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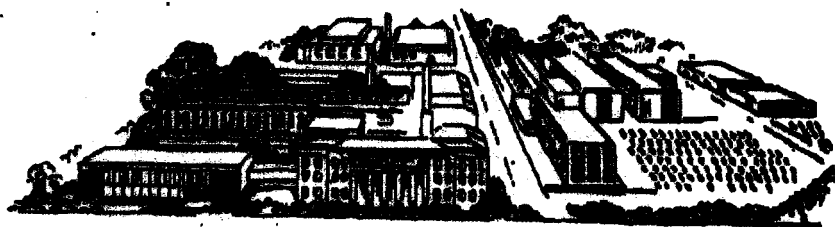
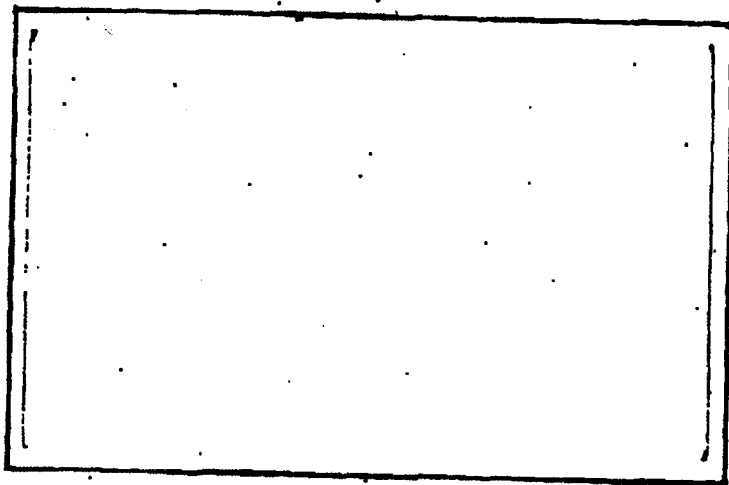
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RESEARCH REPORT



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EXHIBIT

25

PROGRESS REPORT

on

THE PHYSICAL CONCENTRATION OF
TALC ORES - FLOTATION OF ITALIAN
RUN-OF-MINE TALC

to

JOHNSON AND JOHNSON

December 31, 1959

by

Whitman E. Brown

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus 1, Ohio

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5 0 5 K I N G A V E N U E C O L U M B U S I , O H I O

January 15, 1960

Mr. W. H. Ashton
Research Department
Johnson and Johnson
New Brunswick, New Jersey

Dear Mr. Ashton:

We are sending you six copies of our report on "The Physical Concentration of Talc-Ores - Flotation of Italian Run-of-Mine Talc", by Whitman E. Brown. This report, in conjunction with our similar report of July 31, 1959, on the "Flotation of Italian No. 2 Talc", gives the laboratory work that was the basis for the recommendation of a pilot talc-flotation plant and the data on which its design was based.

Sincerely yours,


O. F. Tangel

OFT:jvo

cc: Dr. W. H. Lycan
C. W. Swank

DEDICATED TO THE ADVANCEMENT OF SCIENCE

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PROGRESS REPORT
on
THE PHYSICAL CONCENTRATION OF TALC ORES -
FLOTATION OF ITALIAN RUN-OF-MINE TALC

to
JOHNSON AND JOHNSON

from
BATTELLE MEMORIAL INSTITUTE

by
Whitman E. Brown

December 31, 1959

INTRODUCTION

This is the Third Progress Report on "The Physical Concentration of Talc Ores" and specifically applies to experimental results obtained from the beneficiation of Italian run-of-mine (ROM) talc. For comparative purposes, occasional references are made in the discussion about results obtained from Italian No. 2 talc. *

The objectives of the investigation were:

- (1) To obtain a product that consists essentially of talc platelets
- (2) To reject talc particles that are of a size and shape that create unpleasant dusting while talc is being dispensed from a container
- (3) To obtain a talc product with an obvious luster in order to convey to the consumer the immediate impression that the talc is of the highest quality
- (4) To investigate the variables that affect the grindability of talc

*Brown, W. E., "The Physical Concentration of Talc Ores - Flotation of Italian No. 2 Talc", Battelle Progress Report to Johnson and Johnson (July 31, 1959).

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- (5) To establish that the beneficiation process developed for Italian No. 2 talc is also applicable to the run-of-mine talc.

In addition to achieving the foregoing objectives, it was desirable that the finished talc product meet the following specifications:

Moisture: Not more than 0.15 per cent

Solubility in HCl: Not more than 6 per cent

Fineness: Not less than 99.7 per cent through a 100-mesh Tyler sieve and not less than 98.5 per cent through a 200-mesh sieve

Microscopic Structure: Platelets, and no acicular or excessive granular crystals

Bulk Density: Not less than 22 nor more than 27 pounds per cubic foot, when tested by the Scott Volumeter.

In further keeping with the standards of production, it is desirable that the finished talc product have essentially the same whiteness as that currently being marketed by Johnson and Johnson.

The methods of beneficiation employed in previous work were hydraulic cycloning and flotation. It was established in the earlier investigations that hydraulic cycloning alone not only rejected objectionable dust-forming particles, but also improved the platy content of the talc. However, cycloning alone was not sufficient to obtain the ultimate in purity. Flotation proved to be effective for the removal of more nonplaty talc, tremolite, dolomite, and other accessory gritty and off-color minerals. The combined cyclone-flotation processes developed for Italian No. 2 talc were not effective in improving the luster, as judged by casual observations, although the mineral particles were 98 to 99 per cent talc platelets. If a product consisting of such high-purity mineral particles did not have an improved luster, then a method of comminution, other than roller milling, might affect favorably the morphology of the platelets and the luster. Wet and dry pebble milling seemed logical methods to try.

In addition to obtaining a talc with an improved luster, certain economic factors had to be considered. It was the Sponsor's desire to remove from talcum powder objectionable dust-forming particles: platelets or other forms. Some experiments indicated that particles finer than 10 or 15 microns were easily airborne and, therefore, their removal should improve the powder. Size-distribution experiments, however, showed that about 27 per cent of the Italian No. 2 type of talc was finer than 10 microns and about 40 per cent of the weight was finer than about 14 microns, so that complete rejection of the potential dust, in the final analysis, would

increase the total cost of the raw material in direct proportion to the amount of rejected weight. This does not include the operating cost of the classification process. Battelle believed that carefully controlled wet- pebble-mill grinding might result in a ground product having less of the objectionable fine sizes. Johnson and Johnson was asked to obtain Italian run-of-mine (unground) ore samples, so that the problems related to luster and fine grinding might be investigated in the laboratory.

SUMMARY - ITALIAN ROM TALC

Batch wet grinding in a laboratory pebble mill produced fine-ground talc that had a higher order of luster than that obtained by dry roller milling or dry pebble milling.

Batch wet pebble milling resulted in faster grinding of minus 10-mesh talc through 200 mesh but produced more objectionable fine talc in the minus 10-micron sizes than batch dry pebble milling.

Variables that affect rates of grinding were investigated. It was found that a grinding time of less than 11 minutes and a circulating load of more than 336 per cent may be required to avoid overgrinding. Laboratory experiments were not successful in obtaining a ground product containing less than 35 per cent of the weight finer than 10 microns. Data were obtained, however, that can be used to determine the approximate grinding time necessary to obtain the desired results. This information is discussed with Figure 5 in the "Grinding" section of this report.

It is necessary to grind finer than 100 mesh, because a 100-mesh grind yields products that are gritty, although the high luster is remarkably evident.

If the ROM talc is overground, that is, contains more than about 40 per cent of minus 10-micron particles, one stage of cyclone classification may not be sufficient for satisfactory removal of the fines. However, ROM talc which has not been overground responds satisfactorily to cyclone classification.

Flotation of wet-ground and classified ROM talc was successful. Beneficiated products were obtained that were 97 to 99 per cent platy talc. The yield expected in a continuous operation is 80 per cent of the weight of the flotation feed; this amounts to 56 per cent of the original ore.

The beneficiated talc was an improvement in all respects when compared with the Johnson and Johnson specifications for the raw material currently used in their marketed Baby Powder.

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The beneficiation process developed for Italian No. 2 talc is also satisfactory for Italian ROM talc when the proper crushing and grinding equipment are used.

SAMPLING AND MINERAL EVALUATION OF ITALIAN ROM TALC

Johnson and Johnson arranged for a sample of coarse run-of-mine (ROM) Italian talc to be shipped to Battelle for grinding and flotation experiments, including luster studies of the products from the experiments. Approximately 4,450 pounds of ROM ore were received for this work in July, 1958. One bag containing 150 pounds of talc was reserved for miscellaneous purposes. The remaining portion, containing some pieces up to 1-1/2 inches maximum dimension, was mixed by coning and reduced in quantity by riffing to 268 pounds. The 268-pound sample was roll crushed through a 10-mesh Tyler screen for feed material in the grinding (pebble-milling) experiments. A small but representative portion of the minus 10-mesh talc was ground in a pebble mill to pass through a 200-mesh Tyler screen and examined with a microscope.

Results of the microscope analysis showed that the Italian ROM talc was almost identical to the Italian No. 2 talc in mineral composition. It contained about 90 per cent platy talc, 6 per cent nonplaty talc, 2 per cent dolomite, and 2 per cent tremolite. The Italian No. 2 talc contained about 90 per cent platy talc, 6 per cent nonplaty talc, 3 per cent dolomite, and 1 per cent tremolite.

Because of the nearly identical mineral compositions of the ROM talc and the Italian No. 2 talc, it was implied that beneficiation methods developed for Italian No. 2 material would probably be just as effective for the processing of ROM talc.

EXPERIMENTAL WORK

Grinding

The objectives for grinding ROM talc were threefold:

- (1) Grind the ore through 200 mesh in a manner that would result in the production of less minus 10-micron talc than that contained in Italian No. 2 talc, or significantly less than about 27 per cent

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- (2) Grind the ore in a manner that would result in a ground product having a more prominent luster than that obtainable from Italian No. 2 talc.
- (3) Determine the most expedient method of grinding to produce ground products suitable for subsequent classification and flotation experiments in the laboratory.

Because talc is one of the softest natural minerals, one might expect that it would grind easily and overgrinding would be difficult to avoid.

Preliminary experiments on wet grinding minus 10-mesh talc through 200 mesh indicated that grinding of talc was not so simple as grinding the granular type of minerals.

The reasons are that (1) talc resists grinding because of its lubricity and (2) the high specific surface of liberated talc platelets per unit of weight fixes the maximum grinding density of the slurry at about 45 per cent solids. If the slurry density is increased a few per cent beyond this point, it becomes a sticky paste, which is an impracticable condition for grinding.

