THE Patterson

Monograph Series

PUBLISHED AS A CONTRIBUTION TO TECHNOLOGICAL PROGRESS IN THE INDUSTRIES WE SERVE

A GENERAL CONSIDERATION OF PAINT PASTE FORMULATION

- *Vehicle Solids and Solvents*
- *Grinding Consistency*
- *Paste Volume*

ADVANCED PROCESS EQUIPMENT of *Enduring Satisfaction*

THE *Patterson* FOUNDRY AND MACHINE COMPANY
A Division of Ferro Corporation
East Liverpool, Ohio

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The Monograph Series is issued as a service to the users of Patterson Ball and Pebble Mills. This publication, the first of a series, deals with formulation and wet grinding techniques.

THE *Patterson* FOUNDRY AND MACHINE COMPANY
EAST LIVERPOOL, OHIO, U.S.A.

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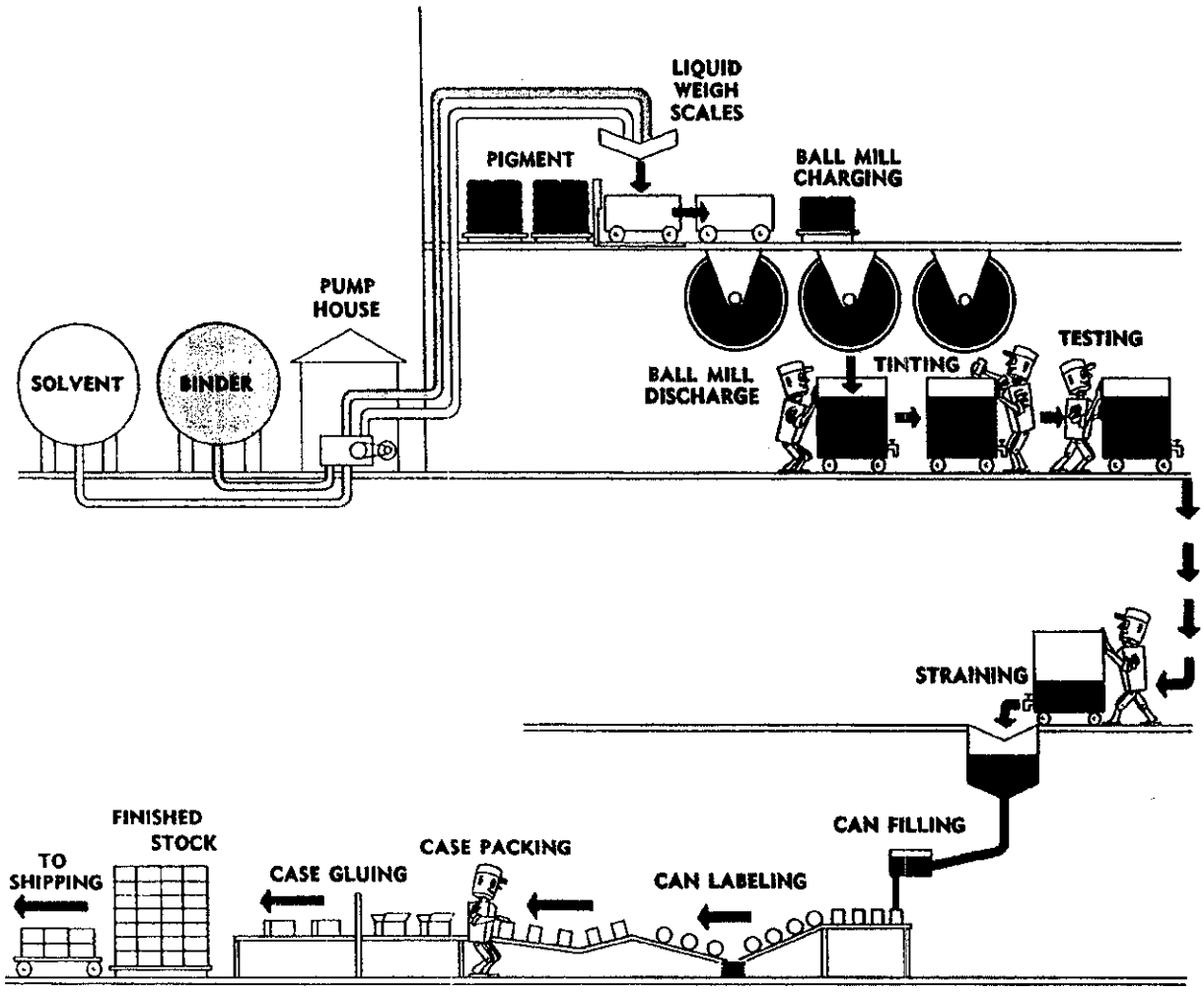

A TYPICAL PAINT PLANT FLOW SHEET

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FORMULATION FOR BALL AND PEBBLE MILLS

PAINT MANUFACTURE requires that a pigment be distributed in a vehicle. Making a quality paint with color stability requires the pigment to be of small particle size and uniformly dispersed so as to remain distributed. The ball or pebble mill is an efficient machine for grinding and dispersing pigments if operated with optimum formulation. Because of the ease of operation they are widely used for producing paint. Fig. 1 illustrates the simplicity of ball mill operation.

