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(R) SAE MANUAL ON BLAST CLEANING

***Foreword*—**This Document has not changed other than to put it into the new SAE Technical Standards Board Format

This report on blast cleaning is a companion to the SAE report on Shot Peening. It is intended to help engineers, management, and shop personnel to increase their knowledge of the process. The information contained herein has been submitted and edited by a group that has had extensive and varied experience with blast cleaning and whose recommendations merit consideration.

1. *Scope*

***Scope*—**Blast cleaning may be defined as a secondary manufacturing process in which a suitable stream of solid particles is propelled with sufficient velocity against a work surface to cause a cleaning or abrading action when it comes in contact with the workpiece.

As indicated in the definition, blast cleaning may be employed for a variety of purposes. Ordinarily, it is considered as a method for removing sand from castings, burrs or scale from forgings, mill products, or heat treated parts; to promote machinability, and to minimize the possibility of interference in actual operation. In addition to this use, blast cleaning also produces an excellent surface for industrial coatings. All these objectives are often accomplished in the one operation.

1.1 History

History—The cleaning problem of removing sand and scale has always been associated with the casting, forging, and heat treating of metal. As recently as the beginning of the twentieth century, foundrymen considered the chisel, hammer, dull file, and wire brush the chief weapons for attacking this problem. Hand tools were gradually augmented by "rattling" or tumbling methods.

Pressure blasting was first introduced in 1870 by Gen. Benjamin Chew Tilghman. He discovered that metals, stone, and glass could be shaded or etched by jets of sand. He took out patents covering pressure blasting with sand driven by compressed air, steam, and water; with sand struck by a paddle wheel, thrown centrifugally, or dropped from a height through a tube. Thus, General Tilghman advanced the principles upon which modern blast cleaning is based.[1]

Tilghman's first commercial machine used a steam blast as a method of propelling the sand. This proved to have several disadvantages. The steam moistened the sand, necessitating a drying operation. It also tended to hide the work, break glass objects, and rust metals. As a result, Tilghman changed to a tank-type compressed air machine, which proved more successful.

1. See "Modern Blast Cleaning and Ventilation," by C.A. Reams, Cleveland, Ohio: Penton Publishing Co., 1939.

Other men and companies entered the blast cleaning equipment field. A natural development was the blasting machine in which sand could be refilled during operation. This was accomplished by pouring sand through a standpipe of sufficient height to overcome tank pressure.

Cabinets and barrels featuring pressure air blasting nozzles were advertised in magazines in 1895. That same year W. W. Sly introduced the exhaust tumbling barrel, which also increased the dust removal problem. This was partially solved by the first cloth screen dust arrester patented in 1897.

Many industries recognized the superior surface quality of castings, forgings, heat treated parts, etc., cleaned by blast cleaning. However, the high operational cost and low productivity of the process at that time limited its use to the cleaning of large castings or products where high quality was necessary regardless of cost.

An old leanto in back of the plant comprised the up-to-date blast cleaning department of 1915. A blower fan provided the ventilation. Wooden walls which splintered were soon replaced by steel sheets. The sand blasting distorted the sheets and cut the nails. Brick was used next and proved more durable. However, the silica dust produced was harmful to the operator.

In 1917 humane sand blast rooms were developed in which the operator stayed out of the blast zone. Downdraft ventilation, rubber-lined steel walls, and better lighting all served to improve the sand blasting operation.

A new phase of development took place with the introduction of metallic abrasives in the 1920's. Acceptance was slow, due to the availability and low first cost of sand. Industry soon recognized the improvement in the quality of the finish and the lower cost, through increased durability of the shot. Improvements in reclaiming the metal abrasive eventually won over most of industry. One of the chief benefits—savings in storage space and handling—was not appreciated until some years after the adoption of metal abrasives.

The development of metallic abrasives began with the use of chilled cast iron shot. The comparatively short shot life of chilled cast iron lead to the development of malleabilized and annealed cast iron shot. Next to be introduced into the metallic abrasive field was cast steel shot and more recently cut wire shot. Although these latest shot have a higher initial cost than the iron shot, their life is much greater. In many instances, they have proved to be more economical than the iron shot. These newer shot demand that the blasting equipment be operated to minimize shot losses.

As more companies produced metallic abrasives, more and more name and classification systems were used. This resulted in the need for standardization of abrasive classification for the entire blasting industry. A big step in this direction was taken in 1943 when a group of shot producers, users, and equipment manufacturers met in Detroit and formed the Shotpeening Committee of the SAE. This committee established size and nomenclature standards for shot and grit (SAE Handbook). Also, the committee has worked, and is still working, on a standard testing procedure for the endurance and wear of metallic abrasives.

With the introduction and acceptance of metallic abrasives, the blast cleaning suppliers were able to offer industry their next big improvement—the use of centrifugal force for blast cleaning. Here the abrasive is thrown by a revolving wheel, which propels the abrasive mechanically. The idea was first proposed in the 19th century but abandoned. The large volume of sand that even the smallest machines required, plus the excessive wear of sand on metals, made its use prohibitive. In 1933 the American Foundry Equipment Co. demonstrated at Benton Harbor, Mich., the use of a barrel-type machine using a wheel to propel the abrasive. Later, the Pangborn Corp. introduced a similar unit at Detroit, and another was introduced by the W. W. Sly Mfg. Co. in Cleveland. Among later improvements was the construction by the Cargill Detroit Co. of operatorless single-purpose equipment to provide process control on certain high production parts.

Mechanization of blasting equipment, metallic abrasives, and the use of centrifugal force led to the development of more high productive cleaning equipment to meet growing production demands. The improved blasting equipment developed includes the tumble type batch cabinets, continuous monorail cabinets, rotating tables, and the latest development—the continuous barrel type.

In the field of general cleaning the centrifugal or airless type is by far the most popular means of metallic abrasive propulsion. However, in the case of specialized or precision cleaning, air propulsion of metallic abrasives is more adaptable because of its ease of control and great flexibility. As parts become more complex in size and shape, specialized cleaning becomes more and more necessary.

Work in the development of abrasives, blasting equipment, processes, and standization goes on. The blast cleaning history has closely paralleled that of mass production. The blast cleaning industry has made many valuable contributions to the industrial growth of America, and will continue to do so.

1.2 Present Status—The present trend of blast cleaning, with few exceptions, is to use the continuous-barrel type of equipment with centrifugal blast wheels for all small castings that can be handled as bulk material. The use of the continuous-monorail type of blast cabinet equipment with centrifugal abrasive propulsion for large castings and forgings is very extensive. These two types of equipment are fast replacing the old pressure blast equipment. The centrifugal type of blast equipment has proved more economical per ton of cleaned castings than the previously used pressure blast equipment, with few exceptions. An exception to the preceding statement is the specific specialized type of pressure blast equipment on a part that has internal pockets and on which it is necessary to direct the blast stream at a small area that cannot be reached with the widely used centrifugal-type equipment.

The present trend in ferrous metal blasting abrasives is toward material having superior breakdown resistance. The result of this progressive change is a lower cost per ton of cleaned castings with reduced abrasive material breakdown provided adequate auxiliary equipment can be installed adjacent to the blast cleaning machine to salvage the blast material that otherwise would be carried out in pockets of the cleaned work and lost.

1.3 Secondary Effects

1.3.1 Combined Cleaning And Peening—Combined cleaning and peening is applicable to parts where it is necessary to remove scale, provided there is no subsequent heat treatment. Parts that are being treated in this manner include automotive connecting rods, axleshafts, and steering knuckles. However, on parts such as axleshafts and steering knuckles, which require machining in critical areas, some of the effectiveness of the peening is lost.

Parts with small surface imperfections may be improved by lessening the effect of the stress-raisers during the cleaning operation.

Some controversy exists on the question of the inspection of blast cleaned parts. It is thought by some that small defects, ordinarily brought out by pickling, will be obscured by the blasting operation. Others claim that these small defects are made less detrimental by the peening action of the cleaning operation. Some surface defects may be concealed to the extent that an inspection other than visual may be necessary.

1.3.2 Use As An Inspection Tool—Blasting is applied to facilitate inspection of selectively hardened parts; this blasting often serves as a cleaning operation as well. The inspection of chilled iron parts and decarburized areas on hardened parts is made easier by blasting. It is also possible by blasting to show leaks in masked areas after carburizing and hardening.