Because of the unusual grinding characteristics of talc, specifically the Italian type, it became necessary to determine what conditions would be required to grind efficiently and what variables have the most influence on the desired results.

A program for grinding experiments was established to investigate the influence of certain variables on the efficiency in producing minus 200-mesh talc. The variables investigated were:

- (1) Effect of weight of talc charged to pebble mill in wet and dry grinding
- (2) Effect of grinding-media weight
- (3) Effect of grinding time
- (4) Effect of pulp density
- (5) Effect of pebble size.

The pebble mill used for these experiments is made of porcelain with inside dimensions of 7-1/2-inch diameter and 7-1/4 inches long. It was rotated at 70 rpm.

Effect of Weight of Talc Charged to Pebble Mill in
Wet and Dry Grinding

Figure 1 shows the effect of the weight of talc charged to the pebble mill on the per cent of talc reduced to minus 200 mesh.

There are two prominent characteristics evident from the data plotted in Figure 1.

- (1) Wet grinding is more effective than dry grinding in reducing the particle size of talc to finer than 200 mesh.
- (2) The percentage of talc reduced to 200 mesh and finer decreases at a constant rate with an increase in the amount of talc charged to the pebble mill.

The data show that, with a charge of 120 grams of talc, which is about 24 per cent of the nominal mill capacity, about 91 per cent of the charge was reduced to 200 mesh in a grinding time of 60 minutes. If, however, the charge is increased to 240 grams, or about 48 per cent of capacity, the amount of talc that is reduced to 200 mesh is about 73 per cent. Finally, if the talc charge is increased to 500 grams, a 60-minute grind will reduce 35 per cent of the charge to 200 mesh.

Dry-grinding characteristics are similar to wet-grinding characteristics with respect to rate of change in grinding with increased loading. However, when a 120-gram charge of talc was wet ground for 60 minutes, about 91 per cent of the slurry was finer than 200 mesh. After dry grinding the same weight of charge, only about 71 per cent of the resulting powder was finer than 200 mesh.

The data plotted in Figure 1 do not immediately reveal all of the facts. Actually, the amount of minus 200-mesh material produced reached a peak when a charge of 400 grams was wet ground or dry ground. The following tabulation of grinding data illustrates this point.

Weight of - 10 Mesh Talc Charge, grams		Per Cent of Charge Ground Finer Than 200 Mesh		Total Weight of Charge Ground Finer Than 200 Mesh, grams	
Wet	Dry	Wet	Dry	Wet	Dry
120	120	90.6	70.5	108.7	84.6
240	240	73.0	59.0	175.2	141.6
400	400	52.7	42.0	210.8	168.0
500	500	39.0	32.0	195.0	160.0

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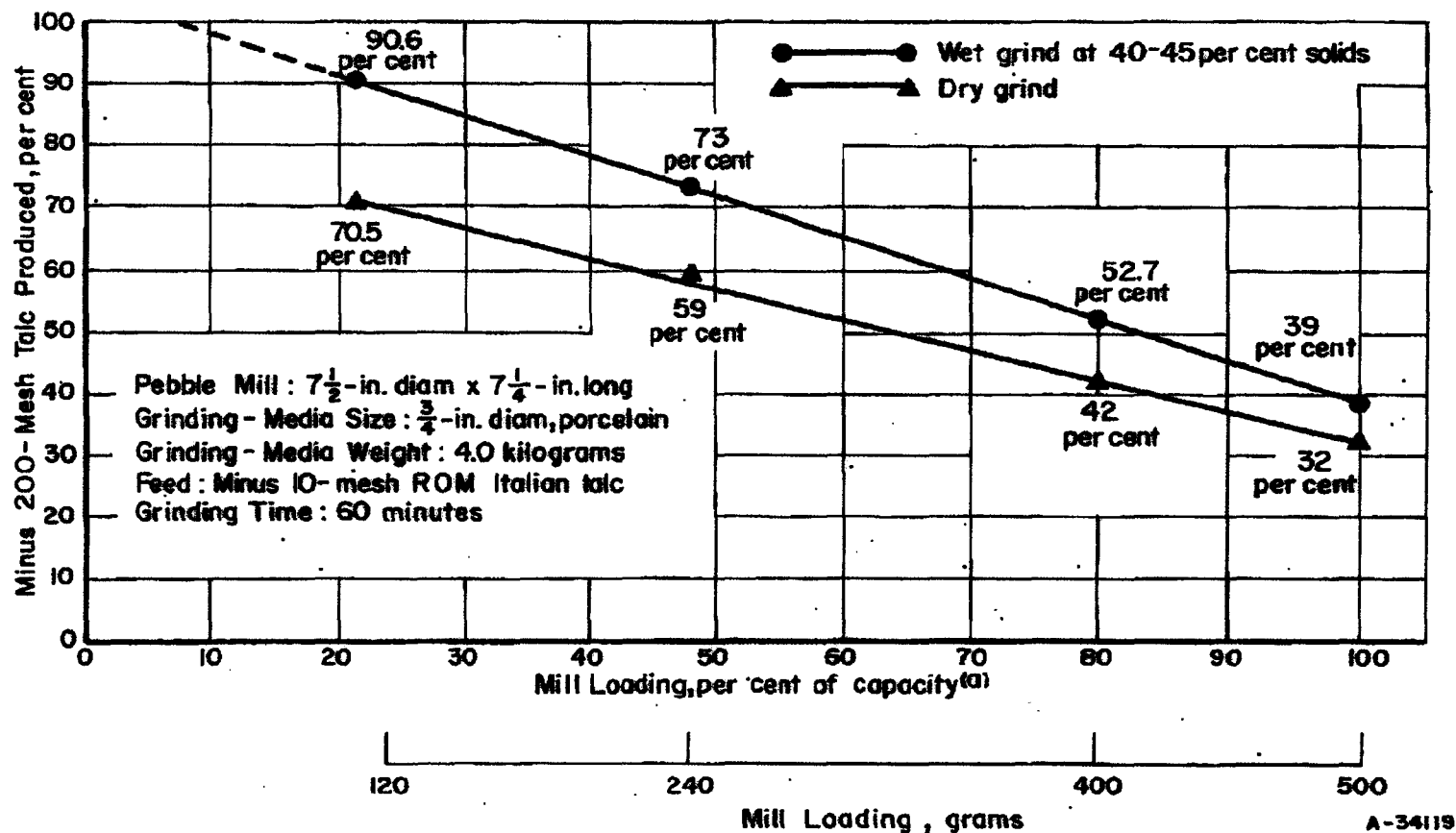


FIGURE 1. THE EFFECT OF THE WEIGHT OF TALC CHARGED TO THE PEBBLE MILL ON THE PER CENT OF TALC REDUCED TO MINUS 200 MESH

(a) Pebble-mill capacity considered to be 500 grams.

Effect of Grinding-Media Weight

Figure 2 shows the effect of the weight or volume of grinding media on the per cent of talc reduced to minus 200 mesh. The curve shows that, as the weight of grinding media was increased from 2.5 kilograms, or about 31 per cent of the mill volume, to 5.0 kilograms, or about 62.5 per cent of the mill volume, the amount of talc that was reduced to 200 mesh was increased from 70 per cent to about 95 per cent. The increased rate of grinding is pronounced as the amount of grinding media is increased up to 50 per cent of the mill volume. Increasing the grinding media in excess of 50 per cent of the mill volume resulted in small increases in producing additional amounts of minus 200-mesh talc. Furthermore, it is not possible to have more than 50 per cent of the mill volume occupied by grinding media in a continuous operation.

Effect of Grinding Time

The next series of experiments were made to determine the effect of grinding time on the amount of talc reduced to 200 mesh. These experiments were made by wet and dry grinding 120-gram charges of minus 10-mesh talc over a range of 15 to 90 minutes.

The data obtained from these experiments are plotted in Figure 3 and show that, as the wet-grinding time is increased from 15 to 60 minutes, the amount of talc reduced to 200 mesh is increased from 50 to 90 per cent. Grinding in excess of 60 minutes resulted in only minor increases in the amount of minus 200-mesh talc produced and appears impractical. Figure 3 also shows that wet grinding is more effective than dry grinding. Although the wet- and dry-grinding curves tend to parallel each other, wet grinding produced from 15 to 30 per cent more 200-mesh material for any given grinding period.

Effect of Pulp Density

Previous experiments established that, when a large percentage of the talc is ground finer than 200 mesh, pulp densities near or in excess of 45 per cent solids resulted in a pasty, nonfluid mass. Experiments were made on grinding 120 grams of minus 10-mesh talc charges at 30, 35, 40, and 45 per cent solids. The resulting data are plotted in Figure 4 and show a gradual increase in grinding efficiency as the per cent solids of the slurry is increased from 30 to 45 per cent. At 30 per cent solids, about 72 per cent of the talc was ground through 200 mesh, and at 45 per cent solids the ground product was about 91 per cent minus 200 mesh.

