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"47 PROCESS" DEVELOPMENT

Process & Methods Study P-1

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ABSTRACT

A study of fundamental relationships of variables involved in the "47 Process" resulted in the establishment of new principles of design and operation. The design of a higher capacity, more efficient dispersion unit was developed. The facilities proposed will permit expansion of the process to most codes currently manufactured in Ball and Pebble Mills at lower investment and operating costs.

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P-1 "47 PROCESS" DEVELOPMENT

I - SUMMARY

A. Nature of Investigation

The purpose of this study was to investigate fully the principles of "47 Process" operation so that optimum design of equipment and operating conditions could be established. Philadelphia Process & Methods Project No. P-1, "47 Process Development Program", was approved and the study undertaken with the following objectives:-

1. Determine the variables affecting quality and through-put rates and establish their limitations.
2. Establish optimum design and operating conditions to increase rates and/or improve quality.
3. Simplify design and specify standards of equipment to reduce installation, repair and operating costs.
4. Provide information for placing additional formulas on "47 Process" and the elimination of two-stage grinds on present products.

B. Results and Conclusions

Investigation of "47 Process" principles resulted in the establishment of the effect of each variable involved in the process. Based on these results, a new design of equipment was developed and evaluated on a semi-works, 6-1/2 gallon, scale. Scale-up to production size was made and equipment standards specified. This design provides increased rates, higher quality of dispersion and eliminates several high cost items in the installation. Maintenance costs also should be substantially reduced.

Alterations to present production vessels were developed and evaluated. These modifications can be made at relatively low cost and provide improved operation.

It is estimated that the proposed installations will more than double the present average production rates and will enable many products now ground on Ball and Pebble Mills to be made by "47 Process" at a substantial annual savings.

C. Recommendations

1. Install "47 Process" system of proposed design as a regular production unit. Provide close follow-up of operation of initial installation and report any deficiency or improvement.

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2. Establish a formal program of study of formula changes for optimum dispersion on "47 Process". Included in this study should be an investigation of all formulas now on Ball & Pebble Mill production to determine revisions necessary for "47 Process" grinding. Two-stage grinds now on "47 Process" should be evaluated for single pass operation.
3. Make simple alterations to present production units to provide improved operation. The modifications include bottom screen, new screen flange, angle hub, fourth agitator disc, and bias-cut 35-mesh screen.
4. As new "47 Process" formulas become available, consideration should be given to the eventual replacement with "47 Process" of all ball and pebble mills as they wear out. Procedure should be such as to provide sufficient backlog of formulas so that any type mill could be immediately replaced with a "47 Process" unit.
5. Auxiliary recommendations are proposed in Section II-F of this report.

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II - DISCUSSION

A. Origin of Investigation

During the years of 1946 and 1947 a new dispersion technique was proposed by Dr. Seymore Hochberg of the Philadelphia Laboratory's Physical Chemistry Group. The new process was developed in the laboratory stage under the Chemical Division Project, P-159, and the Industrial Engineering Division Study, MX-1034. Further investigation on laboratory and semi-works scales was continued under the I.E.D. Project, MX-1123, and Chemical Division Project, P-2024. As a result of these studies and with the assistance of the Philadelphia Process & Methods Group, this new "47 Process" was placed on a production basis.

Utilization of the process grew rapidly during the years 1949 and 1950 as the advantages of the new process became firmly established. During the expansion period, no further development work was carried out and efforts were concentrated on installations as replacements for other grinding equipment. While initial work had indicated substantial quality improvement available, a relatively small number of codes of hard-to-disperse colors could be made on a production scale. In addition, grinding rates were not as great as originally anticipated. Therefore, a special Process & Methods Study was prepared to establish the principles of operation and determine the optimum design of a production unit. This project was authorized in January, 1951, as Process & Methods Study P-1, "47 Process" Development Program.

B. Acknowledgment

Since the potential of "47 Process" has been recognized for some time, all plants using this new dispersion technique have been working toward improved operation. The progress reported by these plants both in design and operation was used to advantage in this study and it is natural to include these advances in this summary report of "47 Process" Development. Important contributions were made by the Process & Methods Groups of all Finishes Division Plants, the Marshall Laboratory and the Philadelphia Plants Operating and Maintenance Departments.

C. Present Operation

In six of the seven Finishes Division plants, there are now 21 production units on the "47 Process" producing approximately 120,000 gallons of mill bases per month at an average operating rate of 24 gallons per hour. Additional units are in use for processing Overspray, for manufacturing small batches and for experimental work throughout the Division. The standard production unit consists of a 23-gallon size grinding vessel with a 500-gallon premix tank and necessary feed regulating controls and auxiliary equipment. In August, 1949, specifications for all equipment used in the "47 Process" were issued so that installations made at any plant would be standardized. No revision of these standards has been issued, and, with the exception of several device memorandums concerning minor alterations, the specifications remain essentially the same.

Production by "47 Process" is now limited to 14.8% of all "Dulux" semi-alkyd and orthodox mill base production. "Dulux" mill bases account for 86.9% of "47 Process" production, equivalent to 22.3% of the total Divisional "Dulux" mill base production (See Exhibit H). Although the advantages of improved quality or reduced operating costs have been established for the products now dispersed by "47 Process", use of this new method has not been further expanded due to the limitations of the process on difficult-to-disperse codes and relatively poor rates on other more easily dispersed products. Lack of fundamental knowledge concerning variables involved in the process has deterred the optimum formulation for the dispersion of many products.

Mechanical difficulties have been encountered throughout the Division with pump failures, insufficient premixing, motor overloads, screen and disc wear, temperature control, etc., resulting in lower capacities and extensive down-time. Specification revisions were needed to provide improved operating equipment and lower cost installations.

D. Course Pursued in Investigation

Experimental work on Process & Methods Study P-1 was performed on a special semi-works "47 Process" installation in the "Dulux" Department of the Philadelphia Plant. The program was divided into specific phases or objectives as follows: (1) Investigation of the variables which affected either quality or dispersion rate or both; (2) Evaluation of simplified or improved vessel design, auxiliary equipment and controls; (3) Development of an improved, low cost design as a standard installation for the Finishes Division. During the course of investigation, it was found desirable to put into effect several modifications to existing production equipment where improved operation could be realized at low cost.

1. Investigation of "47 Process" Variables

A semi-works 6-1/2 gallon "47 Process" unit was installed in the "47 Process" production area of the "Dulux" Department (See Figure 1). This installation consisted of the following equipment:-

- a. Premix Tank - 1000-gallon dish bottom tank with 5 hp. 80 RPM turbine agitator
- b. Vessel Drive- 7-1/2 hp. motor with Reeves variable speed drive - 400 to 1200 RPM output
- c. Feed Pump - Foster 100 RPM, 3 GPM pump with 1/2 hp. gear motor
- d. Standard floor drill press stand.

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The above equipment was selected to permit (a) Reasonably large batches to be made so that raw material or batch-to-batch variations would not affect evaluations; (b) Wide range investigation of variables without horsepower limitations; (c) Complete flexibility of arrangement for new equipment or modifications; (d) Availability of raw materials, equipment and manpower necessary; and (e) Reasonable translation of operating conditions and results to plant scale operation.

"Dulux" Milori Blue Mill Base, 33-532, was initially selected because of its wide range of gloss at various dispersion levels. Due to bodying action in the vessel and fast settling of the premix and feed, the physical difficulties encountered led to the selection of a base currently manufactured by "47 Process". A series of runs, in which 10,000 pounds of "Dulux" Shading Yellow Mill Base, 33-697, were processed, were made to evaluate some of the variables of the process. Operating characteristics and effects of screen area, vessel design, agitator speed and control devices were determined. This easily dispersed base, however, was found insensitive to the quality-affecting variables involved, and test methods indicated satisfactory quality under nearly all conditions. "Dulux" Carbon Black Base, 33-201, was then selected to evaluate the dispersion characteristics of the remaining variables. Reasons for the choice of this particular base included: (a) A more difficult-to-disperse base which would be sensitive to degree of dispersion was needed. This base is difficult to disperse in the conventional steel mill process, requiring 51,000 cycles and could not be adapted to the improved "45" or "46" techniques; (b) No satisfactory "47 Process" formula had been found; (c) W-201 pigment is representative of very fine ultimate particle size pigments used in fast moving color bases; (d) Experience with 33-201 would be typical for other codes which could not be ground by "47 Process" due to hard settling and puffy dispersion, and should also be typical of many bases now requiring two-stage grinds.

In order to evaluate adequately the variables with the Carbon Black Base, it was necessary to overcome the same difficulties experienced initially with 33-532, Milori Blue Base, i.e., prevent settling of premix and high bodying action during dispersion. The settling and clogging difficulties encountered were overcome by a new feed system incorporating recirculation of premix with a continuously operated pump, and an independent level control system. To obtain a satisfactory balance of good dispersion and bodying action, it was necessary to reformulate the base from time to time as design improvements were made.

The variables studied were: (a) power, (b) Agitation, (c) Grinding Media, (d) Formulation, (e) Vessel Design and (f) Throughput Rate. Evaluation of each variable consisted of setting up the desired relationship of variables, sampling at required rates and testing sample for quality. Fineness and gloss tests made on samples taken during the first series of runs with this Carbon Black Base were found inadequate for determining dispersion differences. In most cases the gloss was satisfactory although

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the fineness of grind was too coarse to be read on the Hagman gage. Standard tinting strength tests were not numerical and so could not be correlated. A special test was devised whereby the dispersion of the black base could be numerically described. The du Pont Differential Colorimeter was used to measure the reflectance of a 94-line enamel made from the dispersed base. Since the absolute reflectance of black enamels is very low, resulting in a small range and a high proportionate error, the sample was let-down with a similar white (094-0042) in the ratio of one part black to five of white. Special standard and reference panels were prepared and the colorimeter set to balance at approximately half the scale range. Reflectance readings, then, were a measure of the relative tinting strength of the various samples obtained including standard ball mill ground base. (In this testing method, standard 33-201, ground 51,000 cycles in a SUW mill, resulted in a Lightness Factor read on the colorimeter of 50.0. Higher numbers show poorer tinting strength.) A wide range of reflectance readings, giving a numerical measure of dispersion under various conditions, was obtained. The readings indicated the hue and saturation of bases ground as well as tinting strength. Details of the testing methods used are given in Exhibit R.

2. Equipment Evaluation

a. Vessel Design

Before embarking on the experimental program in connection with this study, a new vessel incorporating several design modifications of the standard "47 Process" vessel, was fabricated. (See Figure 2 - Modified Top Feed Vessel). This 3-1/2 gallon size vessel was designed to overcome screen changeover difficulties, reduce hold-up in discharge jacket and simplify construction. Operation of this vessel was found satisfactory on many runs conducted during the early stages of this study, but did not show any great improvement over the standard design.

The inherent advantages of a bottom-feed, top-discharge type vessel had been recognized, and the design of such a vessel was specified early in the development program. Bottom-feed arrangements have the potential advantages of (1) Less screen wear; (2) Simplified screen changing without sand removal; (3) Lower starting torque; (4) Less short-circuiting of base; (5) Installation of vessel nearer floor level. Such a vessel was fabricated (See Figure 2 - Bottom-Feed Vessel) and subsequent evaluation substantiated the advantages outlined.

During the course of the experimental runs, it was found that increasing the vessel height-to-diameter ratio resulted in improved dispersion. A new vessel made up of four separate sections to give a variable height-to-diameter ratio was

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designed and fabricated to evaluate fully a range of ratios. (See Figure 2 - Variable Height to Diameter Vessel). Substantial improvement in dispersion over conventional vessels was noted. This vessel was the final semi-works unit evaluated and was used as the basis for the proposed improved design production vessel.

Other designs including the current standard design were investigated either on paper or by experimental models during the course of this program. However, no other units were found sufficiently satisfactory to warrant additional evaluation on a semi-works scale.

b. Auxiliary Equipment and Controls

In addition to the aforementioned recirculation system developed for use in the semi-works installation, investigation was made of other auxiliary equipment and controls either necessary or desirable to the operation of the "47 Process".

Methods of premixing and pumping, investigated as necessary auxiliaries to the process, were studied to a large extent by summarizing the experience of the Division and determining the purposes of their utilization. Evaluation of screens was investigated in a similar manner except that actual test runs were carried out with plastic screening.

Feed control to the vessel was studied as an important control feature of any "47 Process" installation. Equipment evaluated included the standard Mercoid electrical control, a percentage timer used in conjunction with the feed pump, a Honeywell Hi-Lift Hand Control Valve, a solenoid gate valve and a butterfly valve lever system. Other methods of feed control were investigated but not evaluated. Equipment for the control of discharge rate was also studied.

Temperature variation throughout the vessel was determined and methods of indicating and controlling the temperature investigated. Other auxiliaries studied, such as agitator drive and discs, and grinding media, will be discussed more fully later in this report.

3. Development of Proposed Design for New Installations

Based on the results obtained in the experimental program, production scale correlations, and the investigations conducted at other Finishes Plants, design standards were established for future installations. The essential parts of the proposed design were evaluated on a 6-1/2 gallon semi-works installation. In the case of the recommended vessel and drive, the resulting design was an engineering compromise of optimum design and practical, low cost, production installation.

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4. Alterations to Present Production Equipment

In the course of the experimental program, improved equipment and methods of operation were developed. Several of these modifications could be adapted readily to present production equipment at a small investment. So that increased productivity could be realized immediately and experience developed on a production scale these alterations were made to several 25-gallon production units at Philadelphia. Modifications thusly evaluated included increased screen area with the use of a bottom screen and addition of a fourth disc to the agitator shaft. An improved screen changing method, developed by the Fort Madison Plant, was also incorporated in these modifications and found very satisfactory. Batches manufactured on these units were followed and the data obtained used in designing the proposed new installations.

E. Results and Conclusions

The results and conclusions tabulated in the Summary are general in nature and are designed for use by Divisional plants to improve the operation of present "47 Process" units and to aid these plants when new installations are contemplated. In order to supplement these results and to provide background for future investigations the following are findings applicable to specific parts of the "47 Process":-

1. Process Variables

a. Power

Increasing the power input to a "47 Process" grind has the greatest effect on improving the quality of dispersion of all the variables involved. The power input to a given grind is dependent upon almost every other variable of the process so that to increase the power input one or more of the other variables must be changed. Some factors affect power to a greater degree than others, and since power is not the sole determining factor of dispersion, a judicious choice of the method of putting power into the grind must be exercised. Furthermore, a practical limit of power input was reached where further increase of power did not produce noticeable quality improvement. This limit has been set at approximately 2.0 Horsepower per gallon of base in vessel, or 1 Horsepower per gallon capacity of vessel. Exhibit C shows the effect of power input on tinting strength of Carbon Black Base at various formulations. This graph is composed of many runs holding constant only the vessel dimensions and base ground.

b. Agitation

(1) Agitator Speed

Power input increases approximately as the square of the agitator speed, the disc size remaining constant. Increasing speed is one of the fastest methods of increasing power up to the practical limit. Exhibit D shows the effect of

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agitator speed on dispersion and indicates a definite tapering-off of the advantage to be gained by increased speed. It would therefore be desirable to set speed at a sufficiently high level and obtain additional power by methods other than further increases in speed. Agitator speed of 900 RPM (a standard motor speed not requiring a reducer) would be the most desirable agitation speed.

Since sand is heavier than most mill bases, a certain amount of centrifuging action is present in the "47 Process". With conventional installations, this action is generally unimportant. However, at high speeds centrifuging of sand will reduce maximum throughput obtainable especially for low viscosity bases. This factor then also imposes an upper limit on speed and points out the desirability of a lighter weight grinding medium.

(2) Agitator Disc Diameter

It was found that peripheral speed alone does not determine power but that the actual disc diameter produces an effect in itself. At the same peripheral speed, larger discs provide slightly higher power and also somewhat improved dispersion. In addition smaller diameter discs prevent sufficient motion of sand and base in the screen area, resulting in serious screen blinding. Experimental runs showed that for a 10-inch inside diameter vessel, 8-inch diameter discs were satisfactory while 5-inch diameter discs resulted in a build-up of a 1/2-inch layer of sand and base on the screen preventing throughput. In an 8-inch diameter vessel both 7- and 6-inch discs were satisfactory. The optimum diameter disc, therefore, would be such as to be large enough to prevent blinding and to provide adequate power for dispersion, but not too large to prohibit further power increases by other methods. This would lead to a design of a vessel with a relatively small diameter using as large a disc as possible (up to 1/2-inch clearance between vessel wall and disc edge).

(3) Number of Agitator Discs

Experimental results showed that increasing the number of discs increased dispersion rate at a very small increase in power requirements. A fourth disc was added to a 23-gallon production unit grinding 33-line Yellow Mill Bases. Twenty batches covering four codes were followed. Test results showed improved fineness and tinting strength on three codes and no change on fourth formula. A power increase of 5% was required for the fourth disc. A vessel long enough to provide room for a large number of discs would be desirable.

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(4) Agitator Disc Spacing

Space between discs was found satisfactory down to a 4-inch clearance. With a bottom-feed vessel location of both top and bottom discs assumes importance. The bottom disc (flat) should be located at the top of the inlet nipple. The level of the sand and base mixture above the top disc was found critical in the operation of the 6-1/2 gallon unit. This level should be sufficiently high to prevent splashing from the angle disc and yet low enough to provide sufficient turnover of material for effective motion at screen and for level control operation. With the 6-1/2 gallon vessel the optimum level was found to be four inches above the uppermost part of the angle disc. In larger diameter vessels and with heavier bases the operating level should not be critical.