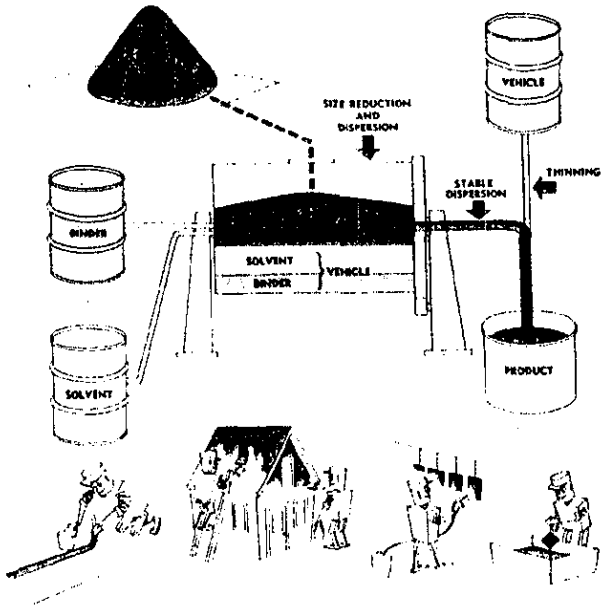


FIG. 1—BALL MILL CONCEPT

Steel ball mills and ceramic lined mills both require a minimum of attention to produce a superior product. *It is possible that the simplicity of operation* has often led mill users to expect results which could not be obtained without proper consideration of formulations.

Successful grinding of paint pigments has often been considered as simple an operation as loading the ingredients into the mill, rotating the mill, and unloading the finished product. This is accurate enough without considering quality and production costs—but today's conditions require production at highest quality with least possible cost.

It is the purpose of this monograph to highlight and consider control of several factors that will accomplish desirable cost reductions:

A SHORTER TIME FOR DISPERSION
A LARGER BATCH OF UNIFORMLY DISPERSED PIGMENT
LESS GRINDING MEDIA WEAR
(a) Less *contamination* of product
(b) More brilliant colors
GREATER UNIFORMITY OF PRODUCT

We will be here concerned with an absolute maximum performance from any mill. If practical considerations influence operation of the mill at less than maximum production, it is still necessary to recognize the ultimate to make an accurate comparison.

Maximum performance requires a matching of:



I. FORMULATION
A General Consideration Of Paint Paste Formulation

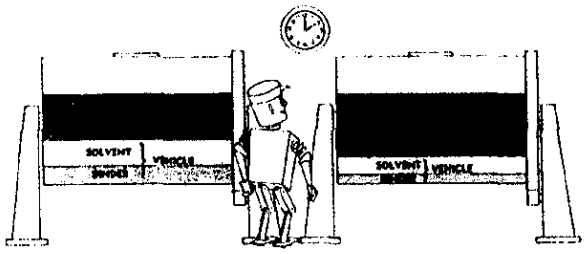
II. MILL LOADING
Optimum Point Paste Charges For Ball Mills

III. GRINDING MEDIA SIZE
Grinding Media Size, Shape And Material

IV. MILL SPEED
Ball Mill Speeds For Maximum Production

This monograph will deal with a general consideration of formulation only. The remaining factors will be covered in later monographs.

Is there an **optimum** paint paste formulation for a ball mill? Is there one paste composition that will insure a ball mill producing more finished paint of a given quality per unit of time than any other. Yes—and this is true of any paint. The mills shown in Fig. 2 are of the same size, yet one produces more paint because of proper formulation.



WHICH MILL LOADING PRODUCES:

★ MORE PASTE?
★ IN A SHORTER TIME?
★ WITH BETTER QUALITY?

TO YIELD MORE PRODUCT AT LEAST COST

FIG. 2—EQUAL SIZE MILLS PRODUCING THE SAME PRODUCT

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FORMULATION FOR BALL AND PEBBLE MILLS

Before proceeding further, we should review the general basic considerations of dispersion, remembering that the **fundamental objective** is the coating of a pigment particle with resin. A study of the particle-resin interface, the peculiarities of precipitating the coating, and the particle size of the pigment are related to this, but the object is coating with resin a pigment particle of the proper size as shown in Fig. 3.

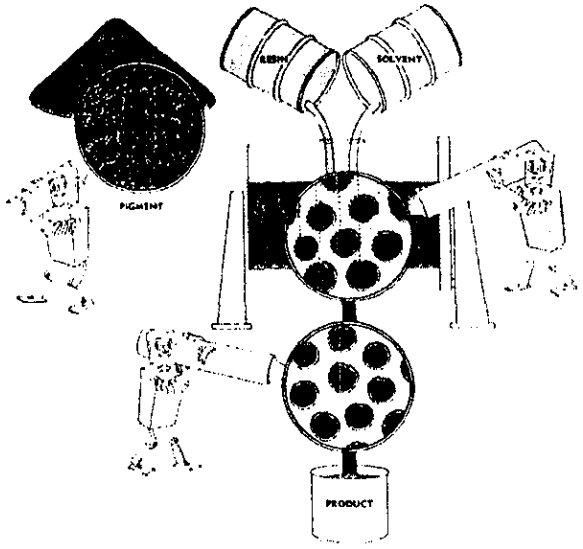

FIG. 3—BASICS OF DISPERSION

Since pigments are derived from two sources, Natural Earth Pigments and Chemical Pigments, the paint manufacturer has the choice of buying the particle size needed or making the particle size desired.

NATURAL EARTH PIGMENTS are mined from their natural deposits, crushed, and finely ground in ball and pebble mills. Suppliers can furnish almost any particle size desired but the smaller particle sizes are usually more expensive because of the additional size reduction cost.

CHEMICAL PIGMENTS having been produced by processes controlling the size would be expected to have the correct individual particle sizing. However, processes following the formation of the pigment—settling, filtering, and drying—tend to agglomerate the individual particles, making the actual pigment received of variable size.