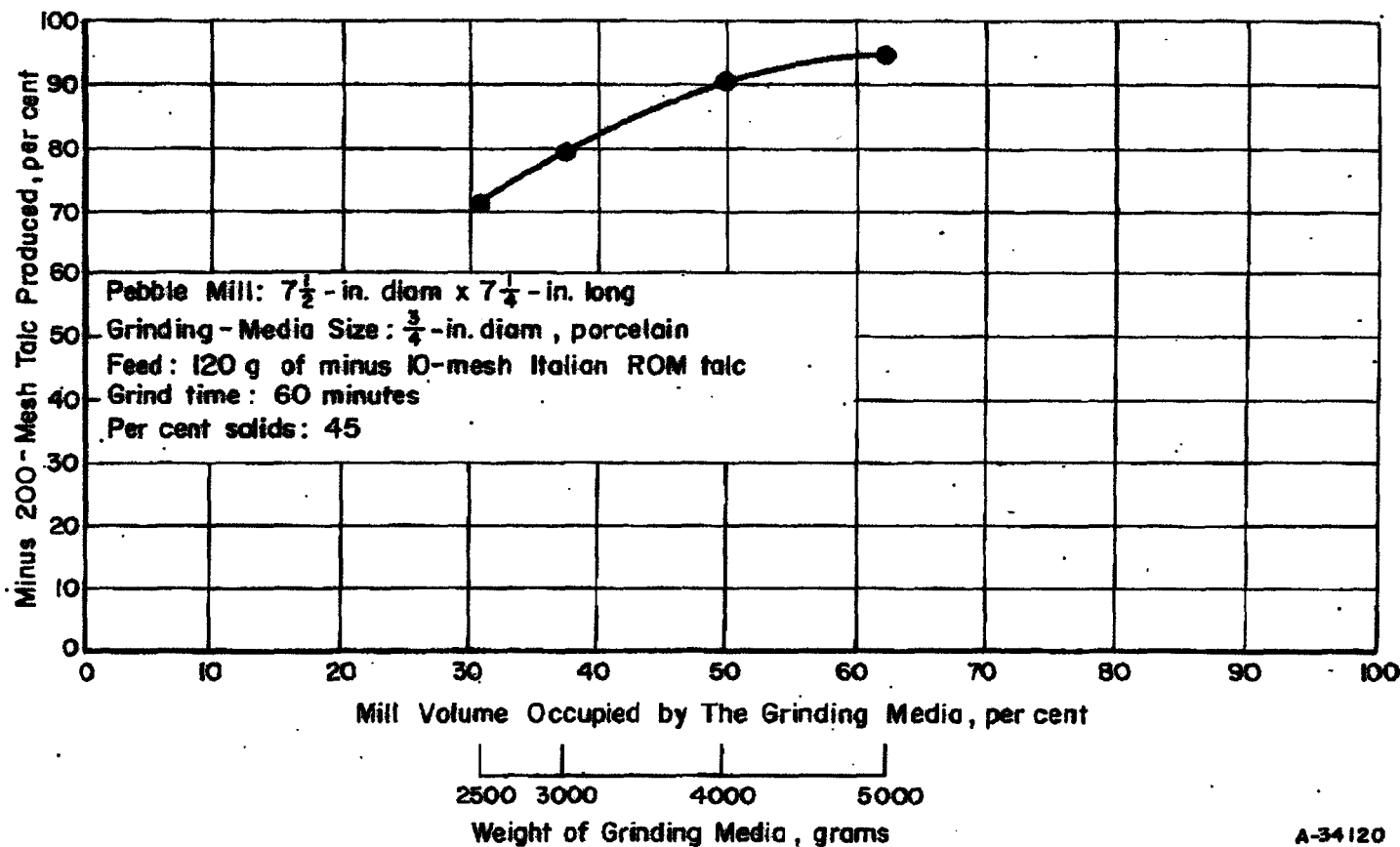


FIGURE 2. THE EFFECT OF THE WEIGHT OR VOLUME OF GRINDING MEDIA ON THE PER CENT OF TALC REDUCED TO MINUS 200 MESH

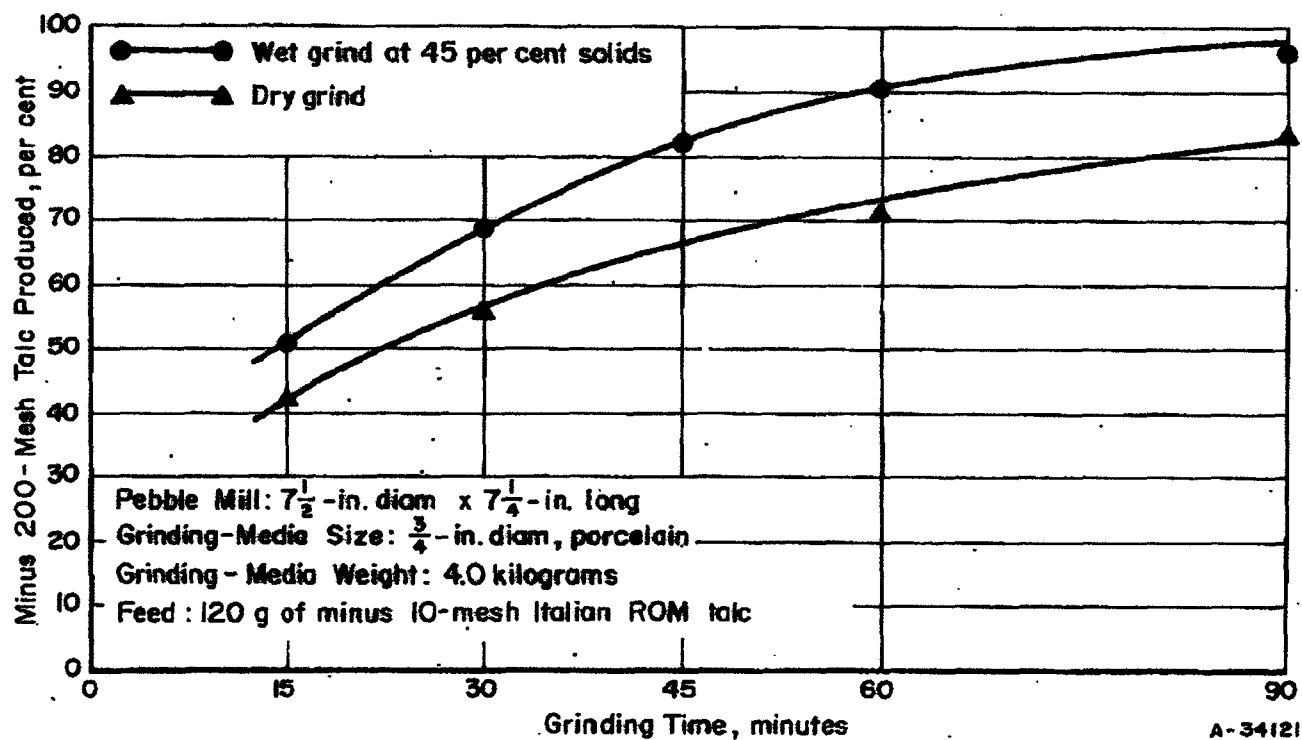


FIGURE 3. THE EFFECT OF GRINDING TIME ON THE PER CENT OF TALC REDUCED TO MINUS 200 MESH

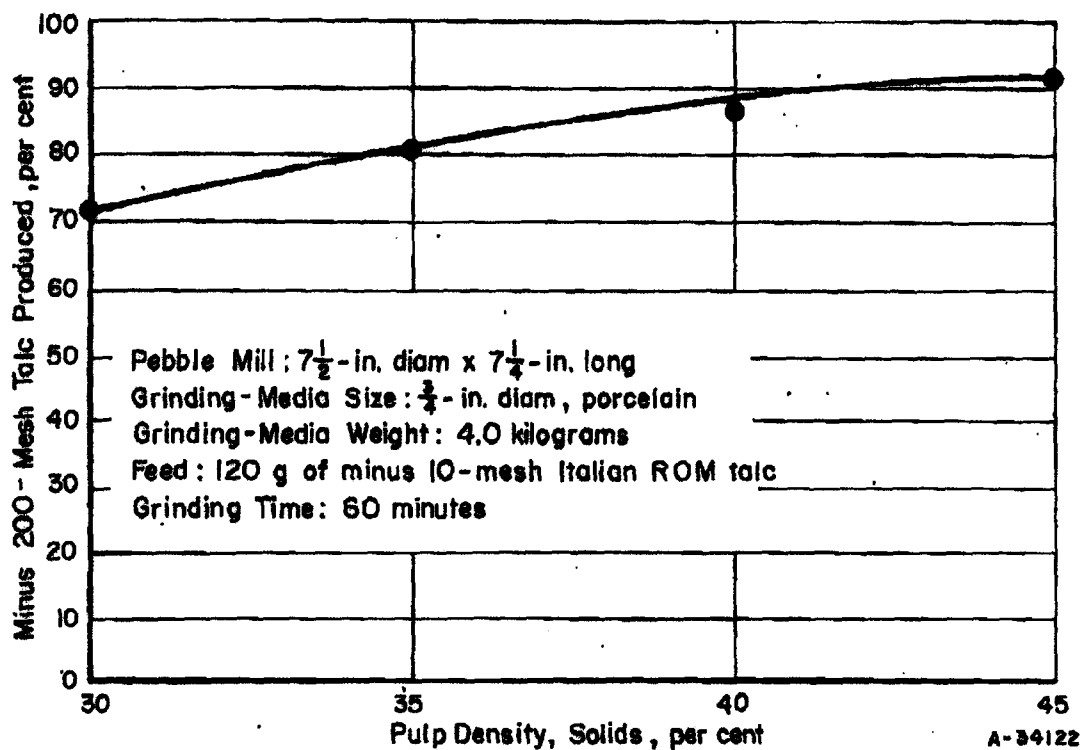


FIGURE 4. THE EFFECT OF THE PULP DENSITY DURING GRINDING ON THE PER CENT OF TALC REDUCED TO MINUS 200 MESH

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Effect of Pebble Size

This part of the investigation was limited to pebble sizes of 0.75-inch diameter, 1.5-inch diameter, and a mixture of the two. Experiments were made using 120 grams of minus 10-mesh talc charges adjusted with water to 45 per cent solids and ground for 60 minutes.

The following tabulation gives the data obtained from this work:

<u>Size of Pebbles,</u> <u>inches</u>	<u>Weight of Pebbles,</u> <u>kilograms</u>	<u>Minus 200-Mesh Talc</u> <u>Produced, weight per cent</u>
0.75	4.0	90.6
0.75 and 1.50(a)	4.0	88.5
1.50	4.0	86.8

(a) About 50 per cent of each size.

These data show that small-diameter pebbles will grind more talc through 200 mesh than large-diameter pebbles in a given length of time. Four kilograms of 0.75-inch pebbles reduced 90.6 per cent of the 120-gram talc charge through 200 mesh. The same weight of 1.5-inch pebbles reduced 86.8 per cent of the charge through 200 mesh.

Effect of Grinding Time on Production of Minus 10-Micron Particles

In the foregoing discussion about the various factors involved in grinding, no effort was made to determine the amount of minus 10-micron talc produced. This was partly because optimum grinding conditions were not known and also because it was planned to combine the most effective grinding conditions and run a series of experiments, using time as the only variable, and obtain more complete size-distribution data. The following grinding conditions were selected as desirable:

Weight of Pebble Charge	4.0 kilograms
Size of Pebbles	0.75 inch
Weight of Talc to Be Ground	120 grams
Solids Content of Slurry	40 per cent

The essentials of the experimental procedure consisted of grinding a charge for 15, 30, 45, and 60 minutes. At the end of each time period, the entire charge was removed from the pebble mill and washed off the pebbles. The ground slurry was screened on a 200-mesh Tyler sieve and the minus 200-mesh portion was treated by sedimentation to remove the minus 10-micron particles. (Minus 10-micron sedimentation time was based on the rate of settling of 10-micron quartz particles.) The three sized products, plus 200 mesh, minus 200 mesh plus 10 microns, and minus 10 microns, were dried and weighed. The resulting data are plotted in

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Figure 5. The three curves shown in the figure permit determination of the amount of any of the three size ranges present in the ground talc at any given time.

It is interesting to note that, after a 60-minute grind, only about 11 per cent of the talc was coarser than 200 mesh, 42 per cent was in the desired size range of minus 200 mesh plus 10 microns, and about 44 per cent was finer than 10 microns. One of the grinding objectives was to produce less than about 27 per cent of minus 10-micron particles and, since a 60-minute grind produced 44 per cent, the time of grinding was much too long. If some shorter time of grind is selected, say 15 minutes or 11 minutes, the desired results are almost obtained. Table 1 shows the weight distributions of the ground products at the end of 15 minutes and of 11 minutes.