2. *References*

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the lastest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J441—Cut Wire Shot
SAE J444—Cast Shot and Grit Size Specifications for Peening and Cleaning
SAE J827—Cast Steel Shot
SAE Handbook

2.1.2 OTHER PUBLICATIONS

“Modern Blast Cleaning and Ventilation,” C.A. Reams, Cleveland, Ohio, Penton Publishing Company, 1939
“Simplified Practic Recommendation 118-50—Abrasive Grain Sizes,” U.S. Department of Commerce Bulletin, June 1, 1950
“Hyrdo-Finish and Hydro Sandblast,” W.I. Gladfelter, Pangborn Corporation
“Fine Particle Blasting or MicroBlast Fluid Honing and Finishing,” E.E. Hawkinson, MicroBlast Manufacturing Corporation
“Fine Particle Blasting—A.P. Neuman and V.W. Nichols, Vapor Blast Manufacturing Company

3. ***Blast Cleaning Machines—***Blast cleaning machines have any or all of the following components: abrasive propelling mechanism; cabinet or enclosure; abrasive cycling and regenerative system; work holding mechanism; load and unload mechanism; and controls.

Abrasive blasting equipment is generally divided into air blast units, airless blast units, and wet blasting machines, according to the method of propelling the abrasive. Air blasting and airless blasting machines are dry processes for general cleaning, while wet blasting is usually restricted to the cleaning and finishing of precision parts requiring special finishes or cleaning action.

3.1 Air Blasting Machines—In air blast equipment the abrasive material is forced by compressed air through a small orifice or nozzle (Figure 1). The abrasive stream takes the shape of a small cone and asserts its effect over a small area. The two advantages of air blasting are its flexibility in cleaning specific areas with a highly concentrated blast pattern and its ability to use both metallic and nonmetallic abrasives. The narrow, coneshape stream of abrasive is ideal for cleaning interior cavities, blind holes, and narrow recesses and localized areas of castings, forgings, and heat treated parts.

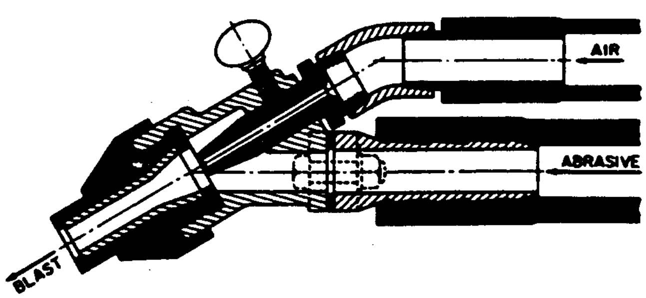

FIGURE 1—INDUCTION NOZZLE

Air blast cabinets are either of the suction feed, gravity feed, or direct pressure types, with the pressure type giving the more powerful blast, which is desirable for removing burned-in sand, heavy scale, etc. The most common form of air blast equipment is that in which the blasting nozzle is manipulated by an operator, who may be located outside or inside the blasting cabinet.

In the large air blast rooms (Figure 2) the operator, in special apparel, manipulates a flexible air blast nozzle to clean large and intricate parts that, because of their size, must remain stationary.

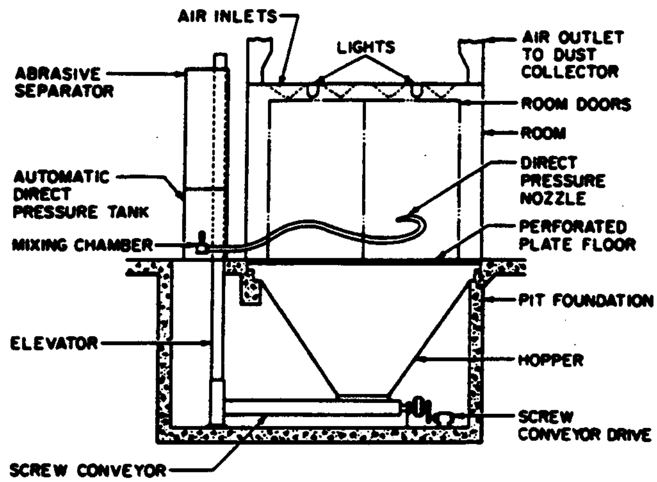

FIGURE 2—HAND BLAST ROOM

In the smaller so-called hand blast cabinet (Figure 3) the operator reaches through the cabinet and manipulates the nozzle and/or the work while viewing his progress through a suitably protected glass window.

Manual cabines, due to their flexibility, are generally used when only a few pieces or work constitute the entire production of that item. For cleaning high production items, single-purpose air blast machines are used, whereby the parts are automatically located in proper relation to the nozzles, blasted, and ejected into storage boxes and onto conveyor lines. These machines are able to use automatic loading devices and are able to operate without an operator.

3.2 Airless Blasting Machines—In airless blasting machines the abrasive material is thrown at the work by means of centrifugal force imparted by one or more rotating wheels located strategically within the cabinet or enclosure (Figure 4). The abrasive forms an elongated, cone-shaped pattern covering a large area and the operator remains outside the machine during the blasting cycle. For large volume, general-purpose cleaning operations, these machines, with their large blast patterns, are ideally suited. The units are built with work handling mechanisms to handle the parts in such a manner that the surfaces requiring cleaning will, at one time or another in their passage through the machine, be exposed to the blast pattern.

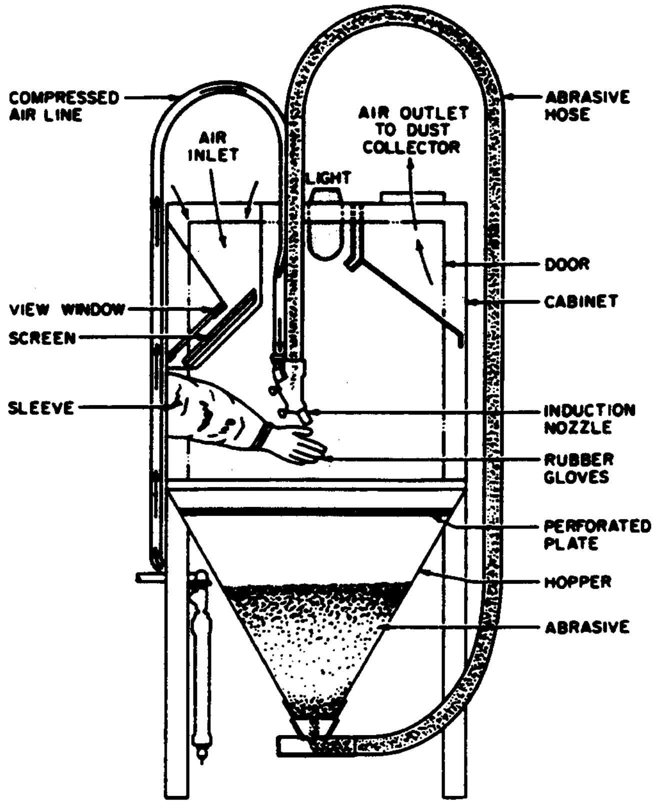

FIGURE 3—INDUCTION CABINET

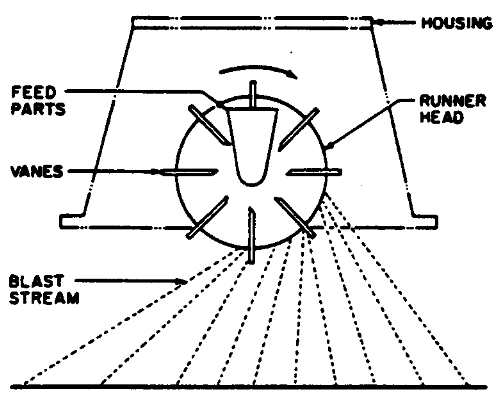

FIGURE 4—CENTRIFUGAL WHEEL

The number of wheel units required and their positioning in any cabinet are influenced by the combination of size, shape, and weight of the work to be cleaned plus the condition of the work and the production required. The most common airless blast machines used for general cleaning are the single-wheel units propelling a fixed downward pattern upon work carried before this pattern and are classified as batch type cleaning machines and continuous-table-type blast cleaning machines.