These are the pigments we must use. If we purchase aggregates, they must reduce to individual particles. If we purchase particles larger than we wish, they must be reduced in size.

It is interesting to compare particle sizes with their resulting Hegeman gauge reading. Referring to Figure 8, it may be seen that a 6 reading on the Hegeman gauge specifies 400 mesh particle size to suit the 25.00 micron well depth on the gauge. Actually particles must be less than 8 microns to obtain a No. 6 reading because the particles stack on top of one another, and because allowance must be made for the resin coating on the particles as indicated in Figure 9.

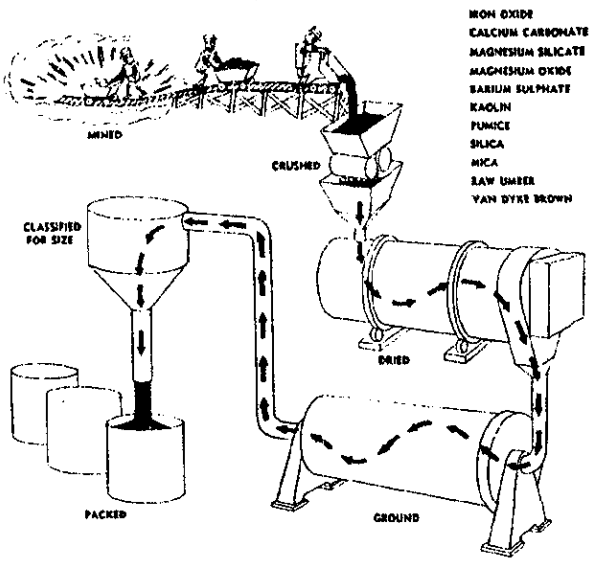

FIG. 4—PROCESSING NATURAL PIGMENTS

Let us now consider the **RESIN** we will precipitate on each pigment particle. It must come from the vehicle. For this reason the solvent used for the resin should be as lean as possible or the resin will prefer to remain in solution. Higher concentration of resins should also be easier to precipitate out of the resin, but this produces higher viscosity. High viscosity hinders dispersion because gases cannot be liberated from the pigment. The paste should be so formulated that the viscosity of the vehicle is not over 30 centipoise. This usually limits the resin or solids content of the vehicle to 15-18%.

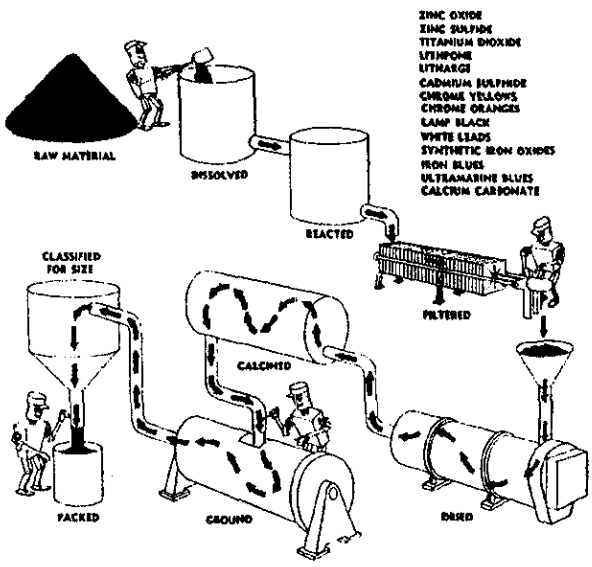

FIG. 5—PROCESSING CHEMICAL PIGMENTS

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FORMULATION FOR BALL AND PEBBLE MILLS

On the other hand, high pigment content is desirable, because the pigment restrains itself from free movement in the vehicle and permits better ball action. Shear forces, caused by the spinning action of the balls, will accomplish most of the dispersion if high pigment content is used. The pigment content should be sufficiently high that the Stormer Consistency will be between 125 and 135 KU when using 1¼ inch Arlcite balls.

Pigment and vehicle having been selected, both are loaded into the mill with solvent as indicated in Fig. 1. The ball mill will promote disintegration of the individual particles, dispersion of the particles in the vehicle, or both. Utilizing both under correct conditions to emphasize the work of the shear component of the moving grinding media will produce the maximum of paint of a higher quality.

The **SHEARING ACTION** in the mill becomes the dominant dispersing force when the pigment and inert concentration is high, and at the same time the viscosity of the grinding vehicle is low. When both of these conditions are fulfilled, the flocculates and particles rub against each other most effectively and frequently and thus cause wetting and dispersion (deflocculation) in the shortest possible time.

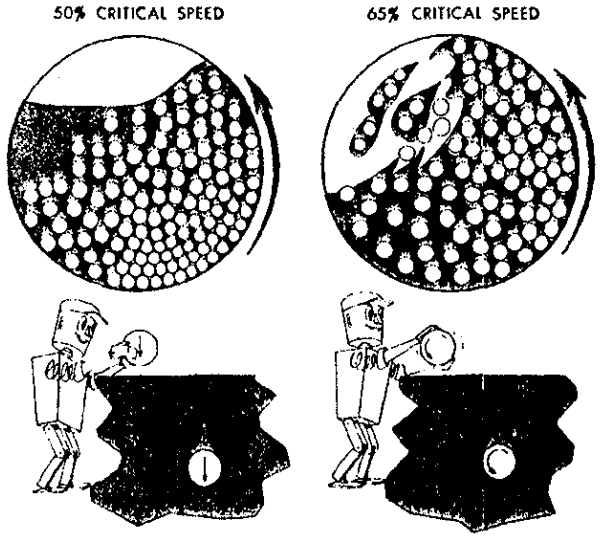

FIG. 6—SHEARING ACTION

Usually the pigments are put in the mill with only a portion of the vehicle called for by the finished formula, the balance being added subsequently in a separate operation. Therefore, a choice must be made of how much of each vehicle component, that is binder and solvent, and how much total vehicle, should be added to the pigment for the grinding operation.