TABLE 1. DISTRIBUTION OF SIZES AFTER 15- AND 11-MINUTE WET-GRINDING PERIODS OF ROM ITALIAN TALC

Sized Product	Distribution			
	Weight Per Cent of Total Product		Weight Per Cent After Removal of Plus 200-Mesh Fraction	
	15 Min	11 Min	15 Min	11 Min
+ 200 mesh	48	58	0.0	0.0
- 200 mesh + 10 micron	36	30	69.2	71.5
- 10 micron	16	12	30.8	28.5
Total	100	100	100.0	100.0

The data given in Table 1 show that 11 minutes should give about the same grind as that found in Italian No. 2 talc. That is to say, after removal of the plus 200 mesh (which in normal operation would be returned to the pebble mill for further grinding), the minus 200-mesh talc contained 28.5 per cent of minus 10-micron particles, compared with about 27 per cent in Italian No. 1. A still shorter time of grind appears necessary, and calculations for a 6-minute grind show that the minus 200-mesh talc would contain about 25 per cent of minus 10-micron particles.

As the time of grind is decreased, the amount of plus 200-mesh talc to be reground is increased and, in a continuous operation, would increase the circulating load. It is common commercial practice to use large circulating loads to minimize overgrinding.

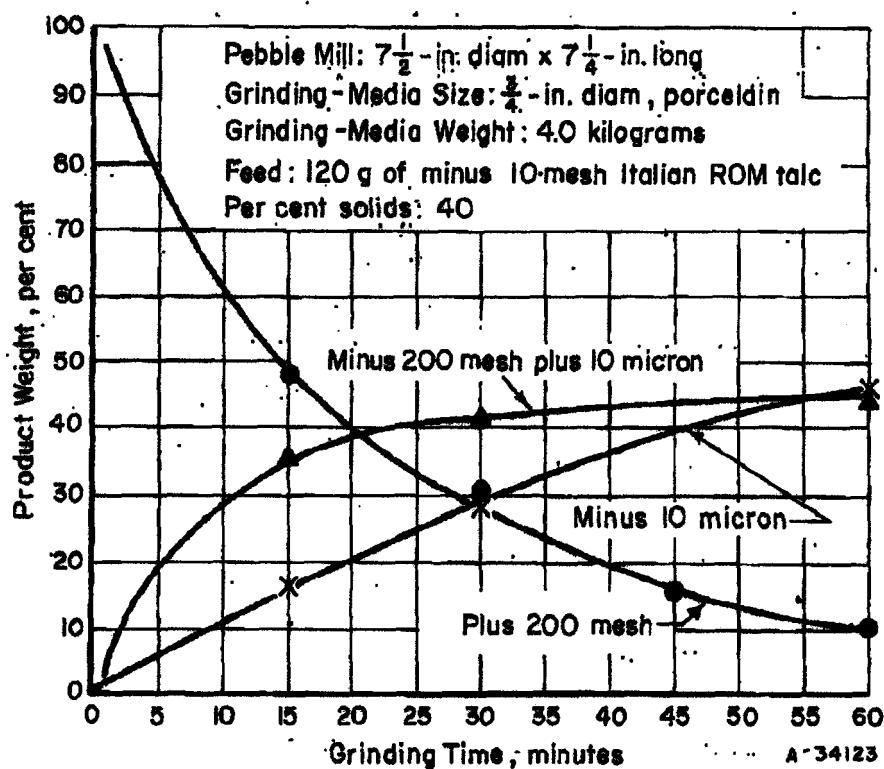


FIGURE 5. THE EFFECT OF GRINDING TIME ON THE
 PER CENT OF MINUS 200-MESH PLUS
 10-MICRON AND MINUS 10-MICRON
 TALC PRODUCED

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The data given in Table 1 and Figure 5 must be used as a guide only, but should be useful for making reasonable estimates for grinding performance and trends.

Grinding studies were carried a step further at a later date (after a number of flotation tests had been made) but are discussed here for conformity.

Simulated Closed-Circuit Grinding

Investigations were made on wet grinding that simulated continuous closed-circuit grinding, although actually consisting of batch grinds of short duration. A circulating load consisting of the unground plus 200 mesh was returned to the mill for further grinding, as is common in continuous-grinding practice.

The essential parts of the procedure were to add a given weight of charge to the pebble mill, grind for a specified time, and screen the ground product on a 200-mesh sieve. The plus 200-mesh portion was returned to the mill as a circulating load and a new amount of minus 10-mesh feed, equivalent in weight to the minus 200 mesh produced, was added to the pebble mill. This was repeated several times, until the mill charge came to equilibrium or, in other words, until the amount of minus 200 mesh produced from each grind was about the same weight as in the preceding grind. The foregoing procedure was followed for grinding periods of 15 minutes on a 120-gram talc charge and 11 minutes on a 240-gram charge. The ground products were separated at 200 mesh and 10 microns in the usual manner, by screening and sedimentation. The results obtained are given in Table 2.

Table 2 shows two separate sets of grinding conditions and the resulting distribution of sizes in the ground products. After a 120-gram charge was ground for 15 minutes, the resulting slurry contained 18 per cent of the weight in particles finer than 10 microns. Only 29.9 per cent of the talc was in the desired particle-size range of minus 200 mesh plus 10 microns. About 52 per cent of the ground product was returned to the pebble mill as a circulating load. After the plus 200-mesh portion was screened out, the minus 200-mesh slurry contained 37.5 per cent of the weight finer than 10 microns. This was considered as overgrinding, because one of the objectives was to grind in a manner that would result in less than 27 per cent of the weight finer than 10 microns.

In order to overcome the excessive overgrinding, an experiment was made that would increase the circulating load substantially. The amount of talc initially charged to the mill was increased to 240 grams and the grinding time was shortened to 11 minutes. The size distribution of the ground product for the 11-minute grinding period shows that 8.0 per cent of

the weight was finer than 10 microns. At first glance, it might appear that the objective had been accomplished. However, after removal of the plus 200-mesh portion of the ground product, the minus 200-mesh material contained 35 per cent of the weight finer than 10 microns. So it is noted that, although the circulating load was increased from 108.7 per cent for the 15-minute grind to 336.3 per cent for the 11-minute grind, and with a doubled charge, the net result is a reduction of minus 10-micron talc from 37.5 per cent to 35 per cent. The reason for such a slight change in the amount of 10-micron material produced is not fully understood. In order to arrive at the objective of producing less than 27 per cent of minus 10-micron talc in the minus 200-mesh product, more variables would have to be investigated, such as shorter grinding time, larger or mixed diameter pebbles, coarser size talc as pebble-mill feed, and perhaps increased dilution.

It was felt that grinding characteristics on a continuous basis, with coarser ore feed, larger diameter pebbles, and continuous classification, would all favor reaching the size-distribution objective; therefore, the laboratory grinding program was terminated.

Another objective of pebble milling was to obtain a product with a noticeably higher luster than that exhibited by the Italian No. 2 talc, which had been dry ground in a Raymond-type roller mill. The first wet-grinding experiment in the pebble mill was successful in this respect. In fact, all wet-grinding experiments gave ground products having a relatively high luster.

The next step in the investigation involved the separation of the minus 10-micron talc from the minus 200-mesh ground product,

Hydraulic Classification of Pebble-Mill Product

Particle-size classification of the pebble-mill product for removal of minus 10-micron particles was necessary in order to prepare a satisfactory flotation feed and at the same time to remove potential dust-forming minerals.

The ground ore from the pebble mill was screened on a 200-mesh Tyler sieve for removal of objectionable oversize talc. The minus 200-mesh portion was adjusted with water to 5 per cent solids by weight and cycloned in a 30-mm-diameter glass cyclone.

A complete description of the cyclone process and of various experiments on the classification of Italian No. 2 talc has been reported* to Johnson and Johnson. In that report, a cycloning procedure was described

*Brown, W. E., "The Physical Concentration of Talc Ores - Flotation of Italian No. 2. Talc", Battelle Progress Report to Johnson and Johnson (July 31, 1959).

and was considered an acceptable method for removal of objectionable fine particles. There was no reason to believe that a change in classification procedure was necessary. If the classification of the ROM ground talc were satisfactory, using the same procedure, it would aid in establishing that the classification part of the beneficiation process was applicable to both the Italian No. 2 and ROM talcs.

The pebble-mill wet-ground products, as reported in Table 3, were screened on 200 mesh and the minus 200-mesh portions were hydraulically cycloned for elimination of as much of the minus 10-micron particles as was practicable in one stage of classification.

In discussing the removal of minus 10-micron particles, it is necessary to qualify the purpose and the results. A preponderance of minus 10-micron particles in a flotation feed creates a voluminous froth that not only is difficult to break down, but also traps the undesirable minerals. Removal of minus 10-micron particles is further desirable because of their dusting potential. However, it is not necessary to remove all of the minus 10-micron particles to obtain a satisfactory froth, nor is it necessary to remove all of such particles to eliminate excessive dusting. Perhaps total dusting tendency never can be eliminated, because particles larger than 10 microns will be airborne occasionally. A compromise was accepted when a product was obtained that would contain about 10 to 12 per cent of minus 10-micron particles. Finally, it would be economically impractical to achieve absolute 10-micron-particle rejection, and it may even be mechanically impossible.

Therefore, in discussions of this nature, "removal of minus 10-micron particles", the meaning is that the product is treated in a manner that results in something less than about 10 to 12 per cent of the weight finer than 10 microns.

The cyclone classification of the ground products was tried with a feed pressure of 14.7 psi applied to the 15-minute-ground product and 14.7 and 23.0 psi applied to the 11-minute-ground product. The results of classification of these experiments are given in Table 3.

Table 3 shows that, when a 15-minute pebble-milled product was cycloned at 14.7-psi inlet pressure, an excessive amount, 48.5 per cent, of the feed weight was rejected in the cyclone overflow. Sedimentation analysis showed that 42 per cent of the weight of the overflow product was of particles larger than 10 microns. Therefore, 32.6 per cent of all the plus 10-micron talc in the cyclone feed was lost or rejected in the cyclone overflow.

When the product of an 11-minute grind was cycloned at 14.7-psi inlet pressure, the amount of cyclone overflow dropped to 36.7 per cent and contained 31.9 per cent by weight of plus 10-micron material.