In the batch type units (Figure 5) the parts are loaded into the machine in one batch in a barrel or in a depressed cavity developed in a large endless type of flight conveyor completely enclosed. When the batch has been cleaned, the machine is opened and the parts ejected.

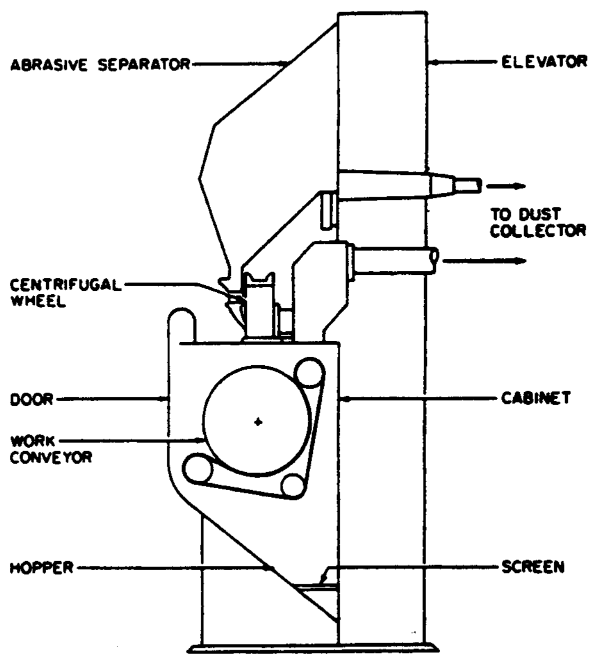

FIGURE 5—BATCH BARREL

The table type machine (Figure 6) consists primarily of a large horizontal table, with or without auxiliary work handling mechanisms, which rotates in a merry-go-round fashion. A portion of the table is opened to the operator allowing him to load and unload parts continuously; the other portion of the table is enclosed and houses the shot blast pattern.

Multiple-wheel machines (Figure 7) are more adaptable to high-production parts and utilize various types of conveyors to pass the parts through their multiple-blast patterns.

3.3 Wet Blasting Machines—In wet blasting equipment very fine mesh abrasives in water suspension are propelled at high velocity. These very fine abrasives react upon the surface of the parts in such a manner as to leave a very fine and especially smooth surface, such as is desirable on precision parts, where details must not be altered, and on parts requiring specially prepared and smooth surfaces.

The abrasive is kept in suspension in water by means of an agitator. This slurry is blasted against the work by the use of compressed air and nozzles similar to air blasting. An added component of this type of equipment is a rinse to remove the adhering abrasive.

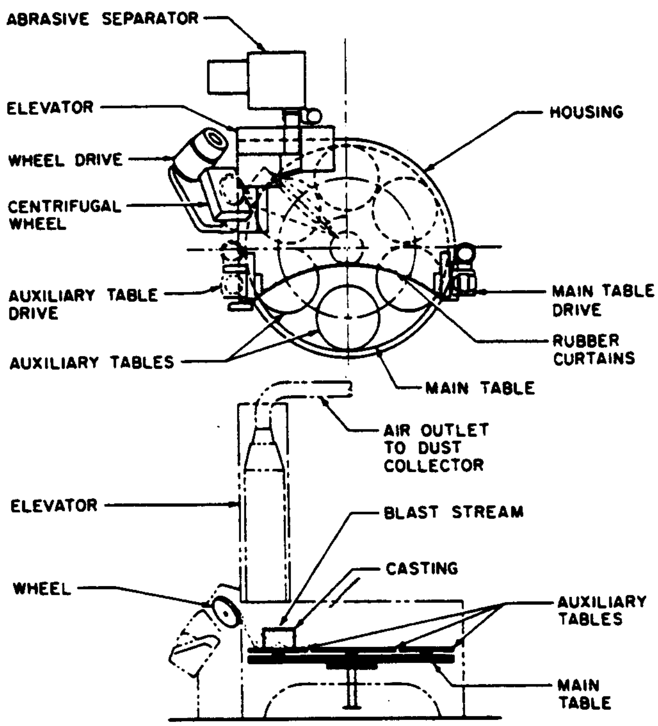

FIGURE 6—TABLE TYPE MACHINE

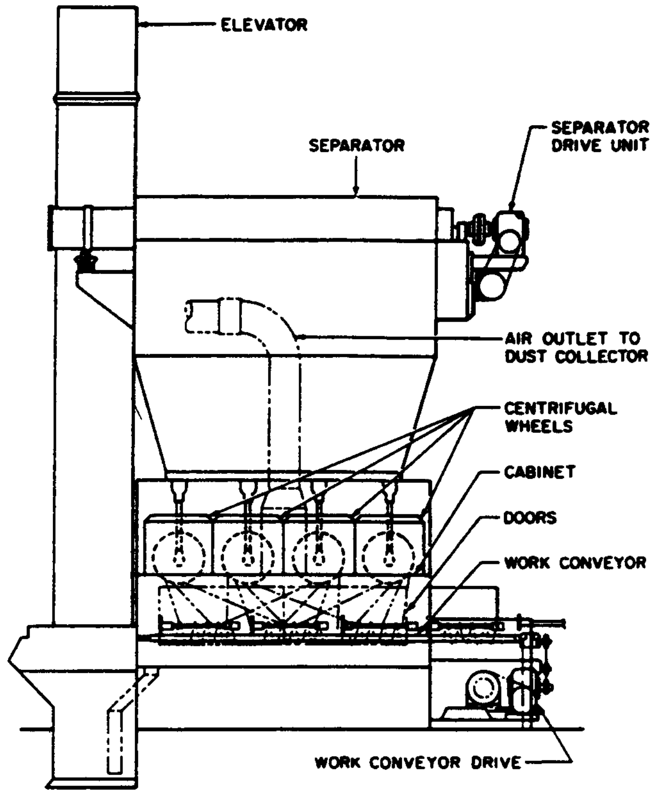

FIGURE 7—MULTIPLE-WHEEL MACHINE

The common wet blasting machine (Figure 8) is a manually operated hand cabinet. For high production, specialized parts, automatic machines are used in which the work is automatically loaded and unloaded from the unit.

3.3.1 CABINETS OR ENCLOSURES—On blast cleaning equipment, since these enclose the blast stream and its rebound, they are subjected to high abrasive wearing conditions. They are constructed of steel and in critical areas are lined with special steel plates and abrasive resistant rubber to withstand this service. The cabinets are the basic structural components of the machine and generally support the other components.

3.3.2 ABRASIVE CYCLING SYSTEM—This is necessary to return the spent abrasive from the lowest point of the machine back to the abrasive propelling device. In most cases ordinary materials handling devices accomplish this task.

Somewhere in the abrasive cycle a separator, or regenerator, is used to remove broken down abrasive and other foreign material from the blast stream. (See discussion in paragraph 6.1.) A dust collection and exhaust system is operated in conjunction with the abrasive handling system.

3.3.3 WORK HOLDING MECHANISMS—These are designed to present the areas requiring cleaning to the blast stream. The features required of these mechanisms are a minimum of moving parts in the blast stream, ability to withstand abrasive conditions, and simplicity. The load and unload mechanisms used in certain blast equipment are generally confined to batch cleaning machines and are simple, general-purpose materials handling units.

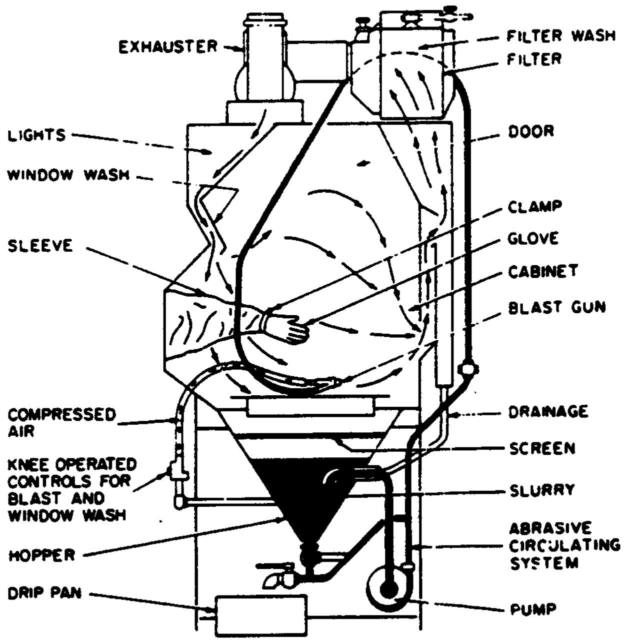

FIGURE 8—SCHEMATIC OF EQUIPMENT FOR WET BLASTING WITH FINE PARTICLES.
(DETAIL ARRANGEMENT VARIES AMONG MANUFACTURERS.)