Of all the pigment-binder-solvent combinations, there is one which produces more finished paint of a given quality per unit of time than any other combination. This must be true of any paint produced in any ball mill.

The limiting factor on **PIGMENT** concentration is the consistency of the mass as shown in Figure 7. It must not be so high that the motion of the grinding elements is unduly impeded or stopped altogether.

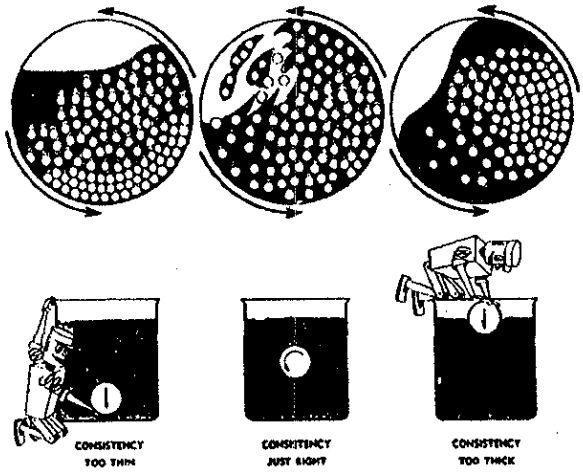

FIG. 7—PIGMENT CONCENTRATION

The ideal amount of **VEHICLE SOLIDS** in solution should be as low as possible and yet obtain deflocculation of the pigment. The presence of more fixed vehicle than that needed for its dispersing function merely lowers the maximum pigment concentration and increases the grinding time due to increased vehicle viscosity.

The **SOLVENT** present in the paste must be a maximum amount consistent with obtaining a stable deflocculation. To precipitate the resin on the surface of the pigment also means displacing the gases originally on the surface (see Fig. 3). The gases can be most readily removed by having the liquid of as low a viscosity as possible. This would ideally be the viscosity of the solvent (about one centipoise).



PARTICLE SIZE APPROX. MESH	DEPTH OF WELLS ON GAUGE MILS	MICRONS	HEGMAN (NORTH STD.) SCALE READING	PRODUCTION CLUB SCALE READING
140	4.00	100.00	0	0.00
—	3.50	87.50	1	1.25
200	3.00	75.00	2	2.50
--	2.50	62.50	3	3.75
325	2.00	50.00	4	5.00
—	1.50	37.50	5	6.25
400	1.00	25.00	6	7.50
—	0.50	12.00	7	8.75
—	0.25	6.25	7½	9.35
—	0.00	0.00	8	10.00

FIG. 8—FINENESS MEASUREMENTS

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FORMULATION FOR BALL AND PEBBLE MILLS

The solvents used in the system should have the lowest solvency for the resin and yet not form gels. In this way the resin content can be reduced to the point where the liquid viscosity is only 10-15 centipoise.

What is the highest pigment concentration obtainable for a given consistency? How can it be determined? Procedures have been worked out by several groups. A good procedure which was published in 1950 was developed by the National Paint, Varnish and Lacquer Association. Known as the Daniel Method, it is described in NPVLA Bulletins 744 and 745.

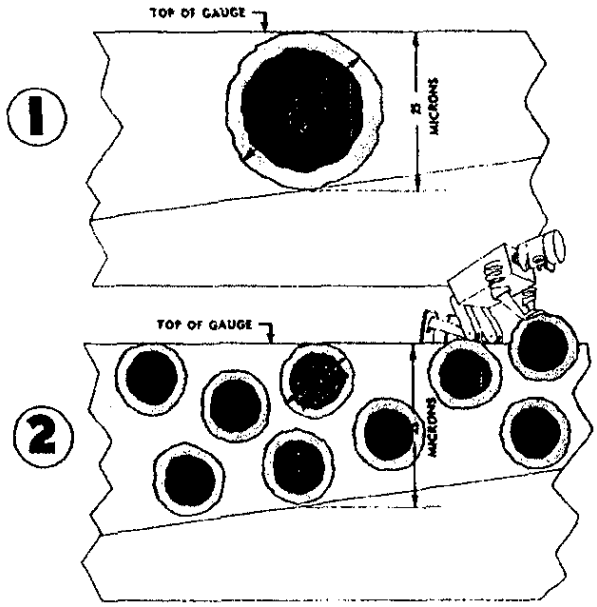

FIG. 9—FINENESS GAUGE DETAIL

This is a systematic method for determining the highest pigment concentration at which the material can move in the mill, so that we may take advantage of the shearing action which is the dominant dispersing force.

Let us first consider two pastes. Both have been made with the same amount of dry powder and just enough liquid to barely wet and make a stiff paste. The amount of liquid to make each paste varies only slightly (depending on the nature of the liquid).

THE FIRST PASTE is a deflocculated dispersed powder-liquid system as shown in Fig. 10. The transformation from the paste consistency to the condition which will let the system flow requires the addition of much liquid. The transformation is gradual. It is difficult to be sure at what point such a system can move in a mill. So much liquid need be added that the powder concentration (at flow consistency) becomes low.

