minutes increases the proportion of composite particles in the rougher concentrates by a significant amount.

In view of the recoveries obtainable on charges ground for 7 and 10 minutes the reagent addition factor (see section 3.3) was investigated for both cases.

For 7 minutes grinding the results of tests (TP 75-TP 87) were very irregular and showed only a general tendency for recovery to increase with increased amounts of reagent, a recovery of over 90% in roughing being obtained only with the maximum addition of 10 lbs./long ton. The values remaining in cleaner tails suggested that a significant number of composite particles was present. The erratic manner in which recoveries exceeded or fell below the general trend suggests that a 7 minute grind could be at or near the critical period, the degree of liberation depending primarily on the mineral occurrence in the particular charge. From these facts it would seem that 10 minutes grinding is probably the lower limit of grinding time which would give consistent results.

Test results for 10 minutes grinding are given in table 6 and are plotted in Figure 5.

Comparing Figure 5 with Figure 3, it will be noted that somewhat higher recoveries are achieved for smaller reagent additions on 10 minutes grinding, especially at 4 lbs./long ton; nevertheless it is still necessary to make an addition of 8 lbs./long ton to achieve 90% recovery.

At this addition also the cleaner efficiency is better; it is possible that lower cleaner efficiencies with the smaller reagent additions may be due to an insufficiency of reagent in the reflotation operation. Comparing the data of Tables 3 and 6 it is notable that lesser amounts of valueless material appear to be floated by the use of the shorter grinding period and grades of concentrates are improved thereby. In contrast to the results obtained on 7 minutes grinding, those for 10 minutes grinding are not erratic and, it is felt that this period is sufficiently above the critical period to give consistent performance. A 10 minutes grind is virtually a -18 mesh (B.S.S.) grind with approximately 23% -200 mesh.

3.6 Rapidity of Flotation.

Although as stated in section 3.1 the standard flotation procedure involved a 4 minutes roughing period it was frequently observed that flotation appeared to fall off rapidly after the first two minutes, the froth became apparently barren and, after a short interval, micaceous components began to float in increasing quantity.

The rapidity of flotation was therefore investigated on double charges of ore, in order to provide sufficient quantities of products for assay, by taking successive concentrates at one minute intervals. The charges were ground with 8 lbs/long ton of reagent 'P' for 45 minutes. The test results are given in Table 7 and are plotted in Figure 6.

Of the values eventually recovered, 83% are collected in the first minute and 92% in the first two minutes, but the second two minutes accounts for only 7% of the values floated and increases the weight of material produced up to two minutes by 56% approximately.

No similar test has yet been carried out on charges ground for 10 minutes, it was not known at the time that grinding could be limited successfully to this short period, but this point should be investigated.

From the results obtained on the 45 minutes grind it is thought that the concentrates obtained in the fourth, third and, possibly the second minutes, will contain the majority of the composite particles with unliberated mineral values, whereas the first concentrate will contain a large proportion of entrained gangue. This may not be the case when the shorter grind is used and microscopic examination of the products will be needed to determine the extent to which all, or part, of the roughing float may need to be reground for cleaning operations.

3.7 pH Effect.

A series of tests were made on charges ground for 7 minutes with 4 lbs/long ton of reagent 'P', in which the pH of the roughing circuit was adjusted in the cell by additions of either sulphuric acid or caustic soda. It should be noted that the choice of grinding time and reagent addition was made on visual observations of previous tests before it was known that both grind and reagent addition were probably insufficient.

The results obtained are given in Table 8.

Tests 88 - 91 in Table 8 were carried out on a parcel of ore which proved to be of somewhat lower grade than the previous parcels used. In test 87 no reagents were added to adjust pH and the pH values are those natural to the ore pulp with the collectors added. In test 88 pH was adjusted by adding sulphuric acid and in 89 - 91 by adding caustic soda.

The results show that the recovery is very adversely affected by increasing acidity, which is in accord with all other tests in acid circuits. The optimum result appears to be obtained at or near the natural pH of the ore pulp as ground with the collector. When the circuit is adjusted to alkalinity there is a steady decrease in recovery as alkalinity increases.

It would be advisable to repeat the pH investigation on feeds ground for 10 minutes and using 8 lbs/long ton of reagent 'P', but it would appear that there might be a somewhat narrow pH range for optimum flotation results between pH 6 and pH 7.

3.8 Summary of the Data Obtained and Further Data Required.

For a roughing circuit based on Whitcol - Fuel Oil tests have established the following data:-

(a) Feed ground to approximately -18 mesh (B.S.S.) is satisfactory.

(b) Reagents should be added to the grinding mill.

(c) Whitcol - Fuel Oil mixtures in the ratio of 3:1 are satisfactory.

(d) Cresylic acid may have some useful effects if used in small quantities and the reagent mixture used might well be Whitcol 3: Fuel Oil 1: Cresylic Acid 0.1.

(e) It is necessary to use at least 8 lbs. of reagent per long ton of ore.

(f) Pulps of density greater than those normally used have no advantages.

(g) Flotation is rapid and over 90% of the total recovery can be collected in two minutes.

(h) pH for optimum results may be between 6 and 7.

The following information is required to complete the survey of circuit conditions or to provide data of possible economic value in operations:-

(i) All tests have been carried out using tap water. The various factors for reagent additions and pH will need to be checked using the water likely to be available at the mine.

(ii) Although 3:1 Whitcol - Fuel Oil ratios are satisfactory both 2:1 and 4:1 mixtures are sufficiently close to the other in effect that some further assessment of their use might be profitable. This would probably be best carried out on a continuous unit and, the choice would ultimately depend largely on the reagent costs involved in relation to the performance obtained. There would not appear to be any reason for altering the cresylic acid proportions relative to the fuel oil.

(iii) The time of flotation required to obtain sufficient recovery should be investigated for the 10 minute grinding period and a mineralogical inspection of the individual products should provide information of use in the cleaning operations.

(iv) A continuous test should be carried out to check the performance in roughing on a grind approximating to that of the 10 minute laboratory period. The introduction of closed circuit ball milling might affect the results either way.

4. OLEATE TYPE REAGENTS

4.1 Sodium Oleate.

Tests were carried out with sodium oleate as a collector both with and without fuel oil or cresylic acid as assistants. All of the tests reported were carried out before it was known that a 10 minutes grind could be used. In all cases reagents used were added to the mill.

The results of these tests are given in Table 9.

It is clear from these results that sodium oleate used without fuel oil is not very selective but used with fuel oil it is as good as Whitcol - Fuel Oil mixtures; in fact there is some indication that it is more selective and reagent consumption is certainly more economical.

4.2 Ammonium Oleate.

For some non-metallic flotation problems ammonium oleate is known to be rather more selective than sodium oleate.

Early tests (TP 36 and 36A) using 1.0 lb. ammonium oleate with either sodium or ammonium sulphide as gangue dispersants gave low recoveries of the order of 10% but the reagents had been added to the cell. When the tests were repeated (TP 37 and 37A) with the reagents added to the mill, nearly 40% recovery was obtained and the flotation was just as selective as that with Whitcol - Fuel Oil mixtures.