For specialized blasting, automatic devices are becoming more prevalent for the handling of individual parts.

3.4 The Machine Controls—In most cases the machine controls are standard electrical and pneumatic devices manipulated by the operator as required. When the machine is used for repetitive tasks these controls are made to function automatically. Special attention is paid to these controls to eliminate the entrance of fine abrasive material which is always present around these machines.

4. Media—Types and Specifications

4.1 Ferrous Abrasives

4.1.1 CAST IRON SHOT—Cast iron shot is made from cupola melted iron generally containing over 21/2% carbon. It is atomized into random sizes and quenched in water to produce ball shaped particles of white cast iron, having a hardness of approximately Rockwell C 65. The random sizes are screened into standard SAE sizes. Cast iron grit is made by crushing cast iron shot and is available in standard SAE sizes. (See SAE J444.)

4.1.2 MALLEABLE IRON SHOT AND GRIT—Malleable iron shot and grit are made by heat treating cast iron shot or grit to reduce the hardness and increase the resistance to fracture. They are available in the standard SAE sizes of shot and grit.

4.1.3 CAST STEEL SHOT—Cast steel shot is high carbon steel, melted in an electric furnace, atomized into random sizes and quenched in water to produce ball shaped particles. It is heat treated and tempered to a uniform martensitic structure of various hardness. It is available in standard SAE sizes. See SAE J827.[2]

2. SAE J827, Cast Steel Shot. SAE Handbook, published by Society of Automotive Engineers, Inc.

4.1.4 CUT STEEL WIRE SHOT—Cut steel wire shot is the product of cold drawn carbon steel wire cut into the form of cylinders with lengths approximately equal to wire diameter. It is available in standard SAE sizes. (See SAE J444 and J441.)

4.2 Nonferrous Abrasives—Nonferrous metallic abrasives are usually used on non-ferrous or stainless steel parts where ferrous shot or grit might cause a contamination problem or an objectionable color. They are generally limited in use and availability, but include copper, aluminum, stainless steel, and zinc. They are available as cut wire, cast or by-product.

4.3 Mineral Abrasives—Mineral abrasives consist of sand, crushed rock, garnet, pumice, and emery. Most of the blasting sands are found in rock formation and are crushed and screened in various sizes for different uses. By far the largest volume of abrasives used lie in this classification, as approximately 500,000 tons of blast sand and 100,000 tons of ground rock and sandstone are used annually in the United States. The use of garnet, pumice, and emery for blast cleaning is very limited. Blast sand and ground rock products are usually available as shown in Tables 1 and 2.

TABLE 1—APPROXIMATE SIEVE ANALYSIS, % (MINERAL ABRASIVES)

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 7	Grade 7 Special	Grade 10
	Retained on						
No. 8 sq Mesh	0.0	0.0	0.0	0.0	1.0	1.0	8.0
No. 10 sq Mesh	0.0	0.0	0.0	0.0	10.0	12.5	40.0
No. 14 sq Mesh	0.0	0.0	25.0	36.0	45.0	47.0	37.0
No. 20 sq Mesh	0.0	5.0	49.0	51.0	32.0	36.0	12.0
No. 30 sq Mesh	1.5	43.0	23.0	11.0	10.0	3.5	1.5
No. 50 sq Mesh	78.5	48.0	3.0	2.0	2.0	0.0	1.5
Passing:							
No. 50 sq Mesh	20.0	4.0	0.0	0.0	0.0	0.0	0.0

Principal uses of the grades are as follows:

Grade No. 1: Blasting soft metal castings, such as aluminum, aircraft and where a "satin" finish is desired.
Grad No. 2: Blasting soft metal castings, for pointing, aircraft, etc.
Grade No. 3: Blasting castings, for enameling, lettering marble, etc.
Grade No. 4: Blasting for metallizing.
Grade No. 7: Blasting for metallizing, general cleaning of scale, castings, etc.
Grade No. 7 (Special): Blasting for metallizing, general cleaning of scale, castings, etc.
Grade No. 10: Heavy blasting, such as removing paint from tank cars, etc., and where air pressure is 110 psi or more.

TABLE 2—SCREENING SPECIFICATIONS[1] (MINERAL ABRASIVES)

	High Limit Screen		Control Screen		Low Limit Screen		Cumulative Screen		Max 3% to Pass
No.	Max Retained, %	Screen No. and Aperture	Max Retained, %	Screen No. and Aperture	Min Retained, %	Screen No. and Aperture	Min Retained, %	Screen No. and Aperture	Screen No. and Aperture
20	0	14 (0.0555)	15	16 (0.0469)	45	18 (0.0394)	80	18 (0.0394) 20 (0.0331)	25 (0.0280)
24	0	14 (0.0469)	20	20 (0.0331)	45	25 (0.0280)	75 -	25 (0.0280) 30 (0.0232)	35 (0.0197)
30	0	18 (0.0394)	20	25 (0.0289)	45	30 (0.0232)	75	30 (0.0232) 35 (0.0197)	40 (0.0165)
36	0	20 (0.0331)	20	30 (0.0232)	45	35 (0.0197)	75	35 (0.0197) 40 (0.0165)	45 (0.0138)
46	0	30 (0.0232)	30	40 (0.0165)	45	45 (0.0138)	65	45 (0.0138) 50 (0.0117)	60 (0.0098)
60	0	40 (0.0165)	30	50 (0.0117)	45	60 (0.0098)	65	60 (0.0098) 70 (0.0083)	80 (0.0070)
70	0	45 (0.0138)	15	60 (0.0098)	45	70 (0.0083)	70	70 (0.0083) 80 (0.0070)	100 (0.0059)
80	0	50 (0.0117)	15	70 (0.0083)	40	80 (0.0070)	70	80 (0.0070) 100 (0.0059)	120 (0.0049)
90	0	60 (0.0098)	15	80 (0.0070)	40	100 (0.0059)	70	100 (0.0059) 120 (0.0049)	140 (0.0041)
100	0	70 (0.0083)	15	100 (0.0059)	40	120 (0.0049)	65	120 (0.0049) 140 (0.0041)	200 (0.0029)
120	0	80 (0.0070)	15	120 (0.0049)	30	140 (0.0041)	60	140 (0.0041) 170 (0.0035)	230 (0.0024)
150	0	100 (0.0059)	15	140 (0.0041)	40	170 (0.0035) 200 (0.0029)	75	170 (0.0035) 200 (0.0029) 230 (0.0024)	270 (0.0021)
180	0	120 (0.0049)	15	170 (0.0035)	40	200 (0.0029) 230 (0.0024)	65	200 (0.0029) 230 (0.0024) 270 (0.0021)	—
220	0	140 (0.0041)	15	200 (0.0029)	40	230 (0.0024) 270 (0.0021)	60	230 (0.0024) 270 (0.0021) 325 (0.0017)	—
249	0	170 (0.0035)	5	200 (0.0029)	8	230 (0.0024) 270 (0.0021)	38	230 (0.0024) 270 (0.0021) 325 (0.0017)	—

1. From U.S. Dept. of Commerce Bulletin dated June 1, 1950, "Simplified Practice Recommendation 118-50—Abrassive Grain Sizes."

The synthetic mineral abrasives include silicon carbide and aluminum oxide and, as the name implies, are man-made in electric furnaces. They are crushed and screened to produce the required sizes. To this may be added glass shot or beads which are manufactured of optical crown glass, soda lime type. They are resistant to atmospheric moisture, dilute acids and alkalis, and are annealed in the spherical shape for stress equalization to reduce wear and fracture. Glass bead size ranges from 0.0005 in and larger.