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TABLE 3. DISTRIBUTION OF WEIGHT AND PARTICLE SIZE OF HYDRAULICALLY CLASSIFIED (CYCLONED) MINUS 200-MESH PEBBLE-MILLED PRODUCTS

Operating Conditions:

Cyclone Diameter, mm	30
Feed Inlet Diameter, mm	6
Overflow Vortex Diameter, mm	11
Underflow Apex Diameter, mm	5.5
Feed Solids Content, per cent	5
Feed Volume Rate, gpm	
At 14.7 psi	2.7
At 23.0 psi	3.3

Grinding Time, min	Cyclone Product	Weight Per Cent	Weight Per Cent in Product		Distribution Per Cent in Product		Remarks
			-10 μ	+10 μ	-10 μ	+10 μ	
15	Feed	100.0	37.5	62.5	100.0	100.0	Feed pressure 14.7 psi
	Overflow	48.5	58.0	42.0	75.0	32.6	
	Underflow	51.5	18.2	81.8	25.0	67.4	
	Total	100.0	37.5	62.5	100.0	100.0	
11	Feed	100.0	35.0	65.0	100.0	100.0	Feed pressure 14.7 psi
	Overflow	36.7	68.1	31.9	71.4	18.0	
	Underflow	63.3	15.8	84.2	28.6	82.0	
	Total	100.0	35.0	65.0	100.0	100.0	
11	Feed	100.0	36.2	63.8	100.0	100.0	Feed pressure 23.0 psi
	Overflow	36.7	75.1	24.9	76.2	14.3	
	Underflow	63.3	13.6	86.4	23.8	85.7	
	Total	100.0	36.2	63.8	100.0	100.0	

Therefore, the amount of plus 10-micron particles lost to the overflow is reduced from 32.6 per cent in the 15-minute grind to 18 per cent in the 11-minute grind.

Further reduction in loss of plus 10-micron particles was achieved by increasing the cyclone feed pressure to 23 psi; at this pressure, 14.3 per cent by weight of the plus 10-micron particles was lost.

Although the foregoing discussion pertains to recovery or distribution of the plus 10-micron particles, it is equally important to know how effective was the rejection of the potential dust, or minus 10-micron particles. Table 3 shows that the highest rejection of minus 10-micron particles to the cyclone overflow was obtained from the cycloning of an 11-minute pebble-mill-ground product at 23-psi cyclone feed pressure. The cyclone overflow contained 76.2 per cent of all the minus 10-micron particles contained in the cyclone feed. Although 23.8 per cent of all the minus 10-micron particles were in the cyclone underflow, this was offset by the high recovery of the plus 10-micron particles. As a result, the cyclone underflow representing 63.3 per cent of the feed weight contained only 13.6 per cent of minus 10-micron particles.

The summary of this work is:

- (1) Classification for 10-micron-particle separation was more effective on the shorter grind, that is, 11 minutes.
- (2) Classification for 10-micron-particle separation was more efficient when the feed pressure was increased from 14.7 to 23.0 psi. This is true for both the best recovery of plus 10-micron particles and highest rejection of the minus 10-micron particles.

Although the data indicate that cyclone feed pressures in excess of 23 psi might result in still higher efficiencies of separation, it is probable that with higher pressures the weight per cent of the overflow product may increase.

Another point worthy of mention is that 14.3 per cent of the original plus 10-micron particles are lost to the cyclone overflow. If this cyclone overflow were to be treated in a second stage of cyclones, some of the plus 10-micron fraction would be recoverable. The amount recoverable, without including an undesirable amount of minus 10-micron-particle weight, probably would not exceed 85.7 per cent of 14.3 per cent, or 12.3 per cent. It certainly should not be less than 6 per cent. Assuming that 60 per cent of the flotation feed weight is recovered, the potential over-all increase is from about 4 to 7 per cent of the original weight of the talc.

B A T T E L L E M E M O R I A L I N S T I T U T E

Flotation

Microscope examination of the ROM head sample revealed that the ore was mineralogically the same as Italian No. 2 talc. Because of the similarity of the two samples, it was believed that the beneficiation procedures of classification at about 10 microns followed by flotation of the plus 10-micron product (cyclone underflow) would be effective when the same flotation conditions were applied.

Generally, the flotation conditions that had given good results with Italian No. 2 talc were pulp densities in the range of 5 to 10 per cent solids, and hydrochloric acid and Dowfroth 200 or 250 as reagents. Hydrochloric acid was used both to neutralize the slurry and as an aid in the depression of fine-size particles. Dowfroth 200 or 250 was selected as the talc frother-collector because it is totally water soluble, requires a minimum of conditioning time, and has no collecting properties for other than the natural-floating-type minerals. Some of the advantages of the Dowfroths are that they do not leave any residual odor or discoloration on dried mineral products, nor do they chemically attack metal or rubber to any significant degree.

Experiments were made on the talc wet-ground through 100 mesh and wet- and dry-ground through 200-mesh. The ground products were cycloned, and the cyclone underflow constituted the flotation feed.

Flotation of Wet-Ground Minus 100-Mesh ROM Talc

The first flotation experiment on ROM talc was made on a sample that had been wet ground through 100 mesh and cyclone classified for removal of fines.

The 100-mesh grind, as a possible maximum size limit, was made for the following reasons:

- (1) Coarse platelets probably would exhibit a higher luster than fine platelets.
- (2) A 100-mesh grind is substantially less expensive than a finer grind.
- (3) A 100-mesh grind produces less fines to be rejected than a finer grind, and consequently the over-all yield or recovery would be greater.
- (4) It was desirable to know whether the froth product from a 100-mesh grind would be gritty, even though platy in structure.

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TABLE 4. FLOTATION RESULTS OBTAINED FROM ROM TALC WET-GROUND THROUGH 100 MESH

Product	Weight Per Cent	Mineral Count, per cent				Reagents Added, lb/ton. of flotation feed		Feed, per cent solids
		Platy	Nonplaty	Dolomite	Tremolite	HCl	Dowfroth 200	
<u>Test 88</u>								
Float-1	66.1	96	3	<1	<1	1.42	0.05	9.3
Float-2	22.9	95	4	<1	<1	0	0.21	--
Underflow	11.0	55	26	16	3	--	--	--
Total	100.0	91	6	2-3	1-2	1.42	0.26	--
<u>Test 89</u>								
Float-1	60.2	97	2	<1	<1	0.0	0.05	10.0
Float-2	20.5	Not evaluated				0.0	0.21	--
Underflow	19.3	Not evaluated				--	--	--
Total	100.0					0.0	0.26	--

Note: Flotation feed was cyclone underflow, which represented 83.0 per cent of the weight of the original ground sample.

Tests 88 and 89 were duplicates, except that hydrochloric acid was used in Test 88 and no acid was used in Test 89. Table 4 shows the experimental conditions and the results.

The results given in Table 4 are not particularly encouraging, because neither experiment yielded a Float-1 product containing more than 97 per cent platy talc. The Float-1 product of Test 88 contained 96 per cent platy talc and Float-1 of Test 89 contained 97 per cent platy talc. The difference between 96 and 97 per cent is not considered significant, and the two tests can be considered to yield the same quality of Float-1 product. However, there was a marked difference in the amount of weight recovered in the Float-1 products. In Test 88, 1.42 pounds of HCl per ton were used, and the Float-1 product represented 66.1 per cent of the flotation feed weight. When no acid was used, as in Test 89, the weight per cent of Float-1 was 60.2 per cent. Prior experience with Italian No. 2 talc implied that the reverse condition would result. That is, higher recoveries usually result when no acid is used, although the platy content might decrease slightly. It would not be safe to call these tests conclusive as long as this anomaly is not confirmed.

Both Float-1 products had a high luster but felt gritty.

The Float-1 product of Test 88 was screened on 150- and 200-mesh Tyler sieves, and the separated fractions were examined by microscope. The results are given in Table 5.

TABLE 5. PROPERTIES OF FLOAT-1 PRODUCT FROM MINUS 100-MESH WET-GROUND TALC

Size, Tyler Mesh	Weight Per Cent	Platy Talc, per cent	Remarks
-100+150	10.1	99	High luster, gritty
-150+200	23.1	98-99	High luster, gritty
-200	66.8	95	High luster, good slip
Total	100.0	96	High luster, gritty

Table 5 shows that the plus 200-mesh particles were 98 to 99 per cent platy talc, whereas the minus 200-mesh particles were only 95 per cent platy talc. Although the plus 200-mesh talc was of high purity, the thickness of the platelets produced a gritty texture. The minus 200-mesh portion, though only 95 per cent platy talc, had both a high luster and a good slip.

It is probable that the platy content of the Float-1 products from a 100-mesh grind could be improved, but, because of the objectionable gritty nature of the powder, it was decided to investigate the results obtainable from the conventional 200-mesh grind.

Flotation of Dry-Ground Minus 200-Mesh ROM Talc

Experiments were made on ROM talc that had been wet-ground and dry-ground through 200 mesh in a pebble mill. The ground products were cycloned for removal of the extreme fines, and the cyclone-underflow products were floated in the usual manner.

Three experiments were made on dry-ground talc and the results are given in Table 6.

The results given in Table 6 show that 97 per cent platy talc was obtained in the Float-1 product of each test. Tests 131 and 132 were made in an identical manner and, although the Float-1 products both contained 97 per cent platy talc, there was a noticeable difference in the weights recovered. Test 131, Float-1, contained 68.7 per cent of the flotation feed weight, but Test 132, Float-1, contained only 63.5 per cent of the flotation feed weight. There is no obvious explanation for this difference in weight recoveries. It is noticed, however, that the weight recovered in the Float-1 combined with the Float-2 is about the same, 91 to 92 per cent, in each of the three tests.

When the Float-1 products were examined under the microscope, it was found that some of the platelet surfaces were pitted. The amount of pitted platelets reporting to the Float-1 product was about 2 per cent, or 95 per cent normal platelets plus 2 per cent pitted platelets. This pitting or pockmarking was not noticed again either in the Italian No. 2 talc or in the subsequent ROM wet-pebble-milled flotation products, and apparently is a characteristic of dry-pebble milling.

Flotation of Wet-Ground Minus 200-Mesh ROM Talc

Flotation tests were made on wet-ground products, after cycloning for rejection of fines, to investigate the effect of acid strength and frother types on the Float-1 products.

