FLOTATION OF LOW GRADE COPPER-NICKEL ORES

M.Sc. Thesis.

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During recent years the development and utilization of that process of ore dressing known as FLOTATION has proceeded by leaps and bounds. Because of its peculiarities, and complete divergence from the principles utilized in the older forms of gravity concentration it was at first looked upon with distrust. Since then, however it has been received with favour and in many cases with the utmost relief as offering the only solution to the concentration problems of certain complex ores or slimes from gravity concentration processes.

General Description.

Briefly, "the process generally consists in the thorough agitation, either mechanically, by air, or by both mechanical means and air of an aqueous pulp with some other substance, usually some sort of oil, which reduces the surface tension of the water, and which capable of being positively adsorbed tends to produce a froth containing most of the valuable mineral.

The froth is then removed by skimming or by allowing it to flow over a lip which retains the bulk of the liquid, together with the non-flotable portion of the ore. The latter is then removed and either discarded or retreated. Other reagents may be added to enhance the flotative properties of the valuable portion of the ore or destroy the flotability of the minerals from which the valuable portion is to be separated." *

* From M.Sc. Thesis of W. Erlenborn. 1921.

HISTORY.

The history of the development of the art can best be studied in the Patent Office records and the evidence given in the innumerable lawsuits which have arisen over the validity of certain patents. Rickard, in his paper, 'The History of Flotation' ,has attempted to collect the facts and harmonize the conflicting claims of many of the early investigators. Little would be gained by attempting to abridge that article here.

THEORY.

*"Although a good deal of experimenting has been done with the process, the theoretical results are not what they should be, apparently because people have insisted upon looking upon the whole thing as very mysterious. This is one of the many industries involving colloid chemistry where the art is far ahead of the science."

Morrison wrote, "Volumes have been written concerning the theory of flotation, but after going through many articles on colloidal chemistry of flotation and reading one article by an eminent writer that most minerals are negatively charged, and another article stating that 'the pulp should not be emulsified', and finding both of these statements refuted at a later date, one loses hope of learning anything from the prophets."+

* Applied Colloid Chemistry,- W.D. Bancroft. McGraw-Hill Co.

\+ A.G. Morrison. - Can. Mining Journal, Sept. 1, 1916

Perhaps the author of the above quotation has expressed himself rather too emphatically, but anyone who has attempted to wade through the highly-scientific, pseudo-scientific, and imaginative morass of flotation theory can appreciate his statements and feel the same disappointment at the more or less unsatisfactory state of this important part of flotation work.

Since that time, 1916, much has been done, but as recently as 1919 Langmuir wrote, "Notwithstanding the importance which the flotation process has assumed in the separation of ores, there has been comparatively little progress in the development of the underlying theory. It is recognized that the process depends upon the formation of thin oil films on the partciles of ore and that owing to the difficulty with which these particles are then wet by water they become readily attached to the air bubbles and are thus carried to the surface. As far as I know, however, no really satisfactory theory of these phenomena has been proposed. The remarkable selective action of some oils on certain ores and the effects produced by small amounts of acids and other substances are very imperfectly understood."

In view of the above, it would require unusual temerity on the part of a junior research student to propound a theory or even attempt to correlate the many and varied and conflicting theories now existing.

Suffice it then, to quote the opinion of some authorities and refer to the bibliography of articles dealing with the theoretical aspect of flotation.

Wiard*, in 1915, wrote, "it can be stated at the present that it (flotation)

* Theory and Practice of Ore Dressing. E.S.Wiard. McG-H. Co.

is due to feeble attractions and repulsions being due to like conditions of potential,while unlike conditions produce attraction."

"The surface phenomena of flotation may be divided roughly into three classes;the formation and properties of the froth;the oiling of the solid particles;and the adhesion of the oiled particles to the bubbles of the froth.

The formation of a froth depends on the presence of substances which can form stable monomolecular films over the surface of the bubbles. In order that the froth may readily form it seems to be desirable to have present a soluble substance having a strong tendency to be adsorbed on the surface of the liquid.

The particular properties of different kinds of oils for the purpose of oiling the solid particles must be made the subject of further careful research. The presence of small amounts of acid and substances which become adsorbed on the solid surfaces or attach themselves to the oil films would be expected to alter the results very materially.

The adhesion or tendency of the particles to attach themselves to the bubbles of the froth is measured by the contact angle formed between the oily surface of the bubble and the contaminated surface of the solid. The results of tests indicate that the selective action by which substances like galena are separated from guartz and calcite is dependent upon the contact angle formed by the oiled surfaces rather than by any selective tendency for the oil to be taken up by some minerals more than by others."*

* The Mechanism of the Surface Phenomena of Flotation.- Dr. Irving Langmuir.- General Electric Review.- Dec. 1921.

That the essential thing is the adsorption of the ore particles at the oil/water interface is shown by the fact that the introduction of saponin kills the flotation of the ore under ordinary conditions although it increases the frothing tremendously. It is customary to say that the ore goes into the interface and the gangue does not,but that is not to be taken too literally. Some gangue always goes into the interface and the percentage increases the finer the gangue. The ideal condition,therefore,is one in which the gangue is coarse relatively to the ore.

Sulman in his classic paper,'A Contribution to the Study of Flotation',* summarizes his theories as follows,-

"Flotation reactions result from the molecular forces acting at the surfaces of solids and liquids arising from unbalanced molecular attractions in the surface layers.

The surface tension of a liquid can be measured,but this is not possible for solids,nor for solid/liquid systems.

The degree of wetting can be relatively quantified by the contact angle made between the free surface of the liquid and that of the solid.

In a possible system of contacts between various phases,that one will take place which produces the greatest adhesion between the phases in contact and therefore the minimum interfacial tension, for liquid/solid adhesion is reciprocal to interfacial tension. Thus,-

1. The adhesion of water and gangue is greater than the adhesion of water and sulphide.

*A Contribution to the Study of Flotation.- H.L.Sulman.- Bulletin 182,Institution of Mining and Metallurgy. London,1919.

2. Oil on the other hand shows a preference for sulphides rather than gangue.

3. Air, if present, will replace water at the surface of sulphides.

4. Air will adhere more strongly to an oiled sulphide particle than to an unoiled particle.

The contact angle formed when one phase is brought into contact with another substance in the presence of a third is a measure of the tendency of one substance to wet another. For pronounced flotability a contact angle approaching and preferably exceeding 90° is required. Contact angles have a maximum and minimum value; the angular difference between these values is the hysteresis of the contact angle and permits a wider range of equilibrium for a floating particle.

If water be the floating medium, an inmiscible fluid (oil) is employed to diminish to greater extent the surface energy of the sulphide, which therefore floats; whilst adhesion between gangue and water (reduction of interfacial energy to a minimum) is promoted by the addition of acid or alkalai to the water, so that the gangue remains submerged.

Pure liquids do not produce a stable froth, but contaminated liquids do, due to the contaminant affording a means of automatically adjusting the equilibrium conditions to the requirements necessary for stable equilibrium. This is brought about by the concentration of the molecules of the contaminant at the surface of the pure or homogeneous liquid (positive adsorption). Fine mineral particles are adsorbed at a pure water surface but give a film of low stability.

"Frothing agents useful in flotation produce a froth with water yet leave a partial strain (mineral-adsorptive energy) at the bubble surface. The mineral adsorption now stabilizes the film, especially if the mineral be minutely oil filmed,still more so if flocculated. Oil is at present the generally accepted substance used for frothing,the soluble portions being positively adsorbed and therefore lowering the surface tension of the liquid;the greater part of the insoluble portion adhering to the flotable minerals, thus increasing their tendency not to be wetted by water and to adhere to the air bubbles.

"Electrical phenomena are concomitants of a minor order;the establishment of differing electrical potentials in frothing apparatus units has so far failed to produce any appreciable result.

"Generally if a substance can be flocculated it can be floated.

"Colloids are detrimental to flotation because they are such active adsorbing agents,due to their large specific surface. They must be either removed or coagulated. This latter may be done by heat or electrolytes. Similarly if the oils in a flotation mixture are emulsified they will not be active in flotation. Emulsified oils are in a condition corresponding to the colloidal state and hence their surface will be extremely active.

"Flotation,then,depends upon bringing about the most advantageous selective adhesions,selective adsorptions,and selective flocculation between the complex of particles in an ore pulp"

It may be said, though,that variations in ore constitution, in the choice or limitation of reagents and in local conditions generally are so wide that each ore will present a flotation problem of its own requiring individual study. Where the factors are so varied flotation must in large degree remain an art as well as a growing science.

Patient empiricism in mill and laboratory by such men as Hoover, Callow, Sulman, Ballot, and a host of others developed a workable and successful process now known as FROTH FLOTATION.

DEVELOPMENT of DIFFERENTIAL FLOTATION.

At first flotation practice was limited to the separation of all the more readily flotable minerals, mainly sulphides, from those less easily floated (gangue and oxides) between which a wide difference exists. As it became apparent that smaller differences in flotability also existed between the various sulphides themselves, methods (indiscriminately called 'selective' 'preferential' or 'differential') were devised to take advantage of the fact.

These developed along the line of limiting the factors conducive to flotation, both in nature and extent, to a degree which would permit the flotation only of the more readily floated sulphides. Many factors are concerned, such as, amount of oil or other flotation agent, volume of air, conditions which affect flocculation or the reverse, acidity or alkalinity of the circuit, etc.

The result obtainable is as a rule not a distinct and sharp separation, but rather the production of two or more concentrates or flotation products, one of which contains, say, a high percentage of mineral A and a small percentage of mineral B, while in the other product mineral B predominates.

It is obvious that to secure successful differential separation the use of very readily frothing oils is to be avoided, and this for two reasons. An easily carrying oil will require a much greater difference in natural or artificial flotability of two or more minerals (usually sulphides) to obtain a separation between them, for it can under ordinary conditions float all the sulphides. Also, the heavy voluminous froth produced is much more likely to carry entrained gangue or undesirable sulphide particles than is the brittle, more evanescent froth of a less soluble and consequently less readily frothing oil.

Differential flotation can be secured in some cases by the use of chemical methods to destroy the flotability of one or more of the ore constituents by alteration of their surfaces. Thus, in the Horwood process for the separation of galena from blende, oxidation of the galena (by roasting or heating in air at a low temperature) was employed to prevent its floating with the blende which was not so readily oxidized.

Surface modifications produced by the action of certain chemicals used as leaches or solutions for agitation, such as certain acids or alkalies have been tried with varying success. One such was the employment of soluble chromates to coat galena with a film of $PbCrO_4$, but the results were partial rather than complete. Reactions which are easy to bring about for separate fragments of substantial size become difficult when applied to the particle assemblages present in a voluminous ore-pulp, or a froth-concentrate, wherein each mineral exists through every range of particle diameter, and associated with particles of other sulphides and of gangue.

SPECIAL PROBLEM (Reasons for)

During 1920-1921, Messrs. Erlenborn and Edwards, working in the Ore Dressing Laboratory of McGill University successfully 'differentially floated' a chalcopyrite-pyrite ore, securing a 98.5% efficiency from a differential standpoint and a recovery of 97% of the total copper in an ore assaying 2.6% copper. These results were so encouraging that Prof. Bell was of the opinion that it might be possible to differentially float the complex copper-nickel-iron sulphide ores of the Sudbury region.

In 1916 some work towards this objective had been carried on at the University of Toronto by Prof. H.E.T. Haultain and F.C. Dyer with the following results.

"The investigators have shown that the nickel and copper minerals can be easily separated by flotation. One flotation product contains about 25% copper and a little nickel. The other sulphide product contains most of the nickel and only a trace of copper. A middlings product contains both copper and nickel in about the proportions in which they occur in the ore.

"The nickel concentrate is remarkably free from copper, the pentlandite and pyrrhotite sink together giving a mixture of the sulphides of nickel and iron that might possibly be used for the direct formation of nickel steel. The copper concentrate is not so free from nickel as is the nickel concentrate from copper.

"The process is original and uses no oils or acids or modifying reagents, but it is quite possible that similar results might be obtained by the Minerals Separation of Callow flotation processes.*

* Canadian Mining Journal,- Aug. 5, 1916

Nothing further has appeared in print concerning the method, and apparently it was not developed by any of the companies operating in the Sudbury district. The separation was effected by film flotation which has of recent years fallen into disuse, mainly on account of operating difficulties.

The capacity of the machines employed is very small, as would be expected when it is considered that the film flotation of one ton of galena would require a surface of one and one half (1 1/2) acres even under the most favourable circumstances. The method is inapplicable to slimes, and the feed for most film flotation machines (the Macquisten Tube is an exception) must be dry. This prevents the retreatment of middlings as they would be oxidized during drying and thus rendered unfloatable.

Under present conditions there is little incentive to employ concentration methods for the copper-nickel ores of Sudbury. Large bodies of ore are worked, the product from which requires little but hand sorting.

"Although hand picking from belts is largely carried on, the richness of the ores being worked at present renders any system of wet dressing on tables, etc., less important than it may become in the future. Much experimental work has been done and there is no doubt that ere long dressing processes, including oil flotation will be employed, as is common with other pyritic ores.

"Magnetic separation has not proved successful or promising, either for crude concentration or for the separation of the magnetic nickeliferous pyrrhotite from the purely copper- or iron-bearing minerals, but although there is little object in any incomplete method of separation under the present methods of refining, it would be highly desirable to be able to obtain even a portion of the nickel as a sulphide mixed with a minimum of copper sulphide if there is any intention of smelting it direct for the production of copper nickel steel."*

As the Mond Nickel Co. pointed out to the members of the Royal Ontario Nickel Commission, "with smelting ores generally, as the grade diminishes, a point is quickly reached at which these ores must receive a previous treatment by some form of concentration. This necessitates a careful separation of the grades of ore by hand-sorting into classes, one of which, the richer or higher in grade, is treated directly in smelting furnaces (being therefore usually known as 'direct smelting ore') and the other of which, the poorer in metal contents or lower in grade, is concentrated before smelting (being therefore usually termed 'concentrating ore').

The Mond Nickel Co. is at present spending a large sum of money in working out the best technical method of concentration for Sudbury ores. By these experiments it will ascertain the economic limits of grades of ore for direct smelting and concentrating. These new limits must be obtained for unmined ores, so as to ascertain especially the lowest grade of ore that can be profitably mined in view of the improved treatment.

*Report of the Royal Ontario Nickel Commission - 1917

The same limits must also be ascertained for the ores already mined,in order to determine the economic limits for the two classes of ores,and especially the lowest grade of ore that can profitably be worked by the improved treatment,after the cost of mining is paid.

When determined,these new limits will become serious operating factors at the mines and the reduction works. This means that large tonnages of material heretofore mined and sorted out as waste,will likewise come by the improved treatment, within the economic working limit.

Hitherto,concentration of the ores in the Sudbury district has been considered impracticable. But,with improved methods and with larger scale operations and greater economies in treatment in other directions,we are just crossing the threshold of a new era in handling the lower grade ores hitherto not considered profitable to mine and reduce."

In connection with the grade of ore now mined and as to the metal content necessary for material to be classed as ore, Mr. A.D.Miles*,said,in substance that all material is classed as ore which lends itself to sorting to a 3% or higher grade of combined copper and nickel. Thus material in situ might be less than 3% but be readily hand sorted to the higher grade,while on the other hand if the mineral is scattered through the rock it could not be hand sorted and so must be classed as 'not ore'.

Mr.A.D.Miles,Pres. Canadian Copper Co.

Some of the ores at present being smelted, with their analyses, are,-

1. To the reverberatory furnace.

Raw Creighton Fines	1.69 % Cu	3.95 Ni	38.0 Fe
" Crean Hill "	2.90	1.85	24.8

2. Blast Furnace. (Can. Copper Co.)

Creighton Ore	1.40	3.90	39.5
Crean Hill Ore	2.50	1.75	24.0

3. Blast Furnace. (Mond Nickel Co.)

Levack	0.5	2.8	45.0
Garson	1.9	2.3	29.1
Worthington	3.4	3.0	26.0
VICTORIA	3.4	1.9	40.2
Garson Quartz	1.1	0.5	10.7

The matte produced from (1.)	9.8	14.5	44.8
" slag " " "	0.21	0.40	34.5
" matte " " (2.)	7.40	16.9	45.0
" slag " " "	0.16	0.32	40.06
" Matte " " (3.)	9.0	11.0	48.0
" slag " " "	0.17	0.22	26.6

In all cases the concentration is about 100 of ore to 23 of matte.

Ore #158 (Laboratory Ore) McGill	1.8	0.9	18.0

From the above it is seen that the laboratory ore is very low in grade and would not be classed as ore at the smelters. The ratio of copper to nickel is very high, much more so than is the case with any of the ores given above, Victoria ore is the only one that approaches this ratio, while in most of the others the nickel exceeds the copper.

LABORATORY PROBLEM.

The laboratory problem was, then,-

1. To produce a medium grade concentrate with a high extraction. This would be merely concentrating for the utilization of low grade ores (or rather what are now termed 'not ore') in the present scheme of smelting.
2. To produce a concentrate containing a portion of the nickel (all the nickel if possible) with most or all of the iron and only a very small amount of copper. This could be used for the direct production of nickel-copper steel.
3. To make a practically complete separation between the copper and the nickel-iron. This if well done would simplify the smelting and refining process.

It is to be understood that the above are three separate and distinct problems which are arranged in their supposed order of difficulty, No. 1 being the most simple.

At the outset it was realized that the complete separation of the copper from the nickel would be almost impossible for the two minerals were most intimately mixed. The difficulties and theoretical reasons therefore, have been treated under the head of 'Differential Flotation'.

LABORATORY WORK.

Part 1.

Tests using a single cell Minerals Separation type intermittent flotation machine.

Part 2.

Tests using a 10 cell continuous Minerals Separation type flotation machine.

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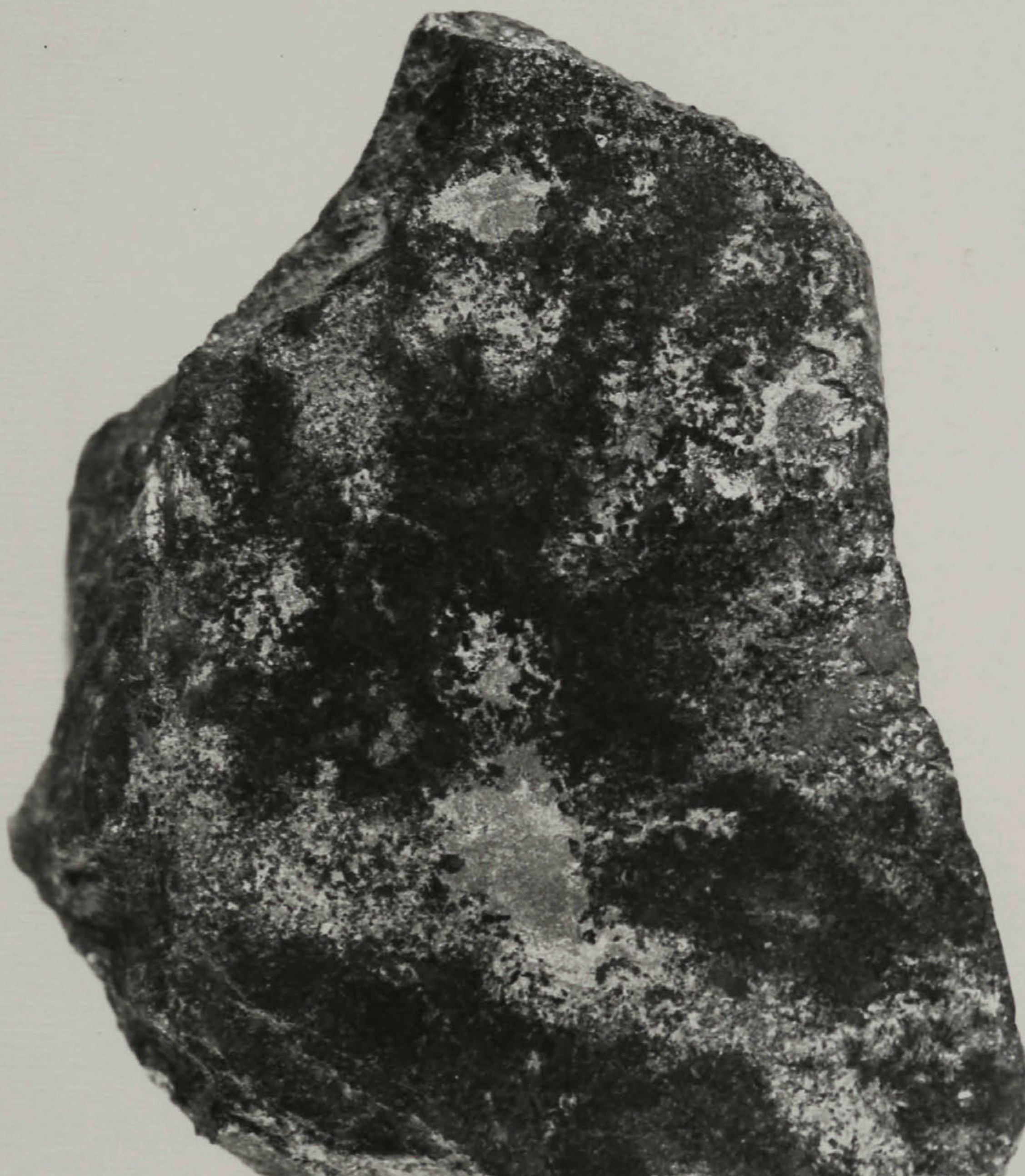
PLATE I.



LABORATORY WORK.

The laboratory experimental work was carried out in two parts.

(a) Tests using a single cell intermittent Minerals Separation type flotation machine.

(b) Tests using a 10 cell continuous Minerals Separation type flotation.

The first part of the work was carried on jointly by Mr. J.E.Saunders,B.Sc.,and the author. Then Mr. Saunders endeavoured to develop the research using a single cell Minerals Separation type sub-aeration machine,while the author's efforts were directed to the 10 cell machine.

The same ore was used in all tests so a description of it and the methods used in the chemical analyses may well be inserted here.

The Ore.

The ore (plate 1). bore the laboratory nunber 158,and was reputed to be from the Victoria Mine of the Mond Nickel Co. It is seen to consist of chalcopyrite and pyrrhotite with a norite gangue. The nickel is most probably isomorphous with the iron in the pyrrhotite for it has been said* that pentlandite is not found in low grade ores,being formed only when the nickel content is comparatively high. No pentlandite was visible on the polished surface of the specimen when examined with a hand magnifier.

* Lectures on Ore Deposits - Dean F.D.Adams.

The average metallic content of the ore was,-

Copper ------------- 1.8 %

Nickel ------------- 0.9 %

Iron -------------18.0 %

Insoluble ---------- 54. %

Specific Gravity -- 3.2

PREPARATION of SAMPLES.

The preparation of the samples was carried out as follows,-

The flotation concentrate or tailing was dewatered on the suction filter (plate4) and the product with the filter paper dried in a steam oven. When thoroughly dry,it was weighed using a filter paper tare,and then carefully brushed from the filter paper.

The cakes formed by the drying were broken by passing them through a 20 or 40 mesh screen. The material was then mixed and two samples cut from it with the small riffles. One of the samples,usually 30 grams or more,was placed in a sample bag for subsequent screen analysis if so desired. The other sample was bucked down to pass an 80 mesh screen and a small sample,about 5-10 grams,taken by numerous dips with a spatula. The remainder of the -80 mesh sample was placed in a sample bag for a check analysis if such should be necessary.

The analysis of low grade copper ores usually presents considerable difficulty;and in this case accuracy,especially in the tailings assay,was essential. The particular reason for this can best be shown by a numerical example.

Feed assay ---- Cu 1.8 %

Product.	% Weight.	Copper %	Weight	% of Total.
Conct.	20	7.0	1.4	77.8
Tails.	80	.50	.4	
	100		1.8	
Conct.	20	7.0	1.4	81.2
Tails	80	.40	.32	
	100		1.72	

Thus an error of 1/10 in the assay of the tails produces an error of 4.5% in the combined weight of concentrate and tails and an error of 3.4% in extraction.

For this reason,and to take care of any slight variation in the ore feed,extractions,etc. were figured on the assay of the feed as calculated from the combined assays of concentrates and tailing. This value should of course check closely with the assay of the ore and when it did not,the samples were re-analyzed.

For certain reasons,such as method of preparation,etc., the grade of the ore was not exactly the same for all tests,although the variation was small. However,the feed for any one series of tests was the same. This is more fully explained in the summary of the tests.

CHEMICAL METHODS.

There are in use four general methods for the determination of copper in ores. They are the iodide,electrolytic,cyanide,and thiocyanate methods.

Of these,the electrolytic and cyanide methods were not applicable in this work. The former requires expensive apparatus with which the laboratory was not equipped,and it is possible that arsenic in the ore would interfere. On the other hand the presence of nickel vitiates the analysis by the cyanide method as the nickel is titrated by the cyanide.

The thiocyanate analysis is the most accurate for low grade copper ores (excepting,of course,the colorometric methods). It depends upon the fact that cuprous copper may be completely precipitated by means of potassium thiocyanate (KCNS) from a solution slightly acid and containing tartaric acid. This precipitate is filtered off and treated with a hot solution of NaOH. The liberated sodium thiocyanate can then be titrated by a standard solution of potassium permanganate.

The method has this drawback which is mainly one of manipulation. The strong,hot,sodium hydroxide solution that must be used rapidly digests the filter paper thus rendering the subsequent washing,which must be thorough,extremely hazardous.

Of course a filter of glass wool and asbestos or an asbestos mat in a Gooch crucible could be used,but the asbestos tends to float away from the glass wool and permit some of the precipitate to escape. This would entirely vitiate the result. If a paper filter is attempted a blank must be run.

The regular iodide method is not applicable to ores with less than 2% of copper but satisfactory results were obtained by using a modified iodide method developed by Messrs. Erlenborn and Edwards in the laboratory last year.

The modification consists in the addition by means of a pipette of 10 cc. of a standard copper solution (1 cc. 0.00401 gm. Cu),titrating as usual and correcting for the copper added. It is obvious that considerable care in the addition of the copper solution is absolutely essential.

The method depends upon the fact that in a solution slightly acid with acetic acid,cupric compounds oxidize potassium iodide with the liberation of iodine. This is then titrated with a standard thiosulphate solution. The reactions are as follows,-

$$Cu(NO_3)_2 + 2KI = CuI + 2KNO_3 + I$$

$$2I + 2Na_2S_2O_3 - 2NaI + Na_2S_4O_6$$

<u>Notes.</u>- Nitrous oxides,ferric ions,free bromine,trivalent arsenic and trivalent antimony must be absent as they will liberate or absorb iodine. Excess of free mineral acid must also be avoided.

The bromine oxidizes the arsenic and antimony to the pentavalent state,in which form they do not absorb iodine. It sometime happens that the blue colour reappears after a time. This is caused by the presence of impurities,especially iron. A large excess of sodium carbonate at the neutralization may operate in same manner and hence should be avoided. In such cases take the first disappearance of the blue colour as the end point.