Since the tap water, used throughout these tests, is hard it was considered that much of the available oleate could have been consumed by Ca^{++} ions and in subsequent tests the oleate addition was increased to 3 lbs/long ton; the results of this test are given in Table 10

The marked improvement in results was encouraging and it was then thought that the sulphide might be exerting an undesirable effect and that reversion to the fuel oil combination, paralleling the Whitcol usage, might be profitable.

Results of such tests using a 20 minutes grind are given in Table 11.

The improvement when fuel oil is introduced is marked but, comparing the results with those for TP 73 (Table 9), sodium oleate is a much better collector although the somewhat better selectivity of ammonium oleate is apparent. It is also notable that it is not easy to clean the rougher concentrate when it is of high grade. When the reagent used is more selective, and/or the froth is less voluminous, less gangue is entrained and the simple reflotation, which drops out such material, is not sufficient to separate the uranium minerals from others which have similar flotation properties under the conditions. Mica and to a lesser extent, rutile and apatite are probably the principal interferants.

4.3 Oleic Acid.

Some tests were carried out with oleic acid but the results were not sufficiently promising to justify further tests in view of the efficiency of sodium oleate, but it should be noted that oleic acid has not been tested in combination with fuel oil.

4.4 Further Work on Oleates.

Sodium oleate should not be a difficult reagent to obtain and would be likely to be cheaper than ammonium oleate. Further work is therefore desirable with sodium oleate and this should be directed toward the establishment of the sodium oleate - fuel oil combination and addition required for optimum results, similar to the procedure used for the Whitcol reagents; the testwork should be carried out on ore ground to give a feed equivalent to that produced by a 10 minutes grind in the laboratory mill.

5. OTHER REAGENTS.

5.1 Acid Circuits.

On another ore of a granitic type it has been found that acid circuits of pH 3.0 to 4.0 were selective when reagents 825 and 801 were used as collectors together with sodium flouride as a depressant for gangue.

This circuit can be preceded by an alkaline grind with caustic soda and desliming prior to acidity adjustment and flotation.

Some preliminary tests and others (TP 8,9 and 15-17) were carried out using such methods, including an alkaline grinding and desliming operation before flotation, but no results were obtained which suggested that further tests on these lines would be profitable.

Amine 220 was also tried as a collector in acid circuit with similar results and in view of the better flotation achieved with reagents 825 and 801 subsequantly, when natural circuits were used, it is thought that this ore is one which does not respond to acid circuits.

5.2 Reagents 825 and 801 in Natural Circuits.

Some interesting results were obtained with reagents 825 and 801 in circuits having a pH natural to the ore and to the reagents used. The results of tests using 3 lbs. 825 and 0.5 lb. 801/long ton of ore, with or without fuel oil and cresylic acid as indicated, are given in Table 12. In all tests charges were ground with the reagents for 20 minutes.

A further series of test results in which 3 lbs. reagent 825 only was used as the collector are given in Table 13.

In the feeds (Table 13) for TP 51,52,53 received 45 minutes and for TP 69 20 minutes grinding. In TP 52 the cresylic acid was added to the cell after a first concentrate had been collected; in all other cases reagents were added to the mill.

The results obtained are not as promising as those obtained with sodium oleate but 825 when used with a smaller quantity of 801 clearly has some collecting properties. The use of cresylic acid is of doubtful value but fuel oil again appears to assist flotation.

5.3 Further Work.

As has already been stated (section 5.1) acid circuits do not appear to be worthy of further consideration but it would be advisable to test Amine 220 in natural circuit with and without fuel oil.

Reagents 825 and 801 obviously have some collecting properties and whilst further tests with these at this juncture are not so important as tests with the oleates, they should be borne in mind.

6. CLEANING OF CONCENTRATES.

In many of the tests quoted, a simple cleaning operation was performed by refloating the rougher concentrate without further reagent additions. In general this resulted in a considerable rejection of weight of material from the concentrate with little loss of uranium values. This is thought to indicate that the material rejected was mainly mechanically entrained in the froth and that the reject contains only a small amount of composites of uranium mineral with gangue in which the latter is the major component.

It was noticeable that, on those occasions when the rough concentrate was richer than usual due to greater selectivity in the operation, reflotation tended to give a higher cleaner tailing. This could be due to the presence of composites which do not float readily in the thinner pulps and different reagent conditions of the cleaning cell or, possibly, to a rearrangement of the order of flotation between the uraniferous constituents and other minerals having nearly comparable flotation properties.

Tests were carried out using potassium permanganate as a possible depressant for gangue on feed ground for 10 minutes. The addition of 0.5 lb. to either the grinding circuit or to the cleaner cell had little effect on the recoveries obtained by the usual roughing and reflotation technique employed. No greater selectivity was obtained and there was, in fact, a slight adverse effect on the uranium recovery.

Further work on the cleaning operations will need to investigate regrinding of the rough concentrate or the refloated concentrate and the use of various depressants. Phosphates, fluorides, silicates and some wetting agents such as "Aerosols" could be tried; as the amount of uraniferous minerals to be collected is small it is better practice, therefore, to depress the major component (gangue) if possible, but the depression of the uranium minerals whilst floating the gangue should not be overlooked.

There is a need for more mineralogical data and chemical analyses on concentrates in order to establish the nature of the cleaning separation to be attempted. This information could well be obtained from the various products resulting from a continuous test involving recirculation of cleaner tailings, recleaner tailings, etc., and, should be directed towards the establishment of the nature of the minerals associated (or floating) with the uranium minerals, the nature and amount of composite particles and the size of the mineral particles in the various products.

From some previous mineralogical and chemical determinations on concentrates there has been an indication that not all of the thorium content of the ore is accounted for by absite, davidite, and rare earth phosphates, and that not all uranium is accounted for by absite and davidite. The recent identification of orthite in the ore by Mr. A. Whittle may account for some or all of these deficiencies and it is obviously of importance to successful cleaning operations that the distribution of the various minerals in the products from different stages of flotation should be known.

7. SUMMARY & RECOMMENDATIONS.

On a feed containing approximately 1.0 - 1.5 lbs. U_3O_8/ long ton, by grinding the ore to -18 mesh (B.S.S.) with 8 lbs/long ton of a reagent containing Whitcol, fuel oil and cresylic acid in the proportion 3:1:0.1 respectively, it is possible to obtain roughing recoveries of 90% and over using laboratory tap water. By reflotation of the concentrate it is possible to reduce its weight by some 50% with only a small loss in recovery. The effects of time of grind, time of flotation, pH, reagent quantity added, pulp density and reagent composition have been investigated.

Sodium oleate used with fuel oil appears to be as good as Whitcol - fuel oil - cresylic acid mixtures and ammonium oleate also appears to have collective abilities.

Acid circuits of acidity greater than about pH 6 are unsatisfactory with any of the reagents tested.