Effect of HCL on Recovery and Quality. The effect of HCL on the flotation of Italian No. 2 talc was discussed briefly in the First Progress Report and in some detail in the Second Progress Report on "The Physical Concentration of Talc Ores". In the Second Progress Report, of July 31, 1959, it was stated in the "Summary" that, "Hydrochloric acid added in the

TABLE 6. RESULTS OBTAINED FROM FLOTATION OF DRY-GROUND, WET-CYCLONED ITALIAN ROM TALC

Product	Weight ^(a) Per Cent	Mineral Count, per cent				Reagents Added, lb/ton of flotation feed			Pulp,	
		Platy	Nonplaty	Dolomite	Tremolite	HCl	Dowfroth 200	Dowfroth 250	pH	Per Cent Solids
<u>Test 103(b)</u>										
Float-1	63.3	97	<2	<1	1	0.00	0.07	0.00	8.6(c)	4.8
Float-2	27.7	Not evaluated				0.00	0.28	0.00		
Underflow	9.0	Not evaluated				--	--	--		
Total	100.0					0.00	0.35	0.00		
<u>Test 131(d)</u>										
Float-1	68.7	97	1	0.8	1	1.54	0.00	0.06	6.9(e)	9.7
Float-2	23.3	Not evaluated				0.00	0.00	0.23	6.9	
Underflow	8.0	Not evaluated				--	--	--		
Total	100.0					1.54	0.00	0.29		
<u>Test 132(d)</u>										
Float-1	63.5	97	1	0.7	1	1.57	0.00	0.06	7.0(e)	8.9
Float-2	28.2	Not evaluated				0.00	0.00	0.25	7.0	
Underflow	8.3	Not evaluated				--	--	--		
Total	100.0					1.57	0.00	0.31		

(a) Weight per cent refers to per cent of flotation feed.

(b) Flotation feed was treated in a 8.50-liter-capacity (nominal) Deco flotation cell. Tests 131 and 132 were made in a 1.75-liter-capacity (nominal) Fagergren flotation feed.

(c) Distilled water was used to form the talc slurry.

(d) Tests 131 and 132 were intended to be duplicate tests.

(e) Deionized water was used to form the talc slurry.

correct quantity, between 1.13 and 2.30 pounds per ton of feed solids, was effective in maintaining the purity of finished talc at 97 to 98 per cent platy particles. This amount of acid created a pulp pH ranging between 6.9 and 7.8 during flotation." It was stated elsewhere in the report that the addition of HCl in amounts up to 2.30 pounds per ton of feed solids would appear to be justified only if it were effective in inhibiting the inclusion of fine talc and aiding in froth control.

Tests 121, 122, 123, and 124 were made to compare the results obtained when acid was used and when it was omitted. Dowfroth 200 was used as the collector-frother in each test. The results given in Table 7 show that, when HCl was used in the amount of 2.05 to 2.34 pounds per ton of flotation feed, the Float-1 product was 99 per cent platy talc. The amount of weight recovered in Float-1 was higher when acid was used than when it was omitted, although the weight recovered decreased when the strength of the acid was increased from 2.05 to 2.34 pounds per ton.

The data given in Table 7 are not fully consistent. In Tests 122 and 124, when no acid was used, the Float-1 products were 97 and 99 per cent platy talc, respectively, and a weight recovery of about 55 per cent of the flotation feed was obtained in each product. If the difference in quality is important, more experiments would be necessary to establish the cause of the difference in platy talc content.

In Test 121, 63.8 per cent of the flotation feed weight was recovered in Float-1 and the product was 99 per cent platy talc. The pH during flotation varied between 6.4 and 6.6. A size distribution, by sedimentation, showed that 19.7 per cent of the Float-1 product was finer than 10 microns. This could mean that the flotation feed had been incompletely classified (the original ore being overground) and that the amount of HCl added had not been highly effective for additional rejection of fine particles during flotation.

Effect of Type of Frother on Recovery and Quality. Two different frothers were investigated to determine the effect on the recovery and quality of the Float-1 products. These frothers were Dowfroth 200 and Dowfroth 250. Both of these frothers are 100 per cent water soluble, although Dowfroth 250 is classed as the stronger of the two. The manufacturer, Dow Chemical Company, Midland, Michigan, claims that less Dowfroth 250 is needed to accomplish the same effect as a larger amount of Dowfroth 200.

The results of experiments that illustrate the influence of the type of frother on flotation results are given in Table 8.

Data given in Table 8 show that, under certain operating conditions, Dowfroth 250 was a stronger frother-collector than Dowfroth 200.

TABLE 7. EFFECT OF HCl ON FLOTATION RESULTS

Product	Weight(a) Per Cent	Mineral Count, per cent				Reagents Added, lb/ton of flotation feed		Pulp Per Cent	
		Platy	Nonplaty	Dolomite	Tremolite	HCl	Dowfroth 200	pH	Solids
<u>Test 121</u>									
Float-1(b)	63.8	99	<1	<1	<1	2.05	0.08	6.4	6.9
Float-2	19.1	95				0.00	0.31	6.6	
Underflow	17.1					--	--		
Total	100.0					2.05	0.39		
<u>Test 122</u>									
Float-1	55.6	97	1	1	<1	0.00	0.08	7.8	6.2
Float-2	27.5					0.00	0.34	6.9	
Underflow	16.9					--	--		
Total	100.0					0.00	0.42		
<u>Test 123</u>									
Float-1(b)	57.5	99	<1	0.4	<1	2.34	0.09	6.7	6.1
Float-2	24.3					0.00	0.35	6.9	
Underflow	18.2					--	--		
Total	100.0					2.34	0.44		
<u>Test 124</u>									
Float-1	55.5	99	<1	0.5	<1	0.00	0.09	8.1	5.9
Float-2	25.4					0.00	0.37	7.0	
Underflow	19.1					--	--		
Total	100.0					0.00	0.46		

(a) Weight per cent refers to per cent of flotation feed.

(b) The Float-1 products of Tests 121 and 123 were given to W. H. Ashton, of Johnson and Johnson, and were considered representative of what may be expected from a pilot-plant operation. These products, although containing an excess amount of minus 10-micron particles, were of interest principally because of their high luster.

TABLE 8. EFFECT OF TYPE OF FROTHER ON FLOTATION RESULTS

Product	Weight(a) Per Cent	Mineral Count, per cent				Reagents Added, lb/ton of flotation feed			Pulp Per Cent	
		Platy	Nonplaty	Dolomite	Tremolite	HCl	Dow 200	Dow 250	pH	Solids
Test 121 Float-1	63.8	99	<1	<1	<1	2.05	0.08	0.00	6.4	6.9
Test 125 Float-1	64.1	98	<1	0.3	1	2.06	0.00	0.08	6.5	6.9
Test 122 Float-1	55.6	97	1	1	<1	0.00	0.08	0.00	7.8	6.2
Test 126 Float-1	66.0	96	1	0.3	2	0.00	0.00	0.08	7.7	6.8
Test 157 Float-1	51.8	97	2	0.3	<1	2.45	0.11	0.00	5.8	5.3
Test 158 Float-1	56.3	97	2	0.3	<1	2.40	0.00	0.11	5.6	5.4
Tests 147-148 Float-1	62.1	97	2	<1	<1	1.66	0.00	0.06	6.4	7.9
Test 142 Float-1	55.9	96	<3	0.2	<1	2.72	0.00	0.09	5.4	6.3

(a) Weight per cent refers to per cent of flotation feed.

A comparison of Tests 121 and 125 shows that, when about 4 pounds of HCl and 0.08 pound of either frother per ton of flotation feed was used (creating a pH of 6.4 to 6.5), the amount of weight recovered in the Float-1 product was approximately 64 per cent. The quality of the floated products was essentially the same at 98 to 99 per cent platy talc particles.

These experiments were repeated without acid, but the amount of frother added was kept at 0.08 pound per ton of flotation feed, and are reported as Tests 122 and 126. When Dowfroth 200 was used, the weight recovered from the flotation feed was 55.6 per cent, compared with 66.0 per cent when the stronger Dowfroth 250 was used. The platy content of the float product, however, was only 96 per cent when Dowfroth 250 was used, compared with 97 per cent when Dowfroth 200 was used.

The weight recovery of 55.6 per cent in the Float-1 product of Test 122 appears too low and probably should not be considered as a firm figure without repeating the experiment.

Tests 142, 157, and 158 were made with increased amounts of acid and frother. The amount of frother was increased to obtain higher recovery and the amount of acid was increased to retard the flotation of undesirable minerals. The results show that, when the acid strength was in excess of 2.40 pounds per ton of feed, it had a definite tendency to decrease the weight recovered, even though the amount of frother-collector was increased from 0.08 to 0.11 pound per ton of flotation feed. In addition to this, the increased acid strength was not effective in improving the platy content beyond 97 per cent.

The conclusions from the experiments reported in Table 8 are:

- (1) Maximum grade and recovery are effected adversely if the flotation-pulp pH is less than 6.4, regardless of which frother is used.
- (2) Dowfroth 250 is a stronger frother-collector for platy talc than Dowfroth 200.
- (3) Better quality float products can be obtained with acid than without, providing the pH does not become less than 6.4.

All Float-1 products from ROM talc had a high luster; that is, the luster from these products was definitely of a higher order than was obtained from any float products from Italian No. 2 talc.

The deionized water used in all flotation experiments from Test 121 through Test 158 had a resistance of 105,000 to 150,000 ohms per cubic centimeter.

The amount of time available did not permit an extensive evaluation of the physical properties of the flotation products, and for the most part the products were rated solely by a microscope mineral count and subjective measurements of luster and feel or slip. The flotation products obtained compared favorably with the Italian No. 2 flotation products with respect to platy talc and dolomite content, and therefore it was believed that the properties of lubricity and alkalinity (pH of moistened, beneficiated products) would be essentially the same for both the ROM and the Italian No. 2 talcs. Bulk density was spot-checked on various Float-1 products and found to be in the range of 23 to 25 pounds per cubic foot.

The amount of minus 10-micron particles contained in the Float-1 products was also spot-checked and found to be between 9 and 20 per cent. The appearance of any excess amount of minus 10-micron particles in the Float-1 products is attributed to overgrinding and incomplete cyclone classification, rather than to flotation. In fact, there is evidence that flotation is helpful in the rejection of minus 10-micron particles.

The weight recovery expected from a continuous operation can be estimated reasonably closely by using data available from Test 121 (see Table 7). In this test, the Float-1 product was 63.8 per cent of the flotation feed weight and the Float-2 product contained 19.1 per cent of the flotation feed weight. By returning the Float-2 product back to the new feed, it would be reasonable to expect that another 63.8 per cent of it would be recovered. Therefore, an estimated weight recovery from the flotation feed would show $63.8 + \frac{63.8 \times 19.1}{100} = 76$ per cent. These calculations do not include a potential additional recovery that may be expected from scavenging the flotation underflow. It would not be unreasonable to expect an additional 3 to 5 per cent recovery by the scavenging step, followed by returning the scavenger froth back to the new feed. On this basis the total projected recovery in a continuous operation would be 80 per cent of the weight of the flotation feed.