4.4 Vegetable Abrasives—Vegetable abrasives include such items as wheat grains, ground corncobs, crushed nut hulls such as walnut or hickory, fruit pits and so forth. These materials are often referred to as "soft grit" and are used in special purpose cleaning and deburring, where the surface must not be marred. Examples of such applications are the cleaning of aircraft, automobile, and diesel pistons, electric motor armatures, and pump impellers.

5. Recommended Practices

5.1 Oxide and Scale Type—Castings, forgings, hot rolled shapes, etc., may be classified into three general groups according to the type of scale or oxide to be removed:

5.1.1 GROUP A—HEAVY SCALE—Examples of this group are as follows:

a. Steel castings.
b. Alloy forgings—heat treated and annealed.
c. Large hot-rolled shapes.
d. Certain heat treated gray iron castings.
e. Miscellaneous parts for surface effect.

5.1.2 GROUP B—MEDIUM SCALE—Examples are as follows:

a. Carbon steel forgings.
b. Miscellaneous gray iron castings.
c. Miscellaneous malleable castings.
d. Light section—hot-rolled shapes and sheet.

5.1.3 GROUP C—LIGHT SCALES, OXIDES, AND CARBURIZING SMUTS—Examples are as follows:

a. Heat treated finished parts.
b. Nonferrous castings.
c. Miscellaneous parts for surface effect.

After a part is classified into its proper group, the next step should be the selection of the size of grit or shot to be used. This selection will depend upon a number of conditions and may require considerable experimentation. To clean effectively, it is necessary to use a grit or shot with sufficient impact to break the scale quickly and yet be small enough for adequate coverage. The coverage factor is particularly important when castings with deep or partially accessible cavities are being cleaned. It may be necessary, in some cases, to blend two or more different sizes to obtain the necessary stabilization of sizes in the machine, especially when using slow breakdown type of abrasives.

A general guide or starting point for selecting abrasive size can be determined through the use of the impact intensity versus wheel speed chart (Figure 9). Group A materials may require 0.006-0.014 ft-lb impact intensity; Group B may require 0.001-0.006 ft-lb; and Group C may require up to 0.001 ft-lb. Therefore, the selection of abrasive size will depend upon the wheel speed, as shown by Figure 9.

For example, a steel casting in Group A would probably require an abrasive size between 0.042 and 0.057 with a wheel speed of 2250 rpm. The abrasive size referred to in Figure 9 is, of course, the stabilized size in the machine as screened from a sample taken at the nozzle or hopper discharge chute.

PARTICLE SIZE	NUMBER OF PARTICLES PER LB
0.020	852,000
0.030	252,000
0.040	106,000
0.050	54,000
0.060	31,000

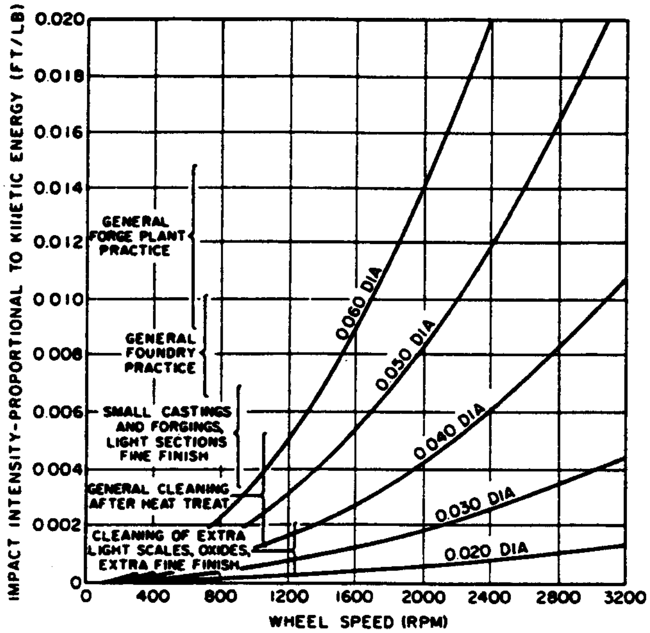

FIGURE 9—IMPACT INTENSITY VERSUS WHEEL SPEEDS FOR VARIOUS SIZE PARTICLES, 19.5 in. DIA STANDARD WHEEL

5.2 Cleaning Practices—The following general cleaning practices are recommended:

5.2.1 The cleaning machine should always be loaded to full capacity in order for the pattern to give proper coverage and to prevent excessive wear on the machine barrel or conveyor.

5.2.2 The frequency of exposure of the parts being cleaned to the abrasive spray is an important factor in minimizing the cleaning cycle time. It is recommended that the action of the parts be investigated, especially in barrel-type machines, and necessary steps be taken to reduce sliding action and to increase tumbling action. In some cases welding steel bars on the barrel or conveyor flights will be sufficient.

5.2.3 Abrasive losses through carry-out can be minimized by tumbling the parts for a predetermined time in batch-type machines, by vibrating parts over a screen in some cases, and by turning by hand or mechanically on the monorail-type machine.

5.2.4 Adjustment and periodic inspection of the blast gate on a gravity-type separator can be facilitated by installing a small spring-mounted screen and air vibrator under the dribble valve to determine effectiveness of the suction in removing the fines from the abrasive without removing useful abrasives. A discharge chute to collect abrasive not passing through the screen can be employed to return the usable material to the cleaning machine.

5.2.5 It is recommended that a production test procedure be established. This procedure will vary somewhat depending upon the type of material being used, type of machine being cleaned, and individual plant practices. However, the data form shown as Figure 10 and the following methods of accumulating and evaluating data may aid in setting up a procedure:

Type Machine ____________ Equipment No. ____________

Number of Wheels ________ Wheel Speed ________ Wheel Diameter ________

Type of Parts Cleaned ____________

____

Type of Abrasive ____________ Abrasive Size ____________

Abrasive Source ____________ Abrasive Cost/Ton ____________

Date	Total Wheel Hours	Cumulative Wheel Hours	Pounds of Abrasive	Cumulative Pounds of Abrasive	Cumulative Abrasive Cost	Cumulative Maintenance Cost

FIGURE 10—PRODUCTION TEST OF ABRASIVE—DATA SHEET

a. The machine wheel hours on an airless blast machine can be accurately determined by installing a time meter on one wheel of the machine. The recorded time must then be multiplied by the number of wheels operating on the machine to determine the total machine wheel hours. A suggested method of wiring is give in Figure 11.

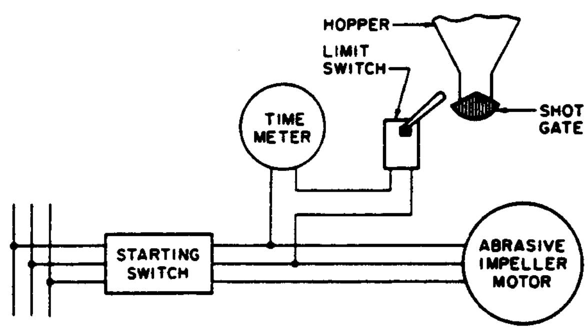

FIGURE 11—WHEEL TIMER

b. An abrasive consumption curve shows graphically not only the abrasive usage rate per wheel hour at any time but also the point at which an abrasive reaches a stabilized condition in the machine. Abrasive cost figures and screen analysis should be based on data obtained beyond the point of stabilization.
Any radical change in the slope of the curve during a test is an indication of excessive abrasive losses, negligence in maintaining the proper abrasive level in the machine, lack of recording new abrasive additions, or defective wheel hour timer circuit. See Figure 12.