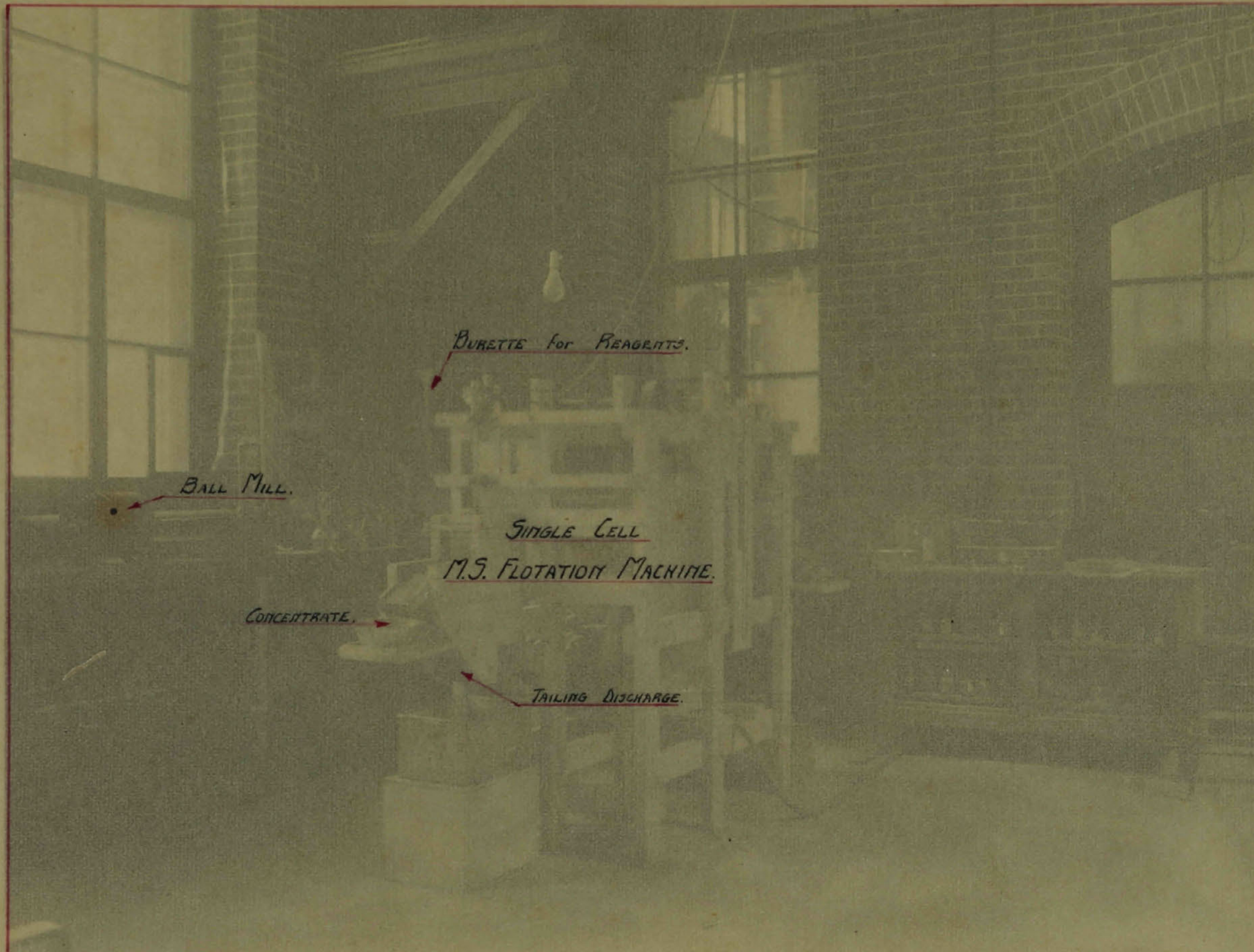
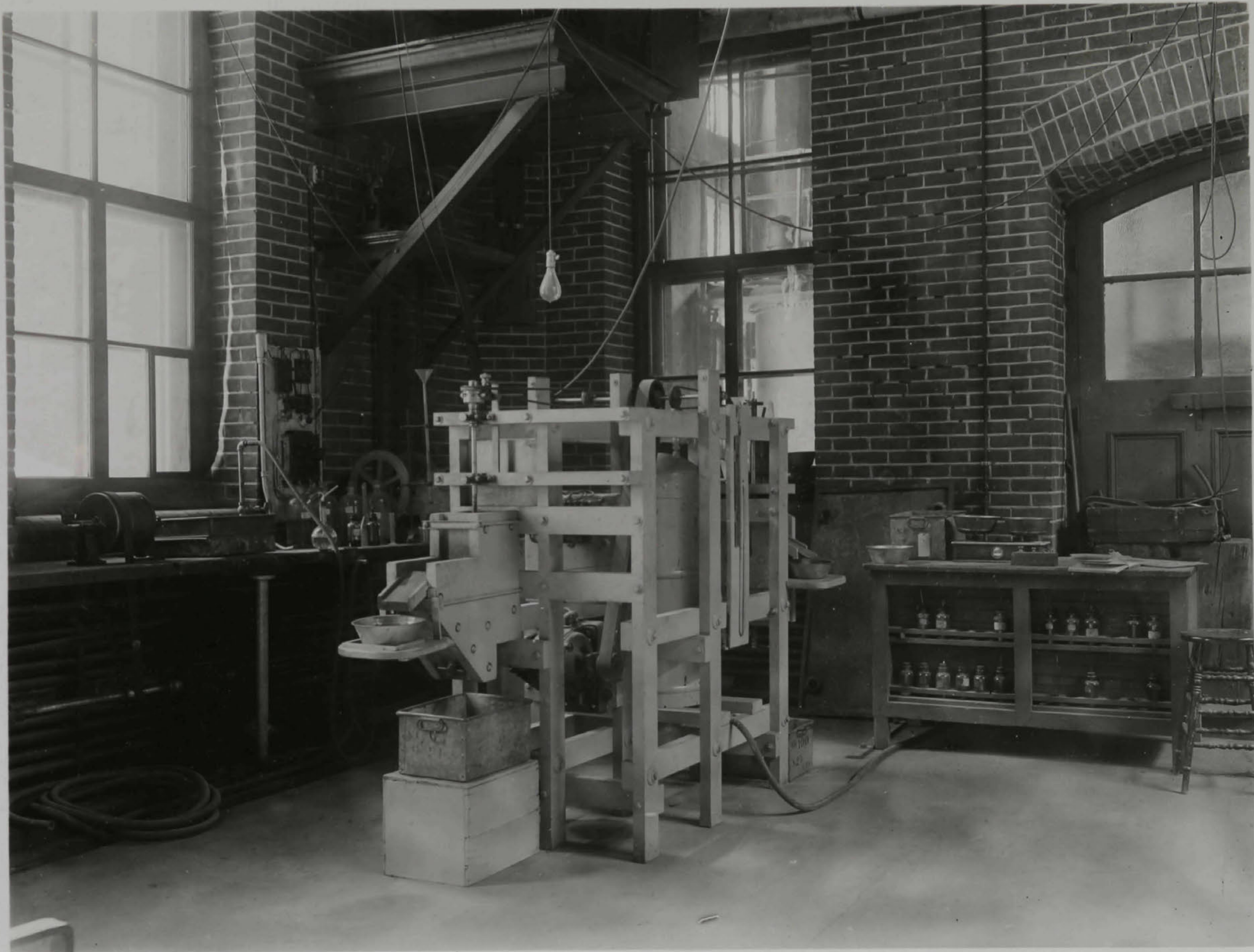

Burette for Reagents.
Ball Mill.
Single Cell
M.S. Flotation Machine.
Concentrate.
Tailing Discharge.

Plate 2.



Notes, (cont'd) It is necessary to add a large excess of potassium iodide to hold the liberated iodine in solution and make the reaction rapid.

Lead and bismuth having yellow iodides cause trouble if present by obscuring the end point.

It is necessary that the acetic acid be added to a solution not too alkaline, as the acetate formed on the addition of the acetic acid to a solution that is strongly alkaline decreases the ionization of the acetic acid thus making the solution insufficiently acid for the reaction between the copper and the iodine to be complete.

Method Of Analysis.

Take 1 gram sample (0.5 gm. if high grade concentrate), add 10 cc. of conc. HNO_3 and 10 cc. of conc. HCl and heat until most of the nitric acid is driven off. Add 10 cc. of 1:1 H_2SO_4 and evaporate to copious H_2SO_4 fumes. (about 3 cc.)

Take up with 25 cc. H_2O and heat until all soluble salts are in solution. Filter off the insoluble matter. The filter and insoluble may be set aside for incineration if it is desired to run the samples for insoluble.

Precipitate the copper from the boiling solution with a strip of pure aluminium. When the iron is all reduced to the ferrous state, all the copper is precipitated. (When the precipitation is complete a white stable foam forms on the liquid in the beaker.)

Decant the hot liquid through a filter, wash the precipitated copper in the beaker several times with small quantities of hot

(water)

water, adding this to the liquid in the filter. The filtrate contains the iron and nickel.

Place the beaker containing the aluminum and the precipitated copper under the drained filter and wash the filter with a little boiling HNO_3 (1:1). Use as little acid as possible, but enough must be added to insure complete solution of the copper. Wash the filter with a little hot water.

Place the aluminum and the dissolved copper on the hot plate and warm for a few minutes; wash and remove the aluminum. Add 10 cc. of bromine water and evaporate to about 3 cc. (All the bromine must be driven off)

Dilute with 25 cc. H_2O. Neutralize the last trace of nitric acid with a saturated solution of sodium carbonate, adding it drop by drop until a green precipitate of copper carbonate forms. When neutralization is complete a stable foam forms if the beaker is agitated. (Avoid a large excess of sodium carbonate)

Dissolve the precipitate with a slight excess of acetic acid. (1:1)

The titration is performed **in the cold solution, volume about** 30 cc. Add 1-3 grams of potassium iodide, depending on the amount of copper in the solution. Titrate with standard sodium thiosulphate. When the yellow colour of free iodine is almost gone, add a few cc. of starch solution and titrate to the disappearance of the blue colour.

The nickel was run by the cyanide method which depends on the following reactions,-

$$Ni(NH_3)_6SO_4 + 4KCN = K_2Ni(CN)_4 + K_2SO_4 + 6NH_3$$

This reaction takes place in a solution slightly alkaline with ammonia and a very large amount of iron may be present without interference if a large amount of sodium citrate be added before making alkaline. The citrate combines with the iron to form un-ionized iron citrate which does not allow the iron to precipitate when the ammonia is added.

The end point of the reaction between the nickel and the cyanide is shown by the disappearance of a turbidity due to the presence of silver iodide. The reaction is,-

$$AgI + 2KCN - KAg(CN)_2 + KI$$

At first the method employed was to oxidize the filtrate from the copper precipitation by means of potassium chlorate, and sodium citrate, neutralize with ammonium hydroxide, and titrate with standard cyanide using silver nitrate and potassium iodide as indicator.

At this time the iron was run by the dichromate method on a separate sample, thus necessitating the weighing of two samples for each determination of copper-nickel-iron. The fact that when the precipitation of the copper is complete the iron is all reduced to the ferrous state was used to combine the iron analysis with that for nickel. In the nickel analysis, as given above, it was necessary to have the iron present in the ferric state and so potassium chlorate was necessary to perform the oxidation.

The Complete method is as follows,-

I R O N.

The filtrate from the copper precipitation is titrated directly with standard potassium permanganate which acts as its own indicator. A slight excess of permanganate turns the solution a permanent pink colour. (The pink colour is not always permanent but the addition of one drop more(or at most two drops) of the permanganate will make it so. This is negligible as it amounts to about 0.0008 gm. iron in a 1 gram sample.)

If the procedure given for the analysis for copper is followed the filtrate will contain the iron as ferrous sulphate,with a slight excess of sulphuric acid,and practically no nitric or hydrochloric acids. These are the conditions necessary for the titration of iron by permanganate.

N I C K E L.

The solution after titration for iron has the iron in the ferric condition. Add 30-40 cc. of a saturated solution of sodium citrate and neutralize with ammonium hydroxide till the solution smells faintly,but distinctly,of ammonia. If the solution has become heated by the neutralization cool again below 20^{o} C.

Add 5 cc. potassium iodide solution and 5 cc. silver nitrate solution and titrate with standard potassium cyanide until the fine suspended precipitate of silver iodide has dissolved and the solution is clear.

<u>Notes</u>,- The reaction between the cyanide and the nickel salt goes on first, then between the cyanide and the silver iodide, The silver iodide thus acts as an indicator and uses up a fixed amount of cyanide. This amount must be determined for the indicator and subtracted from the amount of cyanide used.

The following are important for good results,-

1. The solution must be ammoniacial before titration, as both potassium cyanide and potassium nickel cyanide are split up by acids. Excess of ammonia must be small owing to its dissolving influence on the silver halogen salts.

2. The temperature must not be over 20° C.

3. Sulphate ions should be present during titration. If there are none, add a few cc. of 1:1 H_2SO_4 before the neutralization.

4. The solution should not be too high in nickel. If it is there is apt to be a turbid solution caused by the $Ni(CN)_2$ which gives a good deal of trouble and danger of overtitrating. By more dilute solutions, however, the $Ni(CN)_2$ is continuously dissolved by the KCN so there is no trouble in detecting the end point.

5. Considerable amounts of iron and alumina make the titration very difficult. This may be overcome or lessened by an increase in the amount of sodium citrate. In such cases the solution should stand 5-10 minutes after clearing, and if the precipitate comes back in that time, more cyanide should be added till the liquid is again clear. If the precipitate reappears after fifteen minutes it is of no consequence.

6. The presence of manganese and lime is objectionable. If zinc is present the addition of sodium pyrophosphate will counteract to some extent the bad effects of these metals.

7. Cobalt shows its presence by a similar dark colour in the solution. It reacts with potassium but does not form a similar double cyanide, but salts similar to potassium ferro-cyanide.

$$Co(NH_3)_6 + 6KCN = K_2SO_4 + K_2Co(CN)_6$$

(Potassium Cobalto-Cyanide)

This compound is not stable and readily oxidizes, In general the titration gives the total amount of nickel plus about 3/4 of the cobalt. As the amounts of cobalt are generally very small compared with the nickel, the reactions referred to play an unimportant part.

8. Much difficulty is experienced at first in performing the titration. This can be lessened by placing the beaker on a black glass plate, and having the only source of light very close to the beaker and to one side.

SOLUTIONS, Etc.

SODIUM THIOSULPHATE --- 1 cc. = 0.005 gms. Cu

19.55 gm. pure $Na_2S_2O_3.5H_2O$ in water, 1 gm. NaOH and dilute to i liter. Keep in dark bottle.

POTASSIUM CYANIDE ---- 1 cc. = 0.0025 gms. Ni
11.3 gms pure KCN with a stick of KOK per liter. The KOH is a preservative.

SILVER NITRATE ----- 1 gm. $AgNO_3$ per liter.)
) Indicator.
POTASSIUM IODIDE ---- 40 gms. per liter.)

5 cc. of each of the above used for indicator and this amount requires about 0.35 cc. standard KCN to clear. Determine exact amount by titrating the indicator alone with cyanide.

POTASSIUM PERMANGANATE -- 5.7 gms $KMnO_4$ per litre. Boil and filter. Add 3/4 gm. KOH per 100 cc. solution.

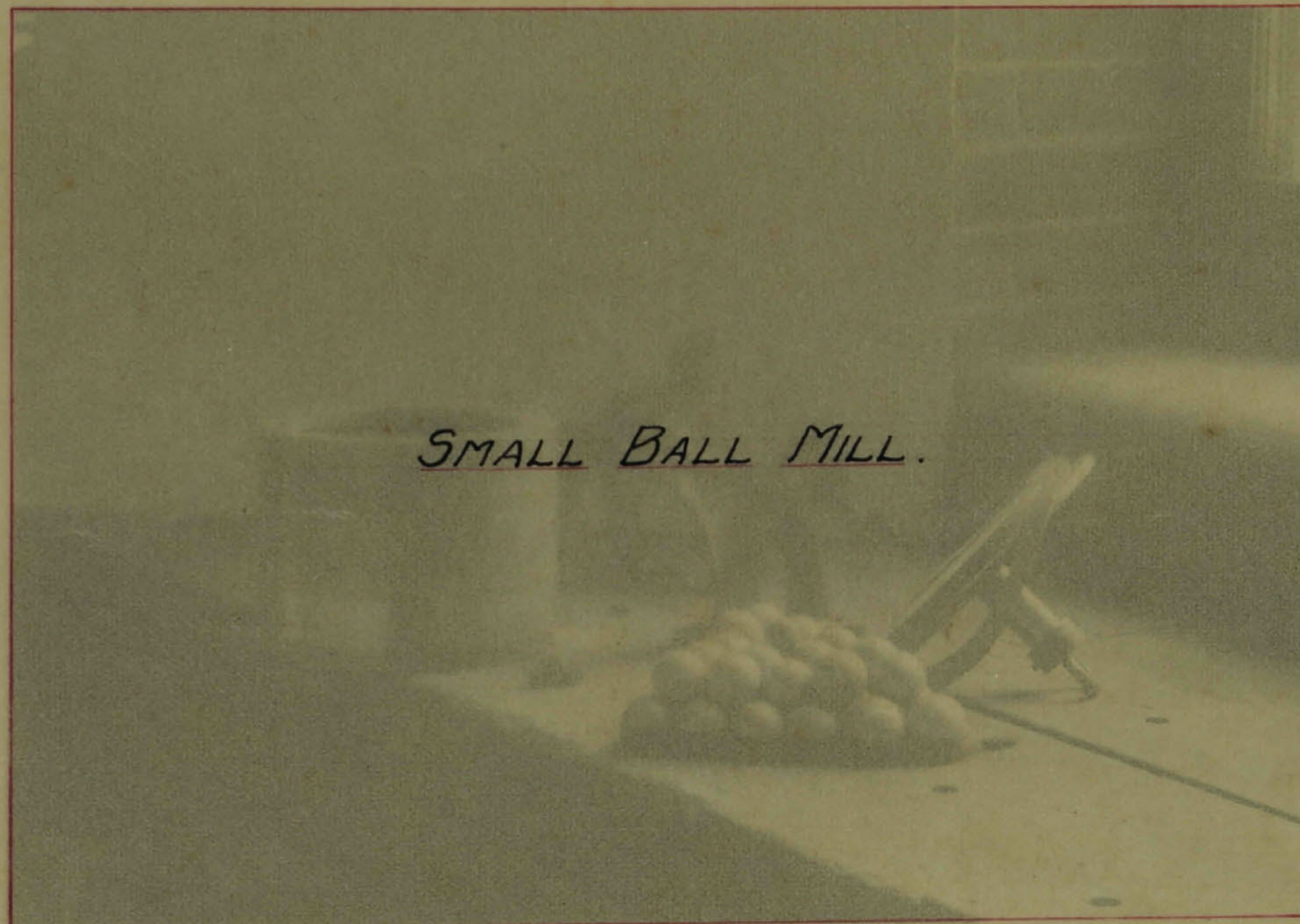
Experimental Apparatus.

The flotation machine, ball mill, suction filters, etc., used for the tests comprising Part One of the work are shown in plates No. 2, 3, 4, and 5.

The flotation machine is of the Minerals Separation type and was designed and built in the laboratory workshops. It consists essentially of an agitation box and a spitzkasten connected at the bottom by a 3/4 in. lead pipe and having a 1 x 2 in. slot at 45° from the agitation box to spitzkasten for the agitation overflow. A series of galvanized iron baffles is inserted in the overflow to check any tangential motion of the pulp and force it to enter the spitzkasten at right angles to the partition between the agitation box and the spitzkasten. Without these baffles the froth builds up from one corner and only a part of the spitzkasten is covered with froth.

The impeller is of the Howard or double fan type, with a solid division between the fans. This type produces a better pumping action than the more usual four blade 45° impeller. It was run at a speed of from 1000 to 1300 r.p.m. (depending upon the condition of the driving belts.) This gives a peripheral speed of 1050 to 1350 ft. per min.

All tests were made on 500 gram. samples of ore which gave a pulp density of about 12:1. This ratio is rather high, much more so than would be used in practice in a large continuous machine, but tends to produce a much cleaner concentrate with probably a lower extraction.



SMALL BALL MILL.

PLATE 3.

The 500 gram sample has been more less standard in the laboratory for some years and it is about the largest amount that can be conveniently handled on th suction filter.

(In flotation experiments at the Colarado School of Mines the pulp ratio used is from 4 1/2 to 6 : 1. The U.S.A. Bureau of Mines recommends 3 1/2 : 1 for certain work.*)

In the experiments the oil was added from a pipette drop by drop and the drops counted. All pipettes were calibrated for the oil with which they were used,hence the weight of a drop of the oil was known. This seems to be a more accurate method than the one recommended by Hyde who uses a Mohr pipette graduated to 1/100 cc.

Reagents such as Na_2CO_3,NaOH,NaCl,etc., were made up by taking 100 grams of the pure dry salt and dissolving in water to 1 litre,thus making a solution such that 10 cc. = 4 lbs/ton of dry ore when a 500 gram. sample is used in the flotation machine.

After the first nine tests all samples were individually ground in the ball mill. The charge for this mill was 500 grams. of ore and 500 cc. water.

Agitation or leaching was carried out in a bottle fitted to the shaking screen mechanism, All agitation tests were with a 1 : 1 pulp,(500 grams ground ore and 500 cc. water)

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*U.S.Bureau of Mines - Bull. No. 205.

Summary of Tests.

To summarize the tests and present the information in such a manner that it is intelligible and yet concise is a matter of very considerable difficulty. It has seemed best to plot the results of Tests No. 1-29, as they are readily adaptable to such treatment. With the subsequent tests, however, which have two concentrates, the plot or graph would become so complicated as to defeat the purpose for which it was made. These tests have, therefore, been tabulated and it is hoped that the information thus presented may be as readily comprehended by the reader as though they had been plotted.

Series 1. (a) Tests. 1,2,3.

These tests were made to determine the action of three kinds of oils in a neutral pulp, or rather a pulp in which the oil was the only addition.

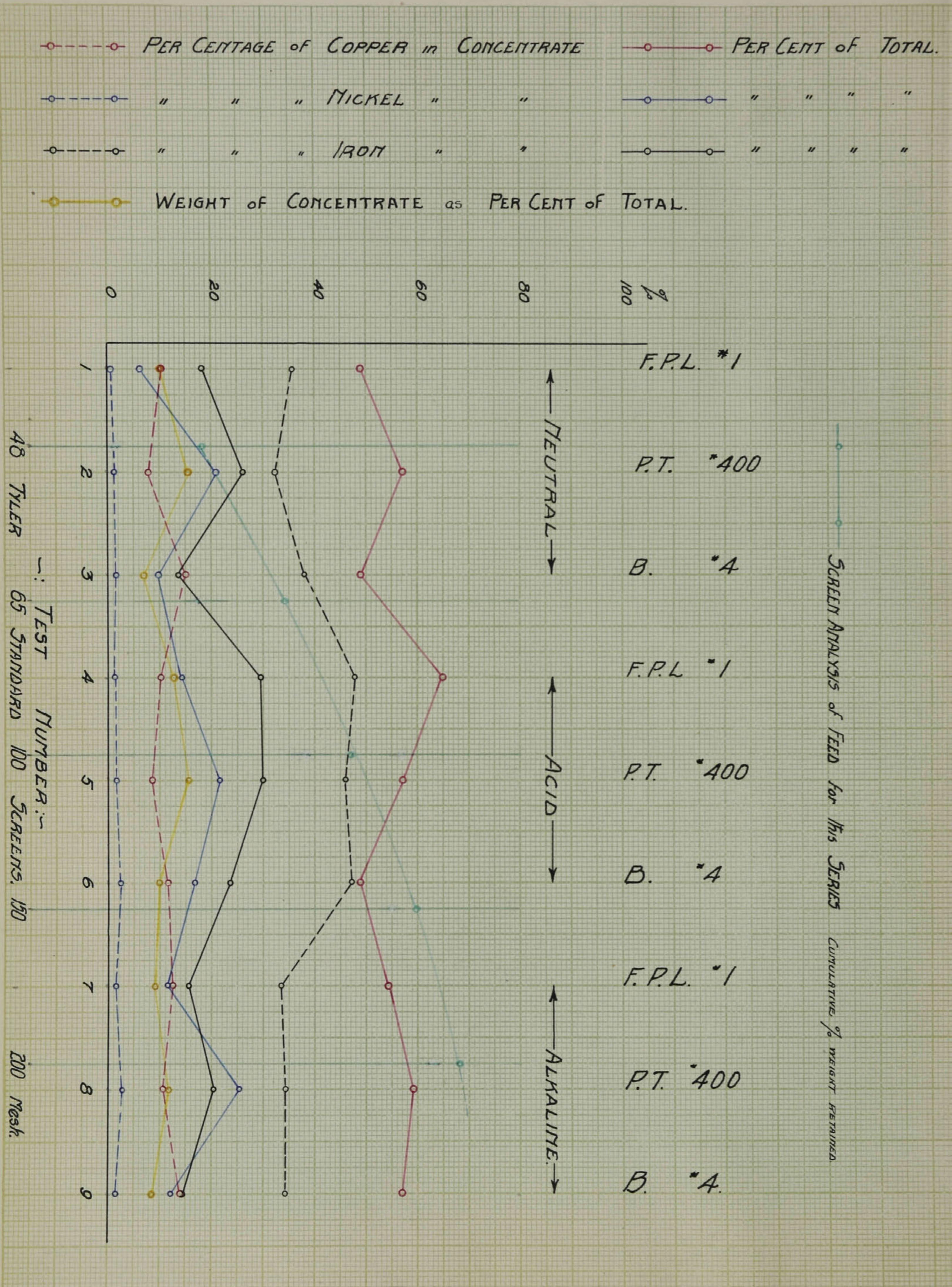
Oils.-

F.P.L.* No.1 - Pine Oil - General Naval Stores No. 5. From longleaf southern pine by the steam and solvent process. - clear light amber colour - Sp. Grav. 0.9330 ; Ref.Ind. 1.4837 (both at 15° C.)

P.T.+ No. 400 - Crude Wood Creosote Oil. - Sp.Gr. 1.025 - Dist. Pts. 190-360° C.-Ref.Ind. 1.4977 Vis. 2.9

Barrett No. 4 - Coal Tar Creosote.

* Forest Products Laboratories of Canada.
\+ Pensacola Tar and Turpentine Co.



PER CENTAGE of COPPER in CONCENTRATE
PER CENT of TOTAL.
" " " NICKEL " "
" " " "
" " " IRON " "
" " " "
WEIGHT of CONCENTRATE as PER CENT of TOTAL.
0 20 40 60 80 100 %
F.P.L. #1
P.T. #400
B. #4
F.P.L #1
P.T. #400
B. #4
F.P.L. #1
P.T. #400
B. #4.
NEUTRAL
ACID
ALKALINE.
SCREEN ANALYSIS of FEED for this SERIES
CUMULATIVE % WEIGHT RETAINED
1 2 3 4 5 6 7 8 9
:- TEST NUMBER :-
48 TYLER 65 STANDARD 100 SCREENS. 150 200 Mesh.

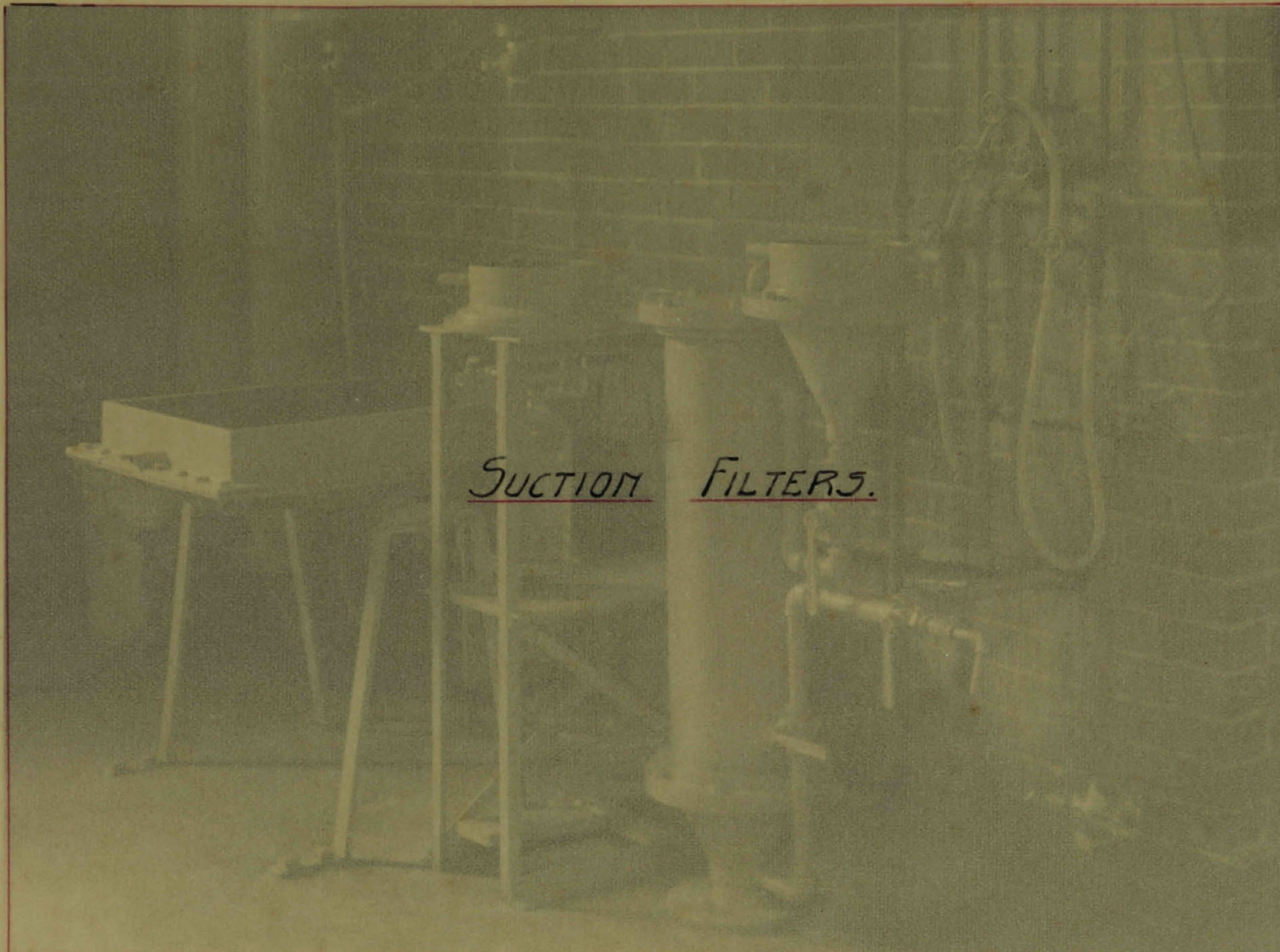
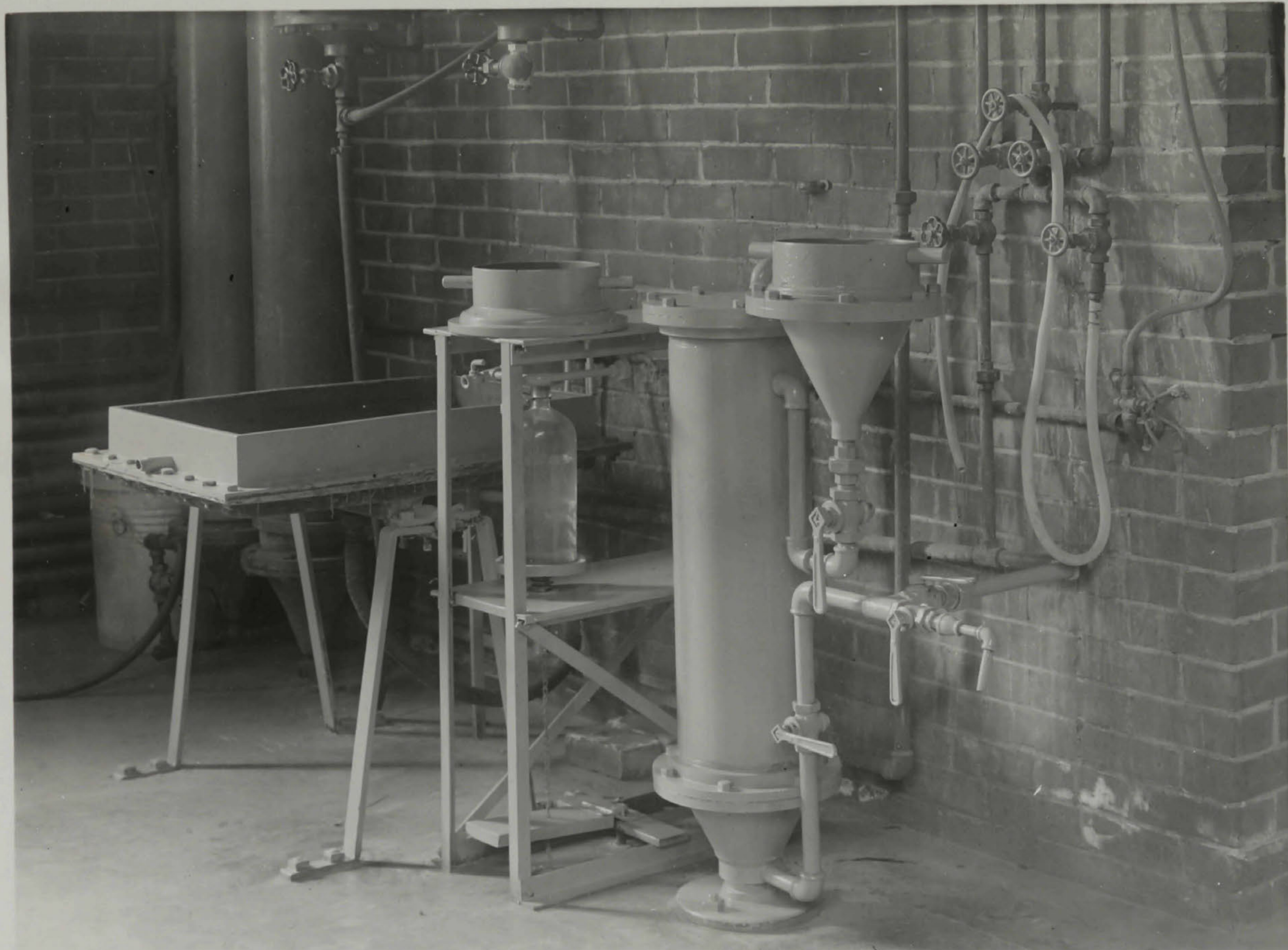


PLATE 4.