THE SECOND PASTE has been prepared to represent a flocculated powder-liquid system (Fig. 11). A few percent additional liquid transforms the unworkable paste to a free flowing mass. Thus the powder concentration at the flow consistency differs only slightly from the powder concentration of the semi-rigid mass.

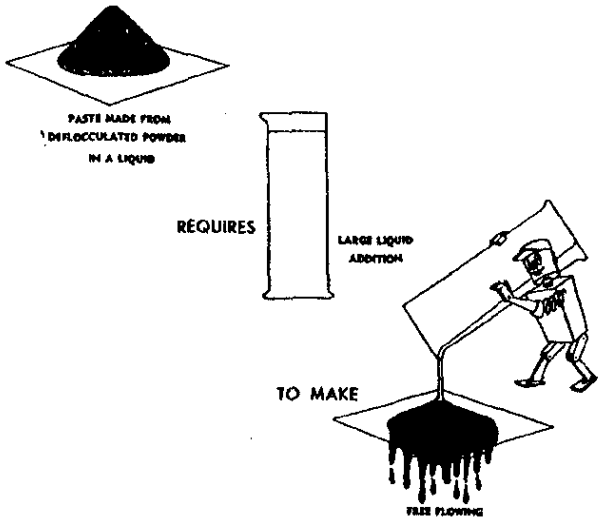

FIG. 10—DEFLOCCULATED PASTE

The factor which controls the flow of the powder-liquid system is primarily the state of flocculation or deflocculation of the particles in suspension. In a deflocculated system each particle is independent of all other particles present and the amount of liquid required to make the mixture flow is much higher than that required to just wet the powder.

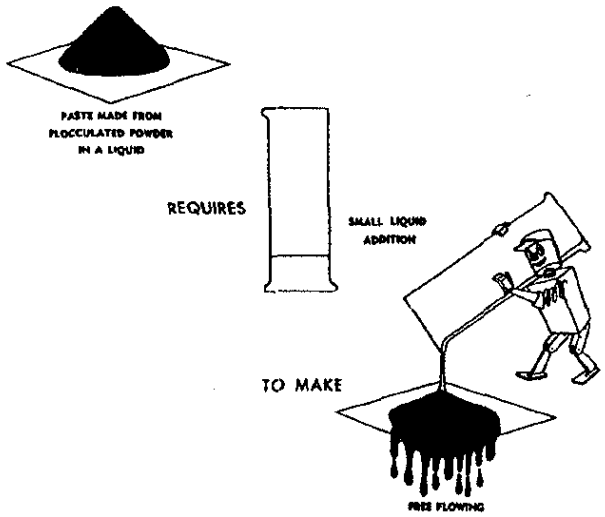

FIG. 11—FLOCCULATED PASTE

Fortunately many paints and especially enamels belong to the flocculated group, and therefore display a sharply definable, high pigment concentration at the transition point from semi-rigid to fluid. We can determine this transition point and call it the **FLOW POINT.** We will then know the maximum pigment concentration at which a simple system would be a workable paste.

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FORMULATION FOR BALL AND PEBBLE MILLS

Recalling that we are looking for maximum pigment concentration to make the shearing action work for us, it would appear that a pigment-solvent mixture would be ideal. The solvent is low in viscosity. The consistency of such a system could be built almost entirely with the pigment. However, the common solvents have no dispersing power for any of the common pigments, and therefore cannot be used as the sole vehicle. Pigments milled in solvents are quickly wetted but remain deflocculated. They cannot be uniformly distributed in the balance of the paint ingredients, and give dull finishes with brush marks.

The vehicles with dispersing power are oils, varnishes, and resins. They are usually quite viscous and have a high solid content. This then limits the pigment concentration for a prescribed consistency.

Mixtures of fixed vehicle and solvent permit a higher pigment concentration than either component alone and our problem is in determining the maximum percentage of pigment which may be incorporated in the vehicle mixture.

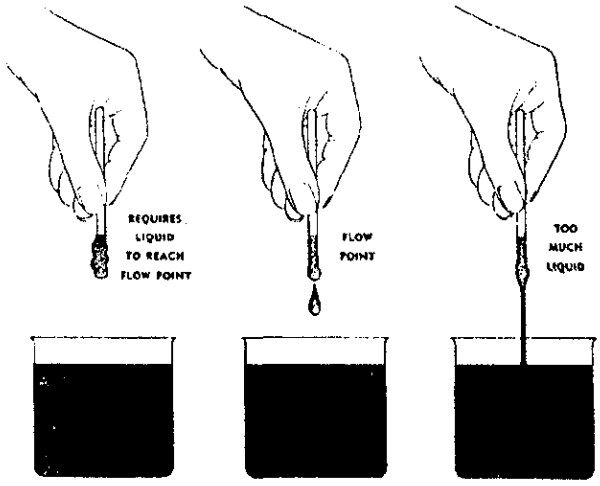

FIG. 12—FLOW POINT

We should regard the fixed solids in the vehicle merely as the dispersing agent for the pigment suspended in the solvent. We should use the least amount of fixed vehicle possible to just disperse the pigment and form the flocculates present in the system as shown in Fig. 13.

The presence of more fixed vehicle than needed for its dispersing function increases the grinding time because of increased vehicle viscosity and at the same time lowers the amount of pigment present in the system.