Reagents 801 and 825 have some collecting power but are inferior to oleate or the Whitcol mixtures in the circuits employed.

Recommendations for further work on the Whitcol mixtures are detailed in section 3.8, for oleates in section 4.4 and for other reagents in section 5.3.

To assist the study of the cleaning operations additional chemical and mineralogical data are required on the occurrence of the minerals in products resulting from a continuous operation involving recirculation of cleaner tails, middlings etc.

As soon as possible chemical determinations of uranium content should be made on a number of test products for which radiometric assays are already available, the number being selected to cover the widest possible range of values and to ensure sufficient confirmation of values. These assays should be plotted against the corresponding radiometric assays to provide a means for correcting test results which have, so far, been based entirely on radiometric assay.

It is also desirable that, at this stage, water local to the mine should be used to check the various facts established with tap water; circuit adjustments, if necessary, can then be ascertained before proceeding to cleaning investigations.

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TABLE 1.

COMPARISON OF DIFFERENT WHITCOL FUEL OIL RATIOS

Test Nº T.P.	Ratio Whitcol Fuel Oil	Feed U_3O_8 lbs./L.T.	CONCENTRATE			CLEANER TAILS			TAILS.		
			WT%	Grade U_3O_8 lbs./L.T.	U% Distn.	WT%	Grade U_3O_8 lbs./L.T.	U% Distn	WT%	Grade U_3O_8 lbs./L.T.	U% Distn.
2	6:1	1·25	11·5	10·1	92·8	18·0	0·5	7·2	70·5	Nil	0·0
1	4:1	1·14	11·5	9·5	95·8	23·8	0·2	4·2	64·7	Nil	0·0
10	3:1	1·11	14·0	7·6	90·8	21·7	0·2	3·7	64·3	0·1	5·5
11	2:1	1·21	15·7	7·2	93·1	20·0	0·1	1·6	64·3	0·1	5·3
12	3:2	1·12	11·1	9·7	96·3	20·6	0·2	3·7	68·3	Nil	0·0
18	3:2	1·15	17·0	6·3	92·9	24·8	0·1	2·1	58·2	0·1	5·0
20	3:2	1·17	12·9	8·2	90·4	26·3	0·2	4·4	60·8	0·1	5·2
13	1:1	0·99	13·3	7·3	97·8	21·5	0·1	2·2	65·2	Nil	0·0
19	1:1	1·08	12·3	7·9	89·7	25·4	0·2	4·7	62·3	0·1	5·6
14	1:2	1·02	8·6	9·5	79·9	23·3	0·3	6·8	68·1	0·2	13·3

TABLE 2.

EFFECT OF CRESYLIC ACID ADDED TO WHITCOL. FUEL OIL MIXTURE

Test No. T.P.	Cres. Acid lbs./L.T.	Feed U_3O_8 lbs./L.T.	CONCENTRATES			CLEANER TAILS.			TAILS		
			WT%	Grade U_3O_8 lbs./L.T.	U% Distn.	WT%	Grade U_3O_8 lbs./L.T.	U% Distn.	W.T%	Grade U_3O_8 lbs./L.T.	U% Distn.
3	0·2	1·10	4·3	18·6	72·9	11·9	1·8	19·5	83·8	0·1	7·6
4	0·4	1·23	5·9	15·0	72·0	14·2	1·3	15·0	79·9	0·2	13·0
5	0·6	1·36	7·4	12·1	65·7	21·7	1·5	23·9	70·9	0·2	10·4
6	0·8	1·28	6·5	14·4	73·1	17·4	1·1	15·0	76·1	0·2	11·9
7	1·0	1·23	9·7	10·2	80·7	18·7	0·5	7·6	71·6	0·2	11·7

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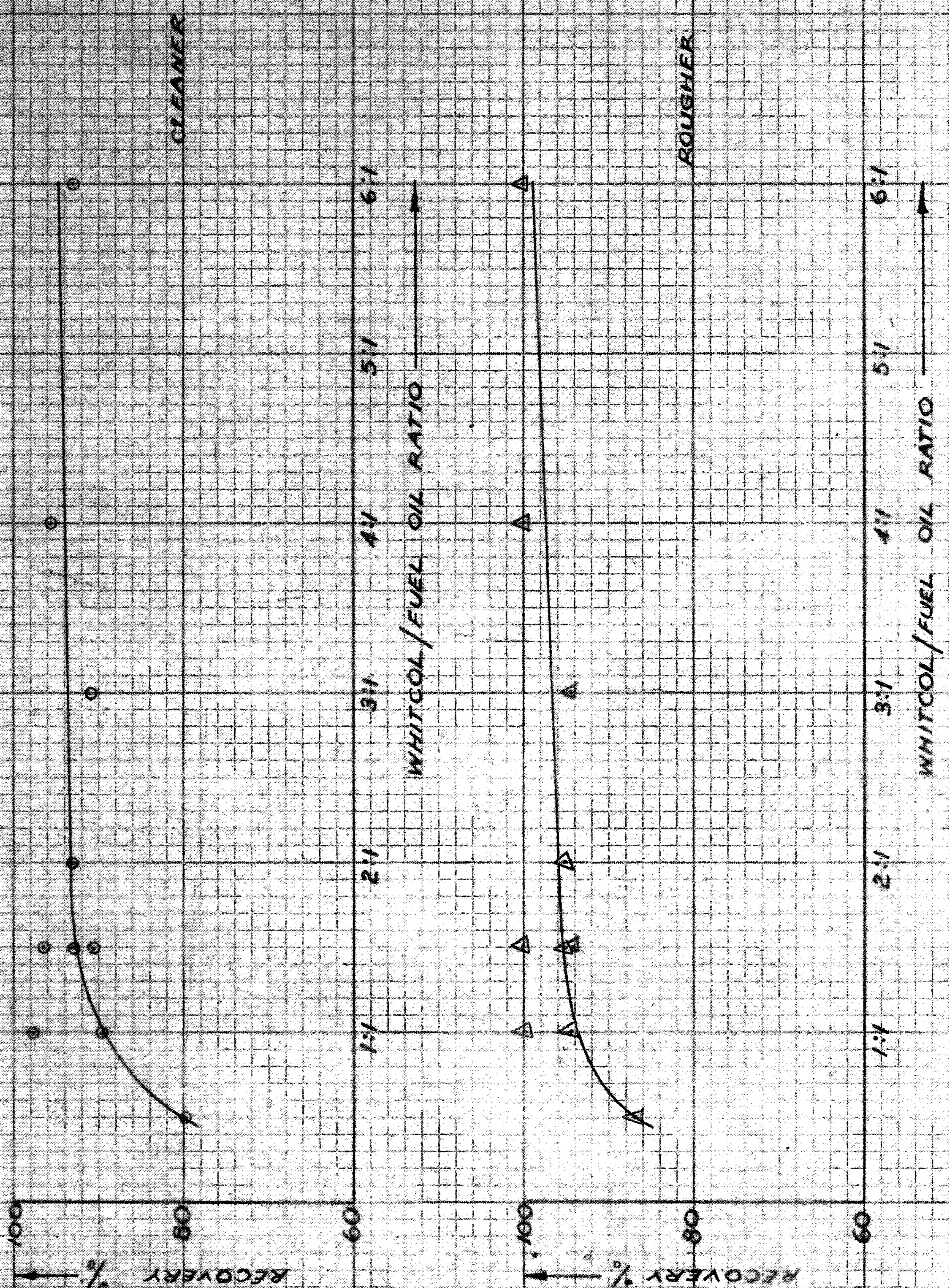
Approved	Passed	Drn.	TABLE Nº 1 & 2 MET. REPORT Nº50.	D.N.	Scale
		Tcd. M.M.S.		Reg.	SM 62.
		Ckd.			
Director	C.D.	Exd.			Date 21·5·53

FIGURE 1

Rougher & cleaner recoveries against Whitcol fuel oil ratios.