As mentioned on the data sheet for Test No. 1,the ore was prepared by taking 100 lbs, of the coarse ore,crushing and screening this on a 40 mesh screen till about 50 lbs. of -40 mesh material had been obtained. Quite naturally this ground ore was slightly higher in grade than the complete ore,and assayed 2.2 % Cu,1.2% Ni,and 19.5 % Fe.

(b) Tests No. 4,5,6.

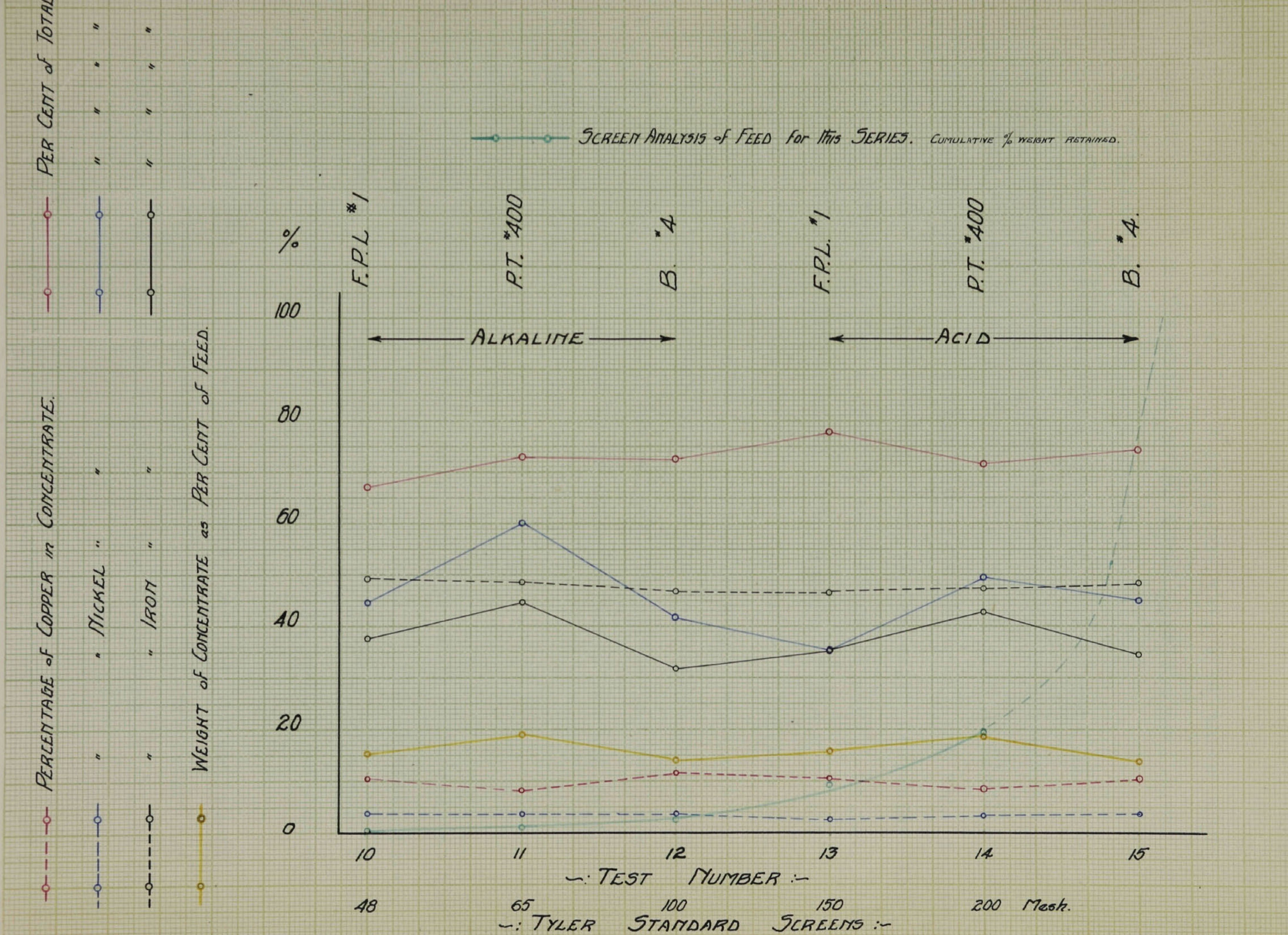
The feed for these tests was the same as for tests No. 1-3, 10 cc. at a time,of a 10% solution of sulphuric acid was added till the pulp was distinctly acid to litmus. The oil in all tests was added by eye,that is no predetermined amount on oil was used, except in a few tests. The reason for this is,that some oils must be present in far greater quantity than others and if the correct amount of a poorly frothing oil (such as B#4) had been taken as standard,this same amount of a more soluble oil would hopelessly over oil the pulp and vitiate the test.

(c) Tests No. 7,8,9.

These tests were the same as the previous ones,but sodium carbonate (8.0 lbs./ton) was substituted for the sulphuric acid.

It is well to note that when an alkali is used,the amount of Barrett No. 4 required is almost halved. This is due to the alkali uniting with part of the oil to form soap which produces a froth.

These nine tests have been taken together because they were


Per Cent of Total
" " " "
" " " "
Percentage of Copper in Concentrate.
" Nickel " "
" Iron " "
Weight of Concentrate as Per Cent of Feed.
Screen Analysis of Feed for this Series. Cumulative % weight retained.
%
F.P.L #1
P.T. #400
B. #4
F.P.L. #1
P.T. #400
B. #4.
Alkaline
Acid
100
80
60
40
20
0
10
11
12
13
14
15
-: Test Number :-
48
65
100
150
200 Mesh.
-: Tyler Standard Screens :-

run with the object of determining the action of three oils commonly used in flotation in the three possible conditions of the pulp,namely,neutral,acid and alkaline.

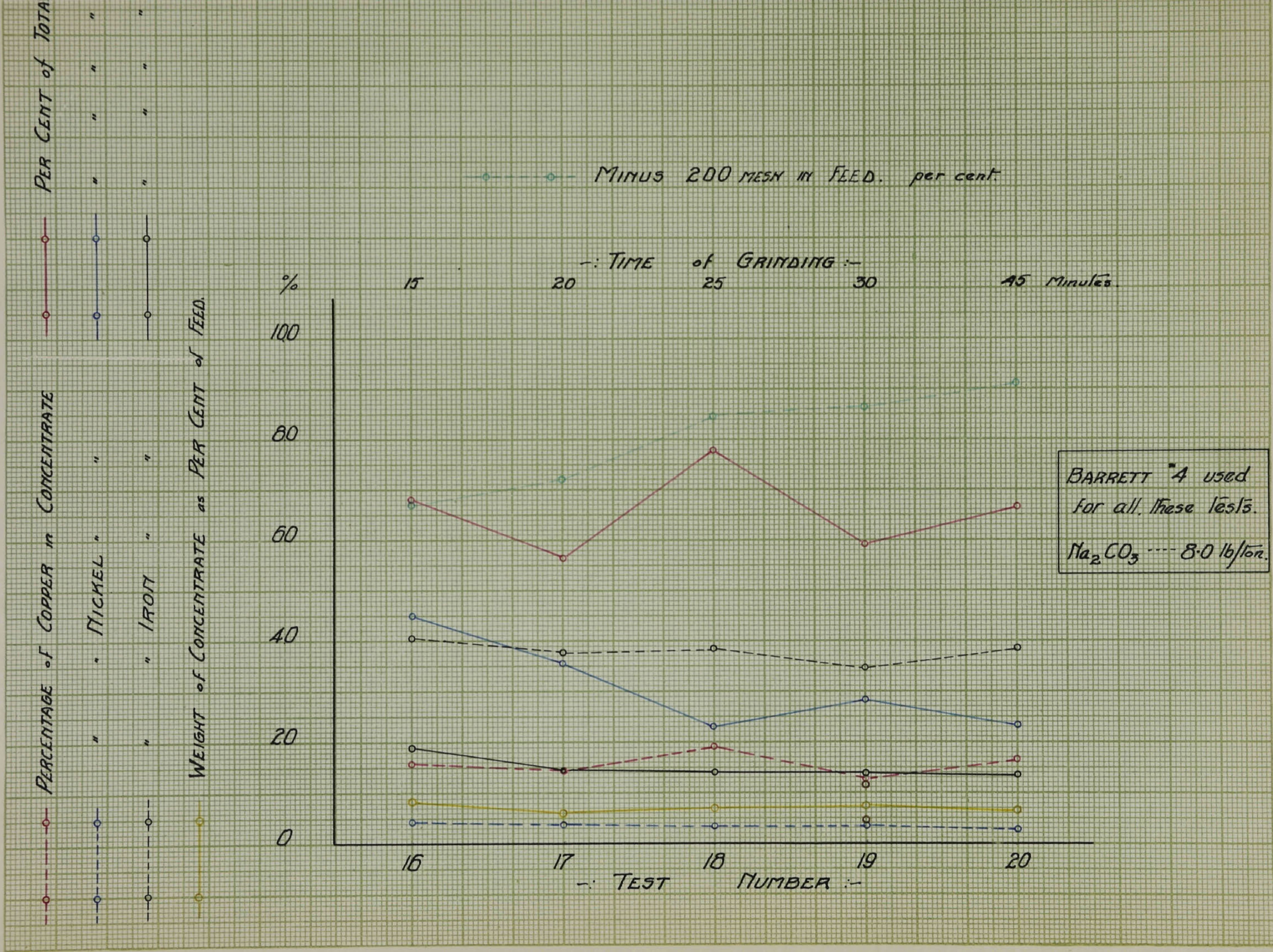
It will be noticed from the graph that Barrett No. 4 in neutral pulp produced the highest grade copper concentrate,but the test was of 45 minutes,while the others were of 21-25 minutes. This shows that B#4 is a very slowly frothing oil and thus raises only the more easily floated portion of the sulphides,unless the test is carried on for a considerable time. It should be,then,the most suitable for differential work because of the time that elapses before the more difficultly floatable sulphides come up.

In all cases the grade of concentrate and total extraction were rather low. This may have been due to surface oxidation of the ore since grinding,or the mineral sulphides may not have been separated from the gangue by grinding(as there was but 32 % of minus 200 mesh material in the feed).

Series 2. Tests No. 10,11,12,13,14,15.

These tests were practically the same as those above,but the feed was ground wet in the small ball mill for 15 minutes. This would remove any surface oxidation and also produced a much finer feed.there being 81.0% of -200 mesh material instead of 32% as before.

Referring to the graph,it is seen that the extraction of copper has risen considerably in all tests. The extraction of nickel is also very much higher,but the percentage of nickel in


PER CENT of TOTA
PERCENTAGE of COPPER in CONCENTRATE
" " NICKEL " "
" " IRON " "
WEIGHT of CONCENTRATE as PER CENT of FEED.
MINUS 200 MESH IN FEED. per cent.
-: TIME of GRINDING :-
15
20
25
30
45 Minutes.
%
100
80
60
40
20
0
BARRETT #4 used for all these tests.
Na_2CO_3 ---- 8·0 lb/ton.
16
17
18
19
20
-: TEST NUMBER :-

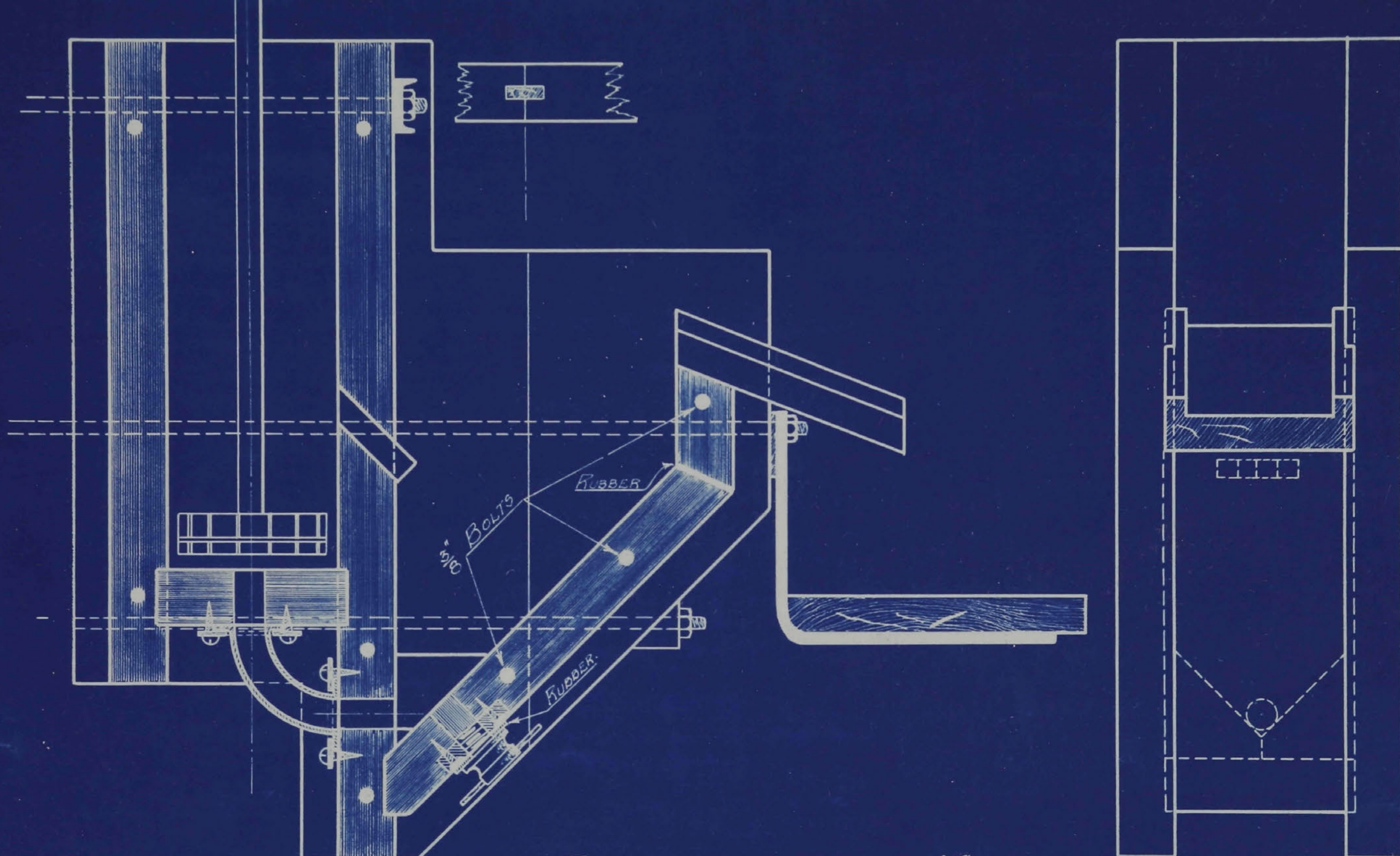
the concentrates from these six tests is almost constant.

As was expected, the most soluble oil (P.T. No.400) gave the greatest weight of concentrate and it contained the greatest amount of iron and nickel.

Series 3. Tests No 16,17,18,19,20.

These tests were for the purpose of determining the influence of fineness of grinding. Two bags of the coarse ore were crushed in the rolls till all passed a screen with 0.241 in. round holes. For each test 500 gms. of this crushed ore was taken and ground in the ball mill. The time of grinding was varied from 15 to 30 minutes by 5 minute increments and the last (Test No. 20) was ground for 45 minutes. Barrett No. 4 with 8.0 lbs./ton sodium carbonate was used in each test. The time of test was extended to 50 minutes. Due to a slip in manipulation in test No. 18,1.2 lbs./ton of oil was added instead of 0.8 lbs/ton This might account for the phenomenal increase in the extraction of copper although the weight of concentrate was not any higher than the average. From these tests it was concluded that fineness of grinding played a small part, so long as the bulk of the feed was -100 mesh. At this degree of comminution the closely intermingled sulphides are probably almost completely released.

It might be well to point out one defect in the preparation of the feed as given above. The screen used, No. 9, was too coarse and the crushed ore as fed to the ball mill varied from +8 to -200 mesh with a very considerable part of it +20 mesh. Thus to reduce all the +20 mesh material to say -65 mesh would require



FLOTATION TEST MACHINE

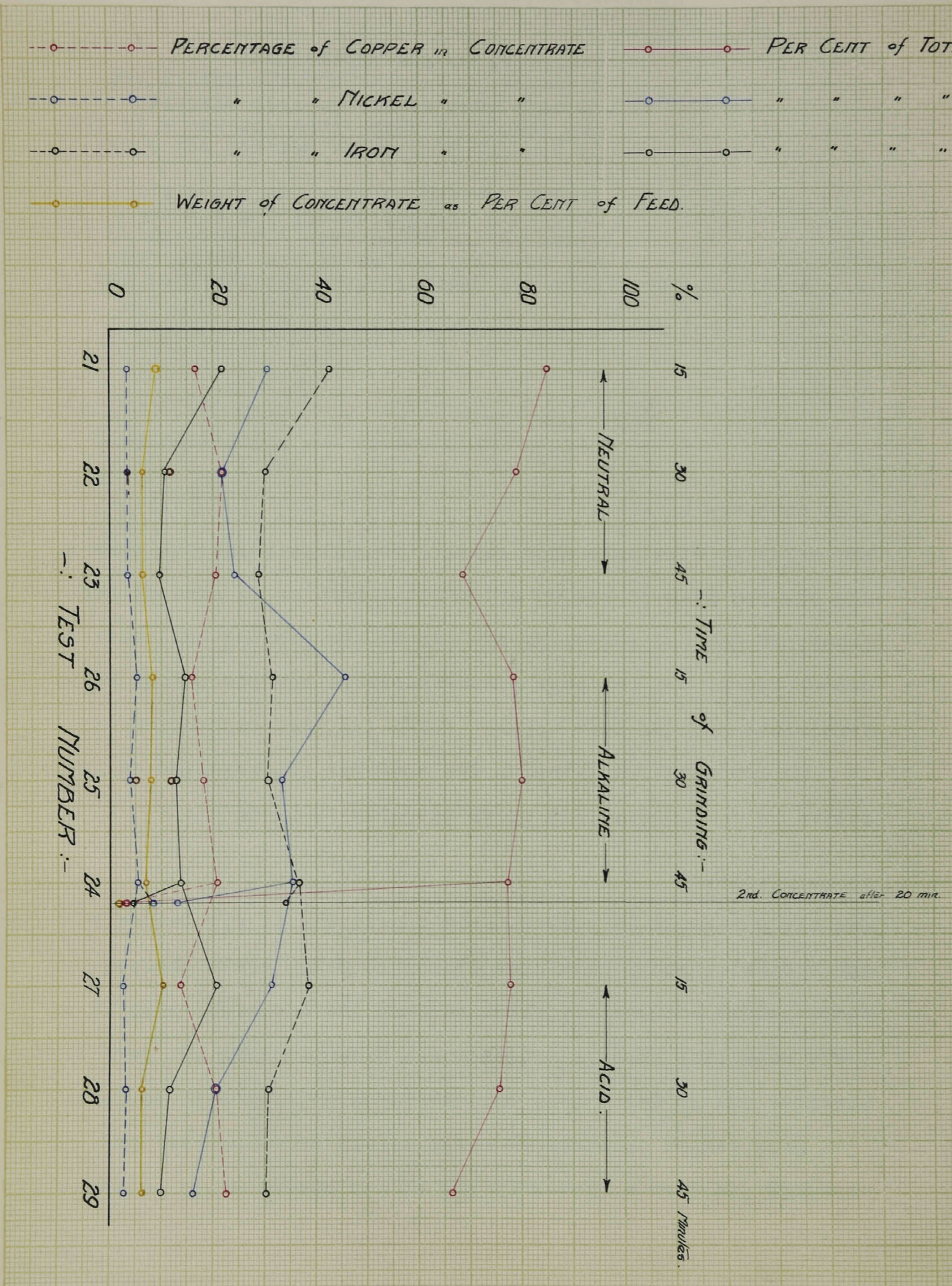
MINERALS SEPARATION TYPE

ORE DRESSING LAB. McGILL UNIVERSITY.

Scale – 3 in. = 1 Foot.

C.L.D.

PLATE 5.


PERCENTAGE of COPPER in CONCENTRATE
PER CENT of TOT
" " NICKEL " "
" " IRON " "
WEIGHT of CONCENTRATE as PER CENT of FEED.
0 20 40 60 80 100 %
21 22 23 26 25 24 27 28 29
TEST NUMBER :-
15 30 45 15 30 45 15 30 45 Minutes.
TIME of GRINDING :-
NEUTRAL
ALKALINE
ACID.
2nd. CONCENTRATE after 20 min.

crushing for such a time that 90% of the charge would be -200.

This degree of crushing would hardly be economical in practice, and to get a feed corresponding more closely to large scale work (yet have it sufficiently granular that the ball mill could remove surface oxidation without the practical sliming of the charge) it would have been better to have 'stage crushed' the ore, screening it between each crushing, till all passed a 14 mesh screen.

<u>Series 4</u>. Tests No. 21,22,23,24,25,26,27,28,29.

So far, even the first of the problems for solution in the laboratory had not been solved. (page 15) The extraction of copper and nickel had been disappointingly low, the former never exceeding 80% while that of the latter reached 60% but once. It was decided then to use an oil mixture such as is used at Cobalt and which is, also, what Hyde terms 'his standard testing mixture.

It consists of,-

20 %	Pine Oil -- F.P.L. No. 1
70 %	Coal Tar Creosote --- F.P.L. No. 24*
10%	Coal Tar.

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* F.P.L. No. 24 - Coal Tar Creosote from the Dominion Tar and Chemical Co., Sault Ste. Marie, Ont. black opaque appearance - generally an excellent collecting oil, but a poor frother unless in alkaline circuit.

It is very similar to Barrett No. 4 and was used as a substitute for No. 4 in the 10 cell machine and in this mixture principally because a large supply was available in the laboratory.

Series No. 5 Tests No. 30,31,32,33, 34.

Test.	Product.	%Weight.	Reagent.	Amt.	Oil.	Cu Conc.	Cu Ext.	Ni Conc.	Ni Ext.	Fe Conc.	Fe Ext.
30	Conct.	8.6	NaOH	5	B#4	15.8	72.0	4.10	34.4	34.8	16.0
	Tails	91.4				0.45		0.73		17.1	
31	Conct	11.7	NaOH	10	B#4	13.0	81.4	5.1	52.5	38.2	23.6
32	Conct	10.0	NaOH	15	B#4	15.4	81.0	4.27	39.4	36.4	20.2
33	Conct.	11.6	NaOH	20	B#4	13.1	78.0	3.85	38.0	36.0	22.6

34	Conct.	10.7	NaOH	10	B#4	13.5	84.5	4.24	43.5	38.4	22.5

This Test (No. 34) run as check on Test No. 31.

While the results of the previous series of tests (Series No.3) showed, more or less, that the effect of grinding was small, yet they were not in very close agreement. It was, then, to check these that the present series was run. (In addition, of course, to the reason given on the previous page). The Series comprises three sets of three tests, nine in all. The first three were in neutral pulp; the next three in a pulp strongly alkaline; (40 lbs/ton Na_2CO_3), while the last three were in acid solution (H_2SO_4 6 lbs./ton). The grinding was varied from 15 to 45 minutes, as shown on the graph.

From the results of these tests it is seen that too great a percentage of slime is detrimental, most probably for the reason set forth on page (5).

Test No. 29, (45 min. grinding, acid pulp) showed the greatest differential flotation there being over 21% difference in the grade of the copper and nickel in the concentrate. Unfortunately the extraction of copper was the lowest in the series. This emphasizes the common statement that high extraction cannot be obtained with high grade concentrate.

<u>Series 5.</u> Tests No. 30,31,32,33.

With this series we began the use of agitation with chemicals previous to flotation; to induce, if possible, some greater differentiation in the flotability of the copper and the nickel.

The ore for these tests was ground, (500 gms. for each test, ground separately) then filtered, not quite dry so as to make

Series No. 5 a.   Tests No. 35,36,37,38,

Test.	Product.	%Weight.	Reagent.	Amt.	Oil.	Cu Con.	Cu Ext.	Ni Con.	Ni Ext.	Fe Con.	Fe Ext.	Ins.	Ins.Ext.
35	Conct.	30.4	NaOH	5	Mix	6.0	93.0	2.82	92.5	37.3	66.2	23.1	12.4
		30.4					93.0		92.5		66.2		12.4
36	1st.Conc	14.8	NaOH	10	Mix	8.9	71.4	3.52	45.0	41.8	34.8	10.8	3.0
	2nd.Conc	13.1				3.2	22.4	3.12	35.8	41.8	32.2	18.3	4.5
		27.9					93.8		80.8		67.0		7.5
37	1st.Conc	16.6	NaOH	15	Mix	8.1	72.8	3.72	51.7	41.9	37.4	10.5	3.3
	2nd.Conc	11.0				3.3	19.6	2.92	27.0	38.9	23.0	19.5	4.0
		27.6					92.4		78.7		60.4		7.3
38	1st.Conc	10.0	NaOH	20	Mix	11.1	63.8	5.20	45.4	38.4	22.6	11.3	2.0
	2nd.Conc	13.6				2.7	21.2	2.72	32.2	42.6	33.3	14.6	3.5
		23.6					85.0		77.6		55.9		5.5

Test.	Product.	%Weight.	Reagent.	Amt.	Oil.	Cu Con.	Cu Ext.	Ni Con.	Ni Ext.	Fe Con.	Fe Ext.	Ins.	Ins.Ext.
39	Conct.	20.2	H_2SO_4	20	Mix	8.6	90.3	2.32	66.5	47.2	53.2	-.-	-.-
		20.2					90.3		66.5		53.2		-.-

----

subsequent removal from the filter paper easy, and weighed. After allowing for the filter paper and the plaque, which is used to carry the filter paper and its load of moist pulp, the moisture in the pulp can be calculated. From this it is simple to calculate the amount of water and chemical that must be added so that the agitation may be in a 1:1 pulp and have the required amount of chemical present.

In this series the amount of chemical, NaOH, was varied while all the other factors were kept as constant as possible.

Curiously, the second test, No. 31, which had NaOH 10lbs./ton gave the highest extraction of copper and the highest extraction of nickel, the extraction of both copper and nickel falling off in the next two tests. The first test, No. 30, (NaOH - 5.0 lb/ton) produced the highest grade of concentrate as regards copper and it was also the lowest in iron, with the lowest extraction of iron and of nickel.

As regards differential separation, then, test No. 30 seemed to give the best results.

This Series was run using Barrett No. 4 oil.

Series 5 a. Tests No. 35,36,37,38.

This series of tests is parallel to series 5, above, but the oil mixture was used instead of Barrett No. 4, and two concentrates were made instead of one.