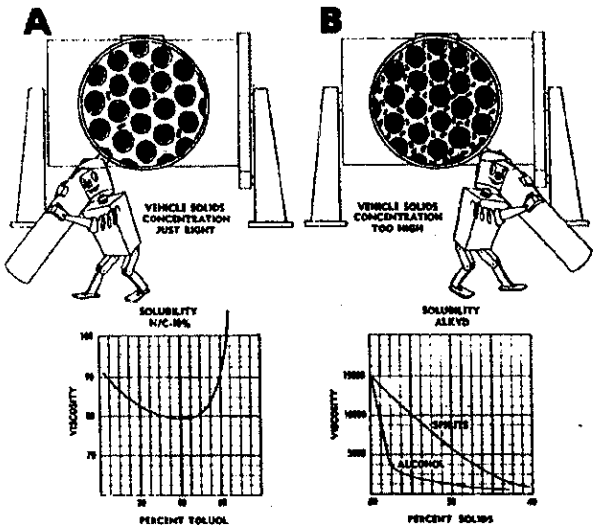

FIG. 13—VEHICLE LIMITATIONS

DETERMINING THE LEAST AMOUNT OF BINDER-SOLVENT SOLUTION TO REACH THE TRANSITION POINT (FLOW-POINT)

Prepare solutions of binder-solvent with different binder content from 5% to 40%. With experience it will be necessary to prepare only a few solutions between 10% and 25%. Lean solvents are used to dilute resin solutions, and no more than a light cloud formed in the lowest concentration. Then place a certain amount of pigment, in this case 20 grams, in a beaker and stir with each solution until the flow point is reached. The flow point is a distinctly recognizable consistency when only a thin even film remains on the rod and when the last few drops falling in one to two second intervals appear to break off the tip of the rod with an elastic snap back like a piece of rubber breaking under load as seen in Fig. 12.

Record the amount of solution needed to reach this flow point (FP) and repeat with solutions of different binder content.

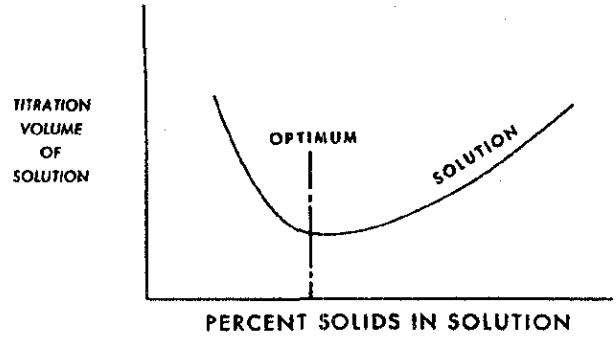

FIG. 14—FLOW POINT GRINDING COMPOSITION

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FORMULATION FOR BALL AND PEBBLE MILLS

In Fig. 14 the amount of solution is plotted as the ordinate against the concentration of the solution on the abscissa with the curve going through a minimum. Thus if the amount of solution is a minimum, the pigment is a maximum.

With a small amount of fixed vehicle and the remainder of the solution pure solvent the amount of solution needed to reach the flow point is reduced because the system is no longer completely flocculated. With more fixed vehicle, less solution is needed to reach the flow point because flocculation decreases even more.

When all the pigment is dispersed, the curve reaches its minimum (with pigment concentration a maximum). Now with solutions of even higher fixed vehicle concentration (and therefore less solvent) the curve rises because of the diminished proportions of solvent.

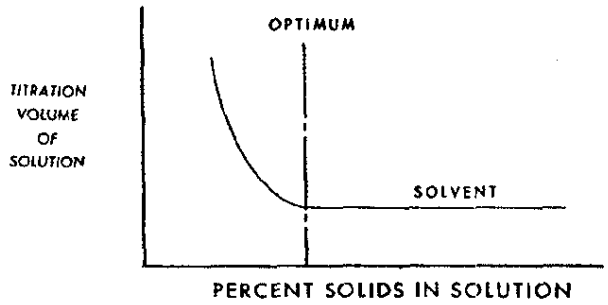

FIG. 15—SOLVENT USED IN FLOW POINT DETERMINATION

It is revealing to compute the solvent used in each FP determination. Fig. 15 shows a plot of solvent concentration against solvent volume used.

Once the minimum flow point (with full dispersion) is reached, the amount of solvent needed to reach the FP is constant and the curve levels off. This means that an excess of binder contributes nothing constructive to the flow characteristics. The presence of more fixed vehicle than that needed for its dispersing function merely lowers the maximum pigment concentration and increases the grinding time due to increased vehicle viscosity.

To calculate the pigment concentration at the point of minimum solution note that the solution requirement for 20 grams of red oxide is 9.9 c.c. of 20% concentration solution. (Refer to Table I)

1 lb. of red oxide therefore requires:

$$\frac{454 \text{ grams/lb.}}{20 \text{ grams}} \times 9.9 \text{ c.c.} = 225 \text{ c.c./lb.}$$

If the original varnish comes in the form of a 50% solution:

$$\frac{20}{50} \times \frac{225}{3785} = .0238 \text{ gallons/pound of oxide}$$

and .0356 gallons of solvent are required to bring 1 lb. of this particular iron oxide to its flow point consistency.

EXAMPLE OF COMPLETE TECHNIQUE

The complete technique for determining the **optimum grind composition** for olive drab enamel is illustrated in Table I.

A finished formulation is shown in the upper left hand block.

Step one is preparation of five mixtures of the medium oil alkyd (50%) with the solvent.

Step two is determination of the amount of each mixture needed to take each individual pigment to its flow point.

Step three is the calculation of the vehicle and solvent requirements per pound of each pigment at the point of minimum solution requirement.