S.M. 54.



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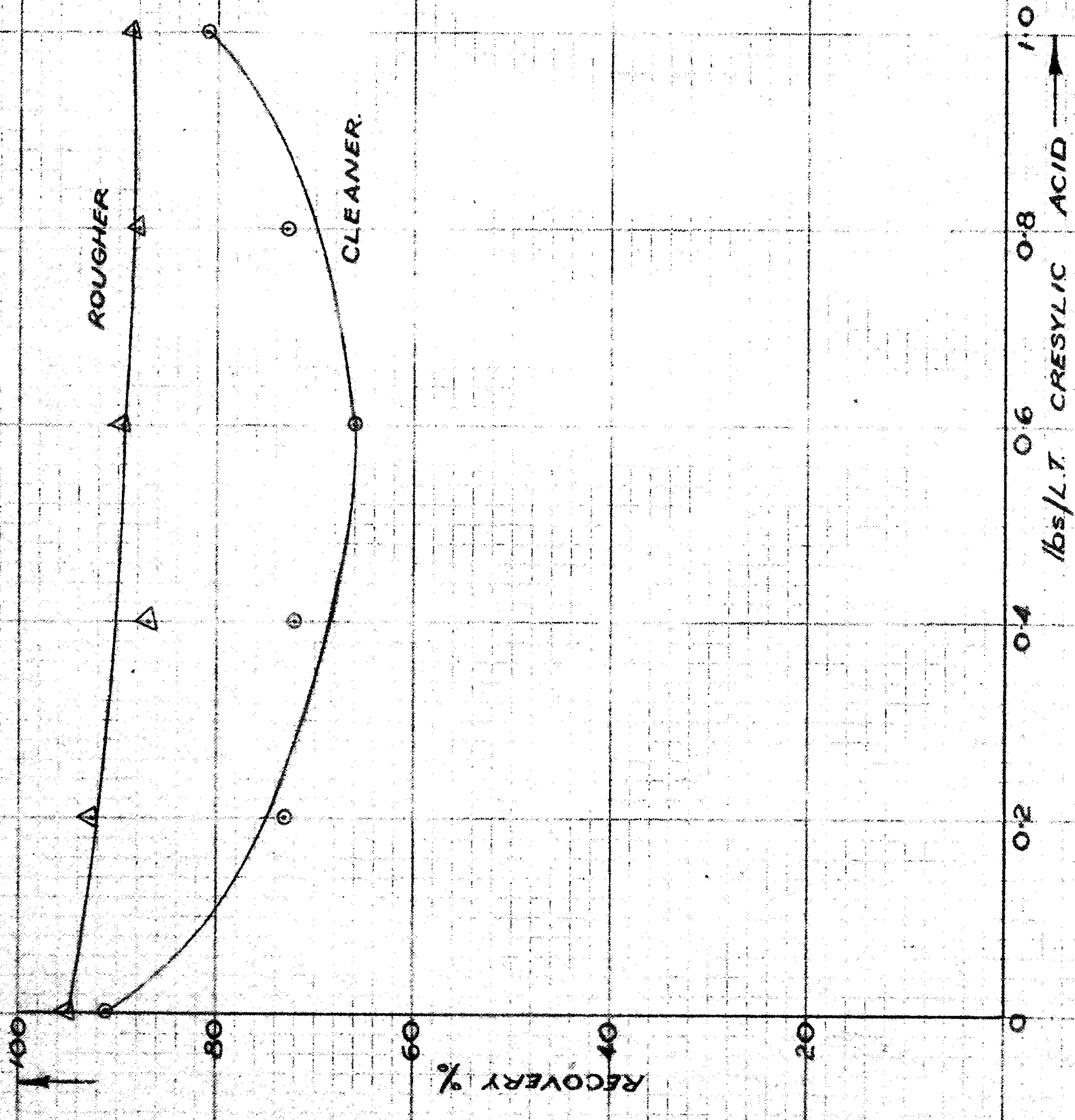
Approved	Passed	Drn.	ROUGHER AND CLEANER RECOVERIES AGAINST WHITCOL FUEL OIL RATIOS	D.M.	Scale
		Tcd C.J.		Reg.	S.M. 54
		Ckd.			
Director	C.D.	Exd.			Date 28·4·63

SM.55.

FIGURE 2

Effect of Cresylic Acid additions
on recoveries.



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Approved	Passed	Drn.	EFFECT OF CRESYLIC ACID	D.M.	Scale
		Tcd. CV	ADDITIONS ON RECOVERIES	Reg.	SM.55.
		Ckd			
Director	C.D.	Exd			Date 28-1-53

TABLE 3.

EFFECT OF VARIATION IN QUANTITY OF REAGENT 'P' USED

Test No TP	Reagent Added lbs./L.T.	Feed U_3O_8 lbs./L.T.	CONCENTRATE			CLEANER TAILS			TAILS		
			WT%	Grade U_3O_8 lbs./L.T.	U% Distn	W.T%	Grade U_3O_8 lbs./L.T.	U% Distn	W.T%	Grade U_3O_8 lbs./L.T.	U% Distn.
21	0·1	1·21	—	—	—	2·0	1·9	3·1	98·0	1·2	96·9
22	0·2	1·33	0·4	1·8	0·5	8·0	1·7	10·2	91·6	1·3	89·3
23	0·5	1·24	0·2	5·2	0·8	2·4	2·6	5·0	97·4	1·2	94·2
24	1·0	1·30	2·0	2·5	3·9	11·6	1·8	16·1	86·4	1·2	80·0
25	1·5	1·28	3·7	1·6	4·6	16·7	1·6	20·9	79·6	1·2	74·5
26	2·0	1·16	4·3	1·9	7·0	14·7	1·3	16·4	81·0	1·1	76·6
27	3·0	1·38	7·1	2·0	10·5	19·6	1·8	25·6	73·3	1·2	63·9
28	4·0	1·14	3·6	2·7	8·6	20·7	2·1	38·2	75·7	0·8	53·2
29	5·0	1·18	9·2	4·1	31·9	21·0	1·5	26·7	69·8	0·7	41·4
30	6·0	1·24	5·1	8·4	34·6	19·9	2·2	35·2	75·0	0·5	30·2
31	7·0	1·21	12·8	5·5	58·4	24·0	1·3	25·9	63·2	0·3	15·7
32	8·0	1·13	19·8	4·8	83·9	25·6	0·5	11·3	54·6	0·1	4·8
33	9·0	1·19	18·9	5·0	79·6	26·8	0·5	11·3	54·3	0·2	9·1
34	10·0	1·25	19·3	5·5	85·0	26·8	0·5	10·7	53·9	0·1	4·3.