The "angle" disc developed at Toledo was evaluated as a replacement for the "wavy" disc. Use of an angle cut hub permits all discs to be made flat and interchangeable. In addition, once the angle hub is cut, all replacements can be made with flat discs. Various angles for this hub were evaluated during the experimental program, and results indicated that angles less than 5-degrees were unsatisfactory for sufficient turnover on bottom-feed vessel. An 11-degree angle hub was found satisfactory. Greater angles were not evaluated due to the increased probabilities of splashing and disc wear.

During the course of investigation, considerable difficulty was experienced on a top-feed vessel with a very low viscosity base due to screen blinding. It was found that throughput rates could be doubled by using a "squeeze" disc arrangement opposite the screen. Two opposite, 11-degree, angle discs with a 1-inch clearance at the minimum point gave a "squeezing" action to produce the higher rates. Wear rate of discs were abnormally high and later developments eliminated the necessity for such an arrangement.

c. Grinding Medium

(1) Type of Medium

During the course of experimental work with Carbon Black Base at low viscosity, a centrifuging action was noted resulting in screen blinding. In an effort to eliminate this action, investigation of media other than sand was undertaken. Various types of media including "Dacron", nylon, silica gel, carborundum and steel shot, were evaluated in laboratory equipment to determine the effect of particle size and specific gravity on dispersion (See Exhibit A). The results as shown in Exhibit B indicate that particle size has a marked effect on the dispersion of this fine carbon black pigment while the influence of specific gravity is not as effective. Although no satisfactory economical small particle size nylon has been found to date, indications are that this medium would be more suitable for fine

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dispersion on "47 Process" than sand. The nylon would permit use of lower viscosity bases, require less power, reduce screen and disc wear, and eliminate centrifuging.

Various types and sizes of grinding media were evaluated in the grinding of hard extenders by "47 Process". Previous work at Flint (Flint "47 Process" Progress Report - December, 1949) showed that sand was unsatisfactory in grinding down bases for Automotive primers but that steel shot gave the required fineness. This finding indicated that a large size, tough grinding medium was required to grind down the large size, hard extender pigments. Laboratory runs with 20-30 mesh sand, 10-20 mesh sand, 3/16" steel shot, 1/4" pebbles, 3 and 5 mm. glass balls were made. Results with 33-903 (90,000 cycle PLV grind) using 4-31 extender pigment showed that the steel shot and glass balls gave satisfactory fineness. The steel discoloration with the steel shot, however, was excessive while the color with glass balls was better than standard which undoubtedly contained a large amount of pebble discoloration.

(2) Sand-to-Base Ratio

The effect of sand-to-base ratio on dispersion is dependent upon the relative ease of grinding of the product in question. On fine particle size pigments the S/B ratio assumes importance and Exhibit E shows the effect of this ratio on the dispersion of 33-201. Carbon Black Base. On the other hand, high sand-to-base ratios generally reduce the maximum throughput ratio obtainable. The current standard ratio of 50/50 is a good compromise and should be used as a starting point for all formulas.

At present, a common practice in "47 Process" grinding is the periodic adjustment of sand load to improve dispersion, eliminate splashing, permit higher rates or to prevent overloading of agitator drive. Adjustments of this nature can easily get out of hand resulting in an unknown amount of sand in the vessel. Indications are that the optimum sand load is 290 pounds (23-gallon units) and this amount should remain constant for all grinds. If improved dispersion is required to meet formula rate, the sand-to-base ratio can be increased by a simple adjustment of the level control paddle (which could easily be calibrated). Since the practical operating limits are 45% to 55% sand this adjustment would not be very great. If, on the other hand, difficulty is encountered with motor overloading or failure to maintain high throughput rates, the sand-to-base ratio could be reduced without removing sand. (This method of adjusting sand-to-base ratio is analogous to ball mill operation where volume loading of the base is adjusted from formula to formula rather than the addition or subtraction of balls to the mill.)

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In general, low sand-to-base ratios (45/55) result in higher throughput rates and lower power requirements and are desirable for easily dispersed products. Low viscosity, light bases where centrifuging becomes a factor, will have a higher possible rate at higher sand-to-base ratios (55/45). The higher ratios will reduce splashing and improve dispersion and are desirable on difficult-to-disperse bases.

d. Formulation

Formulation work was centered on revisions to the two-stage steel mill formula for 33-201, Carbon Black Base. Laboratory runs made to determine the optimum concentrations of pigment, resin and solvent indicated that the higher the pigment concentration and the lower the solvent percentage the easier the initial dispersion (See Exhibit C). The upper limit of pigment concentration to maintain flow in these runs was 12%. However, in every case, it was necessary to grind-in the second portion to bring to overall formula with satisfactory fineness.

The viscosity of the premix of all the Carbon Black base formulations investigated remained constant at approximately 300 cps. The viscosity of the ground base was found proportional to the percent pigmentation and the degree of dispersion and ranged from 500 to 5000 cps. (Viscosities were measured by determining the Krebs Number on the Stormer Viscosimeter. Since base is thixotropic, the viscosity is not constant over the entire range of loadings.) The limiting practical viscosity of the dispersed base was found to be about 2500 cps. at which point the throughput rates obtainable dropped due to the purfy, buttery consistency of the ground base. Since throughput rates are inversely proportional to viscosity, the ideal formulation would be at a low viscosity consistent with quality in order to obtain maximum throughput rates. For carbon black and similar bases containing very small ultimate size particles, the resulting viscosity of the ground base is a good indicator of degree of dispersion.

Since high viscosities generally limit throughput rates and since a grind-in of the second stage is a necessity, the optimum formulation of this carbon black base would be the overall formula dispersed in one pass. Runs with this overall formula in the conventional 2/1 height to diameter ratio vessels resulted in very poor quality but with the 5/1 height to diameter vessel fineness of 0.25 could be obtained. This improvement with the new vessel design makes feasible the formulation of a one-pass system for products currently ground in a two-stage operation.

Although lower operating temperatures increase power input (by increasing viscosity), throughput rates obtainable are not as great as at higher temperatures. It is more desirable to formulate heavier bases and obtain the same viscosity by operating at higher temperatures. Temperatures of 140 to 150°F at the screen area should be satisfactory. Since the temperature of grind was found to increase rapidly as the base approaches

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the discharge point, the area near the screen should be used as the control point if temperature control devices are used. If an automatic controller is not used, a temperature indicator should be placed near the screen area. The use of an automatic controller is a desirable but not necessary feature to the operation.

While present cooling facilities are satisfactory for operating at temperatures above 120°F, use of a greater height-to-diameter ratio vessel indicated the need for greater cooling capacity. At 5/1 height-to-diameter ratio on the experimental vessel, temperatures of 170 to 180°F were reached in less than 1/2 hour operation. It was necessary, therefore, to provide greater rate of flow of cooling water in the design of higher height-to-diameter ratio vessels.

e. Vessel Design

Three experimental vessels of the 6-1/2 gallon size were fabricated and evaluated in the semi-works installation (See Figure 2). Other laboratory size units, including the rotating cylinder unit fabricated by the Everett Plant, were also tested. The results of these investigations led to the selection of the following features for ideal design:

- (1) Large height-to-diameter vessel ratio
- (2) High power per gallon input
- (3) Large discs operating at high speed in a small diameter vessel for best power efficiency
- (4) Large number of discs
- (5) Large screen area
- (6) Bottom-feed, top-discharge
- (7) Screen removal without dismantling unit or shaft
- (8) Large cooling capacity

Most of the above mentioned items were included in the design of the variable height-to-diameter ratio vessel used during the latter part of the experimental program, and the design of the proposed vessel for new production installations is based on these features. With this type vessel and a satisfactory formula, it should be possible to disperse several "easy-to-grind" whites at a rate of 200 gallons per hour and an overall average production on "47 Process" of at least double the present rate average of 24 gallons per hour.

Runs made in the experimental semi-works unit indicated that on uncontrolled throughput, the maximum rate obtainable was proportional to the screen area (See Exhibit F). Two 23-gallon production vessels (one each in Paint and "Dulux" Departments of the Philadelphia Plant) were fitted with a bottom screen to provide approximately 50% additional screen area. Method of installation is shown in Figure 4. A wide variety of mill bases were followed through these units and on several products rates of over 100 gallons per hour were obtained. A few easy to disperse products were found satisfactory by Control Laboratory tests at double the formula rate. Screen wear was found to be no worse than currently experienced on side screens.

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f. Throughput Rate

It has long been known that quality of product is inversely proportional to throughput rates. This relationship, however, is not straight-lined but rather has a changing slope throughout. A change in rate at higher rates has less effect on quality than a similar change at lower rates. At low rates quality is critical, but if a certain product is found satisfactory at say, 50 gph, then there is a good chance that it will be satisfactory at 80 or 100 gph under the same conditions. Therefore, if by an improved design or better operating conditions, the critical rate at which a product is satisfactory can be increased by a relatively small amount then there is a good possibility that at even much higher rates the product will continue to show satisfactory quality. In grinding 33-697, "Dulux" Shading Yellow Base, quality was just as satisfactory at 40 gallons per hour as at 15 gph in the 6-1/2 gallon experimental vessel. Runs with 33-201 showed that rate was critical up to approximately 12 gallons per hour but quality remained essentially unchanged from 12 to 30 gph.

The maximum throughput rates obtainable are directly proportional to (1) Agitator Speed, (2) Screen Area, (3) Temperature, (4) Disc Size and inversely proportional to (1) Sand-to-Base Ratio, and (2) Viscosity.

2. Equipment Design

A new design for future installations of "47 Process" units is proposed based on the results obtained in the investigation of the process variables involved.

a. Vessel

The new design consists essentially of a 30-gallon vessel at a 5/1 height-to-diameter ratio. Based on the conclusions of power requirements as a variable, this unit requires a 30 H.P. direct drive motor operating at 900 RPM agitator speed, thereby eliminating the cost of a reducer unit. This higher vessel has ten discs with a diameter of 10 inches each. Specifications are revised to eliminate the necessity for stainless steel in these discs. The wavy disc is replaced with an angle disc so that only one type of disc need to be carried as spares. This unit incorporates all the advantages of a bottom-feed, top-discharge vessel and should realize the high production rates anticipated. Cooling capacity is increased and screen changeover simplified. Vessel is mounted near the floor with discharge direct to tanks or storage. Although the height of this unit is considerably greater than present vessels, no additional head room is required. Design of the vessel has been simplified so that fabrication cost will be no more than that for current vessels. Assembly of discs and shaft is critical and care should be taken in aligning and balancing. Procedure similar to that outlined in Exhibit U should be followed.

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b. Feed System

Premix facilities should be 500-gallon standard mixers with revised agitator and valve designs to reduce investment costs. Design of this agitator is based on the experience of current installations and the recommendations of the Engineering Department's agitation consultant and is currently in use throughout the Division on many mixing installations. Mill base is fed to the grinding unit through a 5 GPM pump circulating system. With pump running continuously on this circulation system, line clogging should be eliminated for all types of bases and pump wear considerably reduced.

c. Level Control

The circulation system described above precludes the need for Mercoid switch control of the pump. In the proposed installations, level control will be maintained with a simple butterfly valve with paddle and lever system. This level control device was used successfully in the experimental program. Two methods of installation proved satisfactory and are shown in Figures 6 and 7. The following comments concerning these sketches are offered:-

- (1) Figure 6 shows paddle at 130° from front of vessel, material in vessel moving counter-clockwise.
- (2) Figure 7 shows paddle at front of vessel as viewed from rear of vessel. Here the lever system was placed on back side of plate, and valve lever works from bottom of valve.
- (3) While 6" connecting lever was found satisfactory on 6-1/2 gallon vessel, this bar should be slotted to allow adjustments. Smaller 1-1/2" connecting lever should be slotted, also.
- (4) Adjustable stop bar in slot probably not necessary on large units at high throughput rates.
- (5) Fixed point of return spring should be adjustable for perfectly constant level maintenance.
- (6) Paddle is "V" shaped for more sensitive control.

On present installations, the Mercoid switch has the dual role of starting the pump for feeding as level drops and also of turning off the pump in event of power failure of agitator drive. To prevent spills in case of agitator power failure, a safety shut-off valve has been included in the specifications to be installed on the draw-off line just before the level control butterfly valve. This safety valve is a non-clogging, butterfly valve operated by a solenoid wired in the agitator circuit so that in event of power failure, or whenever the agitator is turned off, this valve will close.

- 16 -

Work on the control system was concluded with the evaluation of a Minneapolis-Honeywell Hi-Lift Hand Control Valve with precision indicator for number of turns. Although this valve does not give perfect control, it was found easier to operate and to control than present methods utilizing drilled pipe caps.

Two typical proposed installations are shown in Figures 8 and 9. An installation where the grinding unit is placed in the Grinding Floor is depicted in Figure 9 while the other sketch shows the more conventional Mixing Floor location of the grinding unit. Figure 10 outlines the proposed disc arrangement with detail of the "angle" hub.

Detailed specification list of the proposed standard units is given in Exhibit 6. Estimated installation costs of the proposed standard are shown in Exhibit 7.

3. Other Results

a. Capacity Reports

Investigation of the "47 Process" Capacity Reports issued monthly by all plants revealed that these reports are of limited value due to the method of reporting. In order to take greater advantage of production results by the plants, a revised form for these reports has been proposed. Exhibit 8 outlines certain discrepancies of present calculating methods and details the proposed revisions to the Capacity Reports. A typical, though simplified, example of the proposed method is given in this exhibit.

b. New Testing Procedure

A satisfactory method for determining the degree of dispersion of black bases was formulated during the course of the experimental program. Fineness-of-grind was found to be unsatisfactory for determining small differences in dispersion and no satisfactory color method for low reflectance products exists. Measurement of tinting strength by determining relative color on the du Pont Differential Colorimeter gave reproducible results, numerical values and good correlation. Details of this method of testing are given in Exhibit 9. The method should be applicable to any research or development program where degree of dispersion of low reflectance materials is to be determined.

c. Potential Savings

Expanded use of the "47 Process" could yield an estimated potential annual gross savings of approximately \$900,000 to the Finishes Division (See Exhibit I). These savings are based on the complete elimination of Ball and Pebble Mills as a method of dispersion and upon doubling "47 Process" grinding rates and are summarized as follows:-

- 17 -

<u>Item</u>	<u>Potential Annual Savings</u>
Labor	\$ 307,000
Supplies	38,000
Repair Labor	135,000
Maintenance Material	113,000
Media Replacement	202,000
Depreciation	98,000
Welfare	48,000

Details of the savings calculations are given in Exhibits J, K, L and M.

Although several years would be required to realize such a potential, substantial savings could be obtained within a relatively short period through the use of units with an improved design to provide higher rates, lower maintenance costs and the use of additional formulas on this process.

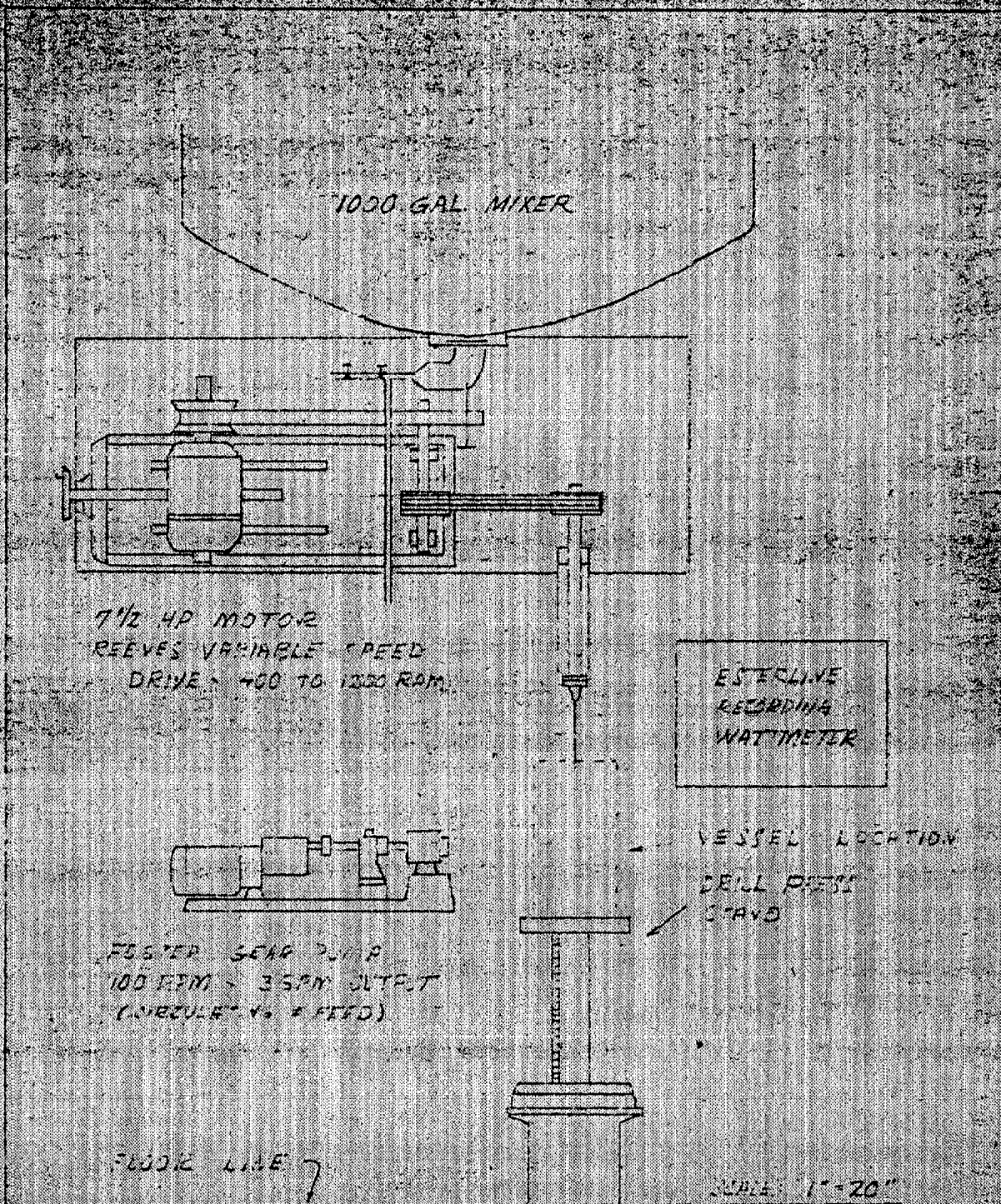
F. Auxiliary Recommendations

In addition to the recommendations listed in the Summary, the following items should be considered for adoption:-

1. Revise "47 Process" Capacity Reports as discussed in this report.
2. Check formulas for optimum sand-to-base ratios and revise these ratios on formula cards where necessary. When an improved operating ratio for any particular formula has been established, the Laboratory should be contacted, a formula revision requested to show the new ratio and the reasons listed leading to the new ratio.
3. Revise rates on formulas as information from capacity reports becomes available.
4. Continue investigation of nylon or other solvent-inert light weight media.
5. Revise "47 Process" operator job description to include spot check for fineness during grind. This would not eliminate final check by Control Lab but would enable maximum rates to be obtained with assurance of satisfactory quality.
6. Use the testing method suggested in this report for research and development programs on any low reflectance products.
7. Further investigate use of 3 to 5 mm. glass balls as a potential grinding medium for extender products. Special emphasis should be placed on extender grinding by "47 Process" because of the large potential savings in investment and grinding media.