Step four is the calculation of the total vehicle and solvent needed to accomplish the grind. This then shows the amount of each to make up the grinding paste.

The optimum and conventional grind compositions are compared in Fig. 16.

For the optimum grind only one-half the paste volume is required and the amount of paste may be doubled. Thus twice as much finished enamel is produced in the mill operation. In addition the grinding time required to reach an equal fineness in this case is reduced from thirty hours to twenty hours because the shear forces are allowed to dominate. If the optimum grind is milled for thirty hours a finer and glossier enamel with less floating is produced than the conventional grind produces in any milling time.

In this case the output of an equal quality enamel is tripled.

	OPTIMUM GRIND COMPOSITION	CONVENTIONAL GRIND COMPOSITION
Chrome Yellow	110 lb.	110 lb.
Calcium Carbonate	144 lb.	144 lb.
Red Oxide	36 lb.	36 lb.
Lamp Black	34 lb.	34 lb.
Paste Drier	6 lb.	6 lb.
Aluminum Stearate	2 lb.	2 lb.
Medium Oil Alkyd	11.3 gal.	66 gal.
Solvent	20.5 gal.	10 gal.
24% Lead Naphthenate	1.0 gal.	1 gal.
	45.8 gal.	90 gal.

FIG. 16—GRIND COMPOSITIONS

SHORTCUTS AND MODIFICATIONS

Many flow point determinations show that most pigments have their optimum at about 20% vehicle solids. A few pigments need less vehicle solids for complete dispersion, about 13-16%.

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FORMULATION FOR BALL AND PEBBLE MILLS

TABLE I—CALCULATION OF OPTIMUM GRIND COMPOSITION FOR OLIVE DRAB ENAMEL

FINISHED ENAMEL
110 lbs. CHROME YELLOW
144 lbs. CALCIUM CARBONATE
36 lbs. PREC. RED OXIDE
34 lbs. LAMP BLACK
6 lbs. Paste Drier
2 lbs. Aluminum Stearate
100 gals. Med. Oil Alkyd (50% Solids)
28 gals. Long Oil Alkyd (70% Solids)
60 gals. Mineral Spirits
2.5 gals. Drier

PREPARE 5 MIXTURES

	ALKYD SOLVENT	CHROME YELLOW 20 gms	CALCIUM CARBONATE 10 gms	RED OXIDE 20 gms	LAMP BLACK 10 gms
MIX. **1**	30cc + 20cc	10.3cc	10.4cc	10.8cc	24.6cc
MIX. **2**	25cc + 25cc	10.1cc	9.4cc	10.2cc	23.4cc
MIX. **3**	20cc + 30cc	9.4cc	**8.8**cc	**9.9**cc	22.2cc
MIX. **4**	15cc + 35cc	**9.0**cc	8.9cc	9.9cc	**21.0**cc
MIX. **5**	10cc + 40cc	9.9cc	9.2cc	10.5cc	22.7cc

TO CALCULATE VEHICLE AND SOLVENT REQUIREMENTS PER POUND OF PIGMENT

	TOTAL SOLUTION (c.c./lb.)	VEHICLE (gal./lb.)	SOLVENT (gal./lb.)
CHROME YELLOW	$\mathbf{9.0} \times \frac{454}{20} = 204$	$\frac{15}{50} \times \frac{204}{3785} = .0162$	$\frac{35}{50} \times \frac{204}{3785} = .0377$
CALCIUM CARBONATE	$\mathbf{8.8} \times \frac{454}{10} = 400$	$\frac{20}{50} \times \frac{400}{3785} = .0423$	$\frac{30}{50} \times \frac{400}{3785} = .0635$
RED OXIDE	$\mathbf{9.9} \times \frac{454}{20} = 225$	$\frac{20}{50} \times \frac{225}{3785} = .0238$	$\frac{30}{50} \times \frac{225}{3785} = .0356$
LAMP BLACK	$\mathbf{21.0} \times \frac{454}{10} = 952$	$\frac{15}{50} \times \frac{952}{3785} = .0755$	$\frac{35}{50} \times \frac{952}{3785} = .176$

TO CALCULATE TOTAL VEHICLE AND SOLVENT REQUIREMENT

	VEHICLE	SOLVENT
110 lbs. CHROME YELLOW	110 × .0162 = 1.78 gal.	110 × .0377 = 4.14 gal.
144 lbs. CALCIUM CARBONATE	144 × .0423 = 6.08 gal.	144 × .0635 = 9.13 gal.
36 lbs. RED OXIDE	36 × .0238 = 0.86 gal.	36 × .0356 = 1.28 gal.
34 lbs. LAMP BLACK	34 × .0755 = 2.56 gal.	34 × .176 = 5.98 gal.
	Total Vehicle 11.28 gal.	Total Solvent 20.53 gal.

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It is therefore possible to reduce the number of flow point determinations to one or two concentrations. It is practical to start with a solution that is 20% vehicle solids (by weight) and 80% solvents, and take additional points on the F.P. curve only if a shortage of solvents in the formula is apparent or if there is a seeding out of resin when the balance of the vehicle is added to the ground paste. This seeding out is due to insufficent dispersing agent or resin with the dispersion. Concentrated resin solutions will suck out the solvent from the dispersion and precipitate the resin. This can be avoided by adding diluted resin solutions.