TABLE 4.

COMPARISON OF NORMAL AND THICKENER PULPS

W/S Ratio	Test No. T.P.	Reagent Added lbs./L.T.	Feed U_3O_8 lbs./L.T.	CONCENTRATE			CLEANER TAILS			TAILS.		
				WT%	Grade U_3O_8 lbs./L.T.	U% Distn.	WT%	Grade U_3O_8 lbs./L.T.	U% Distn.	WT%	Grade U_3O_8 lbs./L.T.	U% Distn.
2·5:1	40	8·0	1·22	23·3	4·3	81·8	29·2	0·6	14·3	47·5	0·1	3·9
5:1	32	8·0	1·13	19·8	4·8	83·9	25·6	0·5	11·3	54·6	0·1	4·8
2·5:1	41	4·0	1·32	14·5	2·7	29·2	27·7	1·3	27·2	57·8	1·0	43·6
5:1	28	4·0	1·14	3·6	2·7	8·6	20·7	2·1	38·2	75·7	0·8	53·2

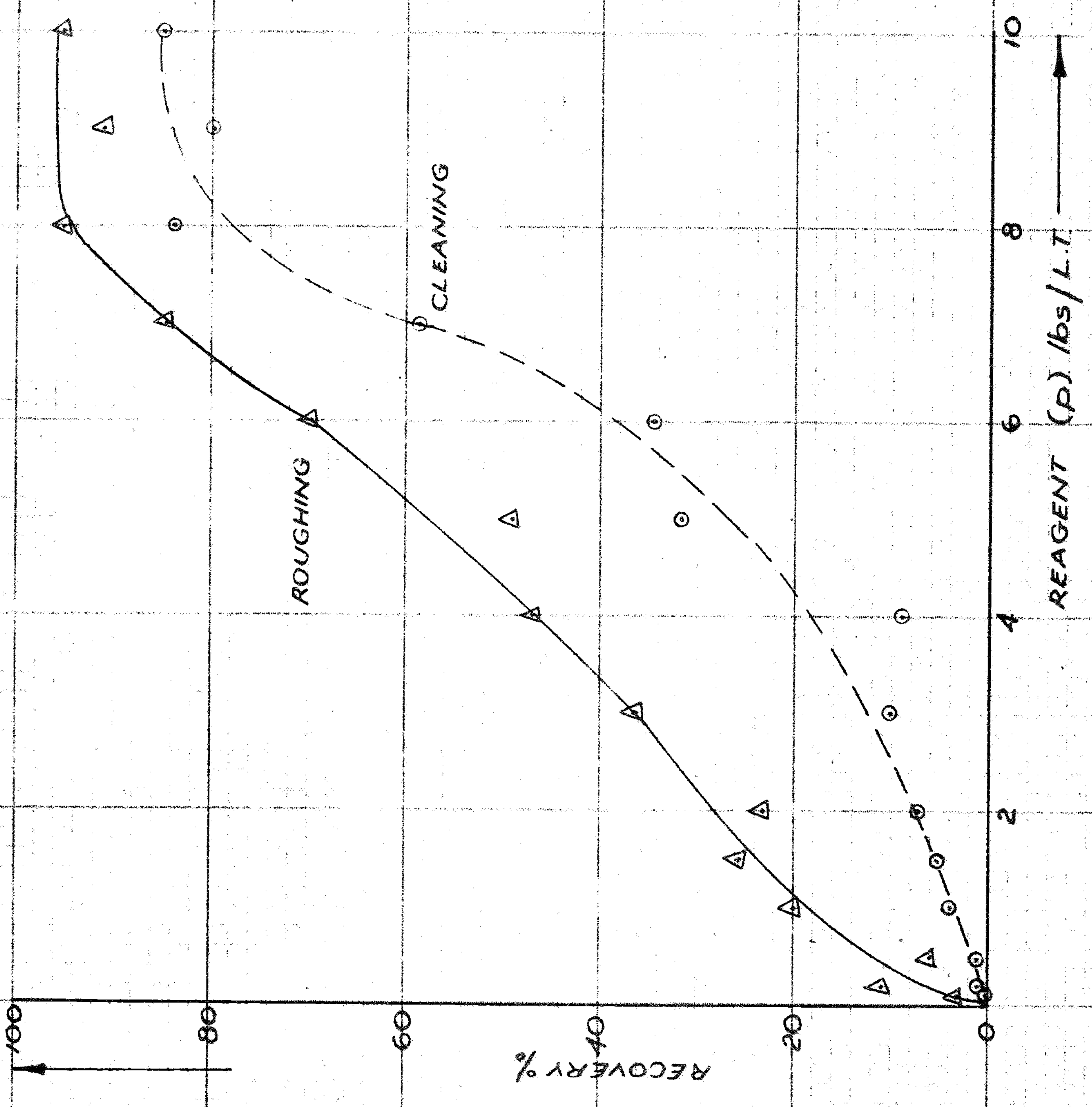
S. A. DEPT. OF MINES

Approved	Passed	Drn.	TABLE No's 3 & 4.	D.M.	Scale
		Trd. M.M.S	MET. REPORT No. 50.	Rec.	S.M. 63.
		Ckd.			
Director	C.D.	Exd.			Date 21·5·53

S.M. 56.

FIGURE 3

Recoveries against quantity of reagent 'P' used.