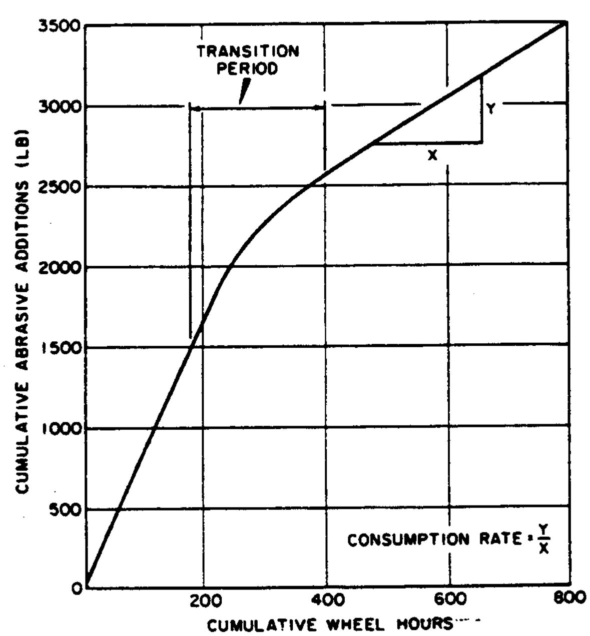

FIGURE 12—ABRASIVE CONSUMPTION CURVE

c. Monthly operating cost figures and/or curves can be generated to show comparative costs of abrasives, maintenance materials, maintenance labor, and productive labor. They can be based on either wheel hours or tons of material cleaned. It must be remembered that two abrasives can be compared economically only if all the direct costs are added into the total operating cost.

6. Production Procedures

6.1 Control of Abrasive Spray Pattern—When setting up a new machine, and periodically during its use, the abrasive spray pattern should be checked. This is done by placing a suitable piece of sheet steel at the same height and in the same position as the work to be cleaned and exposing to the shot blast for a few seconds. Remove and examine the sheet. If the centerline of the shot pattern, as shown on the sheet steel, is not in the center of the work, shift the work location or adjust wheel or nozzle alignment.

6.2 Control of Abrasive Size—Cleaning in a blast cleaning machine is accomplished when sufficient abrasive particles having high velocity impinge on the work surface. The energy or work capability of the abrasive is directly proportional to its mass and the square of its velocity (Figure 9). Fine particles have little mass, thus the energy and work capability is negligible. If these fine particles (generally below 0.0117 in. U.S. standard screen size) are not removed but are allowed to accumulate to be an appreciable percentage of the machine's abrasive content, the cleaning time will be increased proportionately. Thus, control of the abrasive size is necessary to eliminate the finer particles, which break down from continued impact cycles.

The separator of the blast cleaning machine is employed to remove all fine abrasive particles, the fines or sand removed from the work surface, and any heavy flash or scale. The finer materials, if not removed, will cause a contaminating interference, reducing the efficiency of the cleaning operation. The sand, if allowed to circulate through the machine, will cause excessive wear on the blades. Circulation of heavy flash or scale will break blades, wear nozzles, and reduce the life of the machine.

The gravity type separation principle is generally employed in all mechanical type blasting equipment. An air wash or suction from the exhaust system removes the fines, sand, and dust, as this material and the good abrasive fall over the edge of stratifying plates. This type of separator is adjustable so that any size particle can be removed. This adjustment is generally effected by increasing or decreasing the velocity of the air wash by opening or closing baffle plates in the separator exhaust line system.

When adjusting, it is good practice to make a screen analysis of the abrasive as well as the rejected fines. The level of separation should be high enough to remove all fines or sand from the abrasive, and yet low enough so that good abrasive particles (above 0.0117 in. U.S. standard screen size) are not removed from the machine.

In the gravity type system, the abrasive and fines or scale from the work are elevated from a hopper located below the cleaning chamber to the separator above. Coarse separation or the removal of large flash or scale takes place when the elevator bucket content is passed through a perforated plate or screen.

In cases where a greater amount of coarse separation is necessary, a perforated revolving drum replaces the holed plate. The abrasive, fines, or small scale, falls through the drum, while the larger flash or scale carries through to a discharge duct.

After the coarse separation, the abrasive, fines, sand, etc. fall into the fine separating chamber. In one system (Figure 13), this material, after being dispersed by the perforated drum or plate, falls onto an inclined plate. The abrasive, fines, sand, etc. are carried by gravity down the plate and fall over the edge. At this point, the air wash furnished by the exhaust system stratifies the finer material. The heavier good abrasive, having greater momentum, is not capable of stratification and falls directly into the storage hopper. The fines, sand, and dust are lifted by the air wash up into a series of vertical baffles. As the heavier fines are carried down by the air wash, they resist an upward turn and are deposited into a settling chamber where they leave the machine system. The remaining dust held in suspension is carried out the dust collector or main exhaust system.

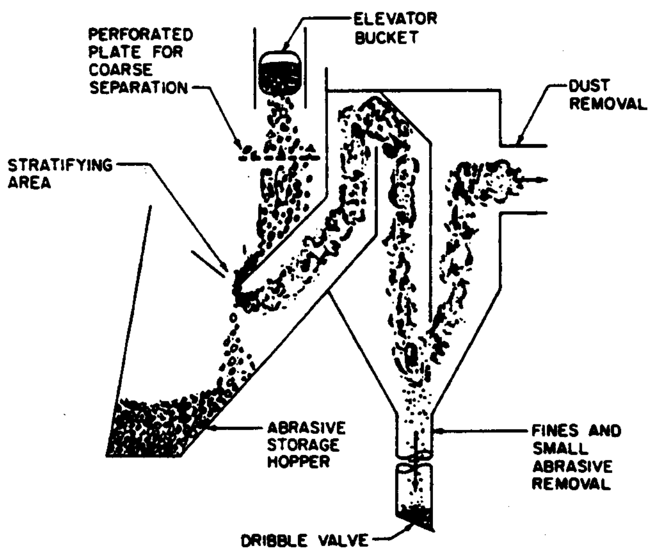

FIGURE 13—SMALL GRAVITY TYPE SEPARATOR

In a second type of gravity system (Figure 14), coarse separation is again effected by a perforated rotating drum or plate. In the fine separation chamber, the material passing through the coarse separator is evenly distributed when it falls through a perforated inclined plate. After being distributed, the particles fall over the edge of a second inclined plate where they become stratified. The material is then conveyed via air and gravity down another incline. As the particles fall over the edge of this plate, the heavier, good particles, having greater momentum, resist the air wash and fall directly into the abrasive storage hopper. The heavier fines are partially turned by the air wash and are deposited into a fines refuse discharge duct. An adjustable skimmer can be regulated to insure that all fines are removed.

Removal of larger or smaller particles is accomplished by adjusting the baffling in the exhaust ducts. The dust collector or main exhaust system (accommodating several machines) draws air from within the machine, causing an air vacuum, which has a dual purpose, that is, to furnish the suction or air wash in the separator to cause stratification of the finer particles and to ventilate the cleaning chamber. Figure 15. Baffles B and C are used to balance the total amount of air removed by the dust collector blower or main exhaust system. Closing baffle C will reduce the air velocity in the separator, but increase the velocity of the cleaning chamber draft. Reducing the air velocity in the separator (closing baffle C) will cause the removal of smaller particles. Increasing the air velocity (opening baffle C) will cause the removal of larger particles. Baffles B or C should never be closed more than halfway, for this will cause abnormal wear on the piping and elbows. If this becomes necessary, baffle A should be closed, reducing the total velocity.

In large-production cleaning installations, greater quantities of abrasive must be separated. In many cases, the same separator is used but in series of one, two, three, etc. One type of multiple-wheel separator employs a rotating table and centrifugal force to distribute the abrasive, fines, sand, etc. evenly over the outer edge of the table where stratification takes place. The good abrasive falls directly into the storage hopper, while the removal of the fines and dust takes place inside a series of internal vertical cylindrical baffles. The air exhaust line is connected to the inner cylindrical baffle (Figure 16). Control of the abrasive size in these larger separators is again effected by adjusting the baffles located in the exhaust lines.