Series No. 6   Tests. 40,41,42,43 -- 44

Test.	Product.	% Wt.	Reagent.	Amt.	Oil.	Cu Conc.	Cu Ext.	Ni Conc.	Ni Ext.	Fe Conc.	Fe Ext.
40	1st.Conc	6.9	NaOH	10	B#4	17.8	63.1%	4.28	29.0%	30.6	11.7%
	2nd.Conc	10.8				1.7	9.4	3.63	38.2	46.8	27.8
		17.7	NaOH	10	B#4		72.5		67.2		39.5
41	1st.Conc	6.2			B#4	19.7	71.8	4.33	29.1	34.2	12.5
	2nd.Conc	16.2			Mix.	1.0	9.5	2.92	51.5	46.4	44.2
		22.4	NaOH	5			81.3		80.6		56.7
42	1st.Conc	6.9			B#4	19.0	73.9	3.88	25.9	35.8	14.1
	2nd.Conc	16.4			mix	0.5	4.7	3.38	53.5	48.0	45.3
		23.3	NaOH	5			7[illegible].6		79.4		59.4
43	1st.Conc	4.4			B#4	23.8*	57.5	3.02	15.9	32.0	8.1
	2nd.Conc	6.6				5.0	18.1	5.30*	41.7	42.8	16.2
		11.0	NaOH	5			75.6		57.6		24.3
44	1st.Conc	22.4				6.8	79.5	2.92	67.7	44.8	53.0
	2nd.Conc	2.6				3.2	4.4	3.22	8.9	38.9	5.5
		25.0	NaOH	5	B#4		83.9		76.6		58.5

Test 43 gave the highest grade Copper concentrate, and also the highest grade Nickel concentrate (2nd.Concentrate) The Iron extraction was the lowest in the series (1st. Conct.) but the weight of concentrate produced was small.

Test 44 is not in the series. For this 25 drops B#4 were added to the pulp before agitation in the bottle.

In test No. 35, only one concentrate was taken as the froth was exceedingly heavy and so it was thought that all the sulphides had been floated at once, thus rendering a second skim futile. The extraction of Copper was 93% and of Nickel 92.5% with a concentrate of 8.8% total Copper and Nickel. This is obviously a solution of the first problem. The ratio of concentration was about 3:1.

The first concentrate from test No. 38, (NaOH - 20 lbs/ton) contained 16.3% of copper-nickel, but the extraction was rather low.

One test was run using sulphuric acid (No. 39) and the results are suprising. The extraction of copper was very high (90%) while the extraction of nickel was lower than in any of the tests of Series 5a. The concentrate contained 10.9% of copper-nickel.

<u>Series</u> 6. Tests. 40,41,42. - 43 - 44.

The first of these tests (40,41,42) were to determine the effect of varying the time at which the second concentrate was taken; while No.43 is a duplicate of test No.42 but with Barrett No. 4 substituted for the Oil Mixture. (It is also a duplicate of test No.30 except that two concentrates were made)

The first concentrates of Tests 40,41,42 clearly show the way in which the nickel and iron go together and also that they float much less readily than the copper.

Series No. 7 Tests, 45,46,47,48.

Test.	Product.	% Weight.	Reagent	Amt.	Oil.	Cu Conc.	Cu Extr.	Ni Conc.	Ni Extr.	Fe Conc.	Fe Extr.
45	1st.Conc	4.6			B#4	18.2*	48.0	1.04	4.8*	36.8	9.4*
	2nd.Conc	13.0			Mix	4.2	31.2	1.96	24.2	44.0	31.6
		17.6	$FeCl_3$	20			79.2		29.0		41.0
46	1st.Conc	15.9			B#4	10.1	87.7*	2.50	36.9	45.6	38.4
	2nd.Conc	6.9			Mix	2.1	8.0	3.96	25.6	43.0	15.8
		22.8	$FeCl_3$	20			95.7*		62.5		54.2
47	1st.Conc	5.7				17.4	57.5	1.44	8.5	40.7	13.4
	2nd.Conc	14.7				2.3	19.5	3.08	47.5	19.5	41.8
		20.4	$FeCl_3$	20	Mix		77.0		56.0		55.2
48	1st.Conc	6.0				16.2	59.5	1.64	9.5	39.6	13.0
	2nd.Conc	9.0				4.7	25.0	2.82	24.5	43.6	21.2
		15.0	$FeCl_3$	10	B#4		84.5		34.0		34.2

Test No. 46 same as Test No. 45, but the Ferric Chloride was washed out of the pulp after agitation so that there would be very little in the flotation machine.

In the light of the requirements for the solution of the second problem (page15) the results of the second concentrate of test No. 42 are especially interesting. Here is a product containing 3.38% nickel,(53.5% of the total nickel) **45.6%** iron and only 0.5 % Copper or 4.7% of the total copper. Surely this approaches a "concentrate containing a portion of the nickel with most of the iron and only a small amount of copper."

The first Concentrate from test No. 43 contains 26.8% copper-nickel and 32% iron. It is considerably higher in grade than the blast or reverberatory furnace matte.

<u>Series 7.</u> Tests No. 45,46,47,48.

In the Eustis process for the direct production of electrolytic iron from pyrrhotite,ferric chloride is used to leach the pyrrhotite. This suggested the use of ferric chloride to produce some surface alteration in the nickeliferous-pyrrhotite in the hope that it would be rendered unflotable or have its flotability so retarded that it would not float with the chalcopyrite. Accordingly this series of tests was run using a ferric chloride leach.

In test No. 45,Barrett No. 4 produced very little froth and this with practically no copper colour. The amount of concentrate was rather small,also. This suggested that the ferric chloride,while it might be valuable as a modifying agent,should not be present in the flotation machine if Barrett No. 4 was to

Series No. 8 Tests No. 49,50,51.

Test.	Product.	% Weight	Reagent	Amt.	Oil	Cu Conc.	Cu Extr.	Ni Conc.	Ni Extr.	Fe Conc.	Fe Extr.
49	1st.Conc	5.7				18.3	53.5	2.46	14.2	37.5	11.5
	2nd.Conc	12.6				3.7	24.8	2.31	29.5	45.1	30.6
		18.3	NaCl	20	Mix.		78.3		43.7		42.1
50	1st.Conc	5.0				18.6	53.7	2.44	11.9	27.8	7.7
	2nd.Conc	9.1				5.6	29.1	3.06	26.7	45.6	22.7
		11.1	NaCl	20	B#4		82.8		38.6		30.4
51	1st.Conc	6.8				8.7	29.0	2.62	18.8	44.3	16.1
	2nd.Conc	23.0				4.9	55.4	2.19	53.1	35.8	44.1
		29.8	NaCl	20	PT400		84.4		71.9		60.2

Series No. 9 Tests No. 52,53

Test.	Product.	% Weight	Reagent	Amt.	Oil	Cu Conc.	Cu Extr.	Ni Conc.	Ni Extr.	Fe Conc.	Fe Extr.
52	1st.Conc	15.9	NaCl	5		8.2	78.0	3.88	59.2	36.4	33.6
	2nd.Conc	6.6	NaOH	5		3.3	12.7	2.96	18.4	48.0	18.3
		22.5			Mix		90.7		77.6		51.9
53	1st.Conc	8.4				16.1	76.5	4.12	37.9	36.6	16.8
		8.4	as Test 52		B#4		76.5		37.9		16.8

be used. Accordingly, in test No. 46 the pulp after agitation was filtered on the suction filter and washed before charging into the flotation machine.

That the supposition was correct is shown by the very great increase in weight of the first concentrate in this test. The extraction of copper in the combined first and second concentrates is also very high, 95.7%

The ferric chloride does retard the flotation of the nickel and iron as the first concentrate from test No. 45 shows. Here the extraction of copper was 48% while that of the nickel was only 4.8% and of the iron, 9.4%.

Series 8. Tests No. 49,50,51.

Common salt, NaCl, is frequently used as a modifying agent in flotation and this series of tests was run to determine its action on this ore using three different oils,

From the standpoint of copper extraction Test No. 50 in which Barrett No.4 was used is the most satisfactory, for the total of 1st. and 2nd. concentrates is 82.8% (but little less than Test No. 51 (84.4%), but the weight of concentrate is less than in the following test consequently its grade is very much higher.

With NaCl as the reagent, it is difficult to choose between Barrett No. 4 and the Mixture, for while the former gives the greater extraction of copper the latter gives the greater extraction of nickel .

Series No. 10 Tests No. 54,55,56,57,58.

Test.	Product.	% Weight.	Reagent.	Amt.	Oil.	Cu Con.	Cu Ext.	Ni Con.	Ni Ext.	Fe Con.	Fe Ext.	Ins	Ins.Ext
58	1st.Conc	5.2	NaCl)	2.5	B#4	23.3*	66.2	4.60	22.6	32.2	9.1	--	----
	2nd.Conc	2.4	Na_2CO_3)	5.0		6.5	8.6	6.00	13.7	33.4	4.4		
		7.6					74.8		36.3		13.5		
54	1st.Conc	4.9	NaCl)	5.0	B#4	22.8	60.0	5.19	22.7	32.4	8.4	5.8	0.5
	2nd.Conc	2.2	Na_2CO_3)	5.0		10.8	13.1	6.92	13.3	38.0	4.5	6.4	0.2
		7.1					73.1		36.0		12.9*		0.7
55	1st.Conc	5.8	NaCl)	10.0	B#4	20.9	67.6	7.10*	40.4	33.4	10.5	5.4	0.6
	2nd.Conc	2.0	Na_2CO_3)	5.0		8.6	9.6	6.48	12.6	39.6	4.4	9.3	0.3
		7.8					77.2		53.0*		14.9		0.9
56	1st.Conc	7.4	NaCl)	15.0	B#4	18.7	70.5	5.24	37.0	33.6	13.9	5.3	0.7
	2nd.Conc	2.6	Na_2CO_3)	5.0		5.1	6.7	4.92	12.2	40.2	5.8	9.0	0.4
		10.0					77.2		49.2		19.7		1.1
57	1st.Conc	6.3	NaCl)	20.0	B#4	21.1	72.5	4.22	25.5	32.6	11.6	4.6	0.6
	2nd.Conc	2.0	Na_2CO_3)	5.0		7.6	8.5	5.86	11.5	39.2	4.5	9.6	0.4
		8.3					81.0*		37.0		16.1		1.0

Test No 55 gave the highest grade of 1st.Conc. as regards Nickel so far obtained. This was also the highest in combined Copper and Nickel (28.0 %)

<u>Series 9.</u> Tests.No. 52,53.

In the series of tests using NaCl as the reagent it was notice that the pulp gave an acid reaction towards litmus, and as we had determined that an alkaline pulp was more suited to Barrett No. 4, this series of two tests was run using salt and sodium hydroxide (5.0 lbs./ton of each).

The results are tabulated and show that the extraction of copper and nickel has been increased in Test 52 (Mix.) very considerably over the corresponding test using NaCl alone.(No.50)

<u>Series 10</u> Tests No. 54,55,56,57,58.

It had been thought for some time that while Barrett No. 4 gave much better results in an alkaline rather than an acid or neutral pulp, the nature of the alkalai was important and that for this purpose Na_2CO_3 was better than NaOH. So, in this set of tests varying amounts of NaCl were used with 5.0 lbs./ton of sodium carbonate.

From the results it is seen that an increase in the amount of salt lowers the grade of the concentrates as regards copper content, (Test No. 57 is an apparent exception.) and at the same time the percentage of nickel is rising to a maximum with 10 lbs. /ton of NaCl and then decreasing. The percentage of iron in the 1st. concentrates shows practically no change.

As noted on the tabulated sheet, Test No.55 gave the highest grade of 1st.concentrate as regards Nickel obtained in the research. It was also the highest in copper-nickel.(28.0%)

Series No. 11 Tests No. 59,60,61,62.

Test.	Product.	%Weight.	Reagent.	Amt.	Oil.	Cu Con.	Cu Ext.	Ni Con.	Ni Ext.	Fe Con.	Fe Ext.	Ins.	Ins. Ext.
59	1st. Conc	5.6	NaCl)	4	B#4	20.7*	63.7	4.5	24.0	33.4	10.0	5.6	0.6
	2nd. Conc	3.2	Na_2CO_3)	4		8.0	14.0	6.6*	22.1	39.6	6.8	8.0	0.5
		8.8					77.7*		46.1		16.8		1.1
60	1st. Conc	6.6	NaCl)	4	B#4	17.9	65.5	5.9	38.4	33.6	12.5	6.3	0.7
	2nd. Conc	1.9	Na_2CO_3)	4		6.4	6.7	5.5	10.2	39.2	4.1	10.5	0.3
		8.5					72.2		48.6		16.6		1.0
62	1st. Conc	5.6	NaCl)	4	B#4	18.5	55.6	5.2	32.0	32.9	10.3	-.-	-.-
	2nd. Conc	3.2	Na_2CO_3)	4		8.6	14.8	4.7	16.4	39.4	16.4		
		8.8					70.4		48.4		26.7	-.-	-.-
61	1st. Conc	6.7	NaCl)	4	B#4	17.4	65.5	5.6	39.0	33.4	12.5	5.9	0.7
	2nd. Conc	2.8	Na_2CO_3)	4		5.6	8.9	4.9	14.5	41.9	6.7	9.0	0.5
		9.5					74.4		53.5*		19.2		1.2

Test No. 59 agitated for 15 min.

" " 62 " " 60 "

Test No. 60 agitated for 30 min.

" " 62 " " 120 "

Series 11. Tests No. 59,60,61,62.

Having tried (Series 10) the effect of varying amounts of salt it now remained to determine the influence of the time of agitation,the amount of chemicals being constant. In these tests the amount of NaCl (4.0 lb./ton) and the amount of Na_2CO_3 (4.0 lb./ton) was the same for all. The time of agitation was varied from 15 minutes to 2 hours.

The results do not seem to run in any particular sequence, which may be due to the fact that the time of taking the 2nd. concentrate was not the same in all the tests,although the total length of the tests was uniform. The time at which to take the 2nd. concentrate was judged solely by the appearance of the froth,and in poor or artificial light this is sometimes very deceptive.

Series 12. Tests No. 63,64,65,66.

Here,as in series 11,an attempt was made to determine the influence of the time of agitation. The chemicals used were ferric chloride (5.0 lbs./ton) and sodium carbonate (8.0 lbs./ton)

In the first test (No.63) only 4.0 lbs./ton of sodium carbonate was used but it was found that the pulp after agitation was acid,hence the amount was raised to 8.0 lbs./ton for the subsequent tests.

Test No. 63 gave the most decided differential effect between the nickel and cooper. The 1st. concentrate containing 25.7% copper and only 1.66% nickel,giving an extraction of

Series No. 12 Tests No. 63,64,65,66.

Test.	Product.	%Weight.	Reagent.	Amt.	Oil.	Cu Con.	Cu Ext.	Ni Con.	Ni Ext.	Fe Con.	Fe Ext.	Ins.	Ins.Ext.
63	1st.Conc	4.4	$FeCl_3$)	5	B#4	25.7	62.3	1.66	7.2	31.1	7.8	4.5	0.4
	2nd.Conc	3.4	Na_2CO_3)	4		4.2	7.9	5.24	17.4	40.0	0.8	7.9	0.5
		7.8					70.2		24.6		8.6		0.9
65	1st.Conc	6.9	$FeCl_3$)	5	B#4	18.0	69.5	4.60	33.5	35.0	13.1	4.1	0.5
	2nd.Conc	8.5	Na_2CO_3)	8		2.9	13.8	2.86	25.5	47.6	22.0	5.8	0.9
		15.4					83.3		59.0		35.1		1.4
66	1st.Conc	6.2	$FeCl_3$)	5	B#4	20.4	71.6	4.46	28.2	31.8	10.7	4.1	0.5
	2nd.Conc	5.0	Na_2CO_3)	8		5.3	14.9	4.66	23.8	44.0	11.8	7.8	0.7
		11.2					86.5		52.0		22.5		1.2
64	1st.Conc	6.6	$FeCl_3$)	5	B#4	18.8	69.0	4.80	34.9	31.6	11.6	5.8	0.7
	2nd.Conc	6.8	Na_2CO_3	8		2.4	8.9	3.30	24.8	46.0	17.4	8.4	1.0
		13.4					77.9		59.7		29.0		1.7

Test No. 63 agitated 15 min. Test No. 65, 30 min., Test No. 66, 60 min. Test No. 64, 120 min.

67	1st.Conc.	8.9	Na_2CO_3	5	Xcake	15.9	94.0	4.93	41.3	30.5	15.5	14.2	2.6
		8.9					94.0		41.3		15.5		2.6

This ore was lower in grade than for all previous tests.

62.3% of copper and only 7.2% of nickel.

Test No. 67.

At the Mines Branch Ore Dressing Laboratory, Ottawa, some work had been done on a copper-nickel ore using a mixture commonly called 'X' Cake in place of oil, so one test using this reagent was made.

'X' is a mixture of 60% alpha-naphthylamin and 40% xylidin. The mixture is non-volatile, non-inflammable and chemically inactive. It has, unfortunately, an exceedingly offensive odour, which is most disagreeable when slight.

When oils are used in a closed circuit only a little less oil is required than when the mill-feed is made up entirely of new water. The insoluble parts of the oil are probably lost entirely, and only a part of the soluble constituents is returned to the cells with the frothing properties unimpaired. With 'X' cake, this has not been found to be the case. Whatever amount is returned in the water from concentrate or tailing is just as efficient as ever. Apparently little or no deterioration occurs in settling ponds, although the water turns a dark brown. Considerably less of the 'X' cake is therefore required if the make-up water is kept at a low proportion of the total.

It produces a much more granular concentrate than oils do, and consequently the concentrate is much more readily filtered.*

The cost of the mixture is about 35 cents/pound in tank car lots, f.o.b. New York.

* E.H. Robie - Eng. and Min. Jour. - Nov.1,1919.

The 'X' cake gave a very high extraction (94%) of copper with a high concentration ratio (11:1) but the extraction of the nickel was disappointing.

In looking back over the results of the sixty-seven tests summarized in the preceding pages, if they are in many cases all too disappointing it is well to remember that it has been calculated* that with only four different oils, three oil percentages, two pulp densities and two changes in temperature the possible combinations exceed the amazing total of 59,000 !

However, this much has been shown,-

1. It is possible to produce a concentrate containing almost 9.% copper-nickel with an extraction of 93% of the two metals.

2. That the separation of the copper from the nickel-iron is difficult, and may prove practically impossible, especially if a high extraction of both minerals is desired.

3. More than 53% of the nickel and 45% of the iron can be obtained in a concentrate which is about 16% of the total ore, by weight, and contains only 0.5% copper.

The first of these appears to be a satisfactory solution of the straight concentration problem of this complex ore, while the third may be useful for the direct production of nickel steel with a small amount of copper.

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L A B O R A T O R Y   W O R K.

Part 2.

Tests on 10 cell Machine.

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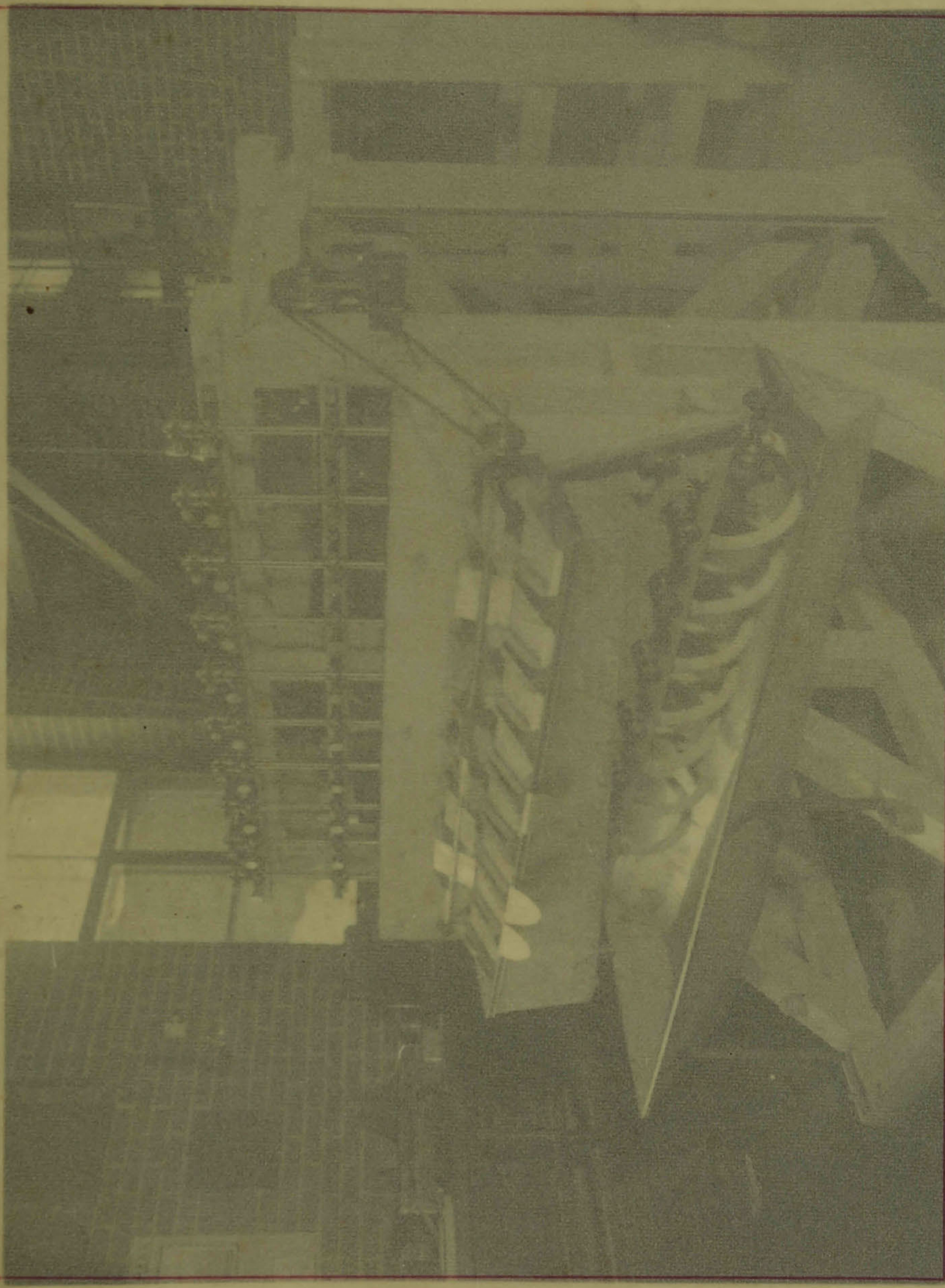
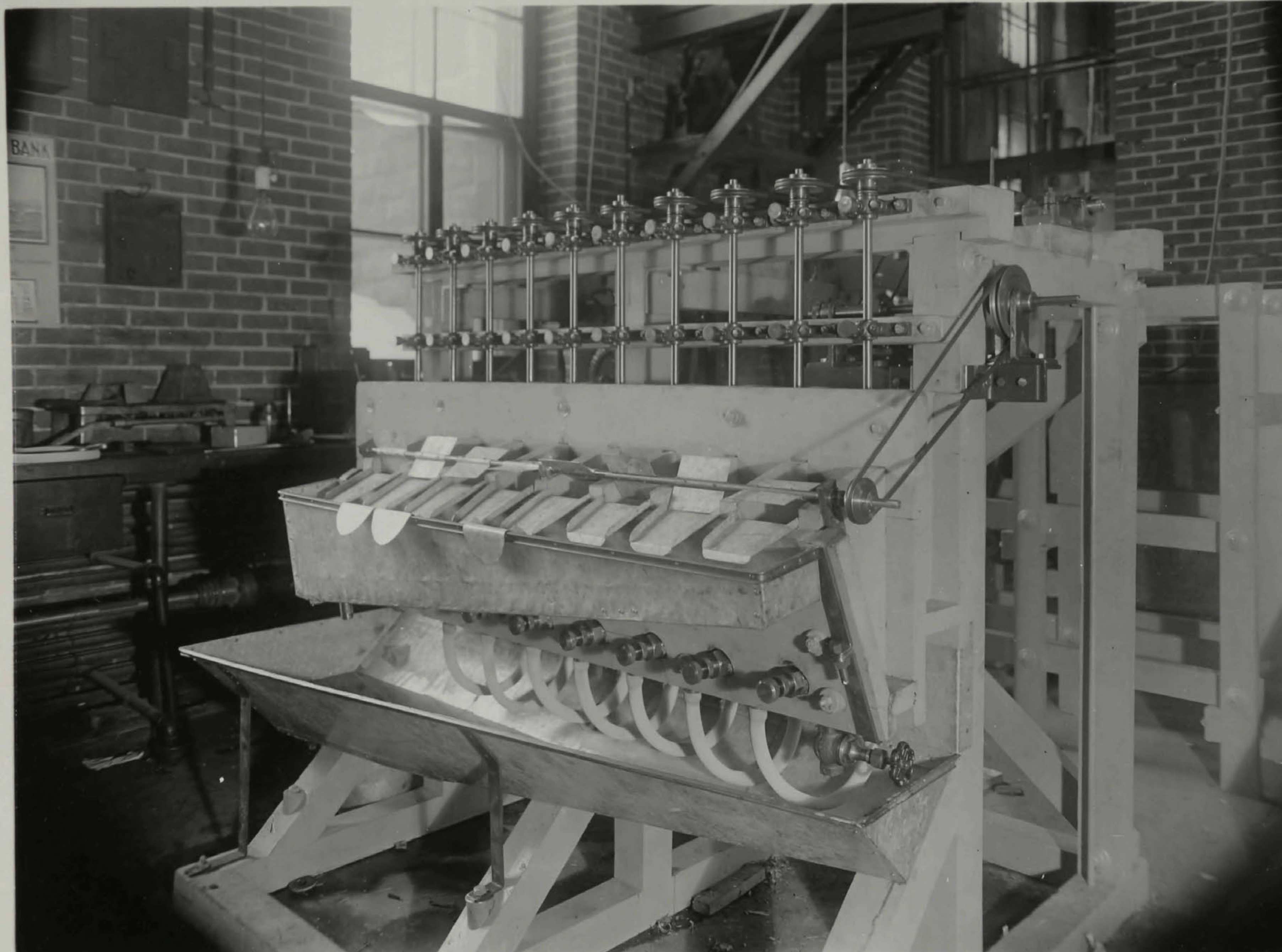
PLATE 6.





EXPERIMENTAL APPARATUS.

The 16 cell continuous Minerals Separation type flotation machine was constructed in the laboratory workshops from designs of Prof. Bell and Mr. Erlenborn.

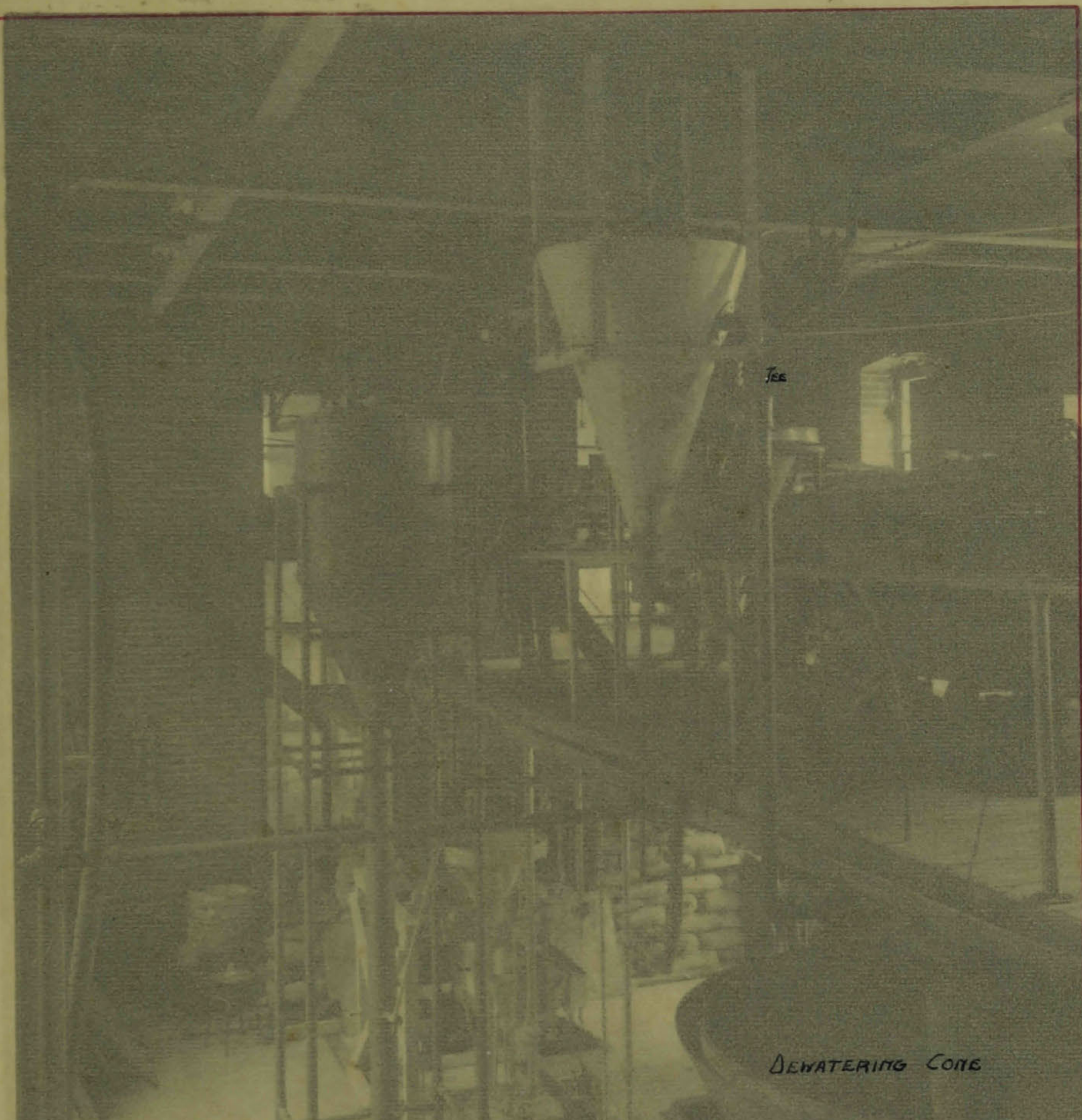
It consists essentially of two primary agitation boxes,and eight cells,each made up of an agitation box and a spitzkasten. The feed enters the first agitation box from the feed cone,passes through a slot in the partition into the second agitation box and thence through a second slot into the agitation box of the first floating cell.