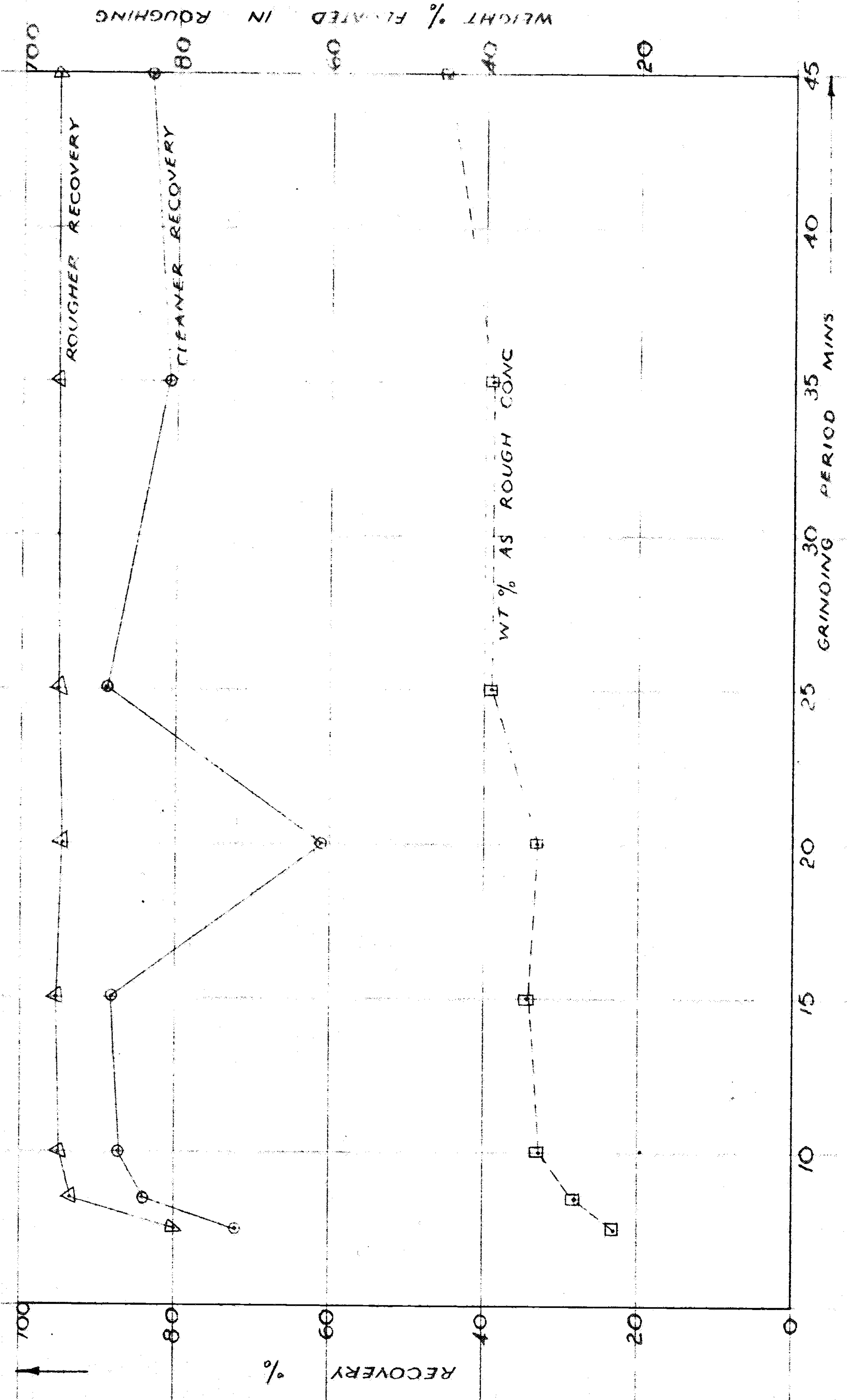
S. A. DEPT. OF MINES

Approved	Passed	Drn.	RECOVERIES AGAINST QUANTITY OF REAGENT "P" USED.	D.M.	Scale
		Tcd. C.J.		Reg.	S.M.56.
		Ckd.			
Director	C.D.	Exd.			Date 28.4.53

S.M.57

FIGURE 4

Effect of grinding period on rougher and cleaner recoveries and wt.% floated in roughing.



S. A. DEPT. OF MINES

Approved
Passed
Drn. C.V
Tcd.
Ckd.
Exd.
Director C.D.

EFFECT OF GRINDING PERIOD ON ROUGHER AND CLEANER RECOVERIES AND WT % FLOATED IN ROUGHING

DM
Reg

Scale

S.M. 57

Date 27.4.53.

TABLE 5.
EFFECTS OF GRINDING
PERIOD VARIATION

Test No. T.P.	Grind Mins	Feed U_3O_8 lbs/L.T.	CONCENTRATE WT%	Grade U_3O_8 lbs/L.T.	U% Distn.	CLEANER TAILS WT%	Grade U_3O_8 lbs/L.T.	U% Distn	TAILS WT%	Grade U_3O_8 lbs/L.T.	U% Distn.
32	45	1·13	19·8	4·8	83·9	25·6	0·5	11·3	54·6	0·1	4·8
43	35	1·33	14·3	7·5	80·6	24·8	0·8	14·9	60·9	0·1	4·5
44	25	1·24	16·3	6·8	89·6	22·6	0·3	5·5	61·1	0·1	4·9
42	20	1·28	5·9	13·2	61·0	27·0	1·6	[illegible]3·8	67·1	0·1	5·2
45	15	1·36	15·4	7·8	88·3	18·8	0·5	6·9	65·8	0·1	4·8
46	10	1·26	13·1	8·4	87·0	19·2	0·5	7·6	67·7	0·1	5·4
59	7	1·13	12·7	7·5	84·3	15·1	0·7	9·3	72·2	0·1	6·4
58	5	1·13	13·5	6·0	72·0	9·5	0·9	7·6	77·0	0·3	20·4

TABLE 6
VARIATION IN REAGENT QUANTITY ON
10 MINUTES GRIND

Test No. T.P.	Reagent Added lbs/L.T.	Feed U_3O_8 lbs/L.T.	CONCENTRATE WT%	Grade U_3O_8 lbs/L.T.	U% Distn	CLEANER TAILS WT%	Grade U_3O_8 lbs/L.T.	U% Distn.	TAILS. WT%	Grade U_3O_8 lbs/L.T.	U% Distn.
60	0·2	1·13	—	—	—	2·7	2·2	4·9	97·3	1·1	95·1
61	1·0	1·23	0·9	3·1	2·3	6·0	2·9	14·2	93·1	1·1	83·5
62	2·0	1·30	2·0	3·4	5·3	9·9	3·6	26·7	88·1	1·0	68·0
63	4·0	1·30	5·9	10·6	48·0	16·5	2·7	34·2	77·6	0·3	17·8
64	6·0	1·24	8·4	10·4	70·2	17·1	1·3	17·8	74·5	0·2	12·0
65	8·0	1·39	12·3	9·3	82·2	18·0	0·6	7·8	69·7	0·2	10·0
66	10·0	1·35	17·1	7·2	91·0	19·5	0·3	4·3	63·4	0·1	4·7