GRINDING CONSISTENCY

The grinding consistency is maintained at about 125 to 135 Krebs Units by adjustments of the amount of pigment used. Generally the consistency does not change greatly from the first hour of dispersion until the finished paste is made. This grinding consistency is chiefly due to plasticity and is obtained by adjustments in pigment used in the charge. It varies with the absorption and particle size of the pigment. Typical percentages of pigment in the paste as found by R. B. Shurtz Bulletin 745 were:

Calcium Carbonate	86%
Titanium Calcium	85%
Titanium Dioxide	78%
Lithopone	79%
Zinc Oxide	79%
Red Oxide	77%
Magnesium Silicate	72%
Chrome Yellow	69%
Yellow Iron Oxide	61%
Carbon Black	27%

The low solids vehicle may have a tendency to flocculate when diluted for removal from the ball mill. This is particularly true if rich solvents are added. It is preferable to add resin solution to the ball mill for "take out" as this will avoid flocculation.

The consistency need not necessarily be measured in the Stormer Viscometer modified to use the paddle with 52.5 mm sweep. Other instruments should show the following range of values for good grinding results.

	Low	High
Stormer Krebs Units	125	135
Parlin Cup (No. 7)	150	210
A.S.T.M. (No. 25)	27	37
Mobilometer 100 gm. 20 cm.	320	420
Ford, No. 4 cup	900	1200
Centipoise	3330	4300

The values for cup viscometers are valid only if the pastes are short and very little material remains in the cup.

The above consistencies are recommended for ball sizes of 1½ and 2 inch for Porox, 1¼ inch for Arlcite, and ⅞ inch for steel. It is necessary to use lower consistencies when smaller ball sizes are used. Table II gives the range of consistencies for the various ball sizes and material.

BALL DIAMETER INCH	POROX	ARLCITE	STEEL
½	55-63	63-72	101-111
⅝	63-77	70-80	114-124
¾	78-87	94-104	125-134
1	96-105	111-121	141-151
1¼	109-118	125-135	—
1½	120-129	135-146	—
2	137-146	—	—
	CONSISTENCIES MEASURED IN KREBS UNITS		
DENSITY OF MEDIA gm/ml	2.38	3.3	7.85

TABLE II—CONSISTENCY OF FINISHED DISPERSION FOR VARIOUS BALL SIZES

CONCLUSION

The ball mill is an efficient machine for dispersing and grinding pigments if proper formulations are used. Vehicle solids contents as developed by the Daniel method should be used as a guide. In many instances somewhat better results are obtained if lower vehicle solids are used than would be indicated by the test results. When lower vehicle solids are used, dispersion can usually be accomplished in a shorter time if consistencies are maintained at the same values as shown in Table II. However, the resulting paste may be more difficult to convert to the finished product since the resin or varnish may form seeds or small precipitated masses in the product. These seeds can be removed if sufficient mixing is provided.

If additional vehicle solids are added to the ball mill paste before removing from the mill, this seeding out can be avoided. The milled paste and the addition should be left in the mill from 20 to 30 minutes to insure a good mixture and better flow characteristics. Also, the paste will not be as subject to seeding out of resin by subsequent mixing operations.

For optimum operating results, the paste formulation should have the lowest possible viscosity for the vehicle. A careful balance of physical-chemical properties are necessary to produce flocculates of the desired size. Consistency of the paste should be above some minimum value dependent upon the ball size and density used.

Applying the basic principles as outlined herein will result in lower production costs because of:

1. Shorter time required for dispersion.
2. Lower cost solvents which can be used in many formulations.
3. Consistently higher quality product.
4. Low rate of ball mill and ball wear.

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GLOSSARY OF TERMS

AGGREGATE	Compound masses of particles held together by gas interfaced.
BINDER	The nonvolatile total solids or film forming ingredient in a protective coating which serves to bind or cement the pigment particles together and form the coating.
CONSISTENCY	The relative stiffness, body or resistance to deformation of a liquid-solid system in bulk; it may be a composite of plasticity and viscosity usually with yield values and thixotropy.
DEFLOCCULATION	The state in which each pigment particle remains independent and unassociated from adjacent particles in a liquid-solid system.
DISPERSION	A scattering. The separation of a whole into basic components which are then moved apart in different directions.
FLOCCULATION	Compound masses of particles held together by liquid components.
FLOW POINT	The state of fluidity of a liquid-solid system when material on a stirring rod flows away, leaving only a thin film. The last few drops break off the rod tip with an elastic snap-back.
GRINDING	To reduce to fine particles by pounding or crushing.
KREBS UNITS	Arbitrary units expressing the consistency of a liquid-solid system as measured on a Stormer Viscometer with the Krebs modification.
MONOGRAPH	A treatise on a particular subject.
PLASTICITY	A property of solid suspensions which causes them to have resistance to flow greater than the liquid in which they are suspended or dispersed. Such systems generally have an initial resistance with no flow which corresponds to a yield value.
SHEAR	The tendency produced by a force to deform by sliding one section along another section.
SOLVENT	Products which dissolve or disperse the film-forming constituent. Usually volatizes during drying and does not become a part of the film or coating.
THIXOTROPY	The property possessed by certain gels of becoming liquid when disturbed, and coagulating again when left undisturbed. The consistency of such gels is influenced by the previous time history of disturbance.
VEHICLE	The liquid portion of any coating. Any ingredient dissolved in the liquid is part of the vehicle.
VEHICLE SOLIDS	The non-volatile portion of the vehicle which may be liquid if above the melting point.
VISCOSITY	A property of fluids which causes them to have a resistance to flow. A measure of the combined effects of cohesion and adhesion in a fluid.
YIELD VALUE	The yield value is that force required to obtain movement of a solid suspension or gel, and is found by extrapolation of the linear portion of the consistency curve.

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