A P P E N D I X

FIGURE 1



SEMI-WORKS EQUIPMENT
ARRANGEMENT DRAWING

STUDY: P-1

TITLE: 47 PROCESS DEVELOPMENT

ENGINEER: RPB

PHOTO PLANT

DATE: 3-15-51

NO. 1438-25

FIGURE 2

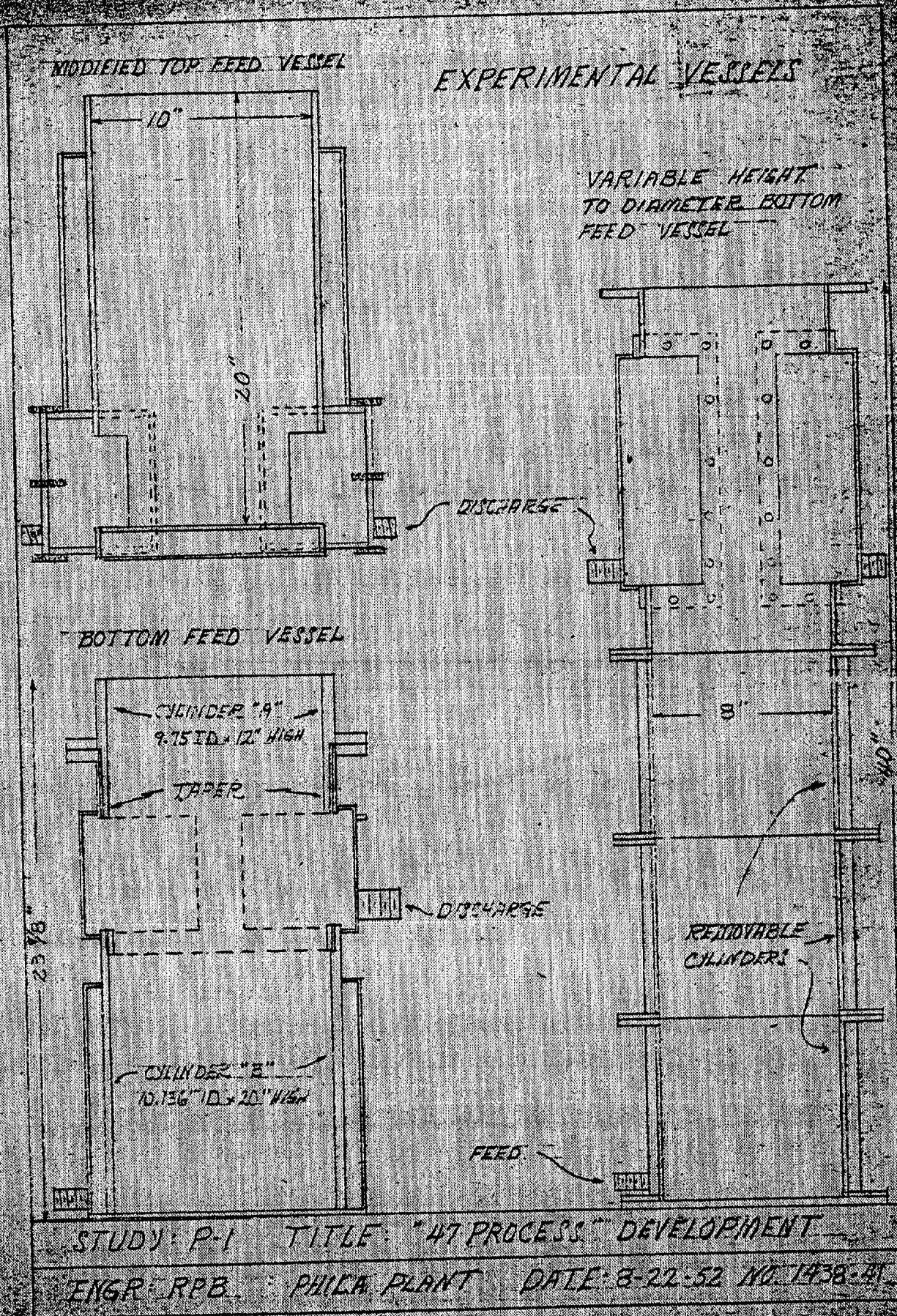
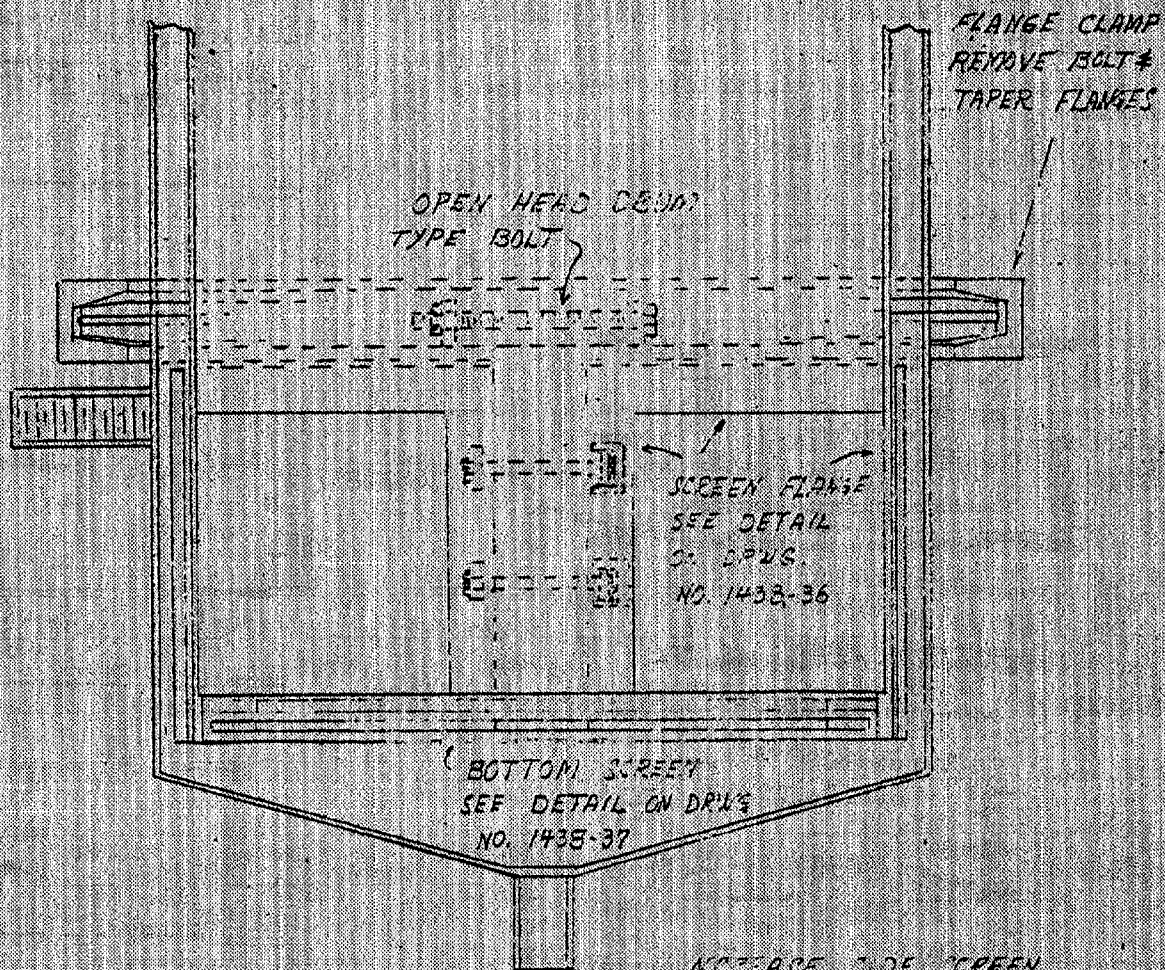


FIGURE 3

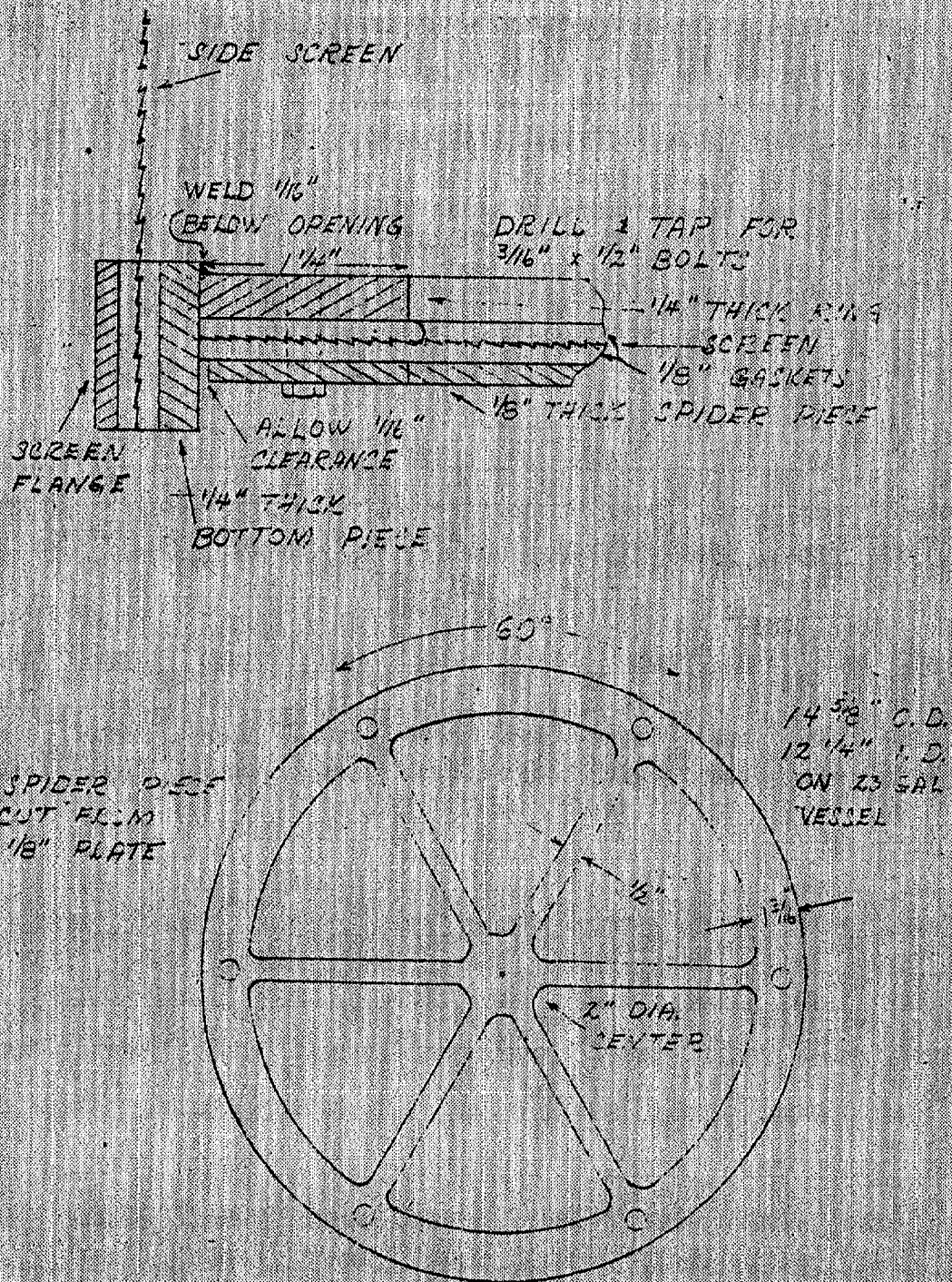


INCREASE SIDE SCREEN
AREA BY REMOVING 2"
ON DIAMETER AT
EACH SIDE OF EACH OPENING
ADD 1" WIDE STRIPS HORIZALLY
ACROSS EACH OPENING

ALTERATIONS TO PRESENT VESSELS

STUDY: P-1	TITLE: "47 PROCESS" DEVELOPMENT
ENGR: R.P.B.	PHILA. PLANT DATE: 4-15-52 NO. 1438-34

FIGURE 4



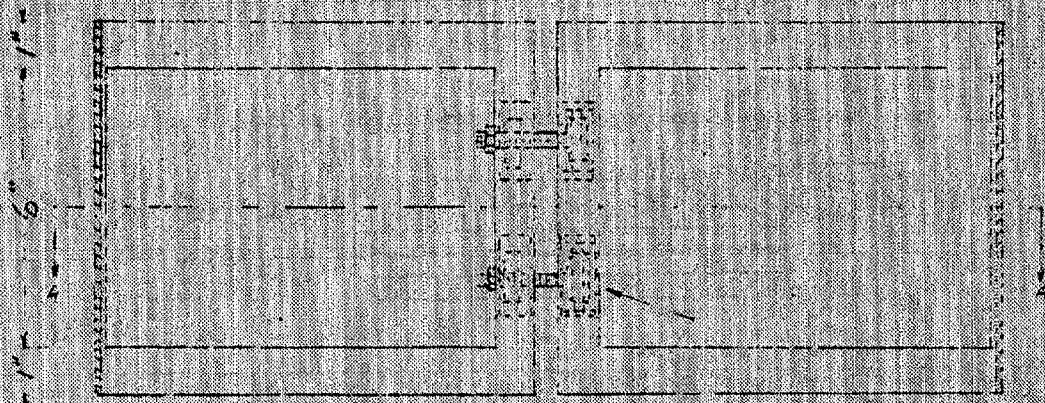
BOTTOM SCREEN ADDITION

STUDY: P-1 TITLE: "47 PROCESS" DEVELOPMENT

ENGR: RPB PHILA. PLANT DATE: 7-28-52 NO: 143837

FIGURE 5

SCREEN FLANGE



MAX OF 1"
TO ALLOW FOR
BOTTOM
JACKET

SWING
BOLT

FLANGE: 1" WIDE
31/16" THICK

1" WIDE SPACES

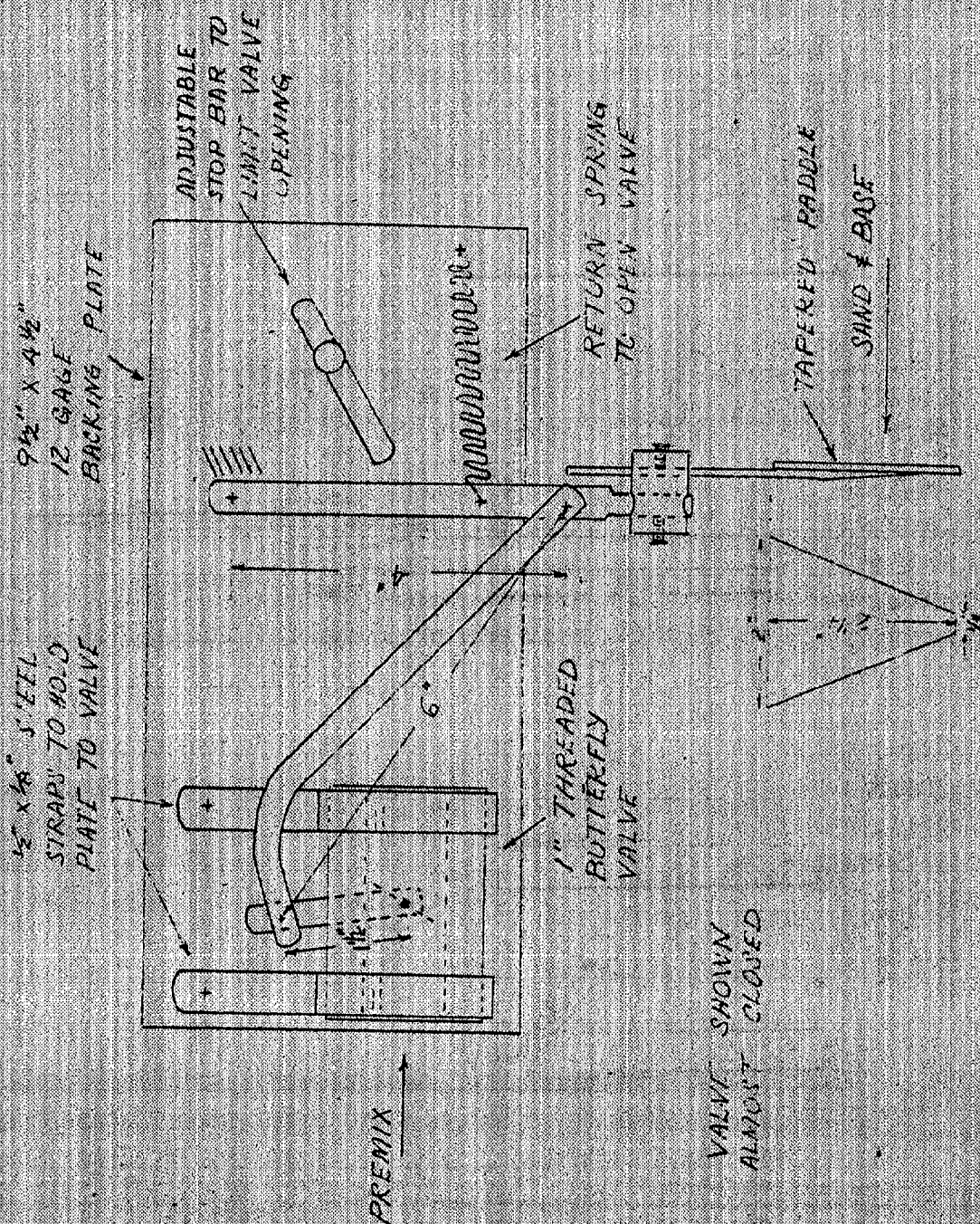
2 1/2" WIDE SPACES
AT 180° FROM
SWING BOLTS