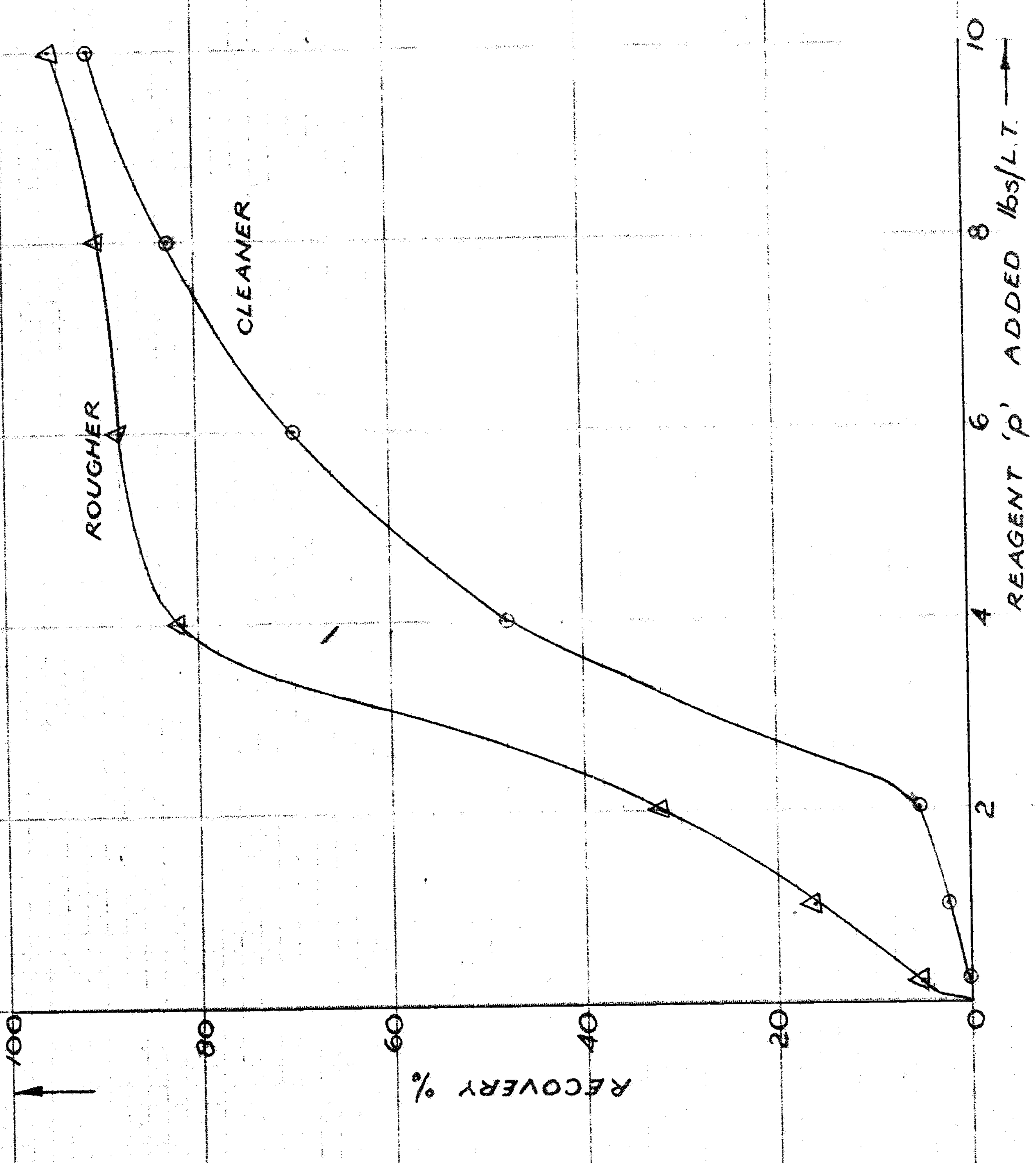
S. A. DEPT. OF MINES

Approved	Passed	Drn.	TABLE No's 5 & 6 MET REPORT. No 50.	D.M.	Scale
		Tcd. M.M.S.		Req.	S.M. 64.
		Ckd.			
Director	C.D.	Exd.			Date 21·5·53

S.M. 58.

FIGURE 5

Recoveries against reagent addition for 10 minutes grinding.



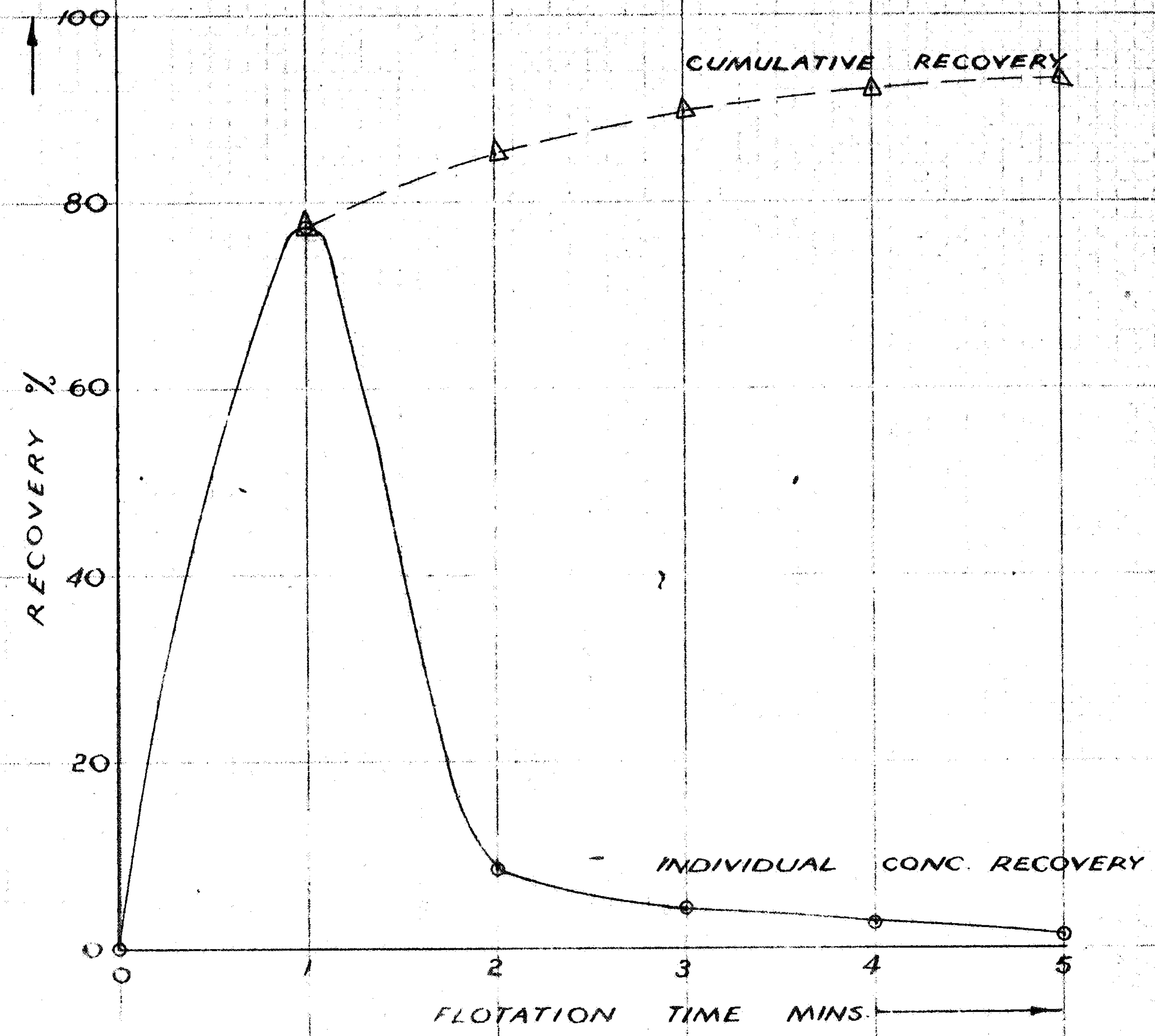
S. A. DEPT. OF MINES

Approved	Passed	Drn.	RECOVERIES AGAINST	D.M.	Scale
		Tcd. C.J.	REAGENT ADDITION	Reg	S.M.58.
		Ckd.			
Director	C.D.	Exd	FOR 10 MINUTES GRINDING		Date 27.4.53

S.M. 59

FIGURE 6

The effect of Flotation time on recovery.