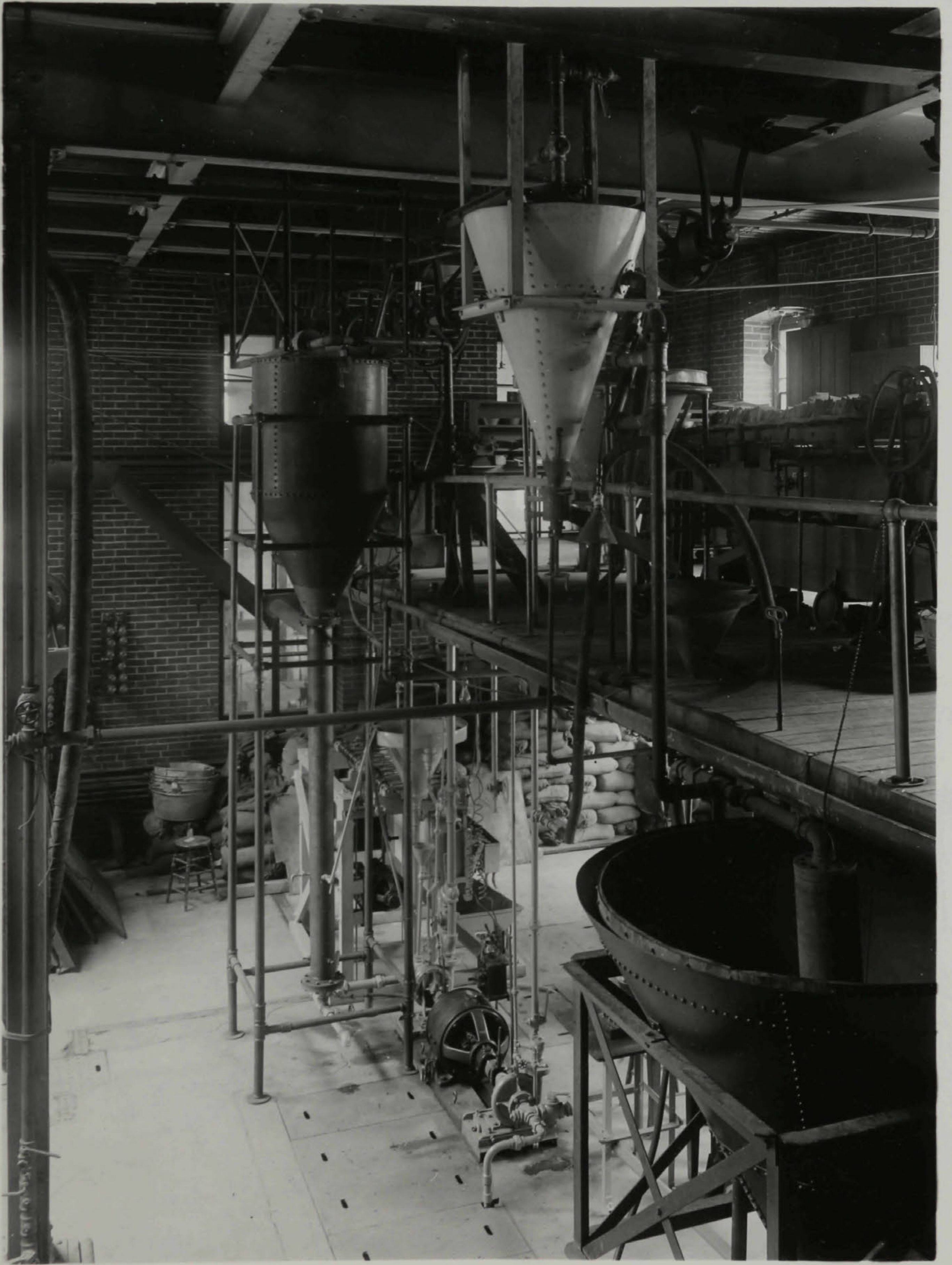
The floating cells are very similar to the single cell machine(plate 5),the main difference being that the return pipe goes from the spitzkasten of one cell to the agitation box of the next cell,thus making the pulp pass through each cell in turn. At present,the return pipes are of 3/4 in. rubber hose,but by changing the nipples,smaller hose may be used if desired.

A horizontal plate valve is fitted in the bottom of each spitzkasten to control the flow through the return pipes. The valve consists of two plates,one movable and one fixed,with a 3/4 in. square hole cut centrally in each. Thus at any opening the shape of the orifice remains unaltered.

The impellers are of the Howard type,as used in the single cell machine. They are driven,by belts from a main drive shaft, at 1000 r.p.m. by a 3 H.P. motor.

PLATE 7.





So far as is known, there are not more than four continuous machines of this type, for laboratory use, in existence. The whole apparatus was new and novel, and as might be expected, many difficulties were encountered. The greatest of these was the problem of feeding.

In large scale practice, the ore after crushing merely passes from the grinding circuit to the flotation machine, and as the process is continuous, no difficulty is experienced in keeping the pulp ratio or density fairly constant. Here, however, it was desired to duplicate, if possible, the small scale single cell tests. To do this would require grinding for each test, then dewatering to a 1:1 pulp, agitating with chemicals, diluting, and then floating. Thus the ore could not be fed directly from the grinding mill to the flotation machine.

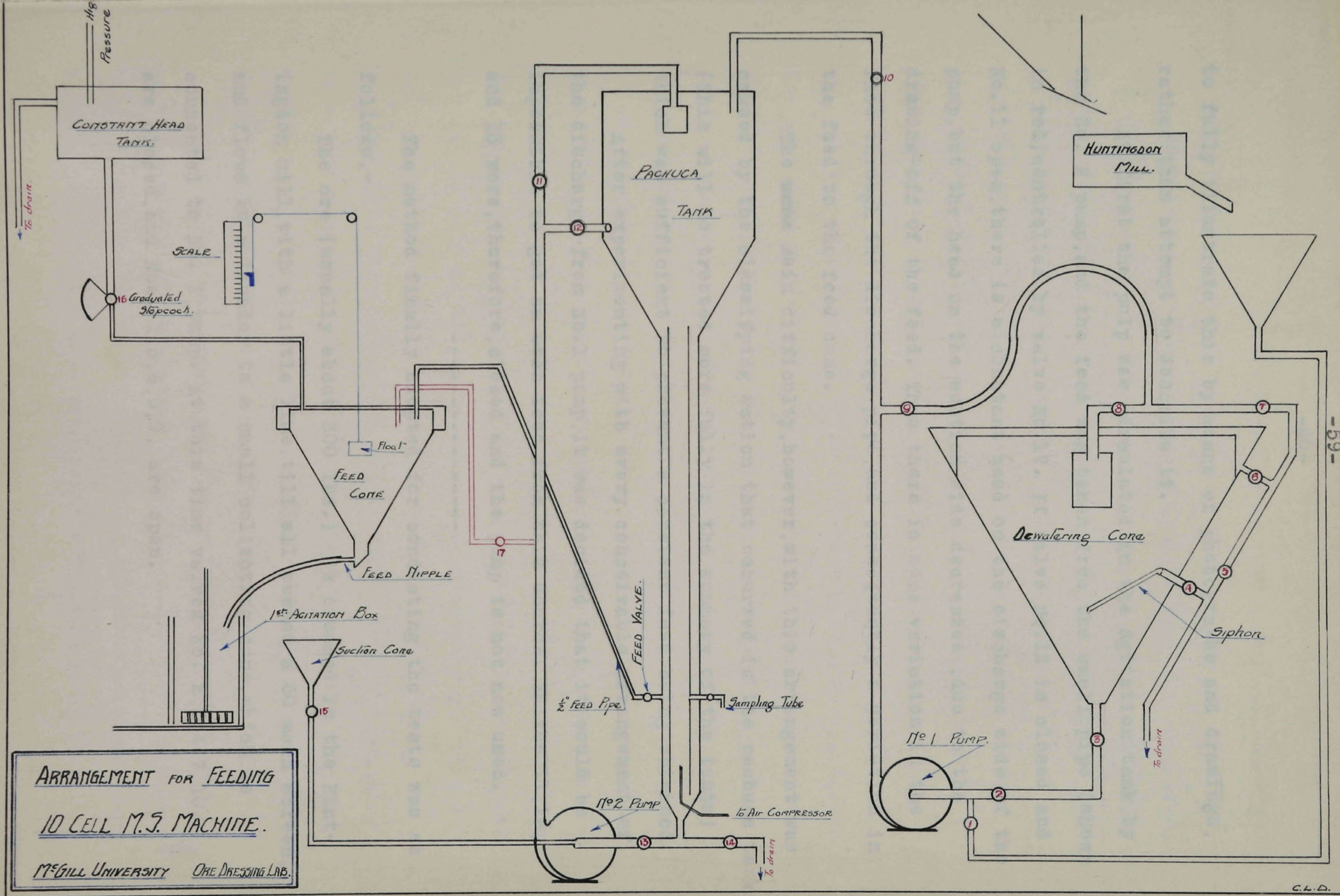
The arrangement of the apparatus is completely shown in plates 6-9, and a sketch to show the piping, etc., is given on page 59
The apparatus may conveniently be divided into three sections.

1. The crushing and dewatering circuit.
   Huntingdon Mill, dewatering cone, No. 1 pump.

2. The agitation or Pachuca tank.
   with pump No. 2

3. The Feed Cone, etc.
   Feed cone, constant head tank, 10 cell machine.

Many different machines, tanks and cones are used which makes a somewhat complicated arrangement. It has seemed best, then,



Hg Pressure
Constant Head Tank.
To drain
Scale
16 Graduated Stopcock.
Float
Feed Cone
Feed Nipple
1st Agitation Box
Suction Cone
15
17
Pachuca Tank
11
12
10
Feed Valve.
½" Feed Pipe
Sampling Tube
To Air Compressor
No 2 Pump
13
14
To drain
Huntingdon Mill.
Dewatering Cone
Siphon
9
8
7
6
5
4
3
2
1
No 1 Pump.
To drain
Arrangement for Feeding
10 Cell M.S. Machine.
McGill University
Ore Dressing Lab.
C.L.D.
16/4/22.

to fully illustrate this by means of photographs and drawings, rather than attempt to describe it.

At first the pulp was circulated in the agitation tank by the No. 2 pump, and the feed was taken from the small pipe (shown in red) controlled by valve No.17. If valve No.12 is closed and No.11 open, there is a constant head on the discharge side of the pump, but the head on the suction side decreases, due to the drawing-off of the feed. Thus there is some variation in the flow through the discharge pipe, and consequently a variation in the feed to the feed cone.

The ~~main~~ main difficulty, however, with this arrangement was caused by the classifying action that occurred in the pachuca tank (This will be treated more fully in the summary of the tests) which was sufficient to prevent a constant feed being obtained.

After experimenting with every conceivable arrangement of the discharge from No.1 pump, it was decided that it would be impossible to get an even feed from this source. Valves 11,12, and 13 were, therefore, closed and the pump is not now used.

The method finally adopted for conducting the tests was as follows,-

The ore (usually about 300 lbs.) is crushed in the Huntingdon mill, with a little lime, till all passes a 60 mesh screen, and flows in a launder to a small collecting cone, which is connected to No. 1 pump. At this time valves No. 2,3,4,7,10. are closed, and Nos. 1,5,6,8,9, are open.

Thus the pulp from the mill is pumped into the distributor of the dewatering cone.

If the amount of water to the mill is properly regulated, the dewatering cone will hold all the pulp,but if there is an excess,practically clear water will overflow (through No. 5and 6) and little ore will be lost.

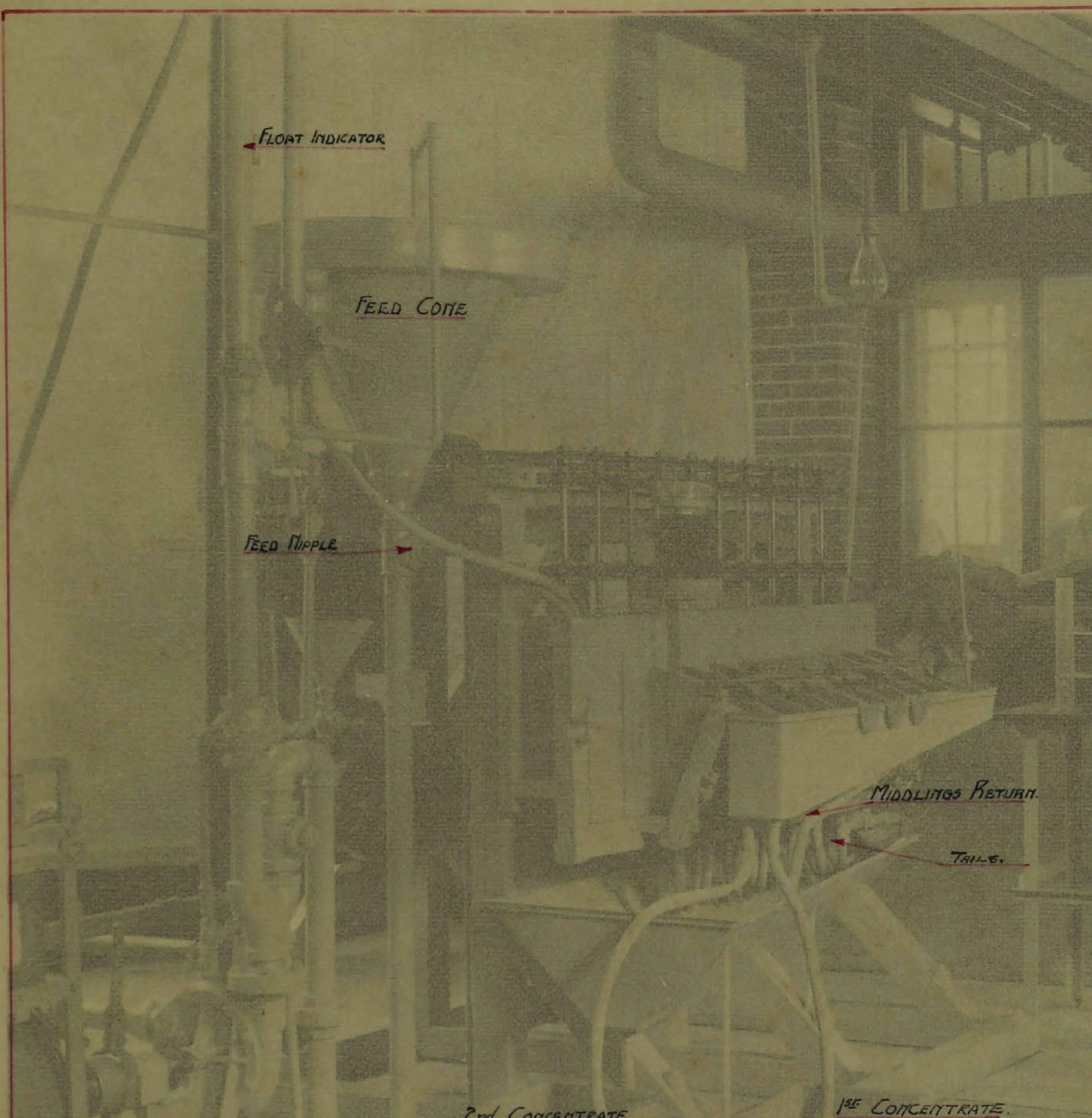
The pulp is allowed to settle overnight. In the morning it is decanted closely (Valve No. 4 open,No.5 closed.),usually to less than 1:1. It must now be transferred to the agitation tank.

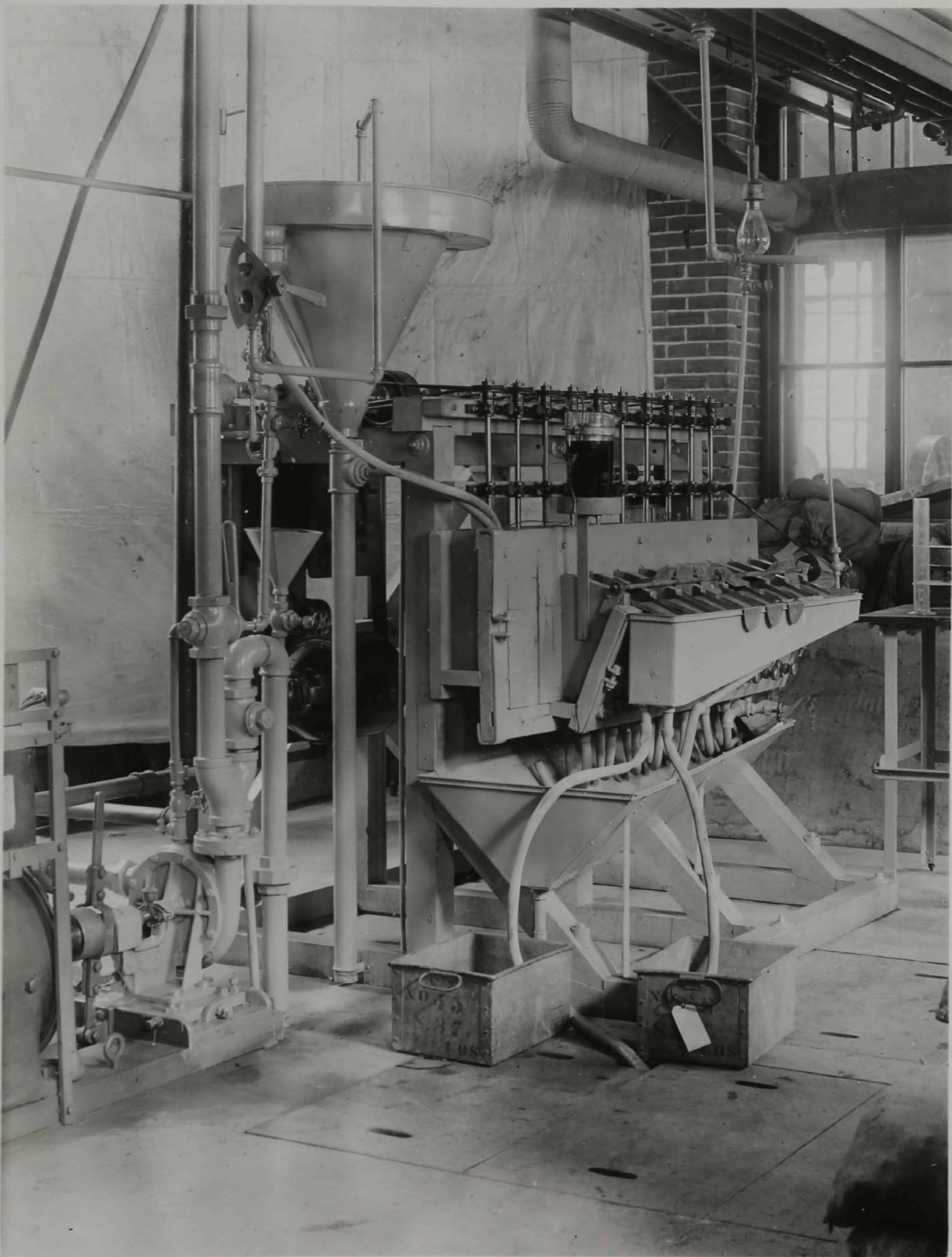
No.1 pump is started,valve No.1 shut,valves No.2,3,9,open. The hose from valve No.9 to the distributor is lifted out of the tee (see Plate 7) and dropped into the dewatering cone. A little high pressure water is run into the pump,and flowing through the suction pipe stirs the thick pulp in the cone so it may be pumped. The pulp is circulated for a few minutes,and then valve No.10 is partly opened,thus allowing part of the pulp to be pumped to the Pachuca. (While dewatering,just sufficient water is added to the Pachuca to enable it to agitate before the pulp is added) Valve No.9 is gradually closed and all the pulp pumped to the Pachuca tank.

Specific gravity samples are now taken from the sampling tube (which connects with the inner 4" pipe) and the pulp should be about 1:1. The chemicals desired are added and the whole allowed to agitate for a certain time.

When agitation is complete the pulp is diluted as much as the capacity of the Pachuca tank will allow (about 3.5 to 4:1). This tends to stop the action of the chemicals,and also gives a pulp that is much more readily fed to the flotation machine.

PLATE 8


FLOAT INDICATOR
FEED CONE
FEED NIPPLE
MIDDLINGS RETURN.
TAIL.
2nd. CONCENTRATE
1st CONCENTRATE.

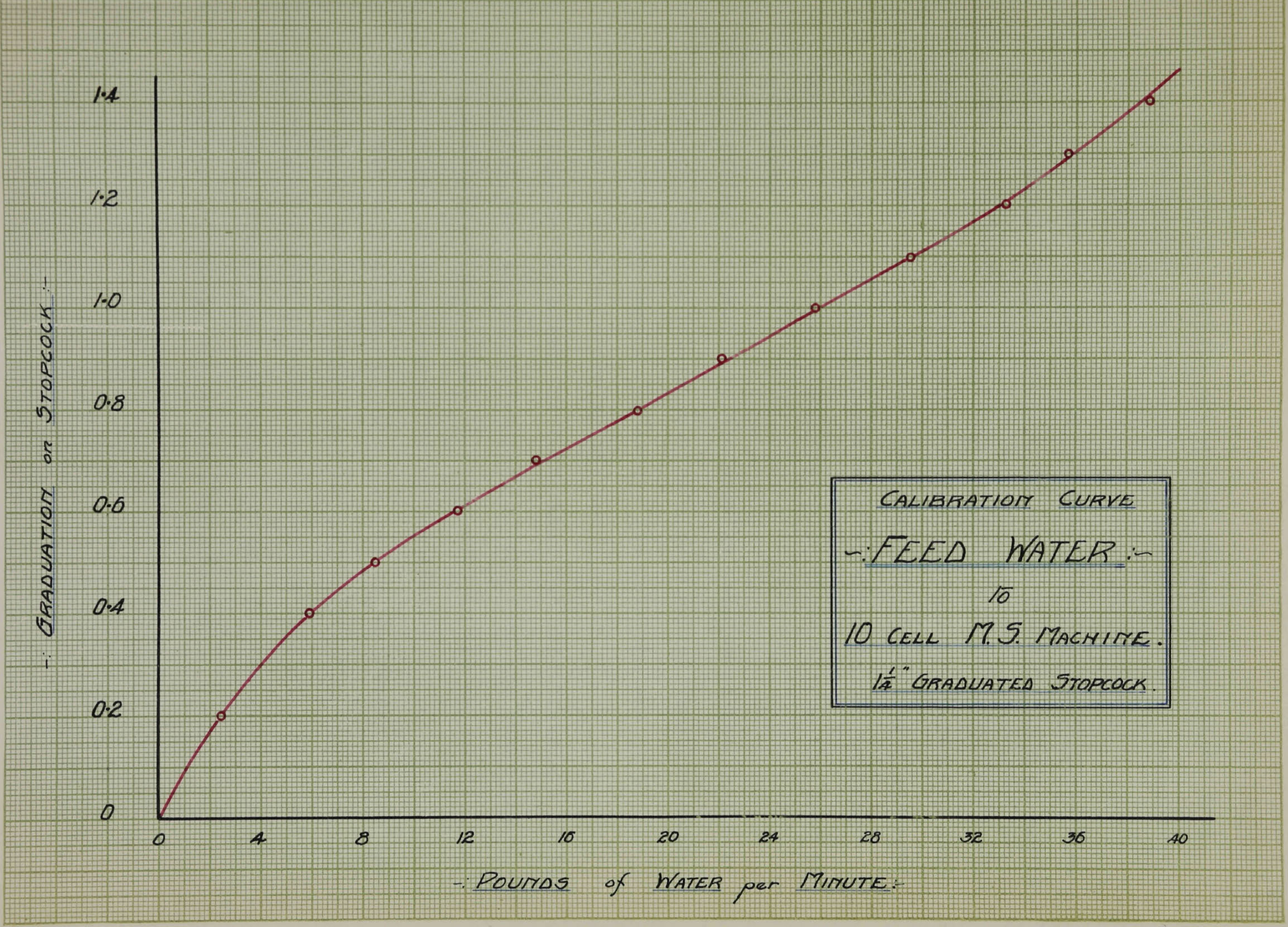


The graduated stopcock which controls the flow of water from the constant head tank to the feed cone is opened to No. 1.1 (29.6 lbs./min.) and the flotation machine started.

Specific gravity samples of the pulp in the agitation tank are taken and the percentage of solids calculated. Then, knowing the amount of feed that the flotation machine will take (about 29 lbs./min.)and the feed (lbs./min. of dry ore) that is desired,a calculation is made to determine the rate at which water must be added to the feed cone, (The feed is much more dilute than can be obtained in the Pachuca,when 300 lbs. of ore is taken.) and the graduation of the stopcock corresponding to this rate is taken from the curve.(page 63)

The stopcock is gradually closed to this mark,and at the same time the feed valve is opened. When the level in the feed cone has become constant,a specific gravity sample is taken at the first agitation box. The pulp ratio will rarely be exactly what it was calculated (paragraph above). This, mainly on account of the graduations on the stopcock preventing the very close setting of the pointer. With a little manipulation of the feed valve and valve No. 16 the specific gravity of the feed to the flotation machine can be raised or lowered to the desired point.

When all is constant,the oil feeder (plate 9,sketch page 66) may be started. When the froth is satisfactory the test is commenced.


CALIBRATION CURVE
-: FEED WATER :-
TO
10 CELL M.S. MACHINE.
1¼" GRADUATED STOPCOCK.
-: GRADUATION on STOPCOCK :-
-: POUNDS of WATER per MINUTE :-
0
0·2
0·4
0·6
0·8
1·0
1·2
1·4
0
4
8
12
16
20
24
28
32
36
40

The froth launders are washed clean, and the pipes from them are turned from the tailings launder into the concentrate boxes (plate 8).

The test is carried on for some definite time. (20-40 min. As the skill of the operators increases the time of test can be lengthened without increasing the amount of ore necessary. This is due to the preliminary adjust~~e~~ments being more rapidly made.)

At the end of the test the launders are washed clean again, and the pipes for the concentrates returned to the tailings launder. Thus all the concentrates produced during the test are collected.

During the test, specific gravity samples of the feed are taken at frequent intervals. These, when bulked together, constitute the feed sample for assay. The tailings are also sampled at intervals during the test.

Immediately after the test, while the conditions are still constant, two (one minute) samples of the feed are taken and immediately weighed. This is later used in the calculation of the weight of ore treated during the test.

The extractions, etc. are figured on the weight of dry ore fed during the test which is calculated from the specific gravity of the pulp (practically a constant during the test), the time of test, and the amount of pulp fed per minute as determined from the one minute feed samples.

OIL FEEDER.

For a time it was feared that the problem of regulating the amount of oil fed to the flotation machine would be insuperable. That it is a difficult one is obvious when it is remembered that the amount of oil used is about 15 to 50 drops per minute, and that the rate should not change, and also that the oil should be added in minute quantities, preferably drops.

Many and various schemes were thought of but most of them required some pump arrangement, or other complicated device.

The design finally adopted is shown in the drawing (page 66) and the oil feeder is shown in place on the flotation machine in plate 9.