STUDY: P-1 TITLE: "47 PROCESS" DEVELOPMENT

ENGR. R.P.B. PHILA. PLANT DATE: 4-16-52 NO 1435-36

FIGURE 6

LEVEL CONTROL VALVE METHOD "A"



STUDY: P-1

TITLE: "47 PROCESS" DEVELOPMENT

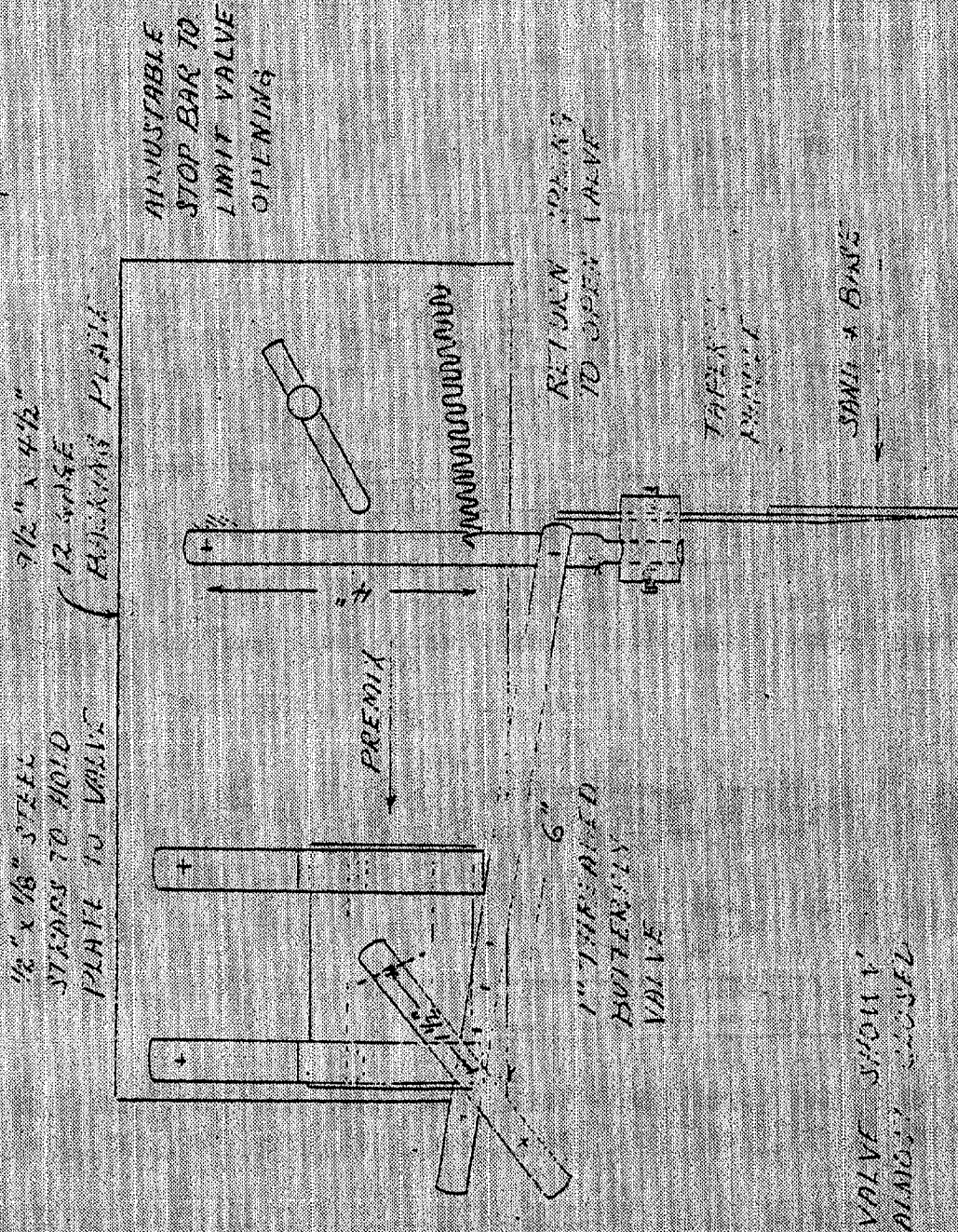
ENGR: RPB

PHILA. PLANT

DATE: 1-31-52 NO. 1438-32

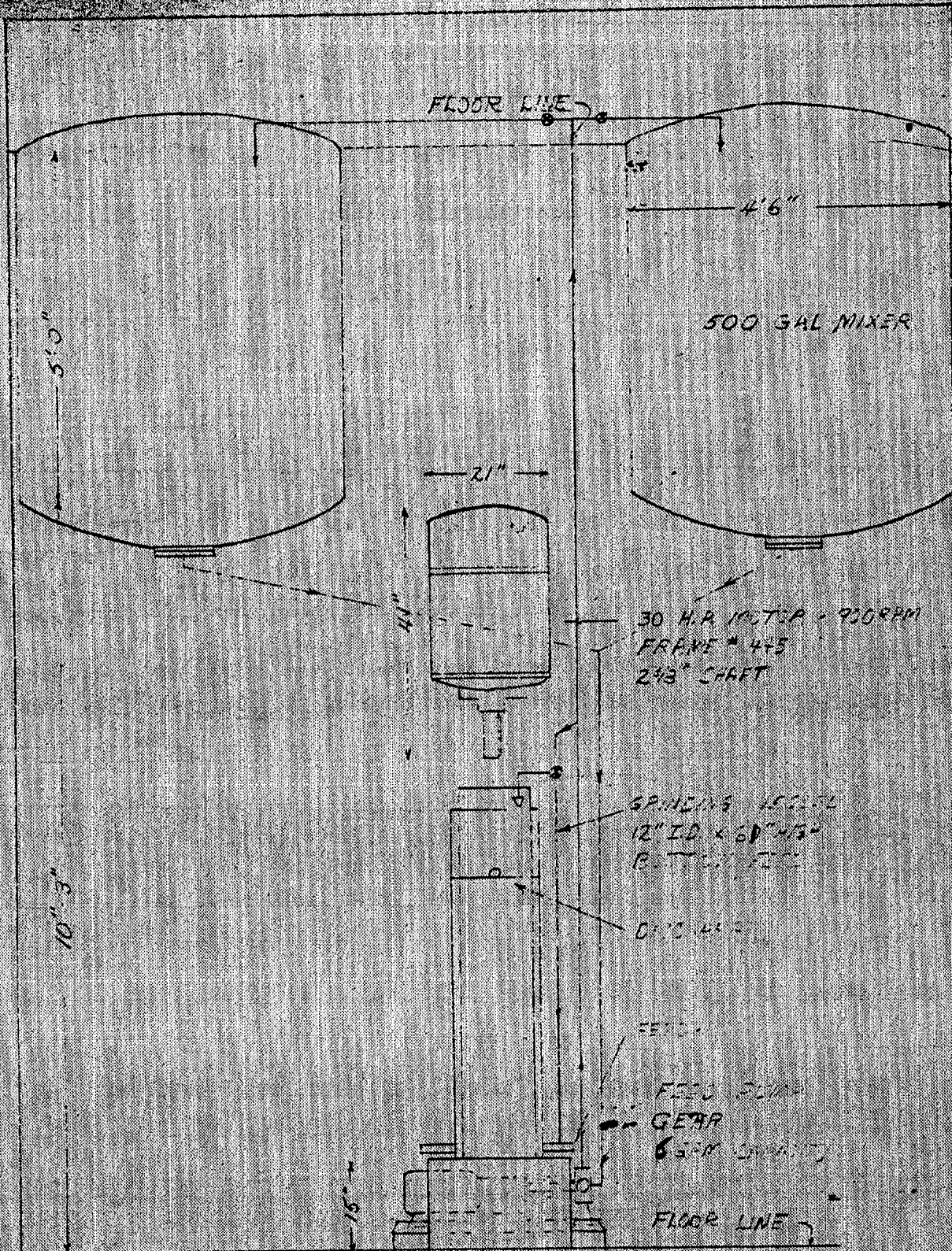
FIGURE 7

LEVEL CONTROL VALVE
METHOD "B"



STUDY: P-1 TITLE: "47 PROCESS" DEVELOPMENT
ENGR: S.P.B. PHILA PLANT DATE: 3-25-52 NO. 1438-42

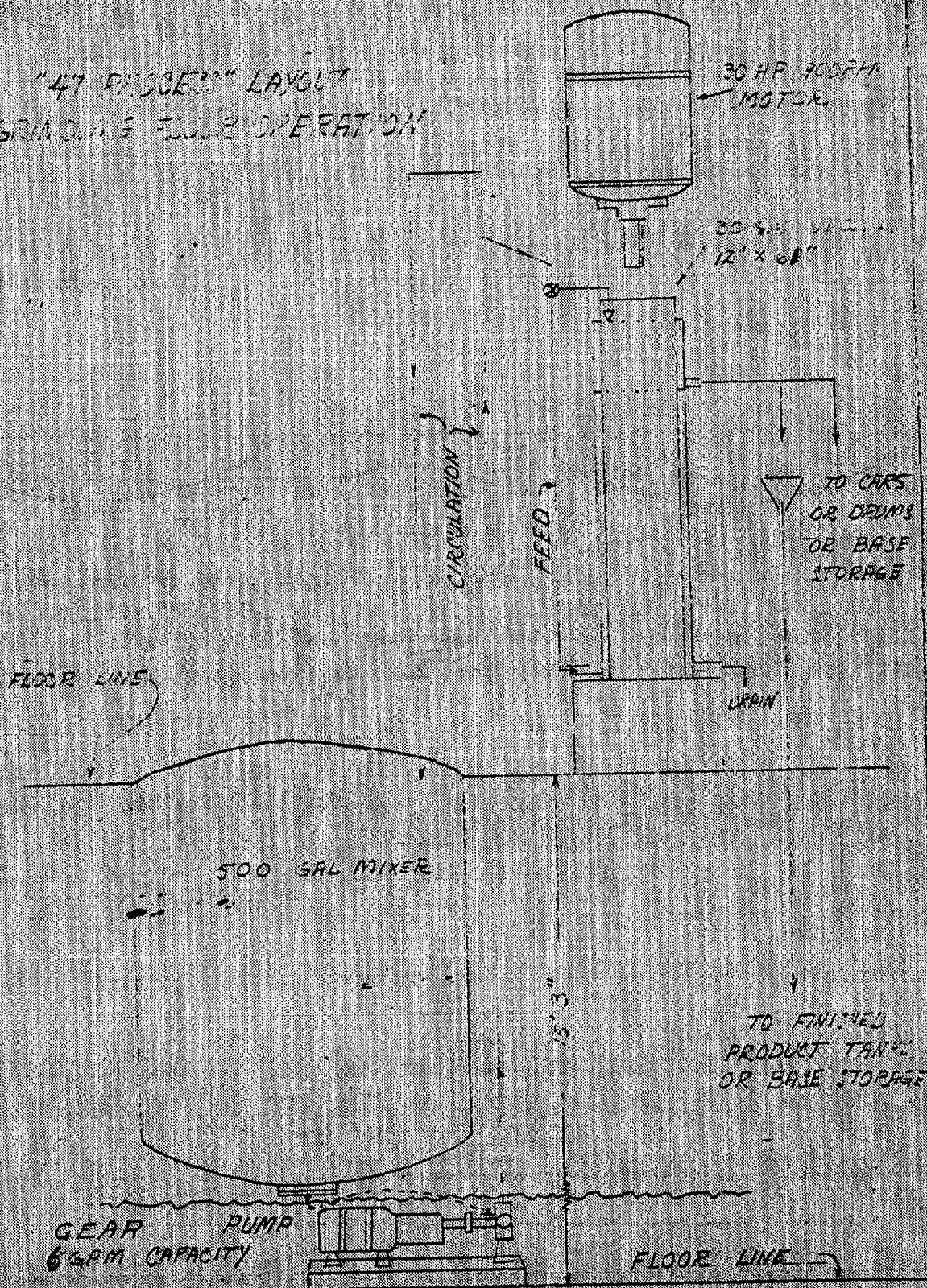
FIGURE 8



TYPICAL PROCESS "41 PROJECT" LAYOUT
 STUDY - P-1 TITLE: "41 PROJECT" DEVELOPMENT
 ENGR: RPB PHILA. PLANT DATE: 8-20-52 NO. 1433-38

FIGURE 9

"41 PROCESS" LAYOUT
GRINDING FLOOR OPERATION



STUDY P.I. TITLE: "41 PROCESS" DEVELOPMENT

ENGR: R.P.B. PHILA. PLANT DATE: 8-21-52 NO. 143B-40

INVESTIGATION OF GRINDING MEDIA

CHARACTERISTICS OF GRINDING MEDIA

Grinding Medium	Maximum % Solids	Ave. Size Microns	Pigment Size For Optimum Grinding (1) Microns	Typical Particle Sizes	
				Microns	Item
1-1/2" Pebbles	60	38,000	3,650	390	40 Mesh
1" Pebbles	60	25,400	3,360	150	80 Mesh
5/8" Steel Balls	60	15,850	2,350	104	150 Mesh
1/2" Pebbles	60	12,700	973	38	400 Mesh
1/4" Pebbles	60	6,300	238	20-50	W-31
3/16" Steel Shot	60	4,760	136	10-40	W-52
Nylon-Large	51	3,000	54	5-40	W-1
Silica-Gel	38	1,700	17.3	3-15	W-98
"Dacron"	62	1,500	13.5	.30	Chrome Yellow
10-20 Mesh Sand	62	1,300	10.1	.30	TiO ₂
20-30 Mesh Sand	62	680	2.8	.10	Lamp Black
Nylon-Small	31	200	.24	.03	Iron Blue
Carborundum-150	57	104	.06	.018	W-201
Carborundum-F	57	50	.015	.012	W-230

(1) - Pigment size for optimum grinding calculated from formula: -

$$\frac{\text{Particle Diameter}}{(\text{Ball Diameter})^2} = 5 \times 10^{-5} \quad (\text{Diameters in microns})$$

Reference: "Micromeritics" - J. M. Dalla Valle

INVESTIGATION OF GRINDING MEDIA

COMPARISON OF GRINDING MEDIA EFFICIENCY - LABORATORY SCALE

A. Dispersion of Carbon Black Base at overall formula of 6.2% pigment

Grinding Medium	Solid Specific Gravity Lbs./Gal.	Volume of Media Used	Average Particle Size Microns	Fineness Mils	Lightness Factor (1)
Nylon - Large	8.8	40	3,000	2.0	98.2
"Dacron"	9.3	47	1,500	4.0	71.1
Nylon - Small	8.8	21	- (2)	2.0	70.1
"Dacron"	9.3	56	1,500	1.5	69.1
Silica Gel	14.1	32	1,700	2.25	67.7
Sand	21.3	36	680	1.0	64.9
3/16" Steel Shot	64.1	53	4,760	1.0	64.0
Carborundum - 150	22.7	44	104	- (3)	56.7
Carborundum - F	22.7	43	50	- (3)	45.3

B. Dispersion of Carbon Black Base at high pigmentation (11.4% pigment)

Grinding Medium	Solid Specific Gravity Lbs./Gal.	Volume of Media Used	Average Particle Size Microns	Fineness Mils	Lightness Factor
Nylon - Large	8.8	40	3,000	2.0	91.0
"Dacron"	9.3	46	1,500	2.5	75.5
Nylon - Small	8.8	21	- (2)	2.5	62.2
Sand	21.3	36	680	1.5	55.9

NOTE: (1) Carbon Black Base ground 61,000 cycles in steel mill gives fineness of 0.25 and lightness factor of 50.0. Higher factor shows poorer tinting strength

(2) Small nylon was needle shaped; 200 microns diameter by about one-inch long.

(3) Carborundum was too fine to obtain complete separation and interfered with fineness readings.

EFFECT OF POWER INPUT

TINTING STRENGTH AT 6 GPH
FOR VARIOUS FORMULATIONS
OF 33-201EUGENE DIETZEN CO.
MADE IN U. S. A.NO. 340 20 DIETZEN GRAPH LAMP
20 X 20 PER INCH

LIGHTNESS FACTOR

6.2 % PIG.