S. A. DEPT. OF MINES

Approved	Passed	Drn	THE EFFECT OF FLOTATION TIME ON RECOVERY	D.M	Scale
		Trd. C.J		Reg.	S.M. 59
		Ckd.			Date 28 4 53

TABLE 7.
TEST TP47
TIME OF FLOTATION EFFECT

Product	WT%	Grade U_3O_8 lbs/L.T.	U% Distribution
conc. 1	18·7	5·6	76·9
conc. 2	10·3	1·1	8·3
conc. 3	9·5	0·6	4·2
conc. 4	6·8	0·5	2·5
conc. 5	4·5	0·2	0·7
Tailing	50·2	0·2	7·4
Head	100·0	1·36	100·0

TABLE 8.
EFFECT OF pH ON RECOVERY

Test No. T.P.	Feed U_3O_8 lbs/L.T.	p.H. Rougher	Rougher Rec%	pH Cleaner	Cleaner Rec%
88	0·71	5·0	17·5	5·3	Nil
87	1·05	6·4	75·6	7·2	45·4
89	0·67	7·5	60·4	8·0	28·8
90	0·78	8·1	44·2	8·2	21·9
91	0·77	8·5	41·2	8·4	14·0

S. A. DEPT. OF MINES

Approved Director	C.D.	M.M.S. Ext.	TABLE N^os^ 7 & 8 MET. REPORT N° 50.		SM 65. Date 21·5·53

TABLE 9.

TESTS WITH SODIUM OLEATE

Test No. T.P	Grind Mins	Reagents Added lbs/L.T.	Product	WT%	Grade U_3O_8 lbs/L.T.	U% Distn.
54	45	3·0 Na.oleate	conc.	23·2	3·3	58·8
			Tailing	76·8	0·7	41·2
			Head	100·0	1·30	100·0
73	20	3·0 Na oleate	Conc.	8·6	12·5	86·7
		1·0 Fuel Oil.	Cleaner T.	10·6	0·8	6·8
			Rougher T.	80·8	0·1	6·5
			Head	100·0	1·24	100·0
74	20	3·0 Na oleate	Conc.	9·2	11·4	86·8
		1·0 Fuel Oil	Cleaner T.	10·0	0·8	6·6
		0·2 Cresylic Acid	Rougher T.	80·8	0·1	6·6
			Head.	100·0	1·21	100·0

TABLE 10

TEST TP 55

AMMONIUM OLEATE AS COLLECTOR

Reagent Added lbs./L.T.	Grind Mins.	Product	WT%	Grade U_3O_8 lbs/L.T.	U% Distn.
3·0 Am. oleate	45	Conc.	4·3	10·5	32·9
1·0 Na_2S		cleaner T.	11·3	4·4	36·3
		Rougher T	84·4	0·5	30·8
		Head.	100·0	1·37	100·0

S. A. DEPT. OF MINES

M.M.S.

TABLE No's 9 & 10.

MET. REPORT. No 50.

S.M.66.

21·5·53

TABLE 11
AMMONIUM OLEATE
FUEL OIL COMBINATIONS AS COLLECTORS

Test No. T.P.	Reagents Added lbs./L.T.	Product	WT%	Grade U_3O_8 lbs./L.T.	U% Distn.
70	3·0 Am̄ oleate	Conc	2·5	8·1	16·3
		Cleaner T.	4·1	7·2	23·7
		Rougher T.	93·4	0·8	60·0
		Head.	100·0	1·24	100·0
71	3·0 Am̄. Oleate	Conc.	2·5	15·2	27·0
	1·0 Fuel Oil	Cleaner T.	5·5	10·3	40·3
		Rougher T.	92·0	0·5	32·7
		Head.	100·0	1·41	100·0
72	3·0 Am̄ Oleate	Conc.	2·7	7·4	14·4
	1·0 Fuel Oil	Cleaner T.	5·9	6·1	26·0
	0·2 Cresylic Acid	Rougher T.	91·4	0·9	59·6
		Head.	100·0	1·38	100·0

S. A DEPT. OF MINES

M.M.S.

TABLE No. 11

MET REPORT No 50

S.M. 67.

21 5 53.

TABLE 12.

REAGENTS 825 & 801 AS COLLECTORS

Test Nº T.P.	Other Reagents Added lbs/L.T.	Product	Weight %	Grade U_3O_8 lbs/L.T.	U% Distribution
49	Nil.	Conc.	9·8	9·0	76·5
		Tailing	90·2	0·3	23·5
		Head	100·0	1·15	100·0
67	1·0 Fuel Oil	Conc.	1·3	6·4	6·7
		Cleaner T.	7·5	4·4	26·8
		Rougher. T.	91·2	0·9	66·5
		Head	100·0	1·23	100·0
68	1·0 Fuel Oil	Conc.	3·0	10·9	31·3
	0·2 Cresylic Acid	Cleaner T.	9·5	4·8	43·6
		Rougher T.	87·5	0·3	25·1
		Head	100·0	1·05	100·0

TABLE 13

REAGENT 825 ONLY AS COLLECTOR.

Test Nº T.P	Other Reagents Added lbs/L.T.	Product	Weight	Grade U_3O_8 lbs/L.T.	U% Distribution
51	0·5 Fuel Oil	Conc.	9·7	4·5	34·9
		Tailing	90·3	0·9	65·1
		Head	100·0	1·25	100·0
52		Conc. 1	8·5	4·9	32·0
	0·2 Cresylic Acid	Conc. 2.	3·0	3·0	6·9
		Tailing	88·5	0·9	61·1
		Head	100·0	1·30	100·0
53	0·2 Cresylic Acid	Conc.	14·5	3·8	44·6
		Tailing	85·5	0·8	55·4
		Head	100·0	1·24	100·0
69	1·0 Fuel Oil	Conc.	2·6	15·5	27·7
	0·2 Cresylic Acid	Cleaner T.	5·8	7·1	28·3
		Rougher T.	91·6	0·7	44·0
		Head	100·0	1·46	100·0

S. A. DEPT. OF MINES

M.M.S.

TABLE Nº'S 12 & 13

MET. REPORT Nº 50.

Ref.

S.M. 68.

Date: 21·5·53