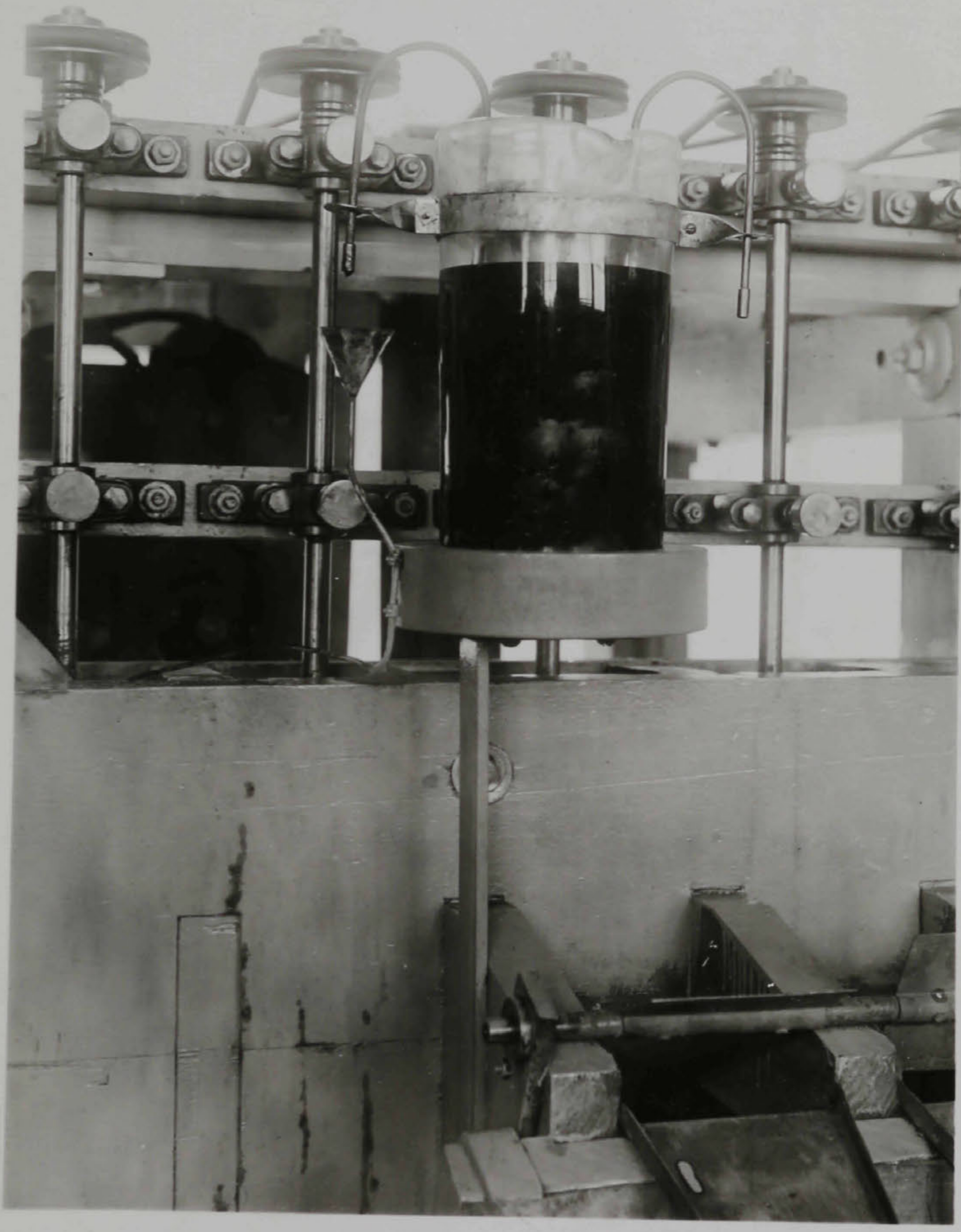
The fundamental idea is obvious, but it may be said that the feeder consists of a float, carrying a siphon tube which terminates in a brass tip through which is bored a fine hole. (0.041 in.dia.) The hydrostatic head can be readily altered by the addition or subtraction of small lead shot which lie in the bottom of the float.

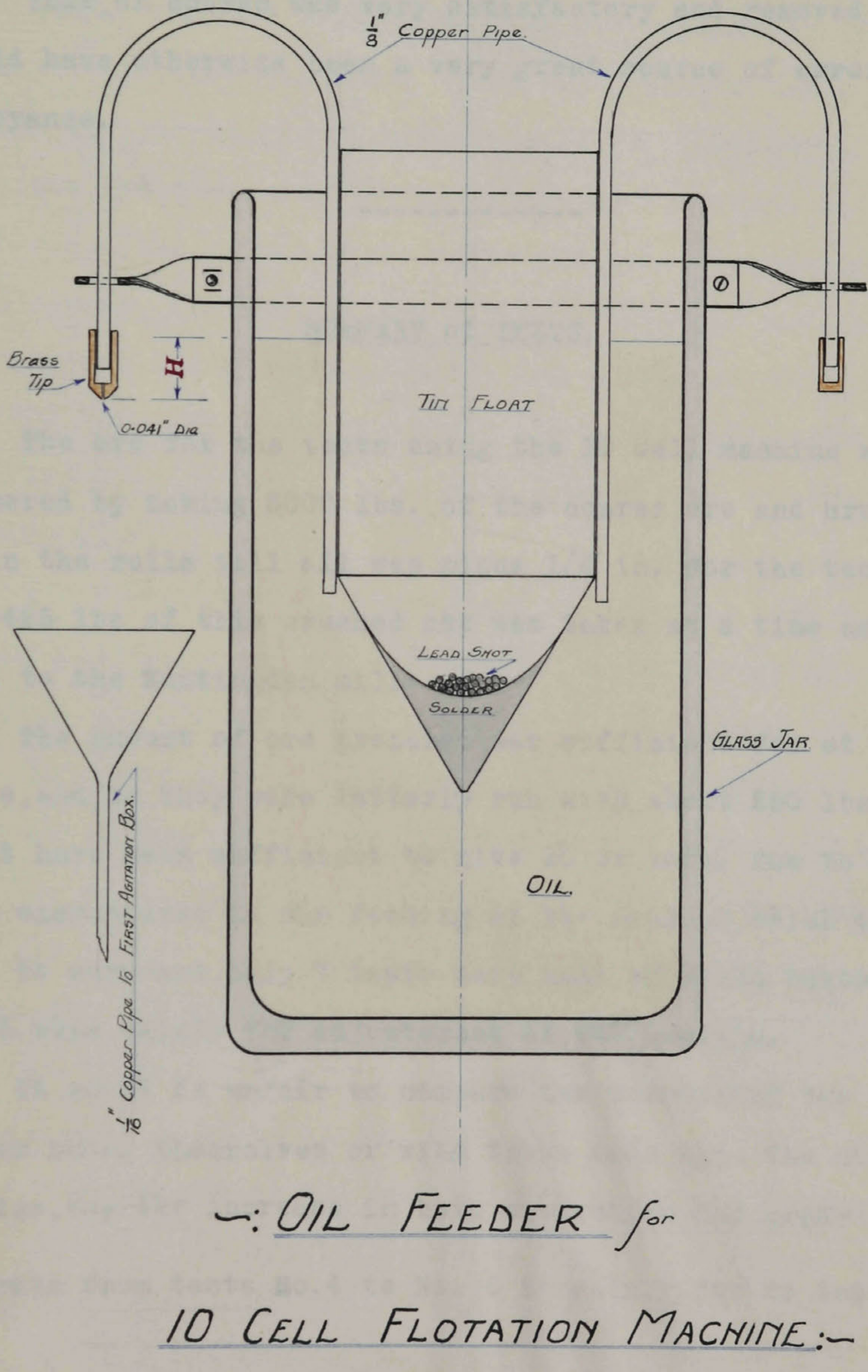
Thus the head causing the oil to drop from the tip or nozzle is constant and the rate of flow should be constant.

Before the feeder was mounted on the flotation machine many tests were made upon it to see that the rate of dropping did not vary. In all of these, the flow changed and the rate of dropping was very irregular.

When it was mounted on the flotation machine and the motor of the latter was running, it was found that the rate of


OIL FEEDER.





—: OIL FEEDER for

10 CELL FLOTATION MACHINE :—

SCALE :- HALF SIZE.

feed did not vary in the slighest degree. The feeder can be set at the beginning of a test to deliver, say, 25 drops per minute and an hour later it will be feeding exactly 25 drops per min.

This, of course, was very satisfactory and removed what would have otherwise been a very great source of error and annoyance.

SUMMARY of TESTS.

The ore for the tests using the 10 Cell machine was prepared by taking 3000 lbs. of the coarse ore and crushing it in the rolls till all was minus 1/4 in. For the tests about 350-425 lbs of this crushed ore was taken at a time as the feed to the Huntingdon mill.

The amount of ore prepared was sufficient for at least 9 tests, and, as they were latterly run with about 250 lbs., it might have been sufficient to give 10 or more. Due to difficulties encountered in the feeding of the machine, which took some time to surmount, only 7 tests were made, of which tests 1, 2, 3, and 4 were mainly for adjustement of the machine.

It would be unfair to compare the results of the tests either among themselves or with those made upon the single cell machine, for the increase in both extraction and grade of concentrate from tests No. 4 to No. 6 is mainly due to better manipulation and regulation of the machine.

Full results have been given of the data sheets and it is only necessary to call attention to a few points here.

Tests No.1 and 2 were run with ore crushed to pass a 40 mesh screen. This was found to be too granular and a 60 mesh screen was put in the Huntingdon mill for the subsequent tests.

The ore remaining in the agitation tank from the second test was dried of the steam table and then screened on a 40 mesh screen. 250 lbs. of the -40 mesh material was taken and dumped into the agitation tank,which contained 300 lbs. of water. The 700 lbs. water was added and the whole agitated with the pump and air. The pulp ratio should have been 4:1 and specific gravity 1.16.

Every possible combination of the top and side discharges of the pump,with and without air,was tried,but no one of them would so mix the pulp that the specific gravity in the outer pipe,the inner pipe,and the feed cone was the same.

During the tests where samples were taken from the feed cone,the discharge from this cone was run into the small suction cone and thence to the pump,thus keeping all the ore (of which the weight was known) in the circuit. Otherwise this would have been run to waste. It was noticed that the pump sucked air through this cone and it was surmised that this had some effect on the results. Hence for many of the tests,no feed samples were taken,and the specific gravity in the inner and outer pipe, only,determined.

During Test No.3 the specific gravity of the pulp dropped continuously during the test,which was on this account a failure. The 1st.,3rd,and 7th. samples (marked on the data sheet by 'S.A.) were screen analysed with the following results.-

		-1-	-3-	-7-
plus	65	9.4 %	3.0 %	----
	100	15.3	7.7	3.6
	150	18.0	13.4	5.4
	200	8.9	9.5	4.7
minus	200	48.3	66.4	86.1
		99.9	100.0	99.8

These conclusively show that the pump,because it was sucking from the very lowest part of the Pachuca tank,was drawing away the coarse material first or,rather,faster than the fine -200 mesh material.

For the reasons given above the pump was discarded and the agitation is now done entirely by air which has proved very satisfactory.

Water Pumping.- 10 cell Machine.

a.	Full speed,1st.valve fullopen	-----------	27.2 lbs./min.
b.	" " " " closed	-----------	24.8 " "
	Both with 3/4 in. hose.		
c.	Full speed, 1/2 in. hose.	-----------	14.7 " "
d.	" " 5/8 " "	-----------	23.0 " "

Velocities,with above quantities.

3/4 in. hose.	---------------	2.45 ft.per sec.
5/8 " "	---------------	2.87 " " "
1/2 " "	---------------	2.75 " " "

Feed nipples.-

3/8" --- 30.6 lb./min. 11/32" ---- 20.72 (6:1) pulp.

In conclusion I wish to express my very sincere thanks and appreciation for the advice given by Dr. J.B. Porter, and the very material assistance rendered by Prof. J.W. Bell, under whose supervision the work was carried out.

Much credit is due Mr. W. Erlenborn for his design and construction of the 10 cell machine.

Mr. R.L. Peek, Superintendent of Refinery, British American Nickel Co., very kindly gave me the notes on the analyses for nickel copper, and iron which have been modified to suit our needs.

C. Leonard Dewar.

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DATA SHEETS.

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ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	1
DATE	Oct. 21,1921 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1250
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Coarse ore crushed and screened till about 50 lbs. of -40 mesh product had been obtained. Oversize thrown away. This -40 mesh material was slightly higher in grade than the original ore, due to the above treatment.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
10,48				500		Charge		
,52	FPL.#1	2						
,54	do	2						
,59	do	2						
11,06	do	3						
,13						End of Test.		
21		9						
						Concentrate	1	49.5
						Tailing	2	440.0
								489.5

REAGENT	%	LBS. P.T.
FPL. #1		0.7

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	12.7
28		150	13.0
35		200	8.1
48	18.1	− 200	31.8
65	16.2	TOTAL	99.9

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	10	10.3	5.1	0.81	0.40	35.9	17.6		
	Tails	90	1.3	5.3	1.31	5.76	17.5	77.0		
				10.4		6.16		94.6		
				2.12%		[illegible].36%		19.3%		

PERCENT OF TOTAL

Cu	Ni	Fe	
49.0	6.5	18.6	
51.0	93.5	81.4	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	2
NOTES:	DATE	Oct. 21 1921
Feed as for Test No. 1.	ORE NO.	158
	PULP RATIO	12 : 1
	R.P.M. IMPELLER	1250
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12.00				500		Charge		
.06	P.T.400	2						
.09	do	3						
113	do	3						
.19	do	3						
.30						End of Test.		
24		11						
						Concentrate	3	77
						Tails	4	420
								497

REAGENT	%	LBS. P.T.
P.T. 400		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	12.7
28		150	13.0
35		200	8.1
48	18.1	– 200	31.8
65	16.2	TOTAL	99.9

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	PERCENT OF TOTAL Ni	PERCENT OF TOTAL Fe	
	Conct.	15.5	8.0	6.15	1.16	1.29	32.6	25.1			57.2	21.0	26.4	
	Tails.	84.5	1.1	4.60	1.57	4.87	16.7	70.1			42.8	79.0	73.6	
		100.0		10.75		6.16		95.2			100.0	100.0	100.0	
				2.18%		1.20%		19.2%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	3
DATE	Oct. 21 1921.19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1250
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 1.

Screen analysis of Feed given on sheet of Test No. 1

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2.33				500		Charge		
.40	B. #4	4						
.55	do	3						
3.15	do	4						
.25						End of Test.		
.45		11						
						Concentrate	5	35
						Tails	6	460
								495

REAGENT	%	LBS. P.T.
Barrett 4		0.88

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	7.1	15.1	5.3	1.61	0.56	38.1	13.3		
	Tails	92.9	1.2	5.5	1.11	5.10	18.1	83.3		
		100.0		10.8		5.66		96.6		
				2.18%		1.14%		19.5%		

PERCENT OF TOTAL

Cu	Ni	Fe
49.0	10.0	13.9
51.0	90.0	86.9
100.0	100.0	100.0

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	5
DATE	Nov. 8 1921 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 1.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,10				500		Charge.		
,13	H_2SO_4		10					
,17	PT. 400	3						
,20	H_2SO_4		10					
,23	PT.#400	2						
,25	do	1						
,33	H_2SO_4		10					
,35	PT.#400	1						
,40						End of Test.		
,23		7	30					
						Concentrate.	9	66
						Tails.	10	425
								491

REAGENT	%	LBS. P.T.
H_2SO_4		12.0
PT. #400		0.56

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	15.5	8.85	5.8	1.76	1.16	46.0	30.3		
	Tails	84.5	1.00	4.3	1.00	4.25	16.5	70.2		
		100.0		10.1		5.41		100.5		
				2.1%		1.1%		20.5%		

PERCENT OF TOTAL

Cu	Ni	Fe	
57.4	21.4	30.0	
42.6	79.6	70.0	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	6
DATE	Nov. 8 1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 1

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,50				500		Charge		
,51	H_2SO_4		20					
,54	B. #4	4						
,51	do	4						
4,02	H_2SO_4		10					
,05	B. #4	7						
,10	do	4						
,20						End of Test.		
29		11	30					
						Concentrate	11	49
						Tailing	12	443
								492

REAGENT	%	LBS. P.T.
Barrett 4		1.44
H_2SO_4		12.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	10	11.5	5.65	2.26	1.11	47.3	23.2		
	Tails	90	1.1	5.87	1.11	4.87	17.1	75.7		
		100.0		11.52		5.98		98.9		
				2.3%		1.2%		20.1%		

PERCENT OF TOTAL

Cu	Ni	Fe	
49.0	16.9	23.5	
51.0	84.1	76.5	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	7
DATE	Nov. 9 1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1265
PULP TEMP. START	17.5 °C
PULP TEMP. FINISH	19,0 °C
PULP TEMP. MEAN	18.3 ° C

NOTES:

Feed as for Test No. 1.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
9,50				500		Charge		
,55	Na_2CO_3		20			10% Solution		
,58	FPL.#1	2						
10,09	do	2						
,18	do	1						
20						End of Test.		
,22		5	20					
						Concentrate	13	46
						Tailing	14	452
								498

REAGENT	%	LBS. P.T.
FPL #1		0,4
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	9.2	12.5	5.75	1.76	0.81	33.4	15.4			53.7	11.5	15.5	
	Tails	90.8	1.1	4.95	1.26	6.24	18.7	84.5			46.3	88.5	84.5	
		100.0		10.70		7.05		99.9			100.0	100.0	100.0	
				2.16%		1.4%		20.1%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	8

NOTES:

Feed as for Test No. 1

Sodium Carbonate added to the pulp in the machine.

DATE	Nov 9, 1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	24. ° C
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
10.35				500		Charge.		
,37	Na CO		20			10% Solution		
,40	PT.#400	2						
,45	do	3						
,50	do	1						
,55	do	2						
11,00						End of Test.		
,20		8	20					
						Concentrate	15	58
						Tailing	16	432
								490

REAGENT	%	LBS. P.T.
PT.#400		0.64
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conc't.	11.8	10.3	6.0	2.77	1.61	34.3	19.9			59.5	25.2	20.4	
	Tails	88.2	0.95	4.1	1.10	4.75	17.9	77.5			40.5	74.8	79.6	
		100.0		10.1		6.36		97.4			100.0	100.0	100.0	
				2.1%		1.5[illegible]		19.9[illegible]						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	9
DATE	Nov. 9,1921 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 1

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.15						Charge		
118	Na_2CO_3		20			10% Solution		
.21	B. #4	2						
.40	do	6						
445	do	3						
.55						End of Test.		
.34		11	20					
						Concentrate	17	42
						Tailing	18	454
								496

REAGENT	%	LBS. P.T.
Barrett 4		0.88
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	8.5	14.1	5.9	1.84	0.77	34.3	14.4		
	Tails	91.5	1.0	4.5	1.23	5.58	18.3	83.0		
		100.0		10.4		6.35		97.4		
				2.1%		1.28%		19.6%		

PERCENT OF TOTAL

Cu	Ni	Fe
56.7	12.1	14.8
43.3	87.9	85.2
100.0	100.0	100.0

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10
DATE	Nov. 14, 1921
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1300
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

-40 mesh ore, as used for previous tests ground in the ball-mill for 15 minutes. Mill charge,- 500 gms. Ore
500 cc. water.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.15				500		Charge		
.20	Na_2CO_3		20			10% Solution		
.23	FPL #1	2						
.39	do	2						
.50						End of test.		
.27		4	20					
						Concentrate	19	77
						Tailing	20	421
								498

REAGENT	%	LBS. P.T.
F.P.L. #1		0.32
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	1.5
28		150	6.8
35		200	9.4
48	0.5	− 200	81.0
65	0.4	TOTAL	99.6

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL CU.	Ni.	Fe.	
	Conc't	15.5	10.3	7.95	3.8	2.9	49.2	37.9			67.7	44.6	37.8	
	Tails	84.5	0.9	3.80	0.85	3.6	14.8	62.3			32.3	55.4	62.2	
				11.75		6.5		100.2			100.0	100.0	100.0	
				2.3%		1.3%		20.0%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	11
DATE	Nov. 14, 1921 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No.10

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12.03						Charge		
.05	Na_2CO_3		20			10% Solution		
.10	PT. 400	2						
.15	do	3						
.25	do	1						
.35	do	1						
.38						End of Test.		
28		7	20					
						Concentrate	21	94
						Tailing	22	399
								493

REAGENT	%	LBS. P.T.
P.T. 400		0.56
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	19.0	8.35	7.85	3.8	3.6	48.8	45.9		
	Tails .	81.0	0.70	2.80	0.6	2.4	14.2	56.7		
				10.65		6.0		102.6		
				2.16%		1.23%		20.8%		

PERCENT OF TOTAL

Cu.	Ni.	Fe.	
73.7	60.0	44.7	
26.3	40.0	55.3	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 12

DATE Nov. 14, 1921 19

ORE NO. 158

PULP RATIO : 1

R.P.M. IMPELLER

PULP TEMP. START ° FINISH ° MEAN °

NOTES:

Feed as for Test No. 10

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,43				500		Charge		
,45	Na_2CO_3		20			10% Solution		
,53	B. #4	2						
3,00	do	2						
,08	do	6						
,28						End of Test.		
35		10	20					
						Concentrate	23	69
						Tailing	24	425
								494

REAGENT	%	LBS. P.T.
B. #4		0.8
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
	Conct.	14	11.5	7.94	3.9	2.7	47.0	32.4		
	Tails	86	0.7	2.97	0.9	3.8	16.3	69.3		
				10.91		6.5		101.7		
				2.2%		1.31%		20.6%		

PERCENT OF TOTAL

Cu.	Ni.	Fe.	
72.7	41.5	31.9	
17.3	58.5	68.1	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	13
DATE	Nov. 14, 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 10

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3.30						Charge		
.32	H_2SO_4		20			10 cc.=1 gm.acid		
.37	FPL.#1	3						
.50	do	3						
.59	do	2						
4.10						End of Test		
33		8	20					
						Concentrate	25	80
						Tailing	26	424
								504

REAGENT	%	LBS. P.T.
FPL.#1		0.64
H_2SO_4		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT	% NICKEL	WEIGHT	% IRON	WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu.	Ni	Fe	
	Conct.	15.9	10.6	8.50	2.9	2.32	46.5	37.2			78.0	35.4	35.2	
	Tails	84.1	0.6	2.54	1.0	4.24	16.2	68.7			22.0	64.6	64.8	
				11.04		6.56		105.9			100.0	100.0	100.0	
				2.2%		1.3%		21.0%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	14
DATE	Nov. 14,1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 10

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4.15						Charge		
.18	H_2SO_4		10			10 cc.=1gm.acid		
.21	P.T.#400	2						
.24	do	2				Very large		
.33	do	5				bubbles.		
.40	do	2						
.50						End of Test		
29		11	10					
						Concentrate	27	92
						Tailing	28	402
								494

REAGENT	%	LBS. P.T.
P.T.#400		0.88
H_2SO_4		4.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	18.6	8.8	8.09	3.23	2.96	47.3	43.5			71.5	49.5	42.7	
	Tails	81.4	0.55	2.21	0.75	3.02	14.5	58.3			20.5	50.5	57.3	
				11.3		5.98		101.8			100.0	100.0	100.0	
				2.28%		1.21%		20.6%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	15

NOTES:

Feed as for Test No. 10, but ground 23 minutes instead of 15.

DATE	Nov. 14, 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	25.0° C
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,55						Charge		
,57	H_2SO_4		20					
5,03	B. #4	2						
,10	H_2SO_4		10					
,12	do		20			Very little		
,14	B. #4	4				froth		
,16	do	6						
,30	do	3						
,40						End of Test.		
37		15	50					
						Concentrate	29	69
						Tailing	30	427
								496

REAGENT	%	LBS. P.T.
Barrett 4		1.2
H_2SO_4		20.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	13.9	10.7	7.37	3.8	2.62	48.3	33.3		
	Tails	86.1	0.6	2.56	0.75	3.20	17.2	73.5		
				9.91		5.82		96.8		
				2.0%		1.19%		19.6%		

PERCENT OF TOTAL

Cu	Ni	Fe	
74.5	45.0	34.4	
25.5	55.0	65.6	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	16
DATE	Nov.22,1921 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Two bags of ore No. 158 crushed in the Rolls till all passed through a screen with 0.   in. round holes (Lab. screen No. 9) For each test 500 gms. of this crushed ore was ground in the ball mill. For this test, ground 15 m.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4.20								
.23						Charge		
.25	Na_2CO_3		20			10% Solution		
.27	B. #4	5						
43.	do	3						
.55	do	2						
5.18						End of Test.		
51		10	20					
						Concentrate	31	43
						Tailing	32	456
								499

REAGENT	%	LBS. P.T.
B. #4		0.8
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20	2.4	+ 100	4.6
28	.3	150	12.0
35	.7	200	10.1
48	.8	− 200	67.0
65	1.7	TOTAL	99.6

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe
	Conct.	8.6	15.9	6.94	4.38	1.88	40.2	17.3			68.0	45.0	19.0
	Tails	91.4	0.7	3.18	0.50	2.28	16.2	74.0			32.0	55.0	81.0
				10.12		4.16		91.3			100.0	100.0	100.0
				2.0%		0.83%		18.2%					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	17
DATE	Nov. 23, 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 16, but ground in ball-mill for 20 min.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
10.05								
.10						Charge		
.13	Na_2CO_3		20			10% Solution		
.15	B. #4	6						
.31	do	2						
.45	do	2						
11.06						End of Test		
51		10	20					
						Concentrate	33	36
						Tailing	34	469
								505

REAGENT	%	LBS. P.T.
B. #4		0.8
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20	3.0	+ 100	3.1
28	.2	150	9.6
35	.6	200	9.5
48	.6	− 200	72.2
65	1.1	TOTAL	99.9

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
	Conct.	7.1	14.3	4.8	3.93	1.41	37.8	13.6		
	Tails	92.9	0.8	3.7	0.55	2.58	17.5	82.0		
				8.5		3.99		95.6		
				1.68%		0.79%		19.1%		

PERCENT OF TOTAL

Cu	Ni	Fe	
56.5	35.4	14.2	
43.5	64.6	85.8	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	18
DATE	Nov. 23, 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 16, but ground in ball-mill for 25 min.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.12						Charge		
.13	Na_2CO_3		20			10% Solution		
.15	B. #4	5						
.31	do	10						
12.08						End of Test.		
53		15	20					
						Concentrate	35	35
						Tailing	36	468
								503

REAGENT	%	LBS. P.T.
Barrett 4		8.2
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20	0.4	+ 100	1.1
28	.3	150	4.5
35	.5	200	7.3
48	.3	− 200	84.6
65	.3	TOTAL	99.3

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	7.0	19.2	6.7	3.62	1.27	38.8	13.3			78.0	23.0	14.0	
	Tails	93.0	0.4	1.9	0.9	4.21	17.4	81.5			22.0	77.0	86.0	
				8.6		5.48		94.8			100.0	100.0	100.0	
				1.7%		1.09%		18.9%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	19
	DATE	Nov.23,1921 19
	ORE NO.	158
	PULP RATIO	: 1
	R.P.M. IMPELLER	

NOTES:

Feed as for Test No.16, but ground wet in the ball mill for 30 minutes.

PULP TEMP.	
START	°
FINISH	°
MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,45						Charged		
,47	Na_2CO_3		20			10% Solution.		
,49	B. #4	5						
3,04	do	3						
,16	do	2						
,39						End of Test.		
50		10	20					
						Concentrate	37	38
						Tailing	38	467
								505

REAGENT	%	LBS. P.T.
$NaCO_3$		8.0
B. #4		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	0.85
28		150	3.36
35	0.62	200	6.26
48	1.94	− 200	86.54
65	0.43	TOTAL	100.00

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conct.	7.5	12.6	4.8	3.42	1.30	34.8	13.2	11.9	4.5	59.2	28.3	13.8	1.7
	Tails	82.5	0.65	3.3	0.65	3.30	17.7	82.6	57.1	266.5	40.8	71.7	86.2	98.3
				8.1		4.6		95.8		271.0	100.0	100.0	100.0	100.0
				1.6%		0.92%		19.0%		53.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	20
DATE	Nov. 23, 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for test No. 16, but ground in ball mill for 45 minutes.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3.47						Charge		
.48	Na_2CO_3		20			10% solution		
.51	B. #4	5						
4.07	do	3						
.19	do	2						
.42						End of Test.		
51		10	20					
						Concentrate	39	34
						Tailing	40	466
								500

REAGENT	%	LBS. P.T.
Barrett 4		0.8
Na_2CO_3		8.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	0.5
28		150	2.3
35	0.4	200	4.5
48	.5	− 200	91.0
65	.3	TOTAL	99.5

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
	Conct.	6.8	16.4	5.57	2.92	0.99	38.5	12.7		
	Tails	93.2	0.6	2.80	0.70	3.26	17.6	82.0		
				8.37		4.25		94.7		
				1.67		0.[illegible]		18.9%		

PERCENT OF TOTAL

Cu	Ni	Fe	
66.5	23.3	13.4	
33.5	76.7	86.4	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	21
	DATE	Nov. 29,1921 19
	ORE NO.	158
	PULP RATIO	: 1
	R.P.M. IMPELLER	

NOTES:

Feed as for test No. 19

Oil mixture ,- { 20% Pine Oil (F.P.L. #1)
{ 70% Coal Tar Creosote (F.P.L. #24)
{ 10% Coal Tar

PULP TEMP.	
START	°
FINISH	°
MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
10.08						Charged		
.10	mix.#1	5						
.15	do	5						
.20	do	5						
.25	do	5						
.30						End of Test.		
.20		20						
						Concentrate	41	46
						Tailing	42	454
								500

REAGENT	%	LBS. P.T.
mix.#1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		— 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% Copper	WEIGHT Copper	% Nickel	WEIGHT Nickel	% Iron	WEIGHT Iron	%	WEIGHT
	Conct.	9.2	16.7	7.8	3.68	1.71	42.4	19.7		
	Tails	90.8	0.3	1.4	0.76	3.44	15.5	70.5		
				9.2		5.15		90.2		
				1.8%		1.03%		18.0%		

PERCENT OF TOTAL

Cu	Ni	Fe	
85.0	30.4	21.8	
15.0	69.6	78.2	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO. 22

NOTES: Feed as for Test No. 19.

-9 screen ore ground wet in ball-mill for 30 min.