9.0 % PIG.

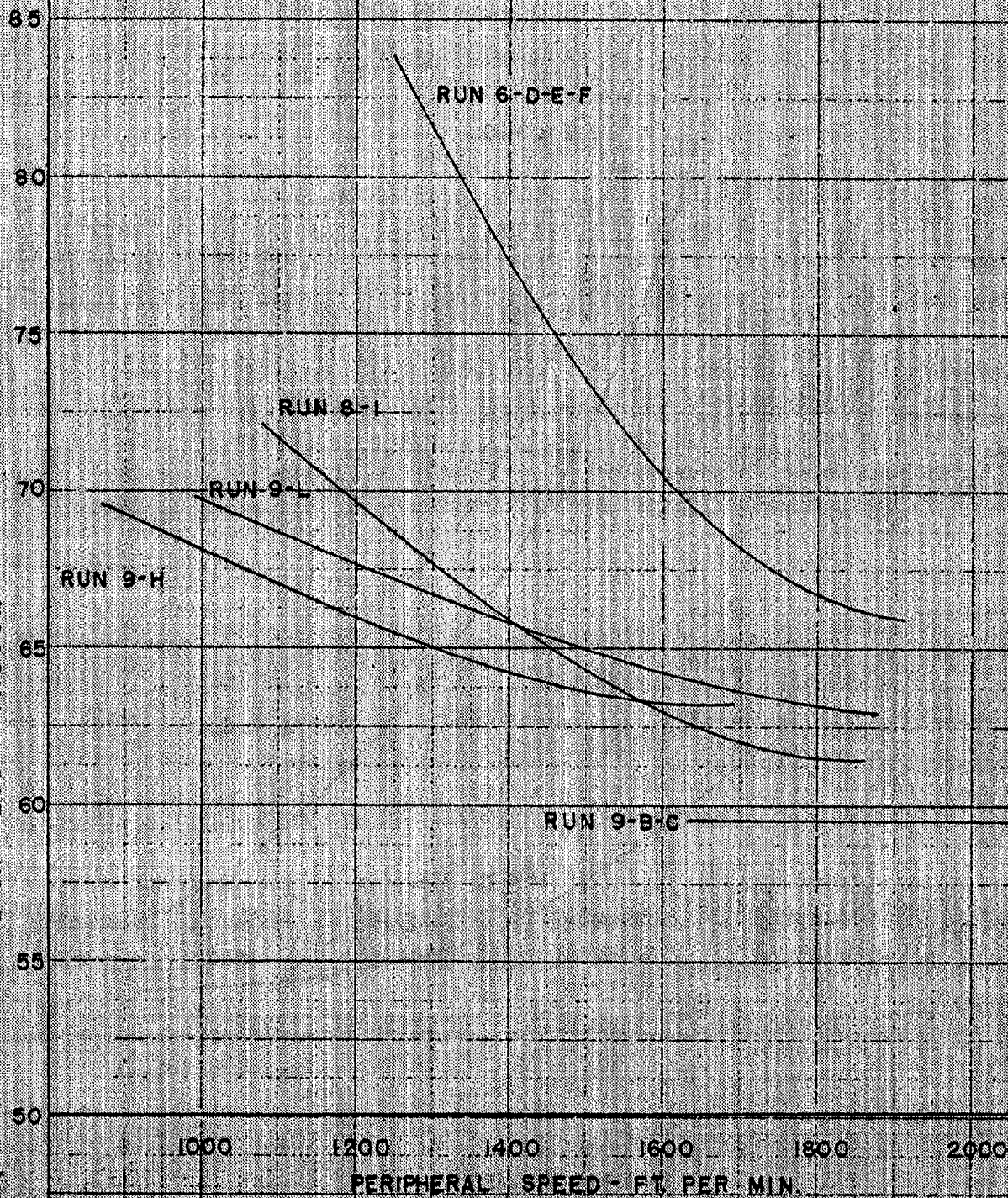
11.4 % PIG.

HORSEPOWER

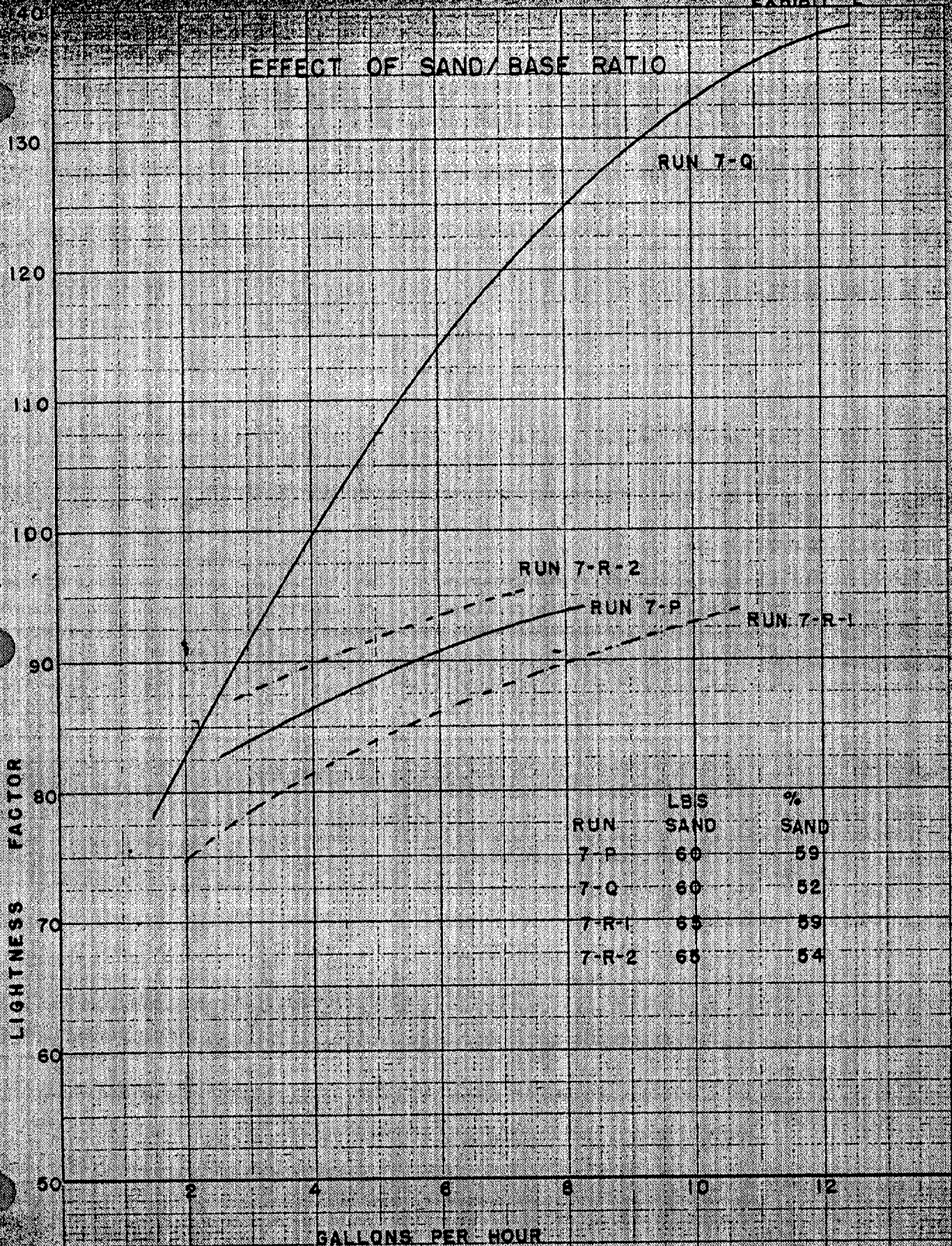
EFFECT OF AGITATOR SPEED

TINTING STRENGTH OF
33-201 AT 6 GPHLUSINE, DETICEN CO.
MADE IN U.S.A.NO. 145 30 DETICEN GRAPH PAPER
20x20 PER INCH

LIGHTNESS FACTOR



EFFECT OF SAND/BASE RATIO

EUGENE DIETZEN CO.
MADE IN U.S.A.NO. 140 30 DIETZEN GRADE PAPER
20 X 20 PER INCH

SUMMARY OF SEMI-WORKS RUNS

33-201 - CARBON BLACK BASE

Run No.	Veget. sel.	% Pig.	No. of Discs	Disc Diam. In.	Lbs. Sand	% Sand	Speed Rpm	Speed Ft./Min.	H.P.	Max. Rate GPH	Finesness at 6 GPH	Lightness at 6 GPH	Remarks
6-D	1	9.0	3	8	67-1/2	54	615	1290	3.4	3	4+	-	
6-E	1	9.0	3	8	67-1/2	56	750	1575	3.8	6	4+	69.3	
6-F	1	9.0	3	8	67-1/2	54	900	1890	5.5	10	4+	66.2	
6-G	1	9.0	3	8	67-1/2	56	975	2045	6.1	-	-	-	
6-J	1	9.0	4	8	67-1/2	56	800	1680	5.1	7	4+	69.2	
6-K	1	9.0	4	8	67-1/2	56	900	1890	6.2	16	4+	64.8	
7-A	1	9.0	4	8	40	50	600	1260	2.0	-	4+	130	Lightness factor estimated
7-B	1	9.0	4	8	45	45	600	1250	2.4	-	4+	116	"
7-C	1	9.0	4	8	45	52	900	1890	3.3	-	4+	97	"
7-D	1	9.0	4	8	50	52	600	1250	2.6	-	4+	111	"
7-E	1	6.2	4	8	50	50	700	1470	2.7	3	-	-	
7-H	1	6.2	4	8	60	57	600	1250	2.5	2	-	-	
7-I	1	6.2	4	6	60	55	900	1418	2.4	3	4+	>140	Lightness factor estimated
7-L	2	6.2	2	5-1/2	17	50	250	361	-	2	4+	>>140	"
7-M	2	6.2	2	5-1/2	17	46	1000	1440	-	2	4+	116	"
7-N	1	6.2	4	6 & 8	50	50	650	1465	2.4	7	4+	135	2 - 8 inch squeeze discs used
7-O	1	6.2	4	6 & 8	60	55	650	1465	2.6	4	4+	116	"
7-P	1	6.2	4	6 & 8	60	59	750	1575	3.2	11	4+	90.2	"
7-Q	1	6.2	4	6 & 8	60	52	750	1575	3.0	13.5	4+	114.4	"
7-R-1	1	6.2	4	6 & 8	65	59	750	1575	3.8	11	4+	86.3	"
7-R-2	1	6.2	4	6 & 8	65	54	750	1475	3.4	11	4+	93.3	"
7-T	1	6.2	4	6 & 8	75	59	750	1575	4.4	-	4.0	80	Two passes at overall formula
8-A-B	3	11.4	4	8	70	55	750	1575	3.8	30.4	3.0	58.7	2nd stage of runs 8-A
8-C	3	11.4	4	8	70	55	900	1890	4.5	25	4+	58.7	"
8-D	3	11.4	4	6	70	56	750	1480	2.1	12.3	3.75	71.5	"
8-E	3	11.4	4	6	70	57	1000	1571	2.1	18	3.75	67.5	"
8-F	3	6.2	4	6	70	57	1000	1571	3.0	6.8	4+	54.7	"
8-G	3	6.2	4	6	70	55	900	1418	2.4	10.2	4+	57.9	"
8-H	3	6.2	4	6	80	55	900	1418	2.8	10.1	4.0	56.1	"
8-I	1	11.4	3	8	60	55	900	1890	4.2	22.8	3.0	62.0	"
8-J	1	11.4	3	8	60	55	750	1575	3.4	22	3.5	62.3	"
8-K	1	11.4	3	8	60	50	500	1050	2.0	21.3	4.0	73.2	"

Run No.	Vessel	3 Pigs	No. of Discs	Disc In.	Disc	LLS. Sand	% Sand	Speed RPM	Speed Ft./Min.	H.P.	Max. Rate GPH at 6 GPH	Maximum Lightness at 6 GPH	Remarks	Unsatisfactory operation
9-A	4	11.4	4	1	77-1/2		58	1000	1835	6.5	-	3.5	59	
9-B	4	11.4	5	7	65		54	1000	1835	6.7	>30	1.25	59	
9-C	4	11.4	5	7	67		55	1150	2110	7.6	-	1.5	59	
9-D	4	11.4	5	7	67		55	900	1650	5.8	-	1.5	61	
9-E	4	11.4	5	7	72		55	900	1650	6.0	-	1.0	61	
9-G	4	11.4	6	6	67		55	900	1418	4.6	10	3.0	62.3	
9-H	4	9.0	6	6	67		54	900	1418	4.8	-	2.5	61.2	
9-I	5	6.2	7	6	90		55	1000	1571	6.1	-	0.25	64	
9-L	5	6.2	7	6	90		56	900	1418	5.1	-	0.25	66	

Vessel Reference	Description
1	6.5 gal. Modified top feed
2	1.8 gal. Standard design
3	6.5 gal. Bottom feed
4	6.5 gal. 4/1 Height to diam.
5	8.0 gal. 5/1 height to diam.

SUMMARY OF "47 PROCESS" PRODUCTIONFINISHES DIVISION - YEAR 1951PRODUCTION BY TYPE

	<u>Total Division Production Lbs.</u>	<u>Manufactured on "47 Process" Lbs.</u>	<u>% By "47 Process"</u>
Total Mill Base - All Lines ⁽¹⁾	143,840,194	22,043,253	14.3
"Dulux" Mill Base	85,912,237	19,194,319	22.3
Orthodox and Semi-Alkyd	56,703,133	380,273	0.67
746 and 46 Lines	5,219,819	2,473,576	39.7

DETAIL OF "DULUX" MILL BASE PRODUCTION
ON "47 PROCESS" BY PLANTS

<u>Plant</u>	<u>Lbs.</u>
Chicago	3,593,581
Everett	1,072,204
Fort Madison	2,177,359
Philadelphia - Ready Mix	2,681,930
Philadelphia - "Dulux"	4,256,019
South San Francisco	1,126,399
Toledo	4,126,527
Total	19,194,319

(1) - Does not include lacquer production.

POTENTIAL SAVINGS SUMMARYPROPOSAL I

All production now on ball and pebble mills be formulated for "47 Process" at present "47 Process" average rates and costs based on Philadelphia Plant's experience of 1951 (See Exhibit 5) expanded to Divisional Production.

	<u>Phila. "Dr."</u>	<u>Phila. Paint</u>	<u>Phila.</u>	<u>Division</u>
Present Costs	\$ 222,913	197,391	400,304	1,374,053
Proposed Costs	<u>142,033</u>	<u>95,937</u>	<u>236,970</u>	<u>793,827</u>
Annual Gross Savings	\$ 61,880	101,454	163,334	\$ 375,226

PROPOSAL II

Production rates of codes on "47 Process" could be doubled in proposed design installations.

	<u>Phila. "Dr."</u>	<u>Phila. Paint</u>	<u>Phila.</u>	<u>Division</u>
Present Costs	\$ 36,334	21,040	57,374	170,993
Proposed Costs	<u>21,665</u>	<u>12,534</u>	<u>34,199</u>	<u>101,930</u>
Annual Gross Savings	\$ 14,669	8,506	23,175	69,063

PROPOSAL III

Combination of Proposals I and II.

	<u>Phila. "Dr."</u>	<u>Phila. Paint</u>	<u>Phila.</u>	<u>Division</u>
Present Costs	\$ 222,913	197,391	400,304	1,374,053
Proposed Costs	<u>77,306</u>	<u>51,313</u>	<u>128,619</u>	<u>432,310</u>
Annual Gross Savings	\$ 123,607	146,078	271,685	\$ 541,743

SAVINGS DETAILDATA SHEET

BASIS:- 1951 Costs and Production of Philadelphia
"Dulux" and Paint Departments.

		<u>Ball & Pebble Mills</u>	<u>"47 Process"</u>
Mill Base Production - Lbs. - "Dulux"		12,361,384	4,239,388
Paint		30,723,080	3,012,156
No. of Grinding Mills - "Dulux"		33	"
Paint		22	2
Production Rate - Lbs./Man Hr. "Dulux"		340	400
Paint		335	490
Purchased Supplies - Cost "Dulux"		\$7,092	\$1,536
Paint		5,724	132
Repair Labor - Cost "Dulux"		\$22,668	\$4,428
Paint		16,968	2,952
Maintenance Materials - Cost "Dulux"		\$17,530	\$1,564
Paint		15,060	1,572
Media Replacement - Cost "Dulux"		\$12,216	\$ 500
Paint		46,188	330
Total Divisional Mill Base Production - Lbs. (1)		30,970,389	22,018,263
Total Divisional Mills (2)		190	25

(1) - Does not include lacquer

(2) - Does not include Farlin

SAVINGS DETAILPROPOSAL "I"

All production now on ball and pebble mills be formulated for "47 Process" at present "47 Process" average rates and costs based on Philadelphia Plant's experience of 1951 (See Exhibit J).