The over-all recovery of high-grade talc from the original ore is also related to the efficiency of the pebble milling and hydraulic cycloning. Ore preparation as followed in Test 121 shows that 48.5 per cent of the original weight was rejected in the cyclone overflow as approximately minus 10-micron particles. This amount, 48.5 per cent, is far too much weight loss and should not be considered realistic, because the talc was overground. Ore preparation as followed in Test 151 (see Appendix) showed that only 31.7 per cent of the weight was rejected as cyclone overflow. This amount is also believed to be greater than would be obtained

from a continuous pilot mill or commercial circuit; 30 per cent is a realistic amount for estimating purposes. Therefore, the over-all estimated weight recovery would be $\frac{70 \times 80}{100} = 56$ per cent of the weight of the original ore.

Not all of the flotation experiments on Italian ROM talc are discussed in the text of this report. A complete tabulation of the experiments, showing the pertinent data, is presented in the Appendix.

PROPOSED PILOT-PLANT FLOWSHEET

Figures 6 and 7 show the proposed flowsheets based on laboratory experiments for crushing, grinding, and beneficiation of Italian ROM talc.

The crushing circuit is to be operated intermittently, to replenish the storage bin, but the grinding circuit is a continuous operation, so that the beneficiation process will have uninterrupted feed. The objective of the flowsheet design shown in Figure 6 is to provide a flexible system for treating a variety of ROM talc ores (not specifically Italian). This circuit is expected to handle talc that may be received in pieces as large as 8- or 10-inch slabs, hammermill in one pass through 1/4 inch, wet grind, and classify at approximately 200 mesh. The minus 200-mesh pulp is expected to leave the circuit at 4 to 7 per cent solids, which is an ideal feed to the beneficiation circuit. It is expected that the amount of minus 10-micron talc produced can be held to a reasonable maximum by controlling the circulating load in the grinding circuit, grinding pulp density, pebble diameter, and total weight of charge, and, finally, by dilution of cyclone feed.

The flowsheet shown in Figure 7 is essentially the same as that developed for processing the Italian No. 2 talc*. Laboratory experiments showed that the same general results would be obtained from either ROM or Italian No. 2 talc. If the grinding circuit could be operated efficiently, a higher yield of beneficiated talc could be expected from the ROM talc than from the Italian No. 2 talc.

* Brown, W. E., "The Physical Concentration of Talc Ores - Flotation of Italian No. 2 Talc", Battelle Progress Report to Johnson and Johnson (July 31, 1959).

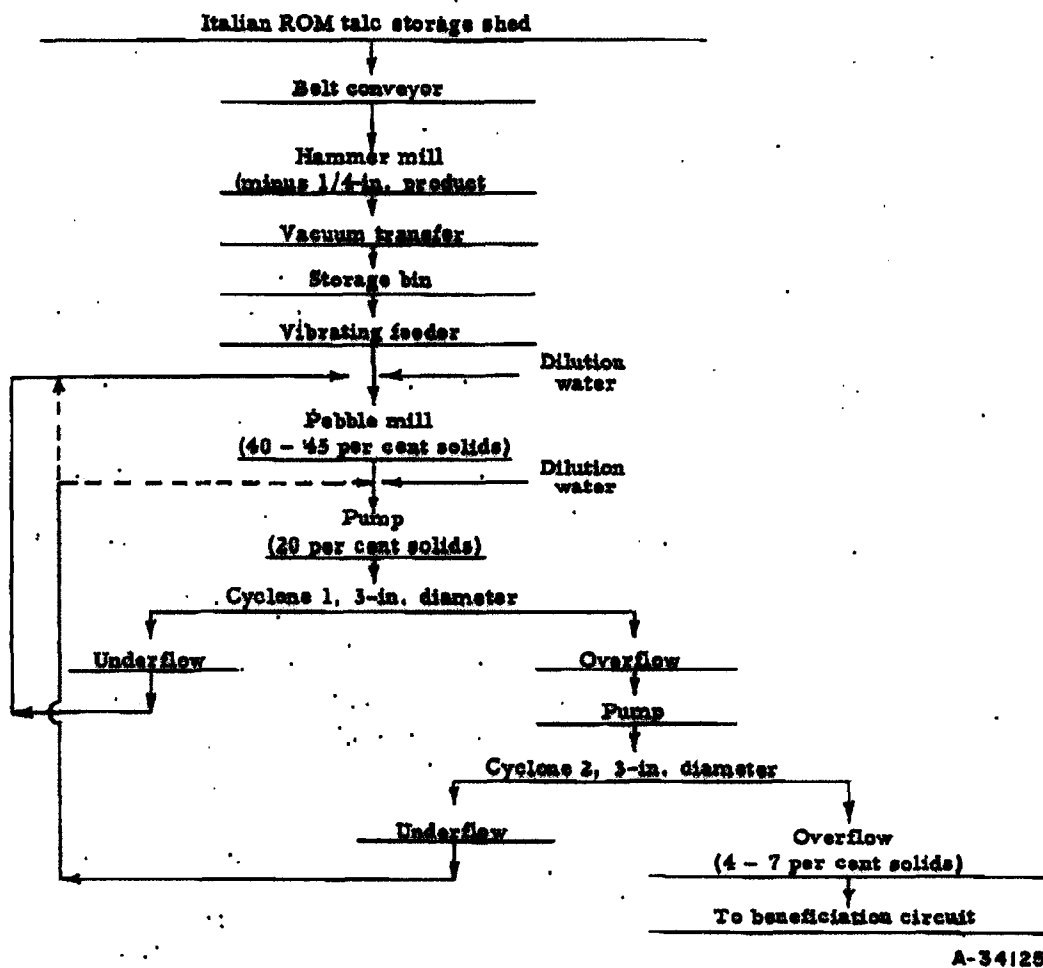


FIGURE 6. PROPOSED PILOT-PLANT FLOWSHEET -
CRUSHING AND GRINDING CIRCUIT

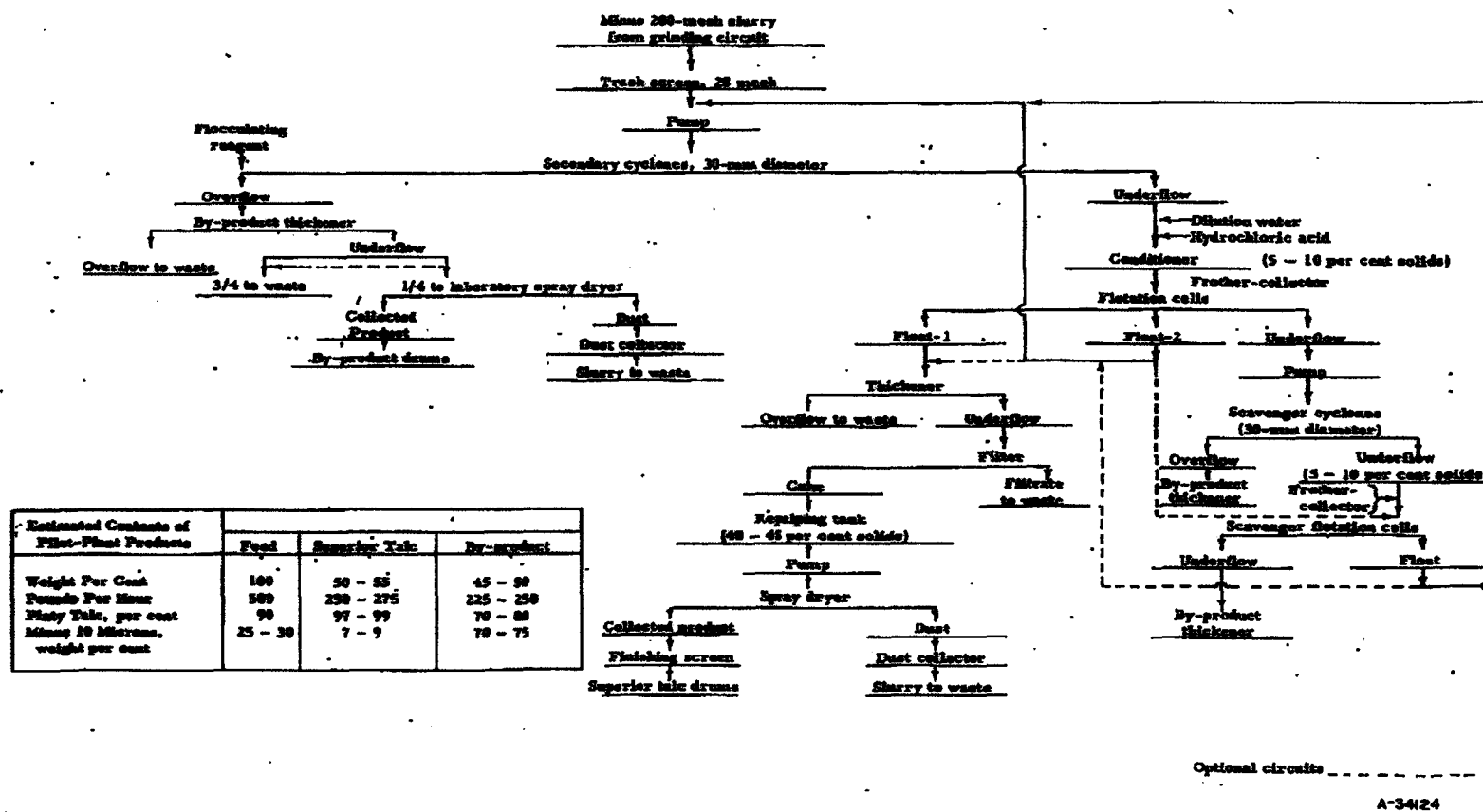


FIGURE 7. PROPOSED PILOT-PLANT FLOWSHEET - BENEFICIATION CIRCUIT

CONCLUSIONS

Data and observations obtained from the grinding, cycloning, and flotation experiments have established that:

- (1) Italian ROM talc can be beneficiated by the combined processes of crushing, grinding, classifying, and flotation. The finished beneficiated talc will have a high luster and will be 97 to 99 per cent platy talc. The yield expected in a continuous operation is 80 per cent of the flotation feed, or 56 per cent of the original ore.
- (2) Wet-pebble-mill grinding is more effective in obtaining 200-mesh grinds than dry-pebble-mill grinding, although less minus 10-micron talc is produced from dry grinding.
- (3) Wet-pebble-mill grinding yields a product that, after cycloning and floating, shows a marked improvement in luster compared with the products obtained from the beneficiation of Italian No. 2 talc.
- (4) ROM talc must be ground finer than 100 mesh, or the resulting flotation products will have a gritty texture.
- (5) The highest quality products were obtained when the flotation feed pulp was maintained at a pH of 6.4 or higher.
- (6) Water-soluble frothers, such as Dowfroth 200 or Dowfroth 250, are good promoters for the flotation of platy talc. There are indications that Dowfroth 250 is the stronger promoter of the two, but it may be slightly less selective.
- (7) The experimental results show that the processes of classification, flotation, and filtering as developed for Italian No. 2 talc can be adapted to Italian ROM talc. No change in equipment types or sizes should be necessary.