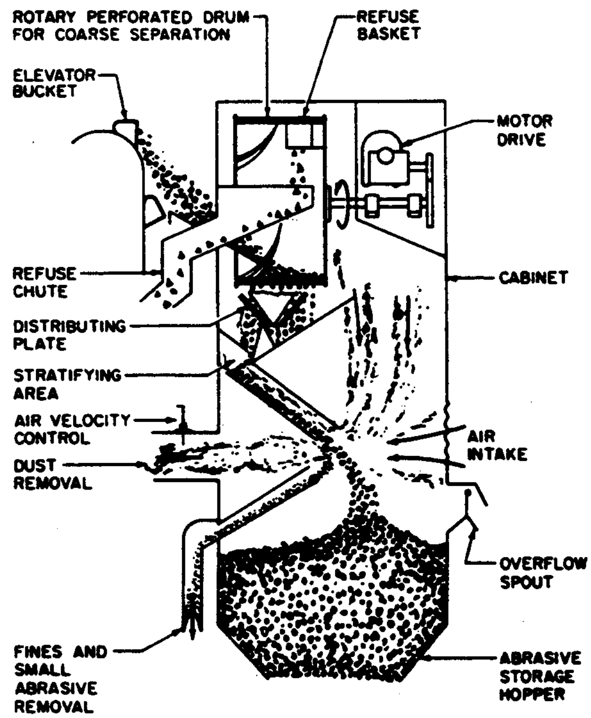

FIGURE 14—LARGE GRAVITY TYPE SEPARATOR

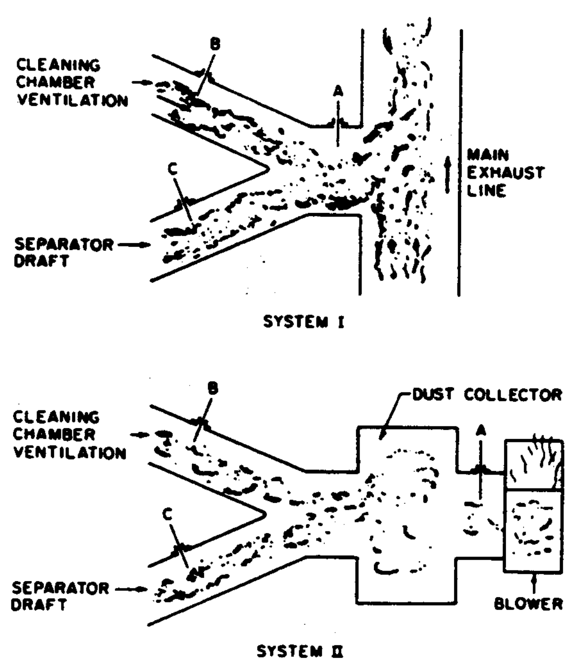

FIGURE 15—SCHEMATIC DRAWING OF PNEUMATIC SYSTEM FOR BLAST CLEANING EQUIPMENT

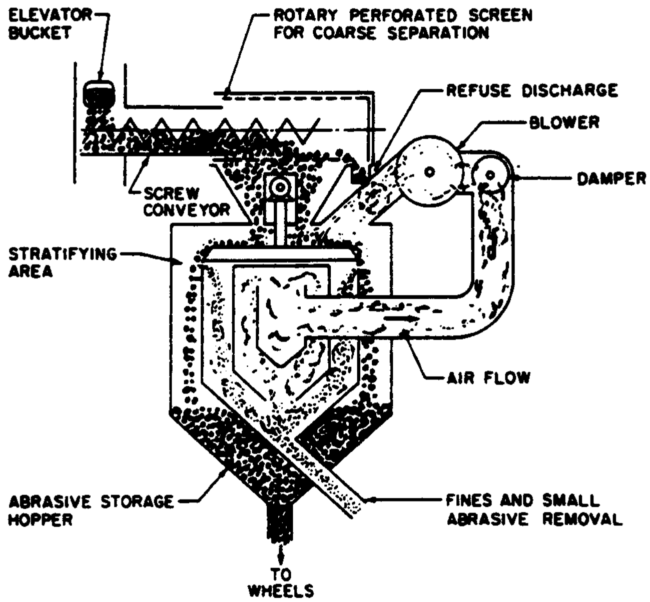

FIGURE 16—ROTARY TYPE SEPARATOR

6.3 **Control of Abrasive Flow Rate—**Cleaning of the work surface is accomplished by particle impact and by having sufficient particles impinge on the work surface—or sufficient coverage. The impact is influenced by the particle size and its velocity. Coverage is influenced by the overall particle size distribution and by the flow rate. Thus, control of the flow rate is necessary to maintain coverage. Increasing the flow rate will offer greater coverage and tend to reduce the cleaning time.

The rate at which a wheel can throw abrasive is largely dependent on the horsepower rating of the motor that rotates the wheel. Equipment having a 15-hp motor and 191/2 in wheel rotating at 2250 rpm will throw a maximum of approximately 350–400 lb of abrasive per minute. A 25 hp motor with a 191/2 in wheel having a larger wheel opening and rotating at 2250 rpm is capable of throwing 600–650 lb/min. Greater flow rates require larger motors, higher-capacity elevators, etc.

In air blast equipment, the abrasive flow is dependent upon nozzle size and rate of flow.

Control of the flow rate is accomplished by controlling the aperture through which the abrasive must pass. A larger opening will allow a greater amount of abrasive flow, while a smaller opening will reduce the rate.

To change the flow rate of a machine using an orifice plate, a complete plate having a larger or smaller opening must replace the one in use. Figure 17. With the adjustable metering device, the opening can be changed by moving the baffle plate in or out. Figure 18.

A gate located below the metering device is actuated to stop or start the set flow of abrasive.

In smaller equipment, where the storage hopper head pressure is not great, an orifice or metering device is not always employed. The flow rate is controlled by merely opening the hopper gate partially or fully. A partially opened gate reduces the rate of flow of the abrasive by diminishing the size of opening at this point.

On a wheel type machine, the motor ampere reading varies with the load on the motor wheel or the abrasive flow rate. The ampere reading then becomes a means of determining the flow rate, once a calibration is made.

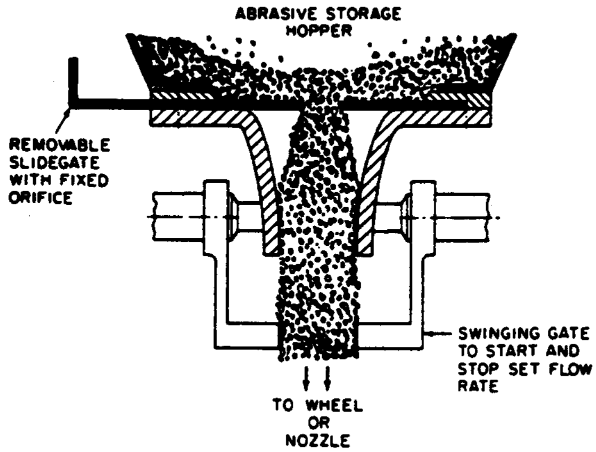

FIGURE 17—ORIFICE TYPE FLOW RATE CONTROL

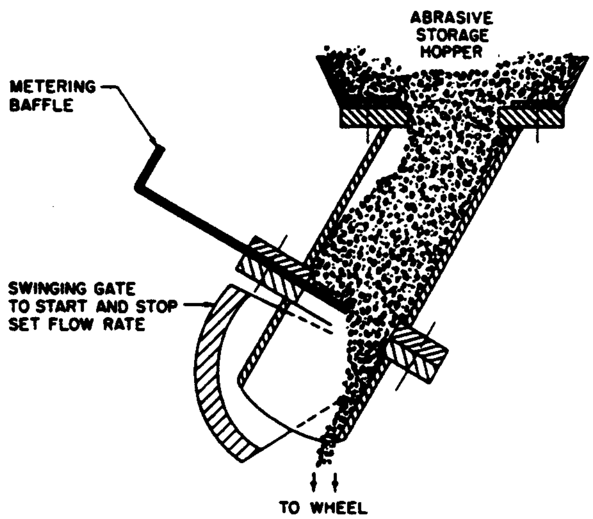

FIGURE 18—METERING BAFFLE TYPE FLOW RATE CONTROL

A recommended method of determining an unknown flow rate is as follows: catch the abrasive that would normally pass through the control orifice receptacle for a period of 15 s. Weigh this abrasive. Multiplying this weight by a factor of 4 will give the weight in terms of pounds per minute.

6.4 Control of Exposure Time—Overcleaning of the work surface is a costly and unnecessary operation. Exposing the work surface to a blast stream for longer periods of time than necessary results in reduced productivity as well as increased abrasive, maintenance, and labor costs per piece. Underexposure, which allows sand or scale to remain on the work surface, is detrimental to tool life and consequently increases the perishable tool costs in the machine shop. Control then becomes necessary to insure that the work is cleaned properly but without excessive over-exposure.