A. Present Facilities - "Dulux" Department1. Labora. "47 Process"

$$\frac{4,289,358 \text{ lbs.}}{100 \text{ lbs./man hr.}} \times (1.33 + 1.88 \times .09 + .07) \frac{\$}{\text{hr.}} = 22,733$$

b. Ball & Pebble

$$\frac{12,361,834 \text{ lbs.}}{340 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = 77,079$$

2. Suppliesa. "47 Process"

11,526

b. Ball & Pebble

7,082

3,628

3. Repair Labora. "47 Process"

14,428

b. Ball & Pebble

22,563

27,096

4. Maintenance Materiala. "47 Process"

11,364

b. Ball & Pebble

17,580

18,144

5. Media Replacementa. "47 Process"

4,500

b. Ball & Pebble

12,216

12,716

6. Depreciation - Based on replacement costsa. "47 Process"

$$.05 \times 4 \times \$9,306 \text{ (See Exhibit G)} = 1,861$$

b. Ball & Pebble

$$\text{Investment based on volume of 22 mills}$$

$$.05 \times \frac{2425}{113} \times \$17,222 \text{ (See Exhibit H)} = 17,596$$

17,596

7. Welfarea. "47 Process"

$$15.89\% \text{ of Direct Labor of}$$

$$.1589 \times \$22,733 = 33,512$$

b. Ball & Pebble

$$.1589 \times \$77,079 = 12,243$$

15,860

Philadelphia "Dulux" Annual Cost ----- \$ 202,913

B. Proposed Facilities - "Dulux" Department

1. Labor

$$\frac{16,651,272 \text{ lbs.}}{400 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = 938,252$$

2. Supplies

$$\frac{16,651,272}{4,289,383} \times 31,535 = 5,960$$

3. Repair Labor

$$\frac{16,651,272}{4,289,383} \times 44,423 = 17,181$$

4. Maintenance Material

$$\frac{16,651,272}{4,289,383} \times 32,569 = 6,068$$

5. Media Replacement

$$\frac{16,651,272}{4,289,383} \times 5,500 = 1,940$$

6. Depreciation

$$.03 \times \frac{16,651,272}{4,289,383} \times 4 \times 9,606 = 7,589$$

7. Welfare

$$.1539 \times 938,252 = 144,133$$

TOTAL 1,441,035

C. Present Facilities - Paint Department

1. Labor

a. "47 Process"

$\frac{3,012,156 \text{ lbs.}}{130 \text{ lbs./man hr.}} \times 2.12 \frac{\text{¢}}{\text{hr.}} = 613,032$

b. Ball & Pebble

$\frac{13,728,080 \text{ lbs.}}{335 \text{ lbs./man hr.}} \times 2.12 \frac{\text{¢}}{\text{hr.}} = 87,659$

2. Supplies

a. "47 Process"

\$4,282

b. Ball & Pebble

5,724

5,856

3. Repair Labor

a. "47 Process"

\$2,952

b. Ball & Pebble

16,968

19,920

4. Maintenance Material

a. "47 Process"

\$1,572

b. Ball & Pebble

15,060

16,632

5. Waste Replacement

a. "47 Process"

\$ 300

b. Ball & Pebble

46,183

46,483

6. Depreciation

a. "47 Process"

$.05 \times 2 \times 9,806$

981

b. Ball & Pebble

Investment based on volume of 32 million

$.05 \times \frac{1,827}{118} \times 1,171,022$

13,769

7. Welfare

a. "47 Process"

15.89% of Direct Labor or

$.1589 \times \$13,032 = \$2,071$

b. Ball & Pebble

$.1589 \times \$67,859 = 10,783$

12,854

Total

\$197,391

D. Proposed Facilities - Paint Department1. Labor

$$\frac{13,735,236 \text{ lbs.}}{490 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = 59,424$$

2. Supplies

$$\frac{13,735,236}{3,012,156} \times \$132 = 602$$

3. Repair Labor

$$\frac{13,735,236}{3,012,156} \times \$2,932 = 13,461$$

4. Maintenance Material

$$\frac{13,735,236}{3,012,156} \times \$1,572 = 7,138$$

5. Media Replacement

$$\frac{13,735,236}{3,012,156} \times \$1,300 = 4,868$$

6. Depreciation

$$.05 \times \frac{13,735,236}{3,012,156} \times 2 \times \$9,806 = 4,472$$

7. Welfare

$$.1589 \times 59,424 = 9,442$$

Total

95,937

E. Divisional Facilities(Present)

Estimated on basis of Philadelphia Plant experience and Divisional production and number of mills.

1. Labor

a. "47 Process"

$$\frac{22,048,268 \text{ lbs.}}{[(400 + 490) + 2] \text{ lbs/man hr.}} \times 2.12 \frac{\text{hr.}}{\text{hr.}} = \$105,039$$

b. Ball & Pebble

$$\frac{30,970,389 \text{ lbs.}}{[(340 + 335) + 2] \text{ lbs/man hr.}} \times 2.12 \frac{\text{hr.}}{\text{hr.}} = 508,609$$

2. Supplies

a. "47 Process"

$$\frac{22,048,268 \text{ lbs.}}{(4,289,388 + 3,012,155) \text{ lbs.}} \times \$ (1536 + 132) = 5,037$$

b. Ball & Pebble

$$\frac{30,970,389 \text{ lbs.}}{(12,351,384 + 10,723,080) \text{ lbs.}} \times \$ (7092 + 5724) = 44,946$$

3. Repair Labor

a. "47 Process"

$$\frac{22,048,268 \text{ lbs.}}{7,301,544 \text{ lbs.}} \times \$ (2422 + 2252) = 22,283$$

b. Ball & Pebble

$$\frac{30,970,389 \text{ lbs.}}{23,034,964 \text{ lbs.}} \times \$ (22,668 + 16,968) = 130,003$$

4. Maintenance Material

a. "47 Process"

$$\frac{22,048,268 \text{ lbs.}}{7,301,544 \text{ lbs.}} \times \$ (1536 + 1372) = 9,471$$

b. Ball & Pebble

$$\frac{30,970,389 \text{ lbs.}}{23,034,964 \text{ lbs.}} \times \$ (17,620 + 15,060) = 114,468$$

5. Media Replacementa. "47 Process"

$$\frac{22,046,263}{7,301,544} \text{ lbs.} \times \$ (510 + 300) = \$2,416$$

b. Ball & Pebble

$$\frac{30,972,389}{23,034,964} \text{ lbs.} \times \$ (12,216 + 46,133) = 204,623$$

6. Depreciationa. "47 Process"

Based on number of standard 25-gallon units
 No. of Std. units for 25 total units = 20.5 std. units
 $20.5 \times .05 \times \$9,806 = 10,051$

b. Ball & Pebble

Based on capacity as compared with 6 x 6 Pebble Mill
 190 total mills x

$$\left[\frac{2425 \text{ cu. ft.} / 128 \text{ cu. ft. per std. mill}}{30 \text{ mills}} \right] \times \frac{1887 / 118}{23} \times 1/2$$

$$= 126.2 \text{ Std. Divisional Mills}$$

$$126.2 \times .05 = 63,223 = 111,393$$

7. Welfarea. "47 Process"

$$.1539 \times \$105,039 = 16,169$$

b. Ball & Pebble

$$.1569 \times \$516,619 = 80,318$$

$$\text{Total} = \$1,074,053$$

F. Divisional Facilities (Proposed)1. Labor

$$\frac{(22,048,268 + 30,970,339) \text{ lbs.}}{445 \text{ lbs./man hr.}} \times 2.12 \frac{\text{hr.}}{\text{hr.}} = \$490,780$$

2. Supplies

$$\frac{103,018,657 \text{ lbs.}}{22,048,268 \text{ lbs.}} \times \$5,937 = 23,523$$

3. Repair Labor

$$\frac{103,018,657 \text{ lbs.}}{22,048,268 \text{ lbs.}} \times \$22,238 = 104,035$$

4. Maintenance Material

$$\frac{103,018,657 \text{ lbs.}}{22,048,268 \text{ lbs.}} \times \$9,471 = 44,230$$

5. Media Replacement

$$\frac{103,018,657 \text{ lbs.}}{22,048,268 \text{ lbs.}} \times \$2,416 = 11,283$$

6. Depreciation

$$.05 \times \frac{103,018,657 \text{ lbs.}}{22,048,268 \text{ lbs.}} \times 20.5 \times \$9,806 = 45,941$$

7. Welfare

$$.1559 \times \$490,780 = 77,935$$

Total

3,706,527

SAVINGS DETAILPROPOSAL "II"

Production rates on "47 Process" could be doubled by using the proposed design installations.

A. Present Facilities - "Dulux" Department

1. Labor				
	$\frac{4,289,388 \text{ lbs.}}{400 \text{ lbs./man-hr.}}$	$\times 2.12$	$\frac{\$}{\text{hr.}}$	$=$
				\$22,733
2. Supplies				1,536
3. Repair Labor				4,428
4. Maintenance Material				1,564
5. Media Replacement				500
6. Depreciation				
	$.05 \times 4 \times \$9,805$	$=$		1,961
7. Welfare				
	$15.89\% \times \$22,733$			3,612
		Total		\$35,334

B. Proposed Facilities - "Dulux" Department

1. Labor - 60% Direct Attention Time				
	$\frac{4,289,388 \text{ lbs.}}{(400 \times .60 \times 2) + (400 \times .40)}$	$\times 2.12$	$\frac{\$}{\text{hr.}}$	$=$
				\$14,209
2. Supplies	$\$1,536 \times .5$			768
3. Repair Labor	$\$4,428 \times .5$			2,214
4. Maintenance Material	$\$1,564 \times .5$			782
5. Media Replacement				500
6. Depreciation				
	$.05 \times 4 \times .5 \times \$9,337$	$=$		934
7. Welfare				
	$15.89\% \times \$14,209$	$=$		2,258
		Total		\$ 21,665

C. Present Facilities - Paint Department

1. Labor

$$\frac{3,012,156 \text{ lbs.}}{490 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = \$13,032$$

2. Supplies

132

3. Repair Labor

2,952

4. Maintenance Material

1,572

5. Media Replacement

300

6. Depreciation

$$.05 \times 2 \times \$9,806 =$$

981

7. Welfare

$$15.89\% \times \$13,032 =$$

2,071

Total

\$ 21,040

D. Proposed Facilities - Paint Department

1. Labor - 60% Direct Attention Time

$$\frac{3,012,156 \text{ lbs.}}{(490 \times .60 \times 2) + (490 \times .40) .09/\text{man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = 8,145$$

2. Supplies

$$132 \times .5$$

66

3. Repair Labor

$$2,952 \times .5$$

1,476

4. Maintenance Material

$$1,572 \times .5$$

786

5. Media Replacement

300

6. Depreciation

Only one-half the number of units required

$$.05 \times 2 \times .5 \times \$9,806 =$$

491

7. Welfare

$$15.89\% \times \$8,145$$

1,294

Total

\$ 12,534

E. Divisional Facilities - Present

1. Labor	
$\frac{22,948,268 \text{ lbs.}}{445 \text{ lbs./can hr.}} \times 2.12 \frac{\$}{\text{hr.}} =$	\$105,039
2. Supplies	5,037
3. Repair Labor	22,238
4. Maintenance Material	9,471
5. Media Replacement	2,416
6. Depreciation	10,051
7. Welfare	16,691
Total	\$170,993

F. Divisional Facilities - Proposed

1. Labor - 60% Direct Attention Time	
$\frac{22,948,268 \text{ lbs.}}{445 \text{ lbs./can hr.}} \times 2.12 \frac{\$}{\text{hr.}} =$	\$105,039
2. Supplies	5,037 x .5
3. Repair Labor	\$22,238 x .5
4. Maintenance Material	\$9,471 x .5
5. Media Replacement	2,416
6. Depreciation	.05 x 20.5 x .5 x 69,808
7. Welfare	1669 x 65,665
Total	\$101,330

SAVINGS DETAILPROPOSAL "III"

Combine Proposals "I" and "II" in that all ball and pebble production be placed on "47 Process" at double present rates. Only one-half the number of units will be required and in addition screen and pump wear will be substantially reduced.

A. Present Facilities - "Dulux" Department

Same as in Proposal "I" - A

\$203,913

B. Proposed Facilities - "Dulux" Department

1. Labor

$$\frac{16,651,272 \text{ lbs.}}{640 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = \$ 55,157$$

2. Supplies

$$\frac{16,651,272}{4,289,388} \times .5 \times \$1,536 = 2,980$$

3. Repair Labor

$$\frac{16,651,272}{4,289,388} \times .5 \times .5 \times \$4,428 = 4,235$$

4. Maintenance Material

$$\frac{16,651,272}{4,289,388} \times .5 \times .5 \times \$1,368 = 1,517$$

5. Media Replacement

$$\frac{16,651,272}{4,289,388} \times .5 \times \$600 = 970$$

6. Depreciation

$$.05 \times \frac{16,651,272}{4,289,388} \times 7 \times .5 \times \$4,337 = 1,023$$

7. Welfare

$$.1589 \times \$55,157 = 8,764$$

Total \$ 77,305

C. Present Facilities - Paint Department

Same as in Proposal "I" - C

\$197,391

D. Proposed Facilities - Paint Department

1. Labor

$$\frac{13,735,236 \text{ lbs.}}{734 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} =$$

\$ 37,140

2. Supplies

$$\frac{13,735,236}{3,012,156} \times .5 \times \$132 =$$

301

3. Repair Labor

$$\frac{13,735,236}{3,012,156} \times .5 \times .5 \times \$2,952 =$$

3,365

4. Maintenance Material

$$\frac{13,735,236}{3,012,156} \times .5 \times .5 \times \$1,572 =$$

1,792

5. Media Replacement

$$\frac{13,735,236}{3,012,156} \times .5 \times \$300 =$$

404

6. Depreciation

$$.05 \times \frac{13,735,236}{3,012,156} \times 2 \times .5 \times \$9,337 =$$

2,129

7. Welfare

$$.1539 \times \$37,140 =$$

5,902

Total

\$ 51,313

E. Present Facilities - Division

Same as in Proposal "I" - E

\$1,374,053

F. Proposed Facilities - Division

1. Labor

$$\frac{103,018,657 \text{ lbs.}}{712 \text{ lbs./man hr.}} \times 2.12 \frac{\$}{\text{hr.}} = \$ 306,743$$

2. Supplies

$$\frac{103,018,657}{22,048,268} \times .5 \times \$5,037 = 11,762$$

3. Repair Labor

$$\frac{103,018,657}{22,048,268} \times .5 \times .5 \times \$22,288 = 26,021$$

4. Maintenance Material

$$\frac{103,018,657}{22,048,268} \times .5 \times .5 \times \$9,471 = 11,058$$

5. Media Replacement

$$\frac{103,018,657}{22,048,268} \times .5 \times \$2,416 = 5,642$$

6. Depreciation

$$.05 \times \frac{103,018,657}{22,048,268} \times 20.5 \times .5 \times \$9,337 = 22,343$$

7. Welfare

$$.1589 \times \$306,743 = 48,743$$

Total

\$ 432,319

ESTIMATE

Purchase and Installation of a 6x6 PLW Mill

	<u>Labor</u>	<u>Material</u>	<u>Total</u>
1 - 6x6 Mill	\$ -	\$ 6,110	\$6,110
7,800 lbs. Pebbles	-	1,287	1,287
Perox Block Lining	600	1,450	2,050
Rig & Install	140	20	160
1 - SKF Trunion Bearings	80	900	980
2 - SKF Jackshaft Bearings	80	250	330
2 - Base Plates for Bearings	40	125	165
1 - Jackshaft	40	200	240
1 - Vee Belt Drive with Pulleys & Belts	200	700	900
1 - Belt Guard	80	40	120
1 - Mechanical Brake	250	650	900
1 - Pair Steel Safety Bands	200	125	325
1 - Limit Switch on Brake	35	25	60
1 - 30 H.P. 900 RPM Explosion Proof Motor	80	1,200	1,280
1 - 30 H.P. Starter, Disconnect Switch, Push Button Station, Wire & Conduit	240	205	445
1 - Sarco Temp. Regulator	150	110	260
2 - Sarco Rotary Unions	40	70	110
1 - Productometer	70	100	170
1 - 2" Discharge Valve	40	35	75
Water Piping	80	30	110
Painting	80	15	95
Safety Guard	50	125	175
Totals	\$ 2,575	\$13,772	\$16,347

Administration: 34% of Direct Labor

.34 x \$2,575 =

875

GRAND TOTAL

\$17,222

NOTE: The above estimate does not include any dismantling and rearrangement charges and assumes the building is prepared to take the installation.

Estimate based on recent proposed Philadelphia Plant Major Project.

ESTIMATE

Installation of a Present Standard 23-gallon "47 Process" Unit.

	<u>Labor</u>	<u>Material</u>	<u>Total</u>
2 - 500-gallon Premix Tanks	\$ -	\$ 1,200	\$1,200
2 - 5 H.P. 100 RPM Vertical Motor Reducers	150	1,200	1,350
2 - Agitators	120	550	670
2 - 2-1/2" Flush Bottom Tank Valves	40	300	340
1 - Foster pump with Motor Reducer	50	640	690
1 - Mercoid Switch Level Control	30	35	65
1 - 10 H.P. Explosion Proof Motor	130	340	470
1 - Philadelphia Gear Reducer	70	340	410
1 - 23-gallon Grinding Vessel	120	200	320
1 - Agitator, Hubs, Discs, Wave & Heat Treat	120	40	160
220 lbs. Sand	-	12	12
Process Piping	100	45	145
Water Piping	30	25	55
Hydraulic Table	30	350	380
Electrical Starters & Wiring	530	370	900
Installation of Tanks	320	120	440
Steel Channels, Frames, Stands, etc.	355	450	805
Totals	\$2,335	\$6,717	\$9,052

Administration: 34% of Direct Labor

.34 x \$2,303 =

784

GRAND TOTAL

\$9,836

NOTE: The above estimate does not include any dismantling and rearrangement charges and assumes the building is prepared to make the installation.

Estimate based on previous Philadelphia Plant projects with adjustments for increased costs.

ESTIMATE

Installation of a Proposed Standard 30-gallon "47 Process" Unit.