DATE	Nov.29,1921 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.03						Charged		
.05	Mix.#1	5						
.10	do	5						
.15	do	5						
.20	do	5						
.25						End of Test.		
20		20						
						Concentrate	43	32.5
						Tailing	44	469.0
								501.5

REAGENT	%	LBS. P.T.
Mix. #1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	% INSOLUBLE	WEIGHT INSOLUBLE	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conct.	6.5	21.8	7.08	3.47	1.13	30.3	9.85	11.8	3.8	79.0	21.9	10.7	1.3
	Tails.	93.5	0.4	1.88	0.86	4.03	17.6	82.5	59.7	280.0	21.0	78.1	89.3	98.7
				8.96		5.16		92.35		283.8	100.0	100.0	100.0	100.0
				1.8%		1.03%		18.4%		56.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	23
DATE	Nov. 29, 1921 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1250
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 20.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,57						Charged		
12,00	Mix.#1	5						
,05	do	5						
,10	do	5						
,15	do	5						
,20						End of Test.		
20		20						
						Concentrate	45	33
						Tailing	46	468
								501

REAGENT	%	LBS. P.T.
Mix. #1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT	% NICKEL	WEIGHT	% IRON	WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	6.6	20.2	6.67	3.43	1.13	28.8	9.5			68.7	24.1	9.9	
	Tails	93.4	0.65	3.04	0.76	3.56	18.45	86.5			31.3	75.9	90.1	
				9.71		4.69		96.0			100.0	100.0	100.0	
				1.9		0.94%		19.2%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	24
NOTES:	DATE	Nov. 29, 1921
	ORE NO.	158
Feed as for Test No. 20	PULP RATIO	12 : 1
	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,23						Charge		
,26	Na_2CO_3		100			10% Solution		
,30	mix. #1	5						
,35	do	5				Very rich look-		
,40	do	5				ing conc't. Good	47	34.5
,45	do	5				froth.		
,50						Conct. still coming		
20		20				up at end of Test.		
2,50						2nd. Conct..	48	8.5
3,05								
						Tailing	49	453.0
								496.0

REAGENT	%	LBS. P.T.
mix. #1		1.6
Na_2CO_3		40.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	1. Conct.	7.0	20.6	7.1	5.59	1.92	36.8	12.7			77.3	35.6	13.7	
	2. Conct.	1.7	3.9	0.3	8.8	0.75	34.2	2.9			3.0	13.9	4.1	
	Tails	91.3	.4	1.8	.6	2.72	17.0	77.0			19.7	50.5	82.2	
				9.2		5.39		92.6			100.0	100.0	100.0	
				1.8%		1.08%		18.6%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	25
DATE	Nov.29.1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1250
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19.
-9 screen ore ground wet in ball-mill for 30 min.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,11						Charged.		
,15	Na_2CO_3		100			10% Solution		
,20	Mix.#1	5						
,25	do	5						
,30	do	5						
,35	do	5						
,40						End of Test.		
20		20						
						Concentrate	50	40.5
						Tailing	51	463.0
								503.5

REAGENT	%	LBS. P.T.
Na_2CO_3		40
Mix. #1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conct.	8.0	18.1	7.32	3.97	1.67	30.4	12.3	12.4	5.0	80.0	33.2	13.0	1.8
	Tails.	92.0	0.4	1.85	0.70	3.24	17.7	82.0	59.6	270.0	20.0	66.8	87.0	98.2
		100.0		9.17		4.85		94.3		275.0	100.0	100.0	100.0	100.0
				1.8%		0.97%		18.8%		54.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	26
DATE	Nov. 29.1921. 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1250
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 16

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,43						Charge		
,46	Na_2CO_3		100			10% Solution		
,50	Mix.#1	5						
,55	do	5						
4,00	do	5						
,05	do	5						
,10						End of Test.		
20		20						
						Concentrate	52	41.5
						Tailing	53	459.0
								500.5

REAGENT	%	LBS. P.T.
Na_2CO_3		40
Mix.#1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe
	Conct.	8.2	15.9	6.6	5.1	2.12	31.6	13.1			78.5	45.8	14.5
	Tails	91.8	0.4	1.8	0.55	2.52	16.8	77.1			21.5	54.2	85.5
				8.4		4.64		90.2			100.0	100.0	100.0
				1.7%		0.93%		18.0%					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	27
NOTES:	DATE	Nov. 30, 1921. 19
Feed as for Test No.16	ORE NO.	158
	PULP RATIO	: 1
	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,22						Charged		
,25	H_2SO_4		15			10% Solution.		
,30	Mix.#1	5						
,35	do	5						
,40	do	5						
,45	do	5						
,50						End of Test.		
20		20						
						Concentrate	54	51
						Tailing	55	449
								500

REAGENT	%	LBS. P.T.
H_2SO_4		6.
Mix. #1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		– 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
	Conct.	10.2	13.9	7.1	2.83	1.45	38.4	19.55		
	Tails	89.8	0.45	2.02	0.71	3.18	16.8	75.35		
				9.12		4.63		94.9		
				1.8%		0.92%		19.0%		

PERCENT OF TOTAL

Cu	Ni	Fe	
78.0	31.3	20.6	
22.0	68.7	97.4	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	28
NOTES:	DATE Nov. 30.1921. 19	
Feed as for Test No.19	ORE NO.	158
	PULP RATIO	: 1
	R.P.M. IMPELLER	1250
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12,02						Charged		
,04	H_2SO_4		15			10% Solution		
,10	Mix.#1	5						
,15	do	5						
,20	do	5						
,25	do	5						
,30						End of Test.		
20		20						
						Concentrate	56	33
						Tailing	57	496
								529

REAGENT	%	LBS. P.T.
H_2SO_4		6.0
Mix.#1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	6.2	20.5	6.75	3.1	1.02	30.8	10.15			75.3	20.2	11.3	
	Tails	93.8	0.45	2.23	0.81	4.02	17.1	84.55			24.7	79.8	88.7	
				8.98		5.04		90.0			100.0	100.0	100.0	
				1.7%		0.95%		18.0%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	29
DATE	Nov. 30.1921. 19
ORE NO.	159
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 20

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2.42						Charged		
.43	H_2SO_4		15			10% Solution		
.50	Mix.#1	5						
.55	do	5						
3.00	do	5						
.05	do	5						
10						End of Test.		
20		20	15					
						Concentrate	58	32
						Tailing	59	467
								499

REAGENT	%	LBS. P.T.
H_2SO_4		6.0
Mix.#1		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	6.4	22.3	7.15	2.74	0.87	30.1	9.6			66.2	16.2	10.0	
	Tails	93.6	0.8	3.7	0.96	4.48	18.4	86.0			33.8	83.8	90.0	
				10.8		5.35		95.6			100.0	100.0	100.0	
				2.1%		1.07%		19.1%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	30
DATE	Dec. 14, 1921.
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19, but after grinding it was agitated for 30 min. in a bottle with 500 cc. water containing 1.25 cc. NaOH, i.e., 5.0 lbs. NaOH per ton of dry Ore.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12.25						Charged		
.27	B. #4	10						
.37	do	5						
.47	do	5						
.53						End of Test		
26		20						
						Concentrate	60	42
						Tailing	61	449
								491

REAGENT	%	LBS. P.T.
NaOH (leach)		5.0
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	8.6	15.8	6.65	4.1	1.72	34.8	14.6			72.0	34.4	16.0	
	Tails.	91.4	0.45	2.02	0.73	3.28	17.1	76.8			28.0	65.4	84.0	
				8.65		5.00		91.4			100.0	100.0	100.0	
				1.76%		1.0%		18.6%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	31

NOTES: Feed as Test No. 30 but 10 lbs./ton NaOH leach.

DATE	Dec. 14.1921. 19
ORE NO.	15 8
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,08						Charge		
,10	B. #4	10						
,20	do	5						
,30	do	5						
,35						End of Test.		
25		20						
						Concentrate	62	57
						Tailing	63	430
								487

REAGENT	%	LBS. P.T.
NaOH (leach)		10.0
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	11.7	13.0	7.4	5.1	2.90	38.2	21.8			81.4	52.5	23.6	
	Tails	88.3	0.4	1.7	0.61	2.62	16.4	70.5			18.6	47.5	76.4	
				9.1		5.52		92.3			100.0	100.0	100.0	
				1.8%		1.1%		18.9%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 38

DATE	Dec. 14, 1921 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 30, but 15 lbs./ton NaOH leach.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,20						Charged		
,22	B. #4	10						
,32	do	5						
42	do	5						
,47						End of Test.		
25		20						
						Concentrate	64	50
						Tailing	65	450
								500

REAGENT	%	LBS. P.T.
NaOH (leach)		15.0
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
	Conct.	10	15.4	7.7	4.27	2.14	36.4	18.2		
	Tails.	90	0.4	1.8	0.73	3.30	16.0	72.0		
				9.5		5.44		90.2		
				1.9%		1.08%		18.0%		

PERCENT OF TOTAL

Cu	Ni	Fe	
81.0	39.4	20.2	
19.0	60.6	79.8	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	33
DATE	Dec. 14,1921 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	20.0 C
PULP TEMP. FINISH	20.8 ° C
PULP TEMP. MEAN	20.4 ° C

NOTES:

Feed as for Test No. 30,but 20 lbs./ton NaOH leach.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
5.08						Charged		
.10	B. #4	10						
.20	do	5						
.30	do	5						
.35						End of Test.		
25		20						
						Concentrate	66	56.5
						Tailing	67	432.0
								486.5

REAGENT	%	LBS. P.T.
NaOH		20.0
(leach)		
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		— 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
	Conct.	11.6	13.1	7.4	3.85	2.18	36.0	20.3		
	Tails	88.4	0.49	2.1	0.83	3.58	16.15	69.7		
				9.5		5.76		90.0		
				1.9%		1.15%		18.0%		

PERCENT OF TOTAL

Cu	Ni	Fe	
78.0	38.0	22.6	
22.0	62.0	77.4	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	34
DATE	Dec. 14 1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 30.

Check on Test No. 31

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.43						Charged		
.45	B. #4	10						
.55	do	5						
12.05	do	5						
.10						End of Test.		
25		20						
						Concentrate	68	53
						Tailing	69	441
								494

REAGENT	%	LBS. P.T.
NaOH (leach)		10.0
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT	% NICKEL	WEIGHT	% IRON	WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	10.7	13.5	7.15	4.24	2.25	38.4	20.3			84.5	43.5	22.5	
	Tails	89.3	0.3	1.32	0.66	2.92	15.8	69.6			15.5	51.5	77.5	
				8.47		5.17		89.9			100.0	100.0	100.0	
				1.72%		1.05%		18.2%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	35
DATE	Jan. 9,1921. 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19.

-9 ore ground wet in ball-mill for 30 min., then leached for 30 min. with NaOH, 5 lbs. per ton.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12.07						Charged		
.08	Mix. #1	15				Very heavy froth		
						that overflowed		
						spitzkasten.		
.28						End of Test.		
20		15						
						At end of Test		
						froth was very dark.		
						Concentrate	70	151
						Tailing	71	346
								497

REAGENT	%	LBS. P.T.
NaOH (leach)		5.0
Mix. #1		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conct.	30.4	6.0	9.06	2.82	4.26	37.3	56.3	23.1	34.8	93.0	92.5	66.2	12.4
	Tails.	69.6	0.2	0.69	0.10	0.35	10.4	35.9	71.5	247 .2	7.0	7.5	38.8	87.6
		100.0		9.75		4.61		92.2		282.0	100.0	100.0	100.0	100.0
				1.96%		0.[illegible]3%		18.5%		56.7%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	36
NOTES: Feed as for Test No. 19.	DATE Jan. 9,1922	19
	ORE NO.	
-9 screen ore ground wet in ball-mill for 30 min, then	PULP RATIO	: 1
leached for 30 min. with NaOH,10 lbs. per ton.	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
1,40						Charged		
,42	Mix. #1	5						
,47						1st. Conct.	72	73
,49	do	7						
,53	do	8						
,57	do	5						
2,02						End of Test.		
20		25						
						2nd. Conc't.	73	65
						Tailing	74	357
								495

REAGENT	%	LBS. P.T.
NaOH		10.0
(leach)		
Mix. #1		2.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	1st.Conc	14.8	8.9	6.50	3.52	2.57	41.8	30.5	10.8	7.9	71.4	45.0	34.8	3.0
	2nd.Conc	13.1	3.15	2.04	3.12	2.03	41.8	27.2	18.3	11.9	22.4	35.8	32.2	4.5
	Tails	72.1	0.16	0.57	0.30	1.07	8.1	28.9	69.4	247.2	6.2	19.2	33.0	92.5
		100.0		9.11		5.67		86.6		267.0	100.0	100.0	100.0	100.0
				1.84%		1.14%		17.6%		54.0%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	37
DATE	Jan. 9,1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19

-9 ore ground wet in ball-mill for 30 min.,then leached for 30 min. with NaOH. 15 lbs. per ton.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2.54						Charged		
.55	Mix. #1	6						
3.00						1st. Concentrate	75	83
.02	do	6						
.08	do	8						
.11	do	5						
.15						End of Test		
20		25						
						2nd. Concentrate	76	55
						Tailing	77	362
								500

REAGENT	%	LBS. P.T.
NaOH (leach)		15.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
5	1st.Conc	16.6	8.1	6.7	3.72	3.08	41.9	34.8	10.5	8.7	72.8	51.7	37.4	3.3
15	2nd.Conc	11.0	3.3	1.8	2.92	1.61	38.9	21.4	19.5	10.7	19.6	27.0	23.0	4.0
	Tails.	72.4	0.2	0.7	0.35	1.27	9.8	37.0	68.2	246.6	7.6	21.3	39.6	92.7
		100.0		9.2		5.96		93.2		266.0	100.0	100.0	100.0	100.0
				1.84%		1.19%		18.6%		53.2%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	38

NOTES: Feed as for Test No. 19.
-9 screen ore ground wet in ball-mill for 30 min., then
leached with NaOH, 20 lbs. per ton for 30 min.

DATE	Jan. 9, 1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3.43						Charged		
.45	Mix.#1	6						
.51						1st. Concentrate	78	50
.54	do	5						
.56	do	6						
4.00	do	3						
.03	do	5						
∝.05						End of Test.		
20		25						
						2nd. Concentrate	79	68
						Tailing	80	383
								501

REAGENT	%	LBS. P.T.
NaOH (leach)		20.0
Mix. #1		2.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
6	1st.Conc	10.0	11.1	5.55	5.20	2.60	38.4	19.2	11.3	5.6	63.8	45.4	22.6	2.0
14	2nd.Conc	13.6	2.7	1.84	2.72	1.85	42.6	29.0	14.6	9.9	21.2	32.2	33.3	3.5
	Tails	76.4	0.34	1.30	0.30	1.15	9.75	37.4	70.1	268.0	15.0	22.4	44.1	94.5
		100.0		8.69		5.60		85.6		283.5	100.0	100.0	100.0	100.0
				1.73%		1.11%		17.1%		56.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	39

NOTES: Feed as for Test No. 19

-9 screen ore ground wet in ball-mill for 30 min., then leached for 30 min. with H_2SO_4, 20 lbs. per ton.

DATE	Jan. 9, 1922
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,54						Charged		
,55	Mix. #1	10						
5,00	Do	5				Froth very dark		
,05	do	5						
,10	do	5						
,15	do	10						
30		35						
						Concentrate	81	100
						Tailing	82	390
								490

REAGENT	%	LBS. P.T.
H_2SO_4 (leach)		20.0
Mix. #1		2.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
	Conct.	20.2	8.6	[illegible]	2.32	2.32	47.2	47.2			90.3	66.5	53.2	
	Tails.	79.8	0.24	0.9[illegible]	0.30	1.17	10.6	41.4			9.7	33.5	46.8	
		100.0		9.54		3.49		88.6			100.0	100.0	100.0	
				1.94%		0.71%		18.1%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	40
DATE	Jan. 13, 1922
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	21.0° C
PULP TEMP. FINISH	21.8°
PULP TEMP. MEAN	

NOTES: Feed as for Test No. 19

-9 screen ore ground wet in ball-mill for 30 min., then agitated for 30 min. with NaOH, 10. lbs/ton.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.30						Charged.		
.33	B. #4	5						
.37	do	5						
.43						1st. Concentrate	83	34
.44	Mix. #1	3						
.46	do	6						
.53						End of Test.		
20		19						
						2nd. Concentrate	84	53
						Tailing	85	413
								490

REAGENT	%	LBS. P.T.
NaOH		10.0
B. #4		0.8
Mix. #1		.72
		1.52

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
10	1st. Conc	6.9	17.8	6.05	4.28	1.46	30.6	10.4		
10	2nd. Conc	10.8	1.7	0.9	3.63	1.92	46.8	24.8		
	Tails	82.3	0.64	2.64	0.40	1.65	13.1	54.0		
		100.0		9.59		5.03		89.2		
				1.95%		1.02%		18.2%		

PERCENT OF TOTAL

Cu.	Ni	Fe	
63.1	29.0	11.7	
9.4	38.2	27.8	
27.5	32.8	60.5	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	41
NOTES: Feed as for Test No.19, treated as for Test No. 35	DATE	Jan. 13,19222 19
	ORE NO.	158
-9 screen ore ground wet in ball-mill for 30 min., then	PULP RATIO	: 1
leached for 30 min. with NaOH, 5 lbs. per ton.	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
1,33						Charged		
,34	B. #4	5						
,37	do	5						
,41						1st. Concentrate	86	31
,43	Mix.#1	3						
,46	do	6						
,54		%				End of Test.		
20		19						
						2nd Concentrate	87	81
						Tailing	88	387
								499

REAGENT	%	LBS. P.T.
NaOH		5.0
(leach)		
B. #4		0.8
Mix. #1		0.72
Total oil		1.52

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
7	1st.Conc	6.2	19.7	6.1	4.33	1.34	34.2	10.6		
13	2nd.Conc	16.2	1.0	0.8	2.92	2.37	46.4	37.6		
	Tails	77.6	0.4	1.6	0.23	0.89	9.5	36.8		
		100.0		8.5		4.60		85.0		
				1.7%		0.92%		17.1%		

PERCENT OF TOTAL

Cu	Ni	Fe	
71.8	29.1	12.5	
9.5	51.5	44.2	
18.7	19.4	43.3	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO. 42

NOTES: Feed as for Test No. 41
Same Test as No. 41, but 1st. Concentrate taken after 5 min.

DATE	Jan. 13, 1922
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1190
PULP TEMP. START	22 °C
PULP TEMP. FINISH	23 °C
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,31						Charged		
,32	B. #4	10						
,37						1st. Concentrate	89	35
,38	Mix. #1	3						
,41	do	6						
,52						End of Test.		
20		19						
						2nd. Concentrate	90	83
						Tailing	91	388
								506

REAGENT	%	LBS. P.T.
NaOH (leach)		5.0
B. #4		0.8
Mix. #1		0.72
Total Oil		1.52

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
5	1st. Conc	6.9	19.0	6.65	3.88	1.36	35.8	12.5		
15	2nd. Conc	16.4	0.5	0.42	3.38	2.81	48.0	39.8		
	Tails	76.7	0.5	1.94	0.28	1.08	9.2	35.7		
		100.0		9.01		5.25		88.0		
				1.78%		1.04%		17.4%		

PERCENT OF TOTAL

Cu	Ni	Fe	
73.9	25.9	14.1	
4.7	53.5	45.3	
21.4	20.6	40.6	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	43
DATE	Jan. 13,1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	23. °C
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 41.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,18						Charged		
,20	B. #4	8						
,25						1st. Concentrate	92	22
,27	do	7						
,30	do	10						
,40						End of Test.		
20		25						
						2nd. Concentrate	93	33
						Tailing	94	445
								500

REAGENT	%	LBS. P.T.
NaOH (leach)		5.0
B. #4		2.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe
5	1st.Conc	4.4	23.8	5.24	3.02	0.67	32.0	7.1			57.5	15.9	8.1
15	2nd.Conc	6.6	5.0	1.65	5.30	1.75	42.8	14.2			18.1	41.7	16.2
	Tails	89.0	0.5	2.23	0.40	1.78	14.9	66.3			24.4	42.4	75.7
		100.0		9.12		4.20		87.6			100.0	100.0	100.0
				1.82%		0.84%		17.7%					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 44

NOTES: Feed as for Test No. 19

500 gms. -9 screen ore ground wet in ball-mill for 30 min. then agitated for 30 min. with NaOH, 5 lbs./ton and 25 drops Barrett No.4

DATE	Jan. 13, 1922
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
5,05						Charged		
,07						1st. Concentrate	95	110
,10						mostly air froth.		
,20						End of Test.		
15								
						Very heavy froth		
						at beginning of Test.		
						2nd Concentrate	96	13
						Tailing	97	369
								492

REAGENT	%	LBS. P.T.
NaOH (Leach)		5.0
B. #4		2.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
2	1st.Conc	22.4	6.75	7.43	2.92	3.21	44.8	48.4			79.5	67.7	53.0	
13	2nd.Conc	2.6	3.20	0.47	3.22	0.42	38.9	5.0			4.4	8.9	5.5	
	Tails	75.0	0.40	1.51	0.30	1.11	10.3	38.0			16.1	23.4	41.5	
		100.0		9.35		4.74		91.4			100.0	100.0	100.0	
				1.90%		0.96%		18.3%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 45

DATE Jan. 16,1922 19

ORE NO. 158

PULP RATIO 12 : 1

R.P.M. IMPELLER 1050

PULP TEMP.	
START	°
FINISH	°
MEAN	°

NOTES: Feed as for Test No. 19.

-9 screen ore ground wet in ball-mill for 30 min. then agitated for 30 min. with $FeCl_3$ 20 lbs. per ton.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
1,16						Charged		
,17	B. #4	10				Very little froth,		
						no copper colour.		
,20	do	10						
,27						1st. Concentrate	101	23
,29	Mix.#1	10						
,37						End of Test.		
20		30						
						2nd. Concentrate	102	65
						Tailing	103	410
								498

REAGENT	%	LBS. P.T.
$FeCl_3$		20.0
(leach)		
B. #4		1.6
Mix. #1		.8
Total Oil		2.4

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
10	1st.Conc	4.6	18.2	4.19	1.04	0.25	36.8	8.5		
10	2nd.Conc	13.0	4.2	2.72	1.96	1.27	44.0	28.6		
	Tails	82.4	0.44	1.80	0.915	3.74	13.0	53.3		
		100.0		8.71		5.26		90.4		
				1.75%		1.05%		18.1%		

PERCENT OF TOTAL

Cu	Ni	Fe	
48.0	4.8	9.4	
31.2	24.2	31.6	
20.8	71.0	59.0	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	46
DATE	Jan.16,1922
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19

-9 screen ore ground wet in ball-mill for 30 min. then agitated for 30 min. with $FeCl_3$, 20 lbs. per ton, filtered, washed and charged.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,43						Charged		
,45	B. #4	10				Froth very dark.		
,50	do	10				Froth very dark		
						and oily.		
,55						1st.Concentrate	104	78
,57	Mix. #1	5						
3,00	do	5				Over oiled.		
,05						End of Test.		
20		30						
						2nd. Concentrate	105	34
						Tailing	106	380
								492

REAGENT	%	LBS. P.T.
$FeCl_3$ (leach)		20.0
B. #4		1.6
Mix.#1		.8
Total Oil		2.4

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
10	1st.Conc	15.9	10.1	7.88	2.50	1.95	45.6	35.6			87.7	36.9	38.4	
10	2nd.Conc	6.9	2.1	0.72	3.96	1.35	43.0	14.6			8.0	25.6	15.8	
	Tails	75.2	0.1	0.38	0.52	1.98	11.2	42.5			4.3	37.5	45.8	
		100.0		8.98		5.28		92.7			100.0	100.0	100.0	
				1.82%		1.07%		18.8%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	47
	DATE	Jan. 16, 1922 19
	ORE NO.	158
	PULP RATIO	12 : 1
	R.P.M. IMPELLER	

NOTES:

Feed as for Test 46, same Treatment.

PULP TEMP.	
START	°
FINISH	°
MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,44						Charged		
,46	Mix.#1	5						
,51						1st. Concentrate	107	28
,52	do	5						
5,00	do-	5						
,06						End of Test.		
20		15						
						2nd. Concentrate	108	72
						Tailing	109	389
								489

REAGENT	%	LBS. P.T.
$FeCl_3$ (leach)		20.0
Mix. #1		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT
5	1st.Conc	5.7	17.4	4.87	1.44	0.40	40.7	11.4		
15	2nd.Conc	14.7	2.3	1.65	3.08	2.22	19.5	35.5		
	Tails	79.6	0.5	1.95	0.53	2.06	11.1	42.8		
		100.0		8.47		4.68		88.7		
				1.75%		0.94%		18.2%		

PERCENT OF TOTAL

Cu	Ni	Fe	
57.5	8.5	13.4	
19.5	47.5	41.8	
23.0	44.0	44.8	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	48

NOTES:

Feed as for test No.47 but leached with $FeCl_3$ 10 lbs.per ton.

DATE	Jan. 17,1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,58						Charged		
12,00	B. #4	10						
,06						1st. Concentrate	98	29
,12	do	10						
,23						End of Test.		
25		20						
						2nd. Concentrate	99	43
						Tailing	100	418
								480

REAGENT	%	LBS. P.T.
$FeCl_3$ (leach)		10.0
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
6	1st.Conc	6.0	16.2	4.80	1.64	0.47	39.6	11.5		
19	2nd.Conc	9.0	4.7	2.02	2.82	1.21	43.6	18.7		
	Tails	85.0	0.3	1.25	0.78	3.26	13.7	58.2		
		100.0		8.07		4.94		88.4		
				1.7%		1.03%		18.4%		

PERCENT OF TOTAL

Cu	Ni	Fe	
59.5	9.5	13.0	
25.0	24.5	21.2	
15.5	66.0	65.0	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	49
DATE	Jan. 24,1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19

500 gms. of -9 screen ore ground wet in ball-mill for 30 min., then agitated for 30 min. with NaCl, 20 lbs. per ton.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,33						Charged		
,35	Mix. #1	5						
,38						1st. Concentrate	110	28
,41	do	5						
,55						End of Test		
20		10						
						2nd. Concentrate	111	62
						Tailing	112	402
								492

REAGENT	%	LBS. P.T.
NaCl (leach)		20.0
Mix. #1		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
3	1st.Conc	5.7	18.3	4.95	2.46	0.69	37.5	10.5			53.5	14.2	11.5	
17	2nd.Conc	12.6	3.7	2.29	2.31	1.43	45.1	28.0			24.8	29.5	30.6	
	Tails	81.7	0.5	2.01	0.68	2.73	13.2	53.0			21.7	56.3	57.9	
		100.0		9.25		4.85		91.5			100.0	100.0	100.0	
				1.88%		0.98%		18.5%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 50

DATE Jan. 14, 1922

ORE NO. 158

PULP RATIO 13 : 1

R.P.M. IMPELLER 1100

PULP TEMP. START 21.5° C; FINISH 22.0°; MEAN 21.7°

NOTES:

Feed as for Test No. 19

Agitated, etc., as for test No. 49

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12,34						Charged		
,35	B. #4	5						
,45						1st. Concentrate	113	25
,46	do	11						
,55						End of Test.		
20		16						
						2nd. Concentrate	114	45
						Tailing	115	426
								496

REAGENT	%	LBS. P.T.
NaCl (leach)		20.0
B. #4		2.0

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT
10	1st. Conc	5.0	18.6	4.65	2.44	0.61	27.8	6.95		
10	2nd. Conc	9.1	5.6	2.52	3.06	1.37	45.6	20.5		
	Tails	85.9	0.35	1.49	0.74	3.15	14.8	63.1		
		100.0		8.66		5.13		90.55		
				1.75%		1.04%		18.2%		

PERCENT OF TOTAL

Cu	Ni	Fe	
53.7	11.9	7.7	
29.1	26.7	22.7	
17.2	61.4	69.6	
100.0	100.0	100.0	

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	51
DATE	Jan. 24, 1922
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	22.5° C

NOTES:

Feed as for Test No. 19

Agitated, etc., as for Test No. 49

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3.17						Charged		
.18	PT.#400	5						
.23						1st. Concentrate	116	34
.27	do	5				Over oiled/		
.38						End of Test		
20		10						
						2nd. Concentrate	117	115
						Tailing	118	351
								500

REAGENT	%	LBS. P.T.
NaCl (leach)		20.0
P.T. 400		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
5	1st.Conc	6.8	8.7	2.96	2.62	0.89	44.3	15.0			29.0	18.8	16.1	
15	2nd.Conc	23.0	4.9	5.64	2.19	2.52	35.8	41.2			55.4	53.1	44.1	
	Tails	70.2	0.45	1.58	0.38	1.33	10.6	37.2			15.6	28.1	39.8	
		100.0		10.18		4.74		93.4			100.0	100.0	100.0	
				2.02%		0.95		18.7%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 52

DATE	Jan. 24, 1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19

500 gms. of -9 screen ore ground wet in ball-mill for 30 min. then agitated for 30 min. with NaCl (5 lbs./ton) and NaOH (5 lbs./ton)

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,57						Charged		
,58	mix.#1	5						
4,06						1st. Concentrate	119	79
,07	do	5						
,13	do	5						
,18						End of Test.		
20		15						
						2nd. Concentrate	120	32
						Tailing	121	386
								497

REAGENT	%	LBS. P.T.
NaCl		5.0
NaOH		5.0
(leach)		
mix. #1		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
8	1st.Conc	15.9	8.2	6.47	3.88	3.06	36.4	28.8			78.0	59.2	33.6	
12	2nd.Conc	6.6	3.3	1.05	2.96	0.95	48.0	15.7			12.7	18.4	18.3	
	Tails	77.5	0.2	0.77	0.30	1.16	10.2	41.3			9.3	22.4	48.1	
		100.0		8.29		5.17		85.8			100.0	100.0	100.0	
				1.67%		1.04%		17.2%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	53
DATE	Jan. 24,1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1200
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	22.5° C