Table 9 shows the Johnson and Johnson specifications for Italian No. 1 talc and includes a comparison of these specifications with the beneficiated products from the Italian No. 2 and ROM talcs.

This table shows that the beneficiated products contain less than 0.75 per cent of dolomite and less than 1 to 3 per cent of nonplaty minerals. The bulk density of the beneficiated product was within the specification of 22 to 27 pounds per cubic foot.

B A T T E L L E ' M E M O R I A L I N S T I T U T E

TABLE 9. COMPARISON OF SPECIFICATIONS WITH THE BENEFICIATED PRODUCTS FROM ITALIAN NO. 2 AND ROM TALCS

Physical-Property Control	Specification	Italian No. 1, Johnson and Johnson Raw Material	Italian No. 2, Laboratory Beneficiated	Italian ROM, Laboratory Beneficiated
Moisture ^(a) , per cent	<0.15	0.05	<0.05	<0.05
Solubility in HCl, per cent	<6	2.1-2.8	<0.75 ^(b)	0.3-0.6 ^(b)
Fineness, per cent through 200 mesh	Not less than 98.5	99.8	99.5	98.5
Bulk density, lb/ft ³	Not less than 22 nor more than 27	23.0	28-29	23-25
Microscopic structure, per cent platy	Platelet showing no acicular or excessive granular crystals	88-90	97-99	97-99
pH (Alkalinity)	7.0-7.5	9.0-9.3	8.1-8.8	8.3-8.6

(a) Moisture content would be significant only from a continuous plant operation, because laboratory products can be dried to any desired moisture content.

(b) Solubility in HCl as reported here is expressed as dolomite content, which was determined from CO₂ assay.

TABLE 9. COMPARISON OF SPECIFICATIONS WITH THE BENEFICIATED PRODUCTS FROM ITALIAN NO. 2 AND ROM TALCS

Physical-Property Control	Specification	Italian No. 1, Johnson and Johnson Raw Material	Italian No. 2, Laboratory Beneficiated	Italian ROM, Laboratory Beneficiated
Moisture ^(a) , per cent	<0.15	0.05	<0.05	<0.05
Solubility in HCl, per cent	<6	2.1-2.8	<0.75 ^(b)	0.3-0.6 ^(b)
Fineness, per cent through 200 mesh	Not less than 98.5	99.8	99.5	98.5
Bulk density, lb/ft ³	Not less than 22 nor more than 27	23.0	28-29	23-25
Microscopic structure, per cent platy	Platelet showing no acicular or excessive granular crystals	88-90	97-99	97-99
pH (Alkalinity)	7.0-7.5	9.0-9.3	8.1-8.8	8.3-8.6

(a) Moisture content would be significant only from a continuous plant operation, because laboratory products can be dried to any desired moisture content.

(b) Solubility in HCl as reported here is expressed as dolomite content, which was determined from CO₂ assay.

FUTURE WORK

Since the completion of the experimental work included in this report, a new reagent combination, involving Aerosol, has been developed. The development has led to improved results and will be presented in a separate report.

An experimental program is now in progress to establish how much of the water used in beneficiation can be re-used without adverse results to the over-all process.

The original notes on the laboratory work described in this report are in Battelle Laboratory Record Books 14668, 15042, 15190, 15456, and 15662. The work was done in the period from July 24, 1958, to April 20, 1959.

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APPENDIX

SUMMARIZED RESULTS OF ALL FLOTATION TESTS MADE ON
ITALIAN ROM TALC

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Test	Preparation					Flotation										Reagents Added, lb/ton of flotation feed					Remarks
	Grind		Oxide			Product	Flotation		Mineral Content, per cent				Pulpity Value	PH of Feed	Per Cent Solids of Feed	HCl (%)					
	Initial Charge Weight, grams	Time Interval, Minutes	Feed, psi	Overflow, weight per cent	Underflow, weight per cent		Weight Per Cent of Flotation Feed	Weight Per Cent of Original Feed	Platy	Heavy	Dolomite	Tremolite				250	250				
88	430	15	14.7	17.0	83.0	Flint-1	66.1	54.9	96	3	<1	<1	Distilled	N.D.(*)	9.3	1.02	0.85	Wet-ground through 100 mesh			
						Flint-2	22.9	19.0	95	4	<1	<1	Distilled			0	0.21				
						Underflow	11.0	9.1	95	26	16	3	Distilled								
89	430	15	14.7	17.0	83.0	Flint-1	66.2	56.8	97	3	<1	<1	Distilled	N.D.(*)	18.0	0	0.25	Wet-ground through 100 mesh			
						Flint-2	26.5	17.0					Distilled			0	0.21				
90	510	60	14.7	25.3	73.1	Flint-1	63.5	46.4	99	<1	Trace	Trace	Distilled		4.3	0	0.07	Wet-ground through 250 mesh			
						Flint-2	16.1	11.8	97	3	Trace	Trace	Distilled			0	0.26				
						Flint-3	14.7	10.7	95	4	<1	<1	Distilled			0	0.65				
91	510	60	14.7	25.9	73.1	Coarser Flint	48.8	35.7	99	<1	<1	<1	Distilled		4.0	0	0.57				
						Flint-2	32.0	23.4	96	3	<1	<1	Distilled			0	0.32				
						Coarser IF Flow	10.8	7.9													
						Underflow	8.4	6.1													
92						Discarded because of contamination.															
93						Discarded because of contamination. Products used for flotation experiments.															
94	510	60	14.7	29.7	70.3	Flint-1	67.3	47.3	94	1	0.4	<1	Distilled	6.9	1.5	0	0.13	Produced for Johnson and Johnson examination			
						Flint-2	22.7	16.0					Distilled			0	0.39				
102	580	60	14.7	Not determined		Flint-1	68.3		97	<2	<1	1	Distilled	8.6	4.8	0	0.97	Dry-ground through 250 mesh			
						Flint-2	27.7						Distilled			0	0.38				
104						Discarded. Results erratic because of overlapping.															
121	120	15	14.7	40.5	51.5	Flint-1	63.0	32.9	99	<1	<1	<1	Distilled	6.4	6.9	2.05	0.08	Flint-1, 89.7 per cent was above 20 microns			
						Flint-2	19.1	1.0	95				Distilled	6.6		0	0.31	Flint-2, 13.1 per cent was above 20 microns			
122	120	15	14.7	40.5	51.5	Flint-1	53.8	28.6	97	1	1	<1	Distilled	7.8	6.2	0	0.08				
						Flint-2	27.6	14.2					Distilled	6.9		0	0.34				
123	120	15	14.7	30.7	49.3	Flint-1	57.5	20.3	99	<1	0.4	<1	Distilled	6.7	6.1	2.34	0.09				
						Flint-2	24.3	12.0					Distilled	6.9		0	0.25				
124	120	15	14.7	30.7	49.3	Flint-1	55.5	27.4	99	<1	0.5	<1	Distilled	8.1	5.9	0	0.08				
						Flint-2	25.4	12.5					Distilled	7.0		0	0.37				
125	120	15	23.8	46.6	53.2	Flint-1	64.1	34.1	99	<1	0.3	1	Distilled	6.5	6.9	2.06	0.08	First test with Dowditch 250			
						Flint-2	23.4	12.4					Distilled	6.5		0	0.22				
126	120	15	23.8	46.8	53.2	Flint-1	66.0	36.1	96	1	0.3	2	Distilled	7.7	6.8	0	0.08				
						Flint-2	21.1	11.2					Distilled	6.8		0	0.33				
129	240	11	23.8	34.7	65.3	Flint-1	65.6	42.8	97	2	0.3	<1	Distilled	6.1	7.5	1.80	0.08	First test with fresh Dowditch 250			
						Flint-2	21.2	13.6					Distilled	6.6		0	0.30				
130	240	11	23.8	34.7	65.3	Flint-1	64.0	41.0	97	2	0.3	<1	Distilled	5.9	7.3	1.94	0.08				
						Flint-2	24.0	15.7					Distilled	6.5		0	0.31				
131	120	15	23.8	25.2	74.8	Flint-1	60.7	51.4	97	1	0.6	1	Distilled	6.9	5.7	1.54	0.06	Dry-ground through 250 mesh			
						Flint-2	22.3	17.4					Distilled	6.9		0	0.23				
132	120	15	23.8	25.2	74.8	Flint-1	63.5	47.5	97	1	0.7	<1	Distilled	7.0	4.8	1.57	0.06	Dry-ground through 250 mesh			
						Flint-2	20.2	11.1					Distilled	7.0		0	0.25				
141	200	11	14.7	36.7	63.3	Flint-1	56.5	35.8	97	<3	0.2	<1	Distilled	5.7	6.7	2.59	0.08				
						Flint-2	27.7	12.5					Distilled	6.4		0	0.34				
142	200	11	14.7	36.7	63.3	Flint-1	55.9	35.4	96	<3	0.2	<1	Distilled	5.4	6.3	2.72	0.08				
						Flint-2	26.9	17.0					Distilled	6.2		0	0.36				
147, 148	200	11	23.8	35.7	64.3	Flint-1	62.1	39.9	97	2	<1	<1	Distilled	6.4	7.9	1.66	0.06				
						Flint-2	23.3	15.0					Distilled	6.3		0	0.27				
151	200	11	23.8	31.7	68.3	Flint-1	54.0	37.4	96	2	<1	1	Distilled	5.9	6.3	2.05	0.05				
						Flint-2	32.9	27.5					Distilled	6.1		0	0.41				
152	200	11	23.8	31.7	68.3	Flint-1	47.8	32.6	97	2	<1	<1	Distilled	6.5	6.3	0	0.05				
						Flint-2	36.8	23.9					Distilled	6.9		0	0.41				
157	200	11	23.8	40.7	59.3	Flint-1	51.8	30.7	97	2	0.3	<1	Distilled	5.8	5.3	1.65	0.11				
						Flint-2	25.5	15.1					Distilled	6.4		0	0.46				
158	240	11	23.8	40.7	59.3	Flint-1	56.3	30.4	99	2	0.3	<1	Distilled	5.6	5.4	2.00	0.11				
						Flint-2	27.0	16.5					Distilled	6.2		0	0.42	4/20/59			

(4) HCl is reported in terms of 36.5 to 38 per cent HCl having a specific gravity of 1.185 to 1.192 at 60 F.

(5) N.D. = not determined.

Note: That all Flint-2 products were examined for mineral distribution. Ordinarily, in a continuous operation, these products would show about 93 to 95 per cent platy talc and would be returned to the flotation circuit for further cleaning.

A-1 and A-2