	<u>Labor</u>	<u>Material</u>	<u>Total</u>
2 - 500-gallon Premix Tanks	\$ -	\$ 1,200	\$1,200
2 - 5 H.P. 100 RPM Vertical Motor Reducers	150	1,200	1,350
2 - Agitators	80	400	480
2 - 3" Powell (Figure 2310) Flush Bottom Valves	40	215	255
1 - 5 GPM Pump and Motor	50	640	690
Steel channels, Frames, Stands, etc.	365	450	815
Butterfly Valve Level Control System	50	20	70
Solenoid Safety Shut Off	30	110	140
1 - 30 H.P. 900 RPM Explosion Proof Motor	80	1,200	1,280
1 - 30-gallon Vessel - New Design	120	200	320
1 - Agitator, Discs and Hubs	100	40	140
275 lbs. Sand	-	14	14
Process Piping	200	90	290
Water Piping	100	50	150
Installation of Tanks	300	120	420
Electrical Starters & Wiring	550	370	920
Honeywell H1 Lift Hand Control Valve	-	50	50
Totals	\$2,215	\$6,369	\$8,584

Administration: 34% of Direct Labor

.34 x \$2,215 =

753

GRAND TOTAL

\$9,337

NOTE: The above estimate does not include any dismantling and rearrangement charges and assumes the building is prepared to take the installation.

Estimate based on previous Philadelphia Plant's projects with adjustments for increased costs and quotations for new items.

EQUIPMENT SPECIFICATION LIST "4" PROCESS"

EXHIBIT Q
(Sheet 1)

I. PREMIX EQUIPMENT

Equipment Piece	30-Gallon	16-Gallon	8-gallon	Remarks (Ref. Dwg.)
A. Mixer	500-gallon, all-welded std. du tone mixer with flanged bottom outlet.	Same	No std.	Dwg. W-78893 revised to show flanged bottom outlet. 6-1/8" bore, 1-1/2" deep.
B. Drive	5HP vertical motor reducer, Class 1, Group 0 motor, full-line gear no. VC-254 with extended shaft, 100rpm.	Same	No std.	Overall shaft length as shown on Dwg. W-97505. Voltage to suit plant.
C. Agitator	40", 30" up travel, 4" projected height, single bottom blade, 1" bottom clearance, for 2-11/16" shaft.	Same	No std.	Dwg. ED-95359 Use 2-11/16" shaft.
D. Valve	3" Powell Valve, V45, 2310 flush type, cast carbon steel bank valve with five flanged face and drilled for standard 6" pipe flange.	Same	No std.	Powell Valve Co. Fig. 2310.

II. FEED SYSTEM

Equipment Piece	16-gallon	8-gallon	Remarks
A. Pump	Viking straight-line unit, 60cc, iron construction with 2" screened port (reduced to 1"), all iron recirculation valve, 35 PSI, and hazardous liquid gland on equivalent, mounted on cast iron base with 1/2", 50 rpm, 3 phase, 60 cycle, glass 1, group B exp. proof Phila. gear motor with class II gear. Voltage to suit plant. Pump to deliver 6 GPM against 25 PSI.	No std.	Voltage to suit plant
B. Piping	Recirculation through 1" iron C/straight runs and bends in place of elbows. Recirculation W/unions to permit easy disassembly. Tap off from recirculation line to level control line. 1/2" male teeoff with 1" male female union. Bevel all pipe ends for smooth flow	No std.	Schematic arrangement Dwg. No. 1438-38 in "47 Process" Report. (Fig. 8)
C. Level Control	Butterfly valve operated through pilot valve lever 25 PSI. Valve is located 11' (W. anemometer) 60" 25 PSI. 1/2" threaded butt-welded valve.	Same where recirculation system used.	Dwg. No. 1438-42, 1438-32 in "47 Process" Report (Fig. 6 & 7)

Equipment Piece	Location	Remarks
D. Safety Shutoff	Discontinued - See Fig. 11 for wiring diagram, specifications and details.	Discontinued - See Fig. 11 for wiring diagram, specifications and details.

III. "47 PROCESS" AGITATOR & DRIVE

EXHIBIT Q
(Sheet 4)

Equipment Piece	30-pullon	16-pullon	8-pullon	Remarks
A. Drive	50HP, 900rpm(nominal). Squirrel cage induction motor for vertical mounting w/shaft down. High starting torque. Frame size 445 Class 1 Group D with 2-3/8" shaft.	15HP, 900rpm(nominal). Squirrel cage induction motor for vertical mounting w/shaft down. High starting torque. Frame size 404 Class 1 Group D with 2-1/8" shaft.	7.5HP, 900rpm(nominal). Squirrel cage induction motor for vertical mounting w/shaft down. High starting torque. Frame size 355 Class 1 Group D with 1-5/8" shaft.	Std. motors as supplied by GE, Allis Chalmers, Westinghouse, etc. voltage specification to suit plant.
B. Shaft	1-15/16" D cold finished SAE 1040 steel shafting.	1-15/16" D cold finished SAE 1040 steel shafting.	1-11/16" D cold finished SAE 1040 steel shafting.	Phila. Diag. Nos.: P-1011 P-1012 P-1008
C. Coupling	Phillie gear steel flanged coupling, size No. 2535 1/2-3/8" bore top half and 1-15/16" bore bottom half. Keyways: 5/8" x 5/16" and 1/2" x 1/4"	Phillie gear steel flanged coupling, size No. 2534 1/2-1/8" bore top half and 1-15/16" bore bottom half. Keyways: 1/2" x 1/4"	Phillie gear steel flanged coupling, size No. 2532 1/2-5/8" bore top half and 1-11/16" bore bottom half. Keyways: 3/8" x 3/16"	
D. Discs	1/4" tool steel hardened to 60 Rockwell C by heat treatment.	Same.	Same.	Detail per Phila. Diag. Nos.: P-1011 P-1012 P-1008
E. Hubs	SAE 1040 cold finished steel shafting, heat-treated to size.			Phila. Diag. Nos.: P-1011 P-1012 P-1008
F. Arrangement	Shaft with 1/2 coupl- ing, hub and discs to be dynamically balanced.	Same.	Same.	Phila. Diag. Nos.: P-1011 P-1012 P-1008

IV. VESSELS

Equipment Piece	Description	Item No.	Quantity	Remarks
A. Vessel	Bottom floor, top and bottom - Same General spec. Detail - Phila. Dwg. No. P-1007			
	Change 5/4 inch hole - Detail - Phila. Dwg. No. P-1010			
	Detail - Phila. Dwg. No. P-1006			
B. Screen	Steel Wire Cloth, 30 mesh, 36" x 60" diam. 6" x 6" holes, bottom 6" with wires to nearest 1/2" from vertical when installed.			Supplier: Buffalo Wire Works Tyler Screen Co., etc. Specification detail per Phila. Dwg. Nos. P-1006 P-1010 P-1007
C. Grate	Flange, 60" dia			Supplier: General Machine Co. Dimensions as specified

V. OTHER

Equipment Piece	30-gallon	16-gallon	8-gallon	Remarks
A. Sand	20-30 mesh, Ottawa Silica, std. ASTM sand.	Same	Same	Supplier: Ottawa Silica Co. Ottawa, Illinois
B. Sand Loading	For 50/50 sand-to-base ratio = 260 pounds. Operating level = 3" from top of vessel.	For 50/50 sand-to-base ratio = 140 pounds. Operating level = 3" from top of vessel.	For 50/50 sand-to-base ratio = 75 pounds. Operating level = 3" from top of vessel.	
C. Vessel & Drive Arrangement	Phila. Dwg. No. P-1011	Phila. Dwg. No. P-1012	Phila. Dwg. No. P-1008	Suggested arrangements only - alter to fit local condition.
D. Discharge Rate Control	Minneapolis-Honeywell HI-Lift Hand Control Valve = 1". M.R. Spec. sheet No. 403 Fig. 2	Same	Same	Convenience only as replacement for perforated pipe caps. Precise calibration not independent of viscosity and grinding rate.

VI. COMPARATIVE SPECIFICATIONS FOR 30-GALLON, 16-GALLON AND 8-GALLON VESSELS

	Size Unit		
	30-gal.	16-gal.	8-gal.
Inside Diameter - inches	12	10	8
Height - inches	61	51	41
Disc Diameter - inches	10	8	6
Number of discs	10	8	7
Sand Load - pounds	260	140	75
Horsepower of Drive	50	15	7-1/2
Speed of Motor - RPM	900	900	900

TESTING PROCEDURE FOR CARBON BLACK BASE, 33-201,SAMPLES FROM "47 PROCESS" DEVELOPMENT STUDYA. FINENESS

1. Stir sample and run fineness, as is, on Hegman Fineness Gage.
2. If sample is not at overall 33-201 formula, make necessary additions to bring to normal formula and repeat fineness test.
3. Reduce overall formula on the ratio of 1 to 1 with thinning solution and repeat fineness test. Thin down solution:-
RC-448 - 2 parts
T-4627 - 1 part
4. Prepare small glass flow-out panel using the reduced sample.

B. GLOSS

1. Prepare finished product formula 094-0201 using overall 33-201 formula sample from A-2 above. Prepare as follows:-

Overall 33-201 formula sample: - 20.0 gms.

Reducing solution: - 29.3 gms.

Reducing solution is made up as follows:-

RC-3083 - 281 gms.

VX-5350 - 60 gms.

H-29 - 108 gms.

2. Using .0033 Doctor Blade prepare draw-down on 4" x 8" glass panel from 094-0201 sample prepared in (1) above.
3. Bake panel 25 min. at 225° F.
4. Read gloss on both Gardner and Universal meters.

C. TINTING STRENGTH

1. Filter through felt strainer unused portion of 094-0201 sample prepared in B-1 above.
2. Make up tinting strength sample as follows:-
1 part 094-0201 - 20 gms.
5 parts 094-0043 - 100 gms.

3. Using .0033 Doctor Blade prepare draw-down on 4" x 8" glass panels from tinting strength sample in (2) above.
4. Bake panel 25 min. at 225°F.
5. Take Green, Blue and Red readings on du Pont Differential Colorimeter after standardizing colorimeter at 50.0. Standardize machine as follows:-
 - (a) Prepare two tinting strength panels as above using standard steel mill ground 33-201 and the same 094-0043 as for test sample.
 - (b) Mark one panel "Standard" and other "Reference" and place in prescribed positions on colorimeter.
 - (c) Set light gate micrometer at 50.0.
 - (d) Adjust Green, Blue and Red knobs until ammeter reads zero on each filter position.
 - (e) Remove "Standard" panel and replace with test sample panel.
 - (f) Take Green, Blue and Red readings.
6. Green reading is lightness factor. The lower the reading the better the tinting strength of the black base.
7. Calculate "r" and "s" values and plot to determine saturation and hue.

CAPACITY REPORTS - "47 PROCESS"

RECOMMENDED REVISIONSI. PRESENT PRACTICE

"47 Process" Capacity Reports have the functions of determining (1) The production by code of bases ground by "47 Process"; (2) The grinding capacity of the various plants' "47 Process" units; (3) The % capacity at which the units are operating; and (4) The rates actually obtained by the plants on each code.

Capacities are determined by summarizing the production of a plant and the hours required to produce this amount and using the following calculation:-

Gallons Capacity = $\frac{\text{Gallons produced}}{\text{Hours required}} \times \text{No. of Std. Units} \times 520 \text{ hours}$
per month $\times$ allowed eff. factor.

% Capacity = $\frac{\text{Gallons produced}}{\text{Gallons capacity}} \times 100$

(*) - This figured for an average of 21-2/3 operating days per month.

In these calculations the Hours Required figure includes wash time for grinding vessel and wash time for premix tank (if grinding vessel is not being used to grind next batch from another mixer), circulation time within grinding unit before discharging, and actual grinding time. Hours required do not include loading, mixing and aging times. An allowable efficiency factor of 90% is used to cover these loss items. One Standard Unit is specified as one 23-gallon unit and a 13-1/2 gallon unit is specified as 0.5 Std. Units.

Certain discrepancies exist in the present calculating methods. For example:-

A. Use of Standard Units in the formula lead to impossible % capacity results. A typical example should make this clear.

Case 1

A 23-gal. unit grinding 12,000 gallons requiring 400 hours for an average rate of 30 gallons per hour results in the following:

Capacity = $\frac{12,000}{400} \times 1.0 \times 520 \times .90 = 14,050 \text{ gallons}$

% Capacity = $\frac{12,000}{14,050} \times 100 = 85.5\%$

Case 2

A 13-1/2 gal. unit grinding same bases in same number of hours would grind at half the rate (for equivalent quality) or 15 gallons per hour resulting in 6,000 gallons of base produced.

$$\text{Capacity} = \frac{6,000}{400} \times 0.5 \times 520 \times .90 = 3,512 \text{ gallons}$$

$$\% \text{ Capacity} = \frac{6,000}{3,512} \times 100 = 171\%$$

Obviously, the latter percentage cannot be correct.

- B. % Capacity as presently calculated is completely independent of gallons produced or rate obtained and depends solely on the hours utilization of equipment. In Case 1 of A above, the % capacity could have been calculated as follows:

$$\frac{400 \text{ hours}}{520 \times .90} \times 100 = 85.5\% \text{ capacity}$$

If the amount produced were doubled the unit would still be operating at 85.5% capacity at double the present rate. If rate were doubled the unit would still be operating at 85.5% capacity at double the amount produced. The % capacity figure is thus in reality a % utilization factor only. Case 2 of A above, enters a factor for number of standard units which is erroneous.

- C. The capacity calculation shows only the amount which could have been produced at the rate experienced during the particular month if all available hours had been used. In this calculation two plants grinding identical bases could have a wide range of capacities. For example:-

Plant 1

Due to ideal scheduling conditions, available storage space, clean equipment, and no raw material difficulties, certain products are ground during the month at an average rate of 30 gallons per hour.

$$\text{Capacity} = \frac{12,000 \text{ gals.}}{400 \text{ hours}} \times 1.0 \times 520 \times .90 = 14,050 \text{ gals.}$$

$$\% \text{ Capacity} = \frac{12,000}{14,050} \times 100 = 85.5\%$$

Plant 2

Due to adverse conditions of scheduling, etc., is able to average a rate of only 15 gallons per hour for same products during the same number of hours so that only 6,000 gallons are produced.

$$\text{Capacity} = \frac{6,000 \text{ gals.}}{400 \text{ hours}} \times 1.0 \times 520 \times .90 = 7,025 \text{ gals.}$$

$$\% \text{ Capacity} = \frac{6,000}{7,025} \times 100 = 85.5\%$$

The report then gives the impression that Plant 2 is operating as efficiently as Plant 1, but has a capacity of only 7,025 gallons.

II. PROPOSED METHOD

A. Definition of Terms

- | | |
|----------------------|---|
| Available Hours | - Actual plant operating hours for each month. Available hours will vary depending upon number of operating days each month. |
| Grinding Hours | - Hours for which each grinding vessel is in use. Includes circulation time in vessel and wash time for vessel after completion of batch. |
| Premix Hours | - Time for loading, mixing and aging before premix is fed to grinding vessel. |
| Standard Unit | - Specified as one 23-gal. unit. 13-1/2 gallon unit equals one-half std. unit. 6-1/2 gallon unit equals one-fourth std. unit. |
| Formula Rate | - Rate given on formula card. Where range is given, use lower rate. |
| Operating Rate | - Rate at which unit is to be run. Equals Formula Rate times Std. Units. |
| Actual Rate | - Total gallons produced divided by Grinding Hours. |
| Theoretical Capacity | - Sum of (Formula Rate x Std. Units x Grinding Hrs. for each code) times available Hours divided by Grinding Hours. |
| Actual Capacity | - Theoretical Capacity x K - |
| K - | - Capacity factor equivalent to .95 for units with two or more premix tanks; .90 for units with one premix tank. |

% Capacity

- Gallons produced times 100 divided by Actual Capacity.

% Utilization

- Grinding Hours times 100 divided by (Available Hours).

% Efficiency

- Gallons produced times 100 divided by sum of (Formula Rate x Std. Units x Grinding Hours x .95). The efficiency factor of .95 is predicted on an average formula rate of 25 gph. with 500-gallon batches, allowing 1 hour for circulation and wash, to give 100%.

B. Monthly "47 Process" Capacity Reports would be prepared at each plant as follows:-

1. Listing by code of lbs., gals., grinding hours and actual rates of production for each "47 Process" installation.
2. Calculation of Actual Capacity, % Capacity, % Utilization, and % Efficiency for each installation.
3. Separate Overspray from regular mill base production.
4. Summary of B-2 and B-3 for plant-wide figures, keeping Overspray separate.
5. Production on 5-1/2 gal. units, if any, will not be reported.

C. Production Planning Committee at Philadelphia would continue to issue Divisional Capacity Reports showing summary of B-3 above for each plant with separate figures for Overspray. In addition, the comparative rate chart showing Actual Rates now prepared by this Committee would be issued to all plants. This chart should also include formula rates for each code shown and should include all codes whose production at any one plant exceeds 500 gallons for the month. It is not necessary to include comparative rates for previous month on this chart.

D. The advantages of this method of reporting would be:-

1. A flexible capacity depending only on size of units and pattern of business.
2. Determination of the actual percentage of capacity at which units were operated, allowing for the reduced capacity of only one premix tank.
3. Separation of utilization, efficiency and percentage of capacity.
4. Comparison of efficiencies of similar units.

E. These reports could be used for the following purposes:-

1. Determination of the need for increased capacity.
2. Determination of codes on which increased Actual Rates are possible (comparison with other plants' experience).
3. Determination of units where increased utilization can be effected.
4. Indication of savings which could be effected by the use of additional premix tank or larger grinding vessel.
5. High-spotting codes on which Formula Rates need revision.

Attached are copies of the proposed forms to be used by each plant and a simplified example of how the report will be filled out.