NOTES:

Feed as for Test No.19, treated as for Test No. 52

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,54						Charged		
,55	B. #4	5						
5,03	do	5						
,08	do	5						
,15						End of Test.		
20		15						
						Concentrate	122	41
						Tailing	123	450
								491

REAGENT	%	LBS. P.T.
{NaCl		5.0
{NaOH		5.0
(leach)		
B. #4		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
20	Conc't	8.4	16.1	6.60	4.12	1.70	36.6	15.0			76.5	37.9	16.8	
	Tails	91.6	0.45	2.02	0.62	2.79	16.5	74.2			23.5	62.1	83.2	
		100.0		8.62		4.49		89.2			100.0	100.0	100.0	
				1.76%		0.91%		18.2%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	54
DATE	Jan. 30 1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 19

500 gms. of -9 screen ore ground wet in ball mill for 30 min., then agitated for 30 min with Na_2CO_3 (5 lbs./ton) and NaCl (5 lbs.per ton)

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,32						Charged		
,35	B. #4	5						
,41						1st. Concentrate	124	24
,44	do	5						
,50	do	10				over oiled		
,55						End of Test		
20		15						
						2nd. Concentrate	125	11
						Tailing	126	455
								490

REAGENT	%	LBS. P.T.
Na_2CO_3		5.0
NaCl		5.0
(leach)		
B. #4		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	% INSOLUBLE	WEIGHT INSOLUBLE	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
6	1st.Conc	4.9	22.8	5.47	5.19	1.25	32.4	7.8	5.8	1.4	60.0	22.7	8.4	0.5
14	2nd.Conc	2.2	10.8	1.19	6.92	0.76	38.0	4.2	6.4	0.7	13.1	13.3	4.5	0.2
	Tails	92.90	0.54	2.46	0.71	3.23	16.0	72.8	57.8	262.9	26.9	65.0	87.1	99.3
		100.0		9.12		5.24		84.8		265.0	100.0	100.0	100.0	100.0
				1.86%		1.06%		17.3%		54.0%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 55

NOTES: Feed as for Test No.19

Treated as for Test No. 54, but 10 lbs./ton NaCl

DATE	Jan. 30, 1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
12.42						Charged		
.43	B. #4	5						
.53						1st. Concentrate	127	29
.54	do-	5				over oiled		
1.03						2nd. Concentrate	128	10
20		10						
						Tailing	129	462
								501

REAGENT	%	LBS. P.T.
NaCl		10.0
Na_2CO_3		5.0
(leach)		
B. #4		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
10	1st.Conc	5.8	20.9	6.06	7.10	2.06	33.4	9.7	5.4	1.6	67.6	40.4	10.5	0.6
10	2nd.Conc	2.0	8.6	0.86	6.48	0.65	39.6	4.0	9.3	0.9	9.6	12.6	4.4	0.3
	Tails	92.2	0.44	2.04	0.52	2.40	16.9	78.1	58.0	268.0	22 .8	47.0	85.1	99.1
		100.0		8.96		5.11		91.8		270.5	100.0	100.0	100.0	100.0
				1.79%		1.02%		18.3%		54%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	56

NOTES: Feed as for Test No.19

Treatment as for Test No. 54 but NaCl 15 lbs./ton

DATE	Jan.30,1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,44						Charged		
,45	B. #4	6						
,53						1st.Concentrate	130	37
,54	do	5						
3,05						End of Test.		
20		11						
						2nd. Concentrate	131	13
						Tailing	132	450
								500

REAGENT	%	LBS. P.T.
NaCl		15.0
Na_2CO_3		5.0
(leach)		
B. #4		0.9

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Insol
8	1st.Conc	7.4	18.7	6.92	5.24	1.93	33.6	12.4	5.3	2.0	70.5	37.0	13.9	0.7
12	2nd.Conc	2.6	5.1	0.66	4.92	0.64	40.2	5.2	9.0	1.2	6.7	12.2	5.8	0.4
	Tails	90.0	0.5	2.25	0.59	2.65	15.9	71.6	59.5	267.5	22.8	50.8	80.3	98.9
		100.0		9,83		5.22		89.2		270.7	100.0	100.0	100.0	100.0
				1.96%		1.04%		17.8%		51.2%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	57
DATE	Jan. 30, 1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	1200
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test No. 19, treated as for Test No. 54, but NaCl, 20 lbs. per ton

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,50						Charged		
,51	B. #4	5						
4,01						1st Concentrate	133	31
,02	do	5						
,11						End of Test.		
20		10						
						2nd Concentrate	134	10
						Tailing	135	455
								496

REAGENT	%	LBS. P.T.
NaCl		20.0
Na_2CO_3 (leach)		5.0
B. #4		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
10	1st. Conc	6.3	21.05	6.52	4.22	1.31	32.6	10.1	4.6	1.4	72.5	25.5	11.6	0.6
10	2nd. Conc	2.0	7.6	0.76	5.86	0.59	39.2	3.9	9.6	1.0	8.5	11.5	4.5	0.4
	Tails	91.7	0.37	1.70	0.71	3.23	16.0	72.8	54.3	246.6	19.0	63.0	83.9	99.0
		100.0		8.98		5.13		86.8		249.0	100.0	100.0	100.0	100.0
				1.80%		1.03%		17.7%		50.2%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	58
NOTES: Feed as for Test No. 19, Treated as for Test No. 54 but 2.5 lbs per ton NaCl	DATE	Jan. 30, 1922 19
	ORE NO.	158
	PULP RATIO	12 : 1
	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4,38						Charged		
,39	B. #4	5						
,49						1st. Concentrate	136	26
,50	do	5						
,59						End of Test.		
20		10						
						2nd Concentrate	137	12
						Tailing	138	460
								498

REAGENT	%	LBS. P.T.
(NaCl		2.5
(Na_2CO_3		5.0
(leach)		
B. #4		0.8

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	%	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	
10	1st. Conc	5.2	23.3	6.05	4.60	1.19	32.2	8.4			66.2	22.6	9.1	
10	2nd. Conc	2.4	6.5	0.78	6.00	0.72	33.4	4.0			8.6	13.7	4.4	
	Tails	92.4	0.5	2.30	0.73	3.36	16.8	77.3			25.2	63.7	86.5	
		100.0		9.13		5.27		89.7			100.0	100.0	100.0	
				1.83%		1.06%		18.0%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 59

NOTES: Feed as for Test No. 19.

500 gms. of -9 screen ore ground wet in ball-mill, then agitated for 15 min. with NaCl, (4.0 lbs./ton) and Na_2CO_3, (4.0 lbs./ton)

DATE Feb. 2, 1922

ORE NO. 158

PULP RATIO 12 : 1

R.P.M. IMPELLER

PULP TEMP.	
START	°
FINISH	°
MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
10,39						Charged		
,40	B. #4	10						
,53						1st. Concentrate	139	28
,54	do	5						
11,05						End of Test.		
25		15						
						2nd. Concentrate	140	16
						Tailing	141	458
								502

REAGENT	%	LBS. P.T.
NaCl		4.0
Na_2CO_3		4.0
(leach)		
B. #4		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		– 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
13	1st. Conc	5.6	20.7	5.80	4.5	1.26	33.4	9.4	5.6	1.6	63.7	24.0	10.0	0.6
12	2nd. Conc	3.2	8.0	1.28	6.6	1.06	39.6	6.3	8.0	1.3	14.0	22.1	6.8	0.5
	Tails	91.2	0.45	2.03	0.64	2.93	16.6	76.1	57.8	264.1	22.3	13.9	83.2	98.9
		100.0		9.11		5.25		91.8		267.0	100.0	100.0	100.0	100.0
				1.82%		1.04%		18.3%		53.2%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	60
	DATE	Feb. 2, 1922 19
	ORE NO.	158
	PULP RATIO	: 1
	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

NOTES:

Feed as for Test no. 19, treated as for test no. 59, but agitated for 30 minutes.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11.23						Charged		
.24	B. #4	10						
.33						1st. Concentrate	142	33
.34	do	5						
.45						End of Test.		
21		15						
						2nd. Concentrate	142	9.5
						Tailing	143	457.0
								499.5

REAGENT	%	LBS. P.T.
NaCl		4.0
Na_2CO_3		4.0
(leach)		
B. #4		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
9	1st. Conc	6.6	17.85	5.90	5.9	1.95	33.6	11.1	6.3	2.1	65.5	38.4	12.5	0.7
12	2nd. Conc	1.9	6.35	0.60	5.5	0.52	39.2	3.7	10.5	1.0	6.7	10.2	4.1	0.3
	Tails	91.5	0.55	2.52	0.57	2.60	16.2	74.0	61.0	278.9	27.8	51.4	84.5	99.0
		100.0		9.02		5.07		88.8		282.0	100.0	100.0	100.0	100.0
				1.80%		1.01%		17.8%		56.4%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	61

NOTES: Feed as for Test No. 19, treated as for Test No. 59, but agitated for 2.0 hours.

DATE	Feb. 2, 1922
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2.17						Charged		
.18	B. #4	10				Froth very dark		
.26						1st. Concentrate	145	33
.30	do	5						
.38						End of Test		
20		15						
						2nd. Concentrate	146	14
						Tailing	147	451
								498

REAGENT	%	LBS. P.T.
$NaCl$		4.0
Na_2CO_3		4.0
(leach)		
B. #4		1.4

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
8	1st.Conc	6.7	17.4	5.75	5.6	1.85	33.4	11.0	5.9	1.9	65.5	39.0	12.5	0.7
12	2nd.Conc	2.8	5.6	0.78	4.9	0.69	41.9	5.9	9.0	1.4	8.9	14.5	6.7	0.5
	Tails	90.5	0.5	2.25	0.49	2.21	15.7	71.0	60.7	273.5	25.6	46.5	80.8	98.8
		100.0		8.78		4.75		87.9		276.8	100.0	100.0	100.0	100.0
				1.77%		0.95%		17.7%		55.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	162
DATE	Feb. 2, 1922
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test no. 19, treated as for Test no. 59, but agitated for 1 hour.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,21						Charged		
,22	B. #4	10						
,27						1st. Concentrate	145	28
,32	do	5						
,42						End of Test.		
20		15						
						2nd. Concentrate	146	16
						Tailing	147	455
								499

REAGENT	%	LBS. P.T.
NaCl		4.0
Na_2CO_3		4.0
(leach)		
B. #4		1.4

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
5	1st. Conc	5.6	18.5	5.18	5.2	1.46	32.9	9.2	----	---	55.6	32.0	10.3	---
15	2nd. Conc	3.2	8.6	1.38	4.7	0.75	39.4	6.3	---	---	14.8	16.4	7.0	---
	Tails	91.2	0.6	2.76	0.52	2.36	16.3	74.2	---	---	29.6	51.6	82.7	---
		100.0		9.32		4.57		89.7			100.0	100.0	100.0	
				1.86%		0.91%		18.0%						

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	63

NOTES: Feed as for Test No. 19.

500 gms. -9 screen ore ground ~~wet~~ in ball-mill for 30 min., then agitated for 15 min. with $FeCl_3$ (5.0 lbs./ton) and Na_2CO_3, (4.0 lbs./ton) After agitation the pulp was neutral to litmus.

DATE	Feb. 13, 1922 19	
ORE NO.	158	
PULP RATIO	12 : 1	
R.P.M. IMPELLER		
PULP TEMP.	START	°
	FINISH	°
	MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
11,34						Charged		
,35	B. #4	10						
,47	do	5						
,55						1st. Concentrate	151	22
,56	Mix. #1	5						
12,02						End of Test.		
27		20						
						2nd. Concentrate	152	17
						Tailing	153	462
								501

REAGENT	%	LBS. P.T.
$FeCl_3$		5.0
Na_2CO_3		4.0
(leach)		
B. #4		1.2
Mix. #1		.4
Total Oil		1.6

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
43		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
20	1st. Conc	4.4	25.7	5.60	1.66	0.37	31.1	6.85	4.5	1.0	62.3	7.2	7.8	0.4
7	2nd. Conc	3.4	4.2	0.71	5.24	0.89	40.0	0.68	7.9	1.3	7.9	17.4	0.8	0.5
	Tails	92.2	0.58	2.69	0.83	3.84	17.4	80.50	58.0	268.0	29.8	75.4	91.4	99.1
		100.0		9.00		5.10		88.03		270.3	100.0	100.0	100.0	100.0
				1.8%		1.01%		17.6%		5[illegible].1%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	64
DATE	Feb. 13, 1922
ORE NO.	
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feed as for Test no. 19.
500 gms. of -9 screen ore gorund wet in ball-mill for 30 min., then agitated with $FeCl_3$, (5.0 lbs./ton) and Na_2CO_3 (8.0 lbs./ton) for 2. hours.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
2,26						Charged		
,27	B. #4	10						
,37						1st. Concentrate	154	33
,39	mix. #1	5						
,47						End of Test.		
20		15						
						2nd. Concentrate	155	34
						Tailing	156	433
								500

REAGENT	%	LBS. P.T.
$FeCl_3$		5.0
Na_2CO_3		8.0
(leach)		
B. #4		0.8
mix. #1		0.4
Total Oil		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
10	1st. Conc	6.6	18.75	6.20	4.80	1.58	31.6	10.4	5.8	1.9	69.0	34.9	11.6	0.7
10	2nd. Conc	6.8	2.35	0.80	3.30	1.12	46.0	15.6	8.4	2.9	8.9	24.8	17.4	1.0
	Tails	86.6	0.46	2.00	0.42	1.82	14.6	63.4	63.3	274.0	22.1	40.3	71.0	98.3
		100.0		9.00		4.52		89.4		278.8	100.0	100.0	100.0	100.0
				1.8%		0.90%		17.8%		55.8%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	65

NOTES: Feed as for Test No. 19, treatment as for Test No. 64, but agitated 30 min.

DATE	Feb. 13, 1922 19
ORE NO.	158
PULP RATIO	12 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,20						Charged		
,22	B. #4	10						
,30						1st. Concentrate	157	35
,31	Mix. #1	5						
,38						End of Test.		
16		15						
						2nd. Concentrate	158	43
						Tailing	159	429
								507

REAGENT	%	LBS. P.T.
(FeCl$_3$		5.0
(Na$_2$CO$_3$		8.0
(leach)		
B. #4		0.8
Mix. #1		0.4
Total Oil		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		— 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
8	1st.Conc	6.9	18.0	6.30	4.60	1.61	35.0	12.2	4.1	1.4	69.5	33.5	13.1	0.5
8	2nd.Conc	8.5	2.9	1.25	2.86	1.23	47.6	20.5	5.8	2.5	13.8	25.5	22.0	0.9
	Tails	84.6	0.35	1.50	0.46	1.97	14.1	60.5	61.5	264.0	16.7	41.0	64.9	98.6
		100.0		9.05		4.81		93.2		267.9	100.0	100.0	100.0	100.0
				1.79%		0.94%		18.4%		5[illegible].9%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	66
NOTES: Feed as for Test No. 19, treated as for Test No. 64, but agitated for 1.0 hour.	DATE	Feb. 13, 1922
	ORE NO.	158
	PULP RATIO	12 : 1
	R.P.M. IMPELLER	
	PULP TEMP. START	°
	PULP TEMP. FINISH	°
	PULP TEMP. MEAN	°

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
4.38						Charged		
.39	B. #4	10						
.47						1st. Concentrate	160	31
.48	Mix. #1	5						
.53						End of Test.		
14		15						
						2nd. Concentrate	161	25
						Tailing	162	442
								498

REAGENT	%	LBS. P.T.
FeCl$_3$		5.0
Na$_2$CO$_3$		8.0
(leach)		
B. #4		0.8
Mix. #1		0.4
Total Oil		1.2

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
8	1st. Conc	6.2	20.4	6.33	4.46	1.38	31.8	9.8	4.1	1.3	71.6	28.2	10.7	0.5
6	2nd. Conc	5.0	5.3	1.32	4.66	1.16	44.0	11.0	7.8	1.9	14.9	23.8	11.8	0.7
	Tails	88.8	0.27	1.19	0.53	2.34	16.4	72.5	62.1	274.0	13.5	48.0	77.5	98.8
		100.0		8.84		4.88		93.3		277.2	100.0	100.0	100.0	100.0
				1.77%		0.[illegible]%		18.6%		55.6%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO. 67

DATE	Feb. 6,1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES:

Feed as for Test No. 19.

500 gms. of -9 screen ore ground wet in ball-mill for 30min.

TIME H. M.	REAGENT	DROPS	C. C.	WEIGHT gms.	R.P.M.	NOTES	SAMP. No's	WEIGHT gms.
3,35				500		Charged		
,36	Na_2CO_3		12.5			10% solution		
,41	X Cake	10						
,56	do	6						
4,01						End of Test.		
20		16						
						Concentrate	192	45
						Tailing	193	460
								505

REAGENT	%	LBS. P.T.
Na_2CO_3		5.0
'X'Cake		1.3

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
20	Conct.	8.9	15.9	7.15	4.93	2.22	30.5	13.7	14.2	6.4	94.0	41.3	15.5	2.6
	Tails	91.1	0.1	0.46	0.69	3.16	16.2	74.5	53.0	241.9	6.0	58.7	84.5	97.4
		100.0		7.61		5.38		88.2		248.1	100.0	100.0	100.0	100.0
				1.50%		1.06%		17.5%		49.7%				

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10c. 1
DATE	March 2,1922 19
ORE NO.	158
PULP RATIO	7 : 1
R.P.M. IMPELLER	1,000
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Ore to Huntingdon Mill --- 404 lbs. Time of Crushing-- 40 m.
Screen--- 40 mesh. Feed Water at No. 1 (48.1 lbs/min)

Agitation --- 30 min. before dilution. Fed with pump,and Air on.
Feed Nipple-- 11/32 with 1/2 in. hose. No weights or Time taken.

TIME H. M.	REAGENT	Specific [redacted] Gravity	Per Cent [redacted] Solids	WEIGHT lbs.	Pulp [redacted] Ratio	NOTES	SAMP. No's	WEIGHT lbs.
3.15	NaCl	1.50	48.3	1.0	1.1:1			
"	NaOH			1.1		Commercial (76%)		
.45				400		Diluted with H_2O		
						Feed water 0.57 --	------	10./m.
						Motor Controller		
						3rd. from bottom.		
						Concentrate	224	---
						Tails	225	~~66~~
						Oil-- 34 drops/min.		

REAGENT	%	LBS. P.T.
NaCl		5.0
NaOH		4.0
F.P.L.24.		

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	19.8
28		150	17.7
35		200	7.9
48	1.3	− 200	36.8
65	16.5	TOTAL	99.8

TIME MIN.	PRODUCT	% WEIGHT	% Copper	WEIGHT	% NICKEL	WEIGHT	% IRON	WEIGHT	%	WEIGHT
	Conct.		9.1		2.78		33.7			
	Tails		0.55		0.81		16.2			
	Feed (?)		1.6		1.2		18.0			

PERCENT OF TOTAL

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10c. 2
DATE	March 18, 1922 19
ORE NO.	158
PULP RATIO	4 : 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Ore to H. Mill --- 423 lbs. Feed Water--#1--48.1 lbs/min. Screen--- 40 mesh. Time-- 43 min. Rate --- 9.8 lbs./min. Trial a failure, Return hose clogged continually and could not be kept clear. Feed cut off while there was about 270 lb. ore in the agitation tank. Pulp was too thick.

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT
11.40		1.375	39.5		1.5:1			
.41	Na_2CO_3			1.0		About 5 lbs/ton.		
"	NaCl			4.0		" 20 " "		
						Fed with pump and air.		
						Feed Nipple-- 5/16		
						Feed was about 6.0 lbs/min.		

REAGENT	%	LBS. P.T.

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	12.9
28		150	13.6
35		200	7.8
48	1.7	− 200	51.0
65	12.9	TOTAL	99.9

TIME MIN.	PRODUCT	% WEIGHT	%	WEIGHT	%	WEIGHT	%	WEIGHT	%	WEIGHT	PERCENT OF TOTAL			

*************************** N O R E S U L T S. ***************************************

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10c. 3
DATE	March 24, 1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: Feeding with pump alone, no air. 4" pipe capped at top. Upper discharge from pump was central in the agitation tank and fitted with distributor.

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT lbs.
3,17						Feed started.		
,25		1.141	17.9		5.5:1	Feed Sample	(1) S.A.	
,35		1.115	15.0		5.7:1	Outer Pipe Sample	2	
,40		1.110	14.4		5.9:1	" " "		
,45		1.090	12.0		7.3:1	Feed Sample		
4,00		1.090	12.0		7.3:1	" "	(3) S.A.	
,05		1.083	11.1		8.0:1	" "	4	
,14		1.065	8.9		10.1:1	" "	5	
,17		1.062	8.5		10.8:1	Outer Pipe Sample	6	
,25		1.057	7.8		11.8:1	Feed Sample	(7) S.A.	
,28						End of Feed.		
62								

REAGENT	%	LBS. P.T.

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	%	WEIGHT	%	WEIGHT	%	WEIGHT	%	WEIGHT	PERCENT OF TOTAL			
	* * * * * * * * * * * * * * *					NO RESULTS * * * * * * * * * * * *								

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	10 c. 4

NOTES: 60 mesh screen in Huntingdon Mill.
Middlings not returned to second mixing cell for further treatment. Feed nipple 11/32 in. with 1/2 in. hose.
Slight decrease in specific gravity of the feed as the test proceeded. Time of Test--- 16 min. Feed 4.35 lbs/min.
Dry Concentrate --- 3.5 lbs.

DATE	March 24, 1922 19	
ORE NO.		158
PULP RATIO		5.8 : 1
R.P.M. IMPELLER		1,000
PULP TEMP.	START	°
	FINISH	°
	MEAN	°

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT lbs.	REAGENT	%	LBS. P.T.
11,20		1.325	35.6		1.7:1	Transferred.					
,30	NaCl			1.0							5.0
	NaOH			0.5		about					2.5
12,00		1.21	25.2		3.0:1	Diluted with H_2O					
,40						Feed Started. Feed Water 8.5/m.					
,54	Oil feeder started, 45 drops per min.										
1,05		1.16	20.0		4.0:1	Feed Sample.					
,06	Feed water raised to #6 (11.7 lbs./min.)										
,14		1.115	15.0		5.6:1	Feed Sample.					
,37		1.110				" "					
,49						Start of Test.					
2,02		1.108				Feed Sample					
,05						End of Test.					
,06		1.102	13.4		6.4:1	Feed Sample.					

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT COPPER	% NICKEL	WEIGHT NICKEL	% IRON	WEIGHT IRON	% INSOLUBLE	WEIGHT INSOLUBLE	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
224	Conc't	4.8	13.3	0.64	1.82	0.09	21.2	1.02	29.5	1.41	48.8	8.3	5.8	3.0
225	Tails	95.2	0.7	0.67	1.05	1.00	16.8	16.0	48.3	46.0	51.2	91.7	94.2	97.0
		100.0		1.31		1.09		17.0		47.4	100.0	100.0	100.0	100.0
	Feed		1.40		1.07		18.1		48.5					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.	FLOTATION TEST NO.	10c. 5

NOTES: Ore to Huntingdon Mill -- 346 lbs. Rate of Crushing-- 8 lb/m
Screen-- 60 mesh.

Feed during test was 29.5 lbs/min of pulp containing 12% solids, giving 3.5 lbs./min. of ore.

DATE	March 29,1922 19
ORE NO.	158
PULP RATIO	8.5 : 1
R.P.M. IMPELLER	1,000
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT lbs.
10,45		1.36	38.4		1.6:1	Transferred.		
.05	Leach							
1,10		1.148	18.7		4.4:1	Diluted.		
.40		1.045	6.3		15. :1	Feed on,Water #0.7 --(14.8lb)		
.50		1.050	6.9		13.5:1	Water #0.6		
2,02		1.093	12.3		7.1:1	Water #0.4		
.05		1.085	11.3		7.9:1	Water #0.45		
.09	---					Oil started--- 48 drops/min.		
.15		1.090						
.27	----	10090				Start of Test.		
.40		1.085				Concentrate	228	2.8
.45		1.090				Middles--------	227	1.3
						Tails----------	229	69.9
.48	-----					End of Test.		74.0
.55		1.085				Feed Sample-- 29.5 lbs/min.		

REAGENT	%	LBS. P.T.
Na_2CO_3		1.0 lb.
NaCl		1.0 "
Leach.		
F.P.L.#24		

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conc't	3.78	20.2	0.76	2.74	0.10	26.8	1.01	14.5	0.55	51.0	9.5	5.8	1.1
	Midds	1.76	5.83	.10	2.59	.05	20.2	.35	38.2	.67	6.7	4.8	2.0	1.4
	Tails	94.46	0.67	.63	.95	.90	16.9	15.95	50.7	47.80	42.3	85.7	92.2	97.5
		100.0		1.49		1.05		17.3		49.0	100.0	100.0	100.0	100.0
	Feed		1.30		1.07		18.1		48.5					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10c. 6
DATE	March 30, 1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	1,000

PULP TEMP.	
START	°
FINISH	°
MEAN	°

NOTES: Ore to Huntingdon mill --- 353 lbs. Screen -- 60 mesh.

Feed 2.6 lbs./min. Time of Test.-- 20 min.
Pulp Feed ------ 29.2 lbs/min.
Feed Nipple 11/32 in. with 1/2 in. feed hose.
Oil started 3.45 --- 50 drops/min. Stopped at ---- 5.05

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT lbs.
12,00		1.53	50.2		1. :1	Transferred.		
2,10		1.183	22.4		3.5:1	Diluted		
3,10						Feed Started.		
,30		1.087	11.6		7.6:1	Water #0.6		
,48		1.060	8.2		11.2:1	" 0.76		
,52		1.065	8.9		10.2:1	" 0.74 (16.0 lbs/min)		
4,06		1.064				Start of Test.		
,10		1.063				Concentrate	231	3.0
,20		1.065				Middling	232	1.5
,30		1.065				Tails	233	48.0
,36		1.063				End of Test.		52.5
,40		1.062						
5,06						Feed Finished.		

REAGENT	%	LBS. P.T.
Na_2CO_3		1.0 lb.
NaCl		1.0 "
(leach)		
F.P.L. #24		

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	COPPER %	COPPER WEIGHT	NICKEL %	NICKEL WEIGHT	IRON %	IRON WEIGHT	INSOLUBLE %	INSOLUBLE WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	Conc't	5.7	20.2	1.15	2.69	0.153	28.6	1.63	12.0	0.69	63.6	12.4	8.8	1.5
	Midds	2.9	8.38	.25	2.74	.080	22.6	.66	27.2	.79	13.8	6.5	3.6	1.7
	Tails	91.4	0.45	.41	1.10	1.005	17.7	16.19	49.3	45.00	22.6	81.1	87.6	96.8
		100.0		1.81		1.24-		18.48		46.5-	100.0	100.0	100.0	100.0
	Feed		1.61		1.22		18.2		47.6					

ORE DRESSING LABORATORY, MINING DEPARTMENT, McGILL UNIVERSITY.

FLOTATION TEST NO.	10c. 7
DATE	March 31, 1922 19
ORE NO.	158
PULP RATIO	: 1
R.P.M. IMPELLER	1,000
PULP TEMP. START	°
PULP TEMP. FINISH	°
PULP TEMP. MEAN	°

NOTES: 60 mesh screen in Huntingdon Mill.

'X' Cake mixture is {60% Crude Alpha-naphthylamin.
{40 Xylidin.

Cells 1-3, 1st.Conc; 4, 5, 2nd.Conc; 6-8 returned to 2nd. mixing cell.

TIME H. M.	REAGENT	SPECIFIC [redacted] GRAVITY	PER CENT [redacted] SOLIDS	WEIGHT lbs.	PULP [redacted] RATIO	NOTES	SAMP. No's	WEIGHT lbs.
3,15		1.183	22.4		3.5:1	Na_2CO_3 added		
,40	—					Oil started (15 drops/min)		
,25						Feed started.		
,45		1.095	12.6		6.9:1	Water #0.55		
,50		1.075	10.1		8.9:1	" 0.7		
,54		1.073	9.9		9.0:1			
4,00		1.073				Start of Test.		
,10		1.075				1. Concentrate	234	8.12
,15		1.073				2. do	235	1.88
,25		1.075				Tailing	236	105.
,35		1.071						115.0
,40						End of Test.		
,50		1.070						
5 ,10						Feed finished.		

REAGENT	%	LBS. P.T.
Na_2CO_3		1.0 lb.
'X' Cake		

SCREEN ANALYSIS OF FEED

GRADE	%	GRADE	%
+ 20		+ 100	
28		150	
35		200	
48		− 200	
65		TOTAL	

TIME MIN.	PRODUCT	% WEIGHT	% COPPER	WEIGHT	% NICKEL	WEIGHT	% IRON	WEIGHT	% INSOLUBLE	WEIGHT	PERCENT OF TOTAL Cu	Ni	Fe	Ins.
	1st.Conc.	7.12	17.3	1.23	4.17	0.296	31.0	2.20	11.5	0.82	70.2	26.6	12.4	1.7
	2nd.Conc	1.65	9.8	.16	4.85	.080	29.0	.48	20.0	.33	9.2	7.2	2.7	.7
	Tails	91.23	0.38	.36	0.81	.738	16.4	15.00	51.7	47.0	20.6	66.2	84.9	97.6
		100.0		1.75		1.11		17.7-		48.2-	100.0	100.0	100.0	100.0
	Feed		1.72		1.24		19.2		47.0					