"47 PROCESS" CAPACITY REPORT

MONTH AUGUST

PHILADELPHIA PLANT

YEAR 1952

AVAILABLE
HOURS 504

OVERALL PERFORMANCE

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-----	-----	-----	-----	-----	-----	-----	-----	-----

Unit Designation	Grind. Hours	Avail. Hours	Gallons Produced	Actual Capacity	Theoretical Capacity	Sum of Col. 9
------------------	--------------	--------------	------------------	-----------------	----------------------	---------------

23-Gal. Unit

No. 1	400	504	10,000	20,340	22,600	18,000
No. 2	450	504	13,000	18,600	19,600	17,500

13-1/2 Gal. U.

No. 3	240	504	1,400	6,426	7,140	3,400
-------	-----	-----	-------	-------	-------	-------

TOTALS	1,090	1,512	24,400	45,366	49,340	38,900
--------	-------	-------	--------	--------	--------	--------

Theoretical Capacity = Total Col. (5)

= 49,340 gals.

Actual Capacity = Total Col. (5)

= 45,366 gals.

% Capacity = $\frac{\text{Total Col. (4)} \times 100}{\text{Total Col. (5)}}$

= $\frac{24,400 \times 100}{45,366} = 53.9\%$

% Utilization = $\frac{\text{Total Col. (2)} \times 100}{\text{Total Col. (3)}}$

= $\frac{1,090 \times 100}{1,512} = 72\%$

% Efficiency = $\frac{\text{Total Col. (4)} \times 100}{\text{Total Col. (7)}}$

= $\frac{24,400 \times 100}{38,900} = 66\%$

UNIT DESIGNATION No. 1

STD. UNITS

1.0

PREMIX TANKS

1

"47 PROCESS" CAPACITY REPORT

PHILADELPHIA PLANT

MONTH AUGUST

YEAR 1952

AVAILABLE
HOURS 504

OVERALL PERFORMANCE

(1) (2) (3) (4) (5) (6) (7) (8) (9)

Lbs. Gallon Gailons Grind. Actual Formulating
Code Produced Weight Produced Hours Rate Rate Rate (5)x(8) Oper-

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A	90,000	10.0	9,000	300	30	50	50	15,000	% Capacity = $\frac{\text{Total Col. (4)}}{\text{Actual Capacity}} \times 100$ = $\frac{10,000}{20,340} \times 100 = 49.2\%$
B	10,000	10.0	1,000	100	10	30	30	3,000	

$$\% \text{ Utilization} = \frac{\text{Total Col. (5)}}{\text{Available Hrs.}} \times 100$$

$$= \frac{400 \times 100}{504} = 79.6\%$$

$$\% \text{ Efficiency} = \frac{\text{Total Col. (4)}}{\text{Total Col. (9)} \times .95} \times 100$$

$$= \frac{10,000}{18,000 \times .95} \times 100 = 58.6\%$$

TOTALS	100,000	-	10,000	400	-	-	-	18,000
--------	---------	---	--------	-----	---	---	---	--------

$$\text{Theoretical Capacity} = \frac{\text{Total Col. (9)} \times \text{Available Hours}}{\text{Total Col. (5)}} = \frac{18,000 \times 504}{400} = 22,600 \text{ gals.}$$

$$\text{Actual Capacity} = \text{Theoretical Capacity} \times K = 22,600 \times .90 = 20,340 \text{ gals.}$$

UNIT DESIGNATION

No. 2

STD. UNITS

1.0

PREMIX TANKS

2

"47 PROCESS" CAPACITY REPORT

PHILADELPHIA PLANT

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Lbs. Gallon Gallons Grind, Actual Formula ating

Code	Produced	Weight Produced	Hours	Rate	Rate	Rate	Rate	(5)x(8)
B	10,000	10.0	1,000	50	20	30	30	1,500
C	120,000	10.0	12,000	400	30	40	40	16,000

$$\% \text{ Capacity} = \frac{\text{Total Col. (4)}}{\text{Actual Capacity}} \times 100$$

$$= \frac{13,000}{18,600} \times 100 = 69.9\%$$

$$\% \text{ Utilization} = \frac{\text{Total Col. (5)}}{\text{Available Hrs.}} \times 100$$

$$= \frac{450}{504} \times 100 = 89.3\%$$

$$\% \text{ Efficiency} = \frac{\text{Total Col. (4)}}{\text{Total Col. (9) x .95}} \times 100$$

$$= \frac{13,000}{17,500 \times .95} \times 100 = 78.3\%$$

TOTALS	130,000	-	13,000	450	-	-	-	17,500

$$\text{Theoretical Capacity} = \frac{\text{Total Col. (9)}}{\text{Total Col. (5)}} \times \text{Available Hours} = \frac{17,500 \times 504}{450} = 19,600 \text{ gals.}$$

$$\text{Actual Capacity} = \text{Theoretical Capacity} \times K = 19,600 \times .95 = 18,600 \text{ gals.}$$

MONTH AUGUST

YEAR 1952

AVAILABLE
HOURS 504

UNIT DESIGNATION No. 3

STANDARD UNITS	0.5
1	0.5
2	0.5
3	0.5
4	0.5
5	0.5
6	0.5
7	0.5
8	0.5
9	0.5
10	0.5
11	0.5
12	0.5
13	0.5
14	0.5
15	0.5
16	0.5
17	0.5
18	0.5
19	0.5
20	0.5
21	0.5
22	0.5
23	0.5
24	0.5
25	0.5
26	0.5
27	0.5
28	0.5
29	0.5
30	0.5
31	0.5
32	0.5
33	0.5
34	0.5
35	0.5
36	0.5
37	0.5
38	0.5
39	0.5
40	0.5
41	0.5
42	0.5
43	0.5
44	0.5
45	0.5
46	0.5
47	0.5
48	0.5
49	0.5
50	0.5
51	0.5
52	0.5
53	0.5
54	0.5
55	0.5
56	0.5
57	0.5
58	0.5
59	0.5
60	0.5
61	0.5
62	0.5
63	0.5
64	0.5
65	0.5
66	0.5
67	0.5
68	0.5
69	0.5
70	0.5
71	0.5
72	0.5
73	0.5
74	0.5
75	0.5
76	0.5
77	0.5
78	0.5
79	0.5
80	0.5
81	0.5
82	0.5
83	0.5
84	0.5
85	0.5
86	0.5
87	0.5
88	0.5
89	0.5
90	0.5
91	0.5
92	0.5
93	0.5
94	0.5
95	0.5
96	0.5
97	0.5
98	0.5
99	0.5
100	0.5

PREMIX TANKS

MONTH

AUGUST

YEAR 1952

**AVAILABLE
HOURS**

"47 PROCESS CAPACITY REPORT

PHILADELPHIA
PLANT

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lbs.		Gallon Gallons	Grind.	Actual Formula	ating			
Code	Produced	Height Produced	Hours	Rate	Rate	Rate	Rate	(5)x(8)

$$\% \text{ Capacity} = \frac{\text{Total Col. (4)}}{\text{Actual Capacity}} \times 100$$

$$= \frac{1,400}{6,426} \times 100 = 21.8\%$$
$$\% \text{ Utilization} = \frac{\text{Total Col. (5)}}{\text{Available Hrs.}} \times 100$$

$$= \frac{240}{504} \times 100 = 47.7\%$$
$$\begin{aligned} \% \text{ Efficiency} &= \frac{\text{Total Col. (4)}}{\text{Total Col. (9)}} \times 100 \\ &= \frac{1,400 \times 100}{3,400 \times .95} = 43.4\% \end{aligned}$$

14,000	-	1,400	240	-	-	3,400
--------	---	-------	-----	---	---	-------

$$\text{Theoretical Capacity} = \frac{\text{Total Col. (9)}}{\text{Total Col. (5)}} \times \text{Available Hours} = \frac{3,400}{240} \times 504 = 7,140 \text{ gals.}$$

Actual Capacity = Theoretical Capacity x K = 7,140 gals. x .90 = 6,426 gals.

CC: J. S. ALLEN - D-8030 - WILM.

Philadelphia Plant
December 21, 1951

Memorandum to Files

"47 PROCESS" DEVELOPMENT PROGRAM
CONSULTATION WITH JOHN CONNOLLY

On December 7, 1951 the principles of "47 Process" dispersion were discussed with Mr. Joan Connolly, Mixing Consultant of the Engineering Department. Emphasis was placed on optimum design of vessel and agitator. The following items were covered:

1. Disc diameter - There should be an optimum disc diameter. Above this optimum point the pumping action will be too great and shearing effect lessened. Below the optimum diameter by-passing will be excessive and power input to shearing will not be sufficient for fine dispersion.
2. Number of discs - An optimum number of discs should be found above which the spiral effect will cause an increase in by-passing.
3. Disc design - Flat plates without any raised sections, as are now used, are the best design to reduce pumping action and impart full force to shearing action. Mr. Connolly now has a patent pending on a disc design with concentric recessed rings. The purpose of this design is to reduce power absorbed and concentrate power nearer the periphery of the disc. The effect, while small, can be measured. Use of this design may be advantageous.
4. Baffles - Vertical baffles would hinder rather than help dispersion in the "47 Process" unit. Horizontal outer rings probably would not further reduce by-passing since this must be negligible at present.

Other items of a general nature concerning "47 Process" operation were also discussed.

PROCESS AND METHODS GROUP

RPE:hr

BY: R. P. BALMERT

CC: J. S. ALLEN - D-8030 - WILMINGTON
H. R. AYRES - PHILA. PLANT
W. G. PRUTZMAN - " "
H. G. WETTIG - " "
H. R. CARR - " "

Philadelphia Plant
March 15, 1950

C. W. CLARK
CHICAGO PLANT

ATT: P. B. HUCK

"47 PROCESS" DRIVE

Reference your letter of March 7.

The procedure we follow in aligning disc and drive shafts on "47 Process" agitator units is as follows:

GEAR REDUCER ASSEMBLY

Make up Philadelphia gear reducer output shaft.

Indicate and make sure it is running true before fitting and installing male half of coupling.

We use #2530 Philadelphia Gear Steel flanged couplings.

Bore out coupling to a force fit on gear reducer output shaft.

Fit up coupling, assemble, and indicate both outside diameter and face; make sure it is running true.

If not true, remove shaft from gear reducer. Set up in lathe with coupling assembled and machine until face and diameter of coupling check $\pm .001$ ".

DISC SHAFT ASSEMBLY

Bore out female half of Philadelphia Gear #2530 steel flanged coupling to fit the disc drive shaft; also a force fit.

Fit up coupling to disc shaft pin coupling to shaft or backweld.

Set up complete shaft with female half of coupling in lathe.

Indicate shaft and coupling outside diameter, and face to make sure face and diameter are true with shaft.

If out, machine face and diameter until they check $\pm .001$ ".

DISC SHAFT ASSEMBLY (Continued)

Assemble shaft on gear box; install coupling bolts.

Set up on test stand holding the gear box with disc shaft attached in vertical position.

Bolt or clamp assembly to stand level and plumb up true.

Rotate the input shaft by hand.

Indicate the disc shaft at top, center, and bottom. The shaft should be true within the limit of $\pm .002$ at the bottom of disc shaft.

STRAIGHT DISC

The discs should be bolted thoroughly to the respective hubs, and marked in place, trued up and balanced before heat treating.

After heat treating they should be re-checked for distortion or warpage.

WAVY DISC

Extra care should be taken in checking the waves, making sure that they are all the same depth and balance. If they don't check and balance, excessive vibration will be set up in the apparatus causing damage to the screens.

Checking the depth of waves and balancing of these discs should also be done before heat treating.

If there is any further information you may need please advise.

D. E. HENLEY

TFH:egv

BY: T. E. ROES

IV - BIBLIOGRAPHY

Marshall Laboratory Report No. 884 - "Exploratory Research Report - '47 Process'". S. Hochberg. October, 1947.

ED-1916 - "Final Report - MX-1123 Investigation of the '47 Process'". Engineering Dept., Industrial Engineering Division, Marshall Laboratory. May, 1948.

Memorandum - "Some Basic Principles of '47 Process'" - W. P. Colio, Marshall Laboratory. August, 1949.

Memorandum - "Equipment Specifications for '47 Process'" - Philadelphia Process & Methods Group. August, 1949.

Progress Report - "Flint '47 Process' Progress Report" - Flint Process & Methods Group. December, 1949.

Parlin Laboratory Research Report No. 977 - "Investigation of '47 Process' as applied to 'Ducc' Manufacture" - L. I. Miller. April, 1950.

Philadelphia Process & Methods Notebooks No. 3, No. 4 and No. 5435. 1951-1952.

Philadelphia Process & Methods Files 1400 to 1495 Inclusive.

T-1 "47 Process' Overload Study - Elimination of Power Overloads on Agitator Motors" - Toledo Plant. September, 1951.

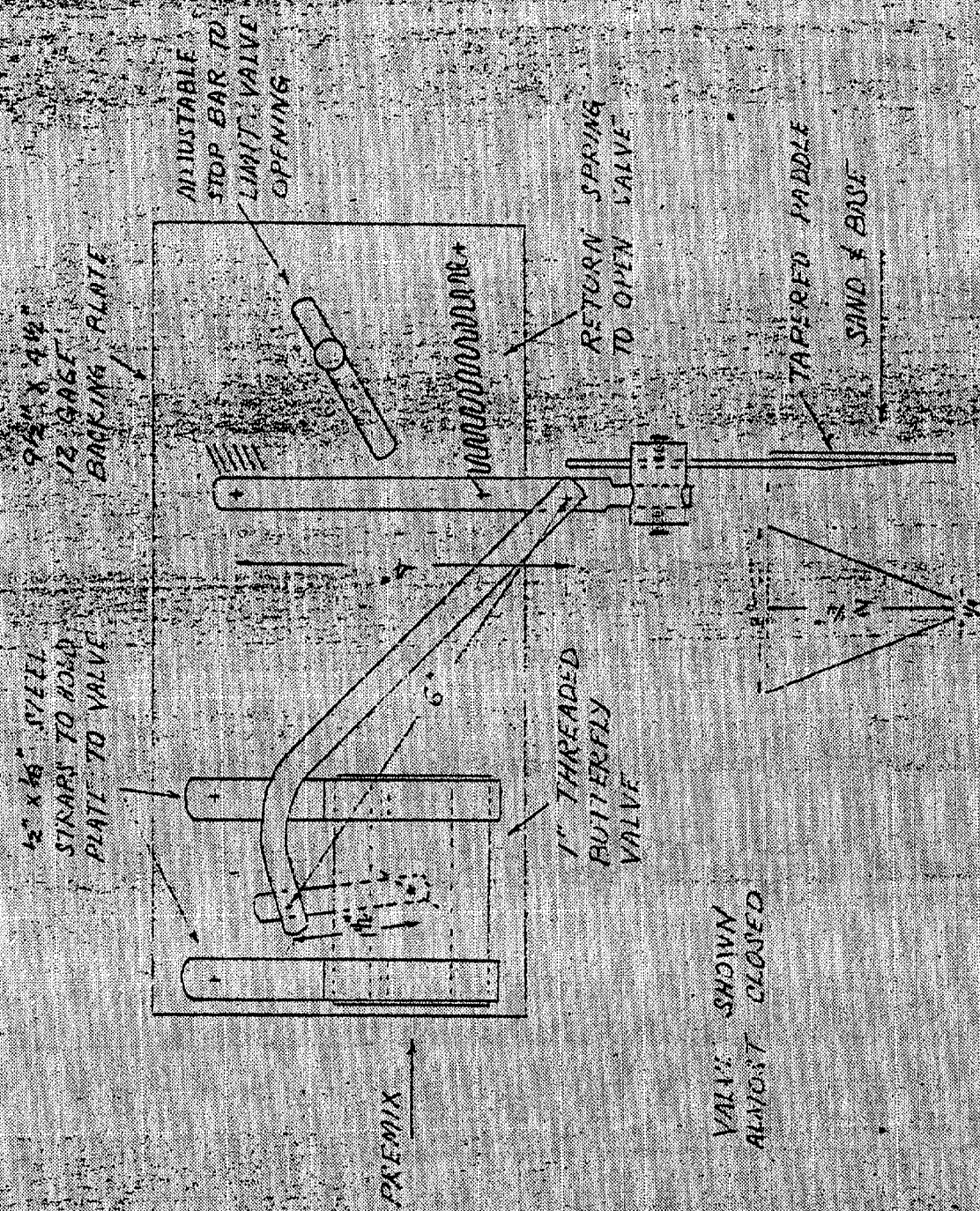
Fort Madison Device Memorandum #28 - "Clamp-on Screen for '47 Process'". June, 1952.

South San Francisco Device Memorandum #25 - "'47 Process' Premix Tank Agitator" - June, 1952.

Toledo Device Memorandum #59 - "'47 Process' Temperature Controller". June, 1952.

FIGURE 6

LEVEL CONTROL VALVE METHOD "A"



VALVE SHOWN
ALMOST CLOSED

STUDY P-1 TITLE: "HT PROCESS" DEVELOPMENT
ENGR: RPE DATA PLANT DATE: 3-31-52 NO: 1938-32

IV - BIBLIOGRAPHY

Marshall Laboratory Report No. 884 - "Exploratory Research Report - '47 Process'". S. Hochberg. October, 1947.

ED-1916 - "Final Report - MX-1123 Investigation of the '47 Process'". Engineering Dept., Industrial Engineering Division, Marshall Laboratory. May, 1948.

Memorandum - "Some Basic Principles of '47 Process'" - W. P. Colio, Marshall Laboratory. August, 1949.

Memorandum - "Equipment Specifications for '47 Process'" - Philadelphia Process & Methods Group. August, 1949.

Progress Report - "Flint '47 Process' Progress Report" - Flint Process & Methods Group. December, 1949.

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