When cleaning castings, exposure times vary with the size and contour of the work. Smaller parts, which tend to pack close together while being tumbled, or parts with deep cavities generally take a longer cleaning cycle than large, bulky parts. There are some cleaning time differences encountered between castings of the same type, varying pouring temperatures being the cause. High temperatures cause the sand to burn in and become more difficult to remove, necessitating a longer cleaning time. When cleaning forgings, the type of heat treat scale as well as the material, size, and contour of the part affects the cleaning time.

Methods of controlling the exposure time differ with the type of equipment. For machines that clean the work in batch loads, this control many times is left up to the experience of the cleaning room supervisor and the operator. Work of a particular type is known to take a prescribed amount of time and is cleaned that long. At the end of this period the abrasive flow and wheel are stopped and the work is emptied. A new work batch is then loaded.

Recently, the use of automatic cycle time controls for batch type equipment has come into being. After the work has been loaded, the door is closed and the timer is set to a prescribed time period. The hopper gate automatically opens after the wheel has reached its rated rpm. Cleaning is then carried out and stopped automatically at the termination of this time. A light or buzzer indicates when the batch load is ready for unloading. The operator can do other necessary work without being concerned about overcleaning. In some cases, two operators can run three machines, and production increases have been obtained by the use of this device.

In monorail type equipment, heavier parts such as engine heads or blocks are hung onto a monorail hook and carried in front of several blast cleaning wheels. Exposure time is controlled by varying the speed at which the monorail conveys the parts through the machine. In the continuous barrel type of equipment, the work is placed in the cleaning chamber at one end, conveyed through the barrel under the blasting wheels via a tumbling action, and then emptied at the exit end. In the two barrel type machines available today, two disticnt methods are employed to control exposure time. In one, the angle that the barrel is to the horizontal is adjustable to affect the rate at which the parts are transported through the cleaning chamber. Increasing the angle forces the parts through faster, reducing the cleaning time; decreasing the angle increases the time.

In a second type the barrel is horizontal and the rate at which the parts are fed controls the exposure time. The entering parts force the work through the machine. The faster the parts are placed in the cleaning chamber, the faster they come out, thus reducing the cleaning time.

In automatic air blast equipment, exposure time in front of the blast is controlled by cycle timers or by varying the conveyor or transfer speeds and feeds.

6.5 Ventilation of Abrasive Blast-Cleaning Equipment

6.5.1 IMPORTANCE OF PROPER VENTILATION—The proper installation and maintenance of an adequate exhaust and dust collector system are necessary to efficient, satisfactory operation of abrasive blast equipment.

The operation will not only wear down the abrasive material passed through the wheel or nozzle, but will "grind" the material being removed from the work, whether sand, scale, paint, rust, etc., into a dust of varying fineness.

The fine dust must be continuously removed from the blast machine to prevent contamination of the air surrounding the machine, since the dust is a hazard to personnel and equipment.

The coarse dust blasted from the work must be continuously removed from the abrasive cycling system, in order to return a proper blasting mixture to the wheel or nozzle. In many equipment models, this coarse dust is air-washed away only by the exhaust system.

Dust slows down the cleaning action, increases the length of cleaning cycle, discolors the work, and greatly increases wear.

6.5.2 ELEMENTS OF AN EXHAUST SYSTEM—An exhaust or ventilation system consists of:

6.5.2.1 *Piping or Duct Work*—An adequate system of duct work must be constructed of suitable materials, properly supported, properly proportioned regarding pipe diameters, elbow radius, length of tappers, etc., and maintained in good condition.

Follow the recommendations of the equipment manufacturer in regard to system design, materials of construction, etc. Have a competent metalsmith install the system, preferably someone who has had wide experience in the design and installation of industrial exhaust systems.

6.5.2.2 *Dust Collector*—An adequate dust collector is an important part of the exhaust system. It must have ample capacity for both the air volume and dust load involved. The dust collector type must provide collecting efficiency in keeping with the requirements of the point of discharge of the cleaned air. The unit must be operated and serviced in accordance with manufacturers' recommendations in order to realize the greatest value and utility.

There are several types of collectors commonly in use on abrasive blast equipment:

a. Dry-Type Dust Collectors

1. Cloth tube (bag or stocking type). Uses woven fabric bags without an internal wire mesh support.
2. Cloth envelope or screen type. Uses woven fabric bags over an internal supporting wire mesh frame.
3. Dry centrifugal (high efficiency cyclone), which is characterized by relatively small diameter body with relatively long cone. It often has a small constant unit capacity and is usually employed in multiples.
4. Dry centrifugal ("common" cyclone), which is characterized by relatively large-diameter body with short or medium cone length. Usually, a single unit is employed, with size varying according to capacity required.
5. Dry dynamic (combination exhauster-collector), which is usually used with trap or precleaner to catch bulk of extremely coarse dust.

b. Wet-Type Dust Collectors

1. Wet centrifugal, usually in the form of a tower with multiple stages of baffles to provide increased area of wet surfaces for impingement and a tortuous path for the dusty air.
2. Wet orifice type employing specially shaped passages for the concurrent flow of air and water, plus baffles for impingement. Some models employ power-driven rolls or drums for water.
3. Wet dynamic type (combination exhauster-collector) often employing a primary chamber for the settling of coarse dust and the storage of collected sludge.

Collector types (a3), (b1), and (b2) must be operated at rated capacity for maximum efficiency. It is wise to provide a gated stub in the pipeline to such a collector to provide make-up air, if necessary.

A central exhaust system serving several machines, possibly of different types, is often used successfully. However, an individual exhaust system for each blast machine is recommended as being a more flexible arrangement.

6.5.2.3 *Exhaust Fan and Necessary Drive Equipment*—The exhaust fan is the third main component of an exhaust system. There is a limited number of proper types of exhausters. These are: small cast iron or large steel plate "planning mill" exhausters, and large steel plate backward pitched blade exhausters with load limiting characteristics. Less satisfactory types are the propeller fan, "axial" flow fan, and so-called ventilating (low pressure) fans used in comfort air conditioning systems.

The exhaust fan casing and rotor must be whole, and suitably balanced. The rotor must revolve in the right direction (blade tips moving in the same direction as the path of air coming from the outlet) and the rotor must be located from side to side in the casing, according to manufacturer's recommendation. The drive must operate with minimum slippage. Direct-connected fans are seldom used. A V-belt drive with overhung sheave is the popular type of drive.

6.5.3 ADJUSTMENT OF AN EXHAUST SYSTEM—An abrasive blast exhaust system should be adjusted so that the machine surroundings are visibly clean during the blasting cycle, and so that the abrasive is nearly free from fines and dust. However, this condition may never be achieved if the machine dust seals, etc., are not in a first class condition. It is also possible to process work so abnormally dirty as to be beyond the capacity of the abrasive separator and any reasonable size of exhaust system.

6.5.3.1 *Abrasive Separators*—There are three basic types of abrasive separators used on blast equipment. These are as follows: gravity separator, closed-cycle gravity separator, and rotary separator. Their function is to airwash useless fines and dust from the abrasive stream after they have been spent against the work. The basic operation of the three types is the same: the abrasive is cascaded in a spreadout stream or curtain over the end of an inclined shed plate. Air is exhausted through this stream into a duct under this shed plate. An expansion chamber within the separator settles out a coarse fraction of the sand or scale. This is discharged through a dribble (airlock) valve, and flexible tubing, to a floor box. In the gravity separator, all the exhausted air passes to the exhaust system. In the closed-cycle gravity and rotary separators (having an integral exhaust fan independent of the ventilating system) the air is returned to the separator, except for a controllable fraction, which is bypassed into the exhaust system. The separators with integral fans will remove coarse contaminants, with a fixed airflow, independent of the exhaust system. The bypass into the exhaust system reduces the recycling fine dust to a satisfactory level.

An uneven or discontinuous curtain of abrasive over the shed plate will upset the separator operation. With a proper curtain, the separator blast gate (gravity separator) should be opened to the point of carrying over a detectable amount of full sized shot or grit, then backed off slightly. A proper blasting mixture will include fractions of smaller-than-full-size new abrasive, up to the fifth smaller commercial size. However, it is false economy to try to hold the bulk of finer metallic particles in the stream. The fraction settled out in the separator expansion should be thrown away, or used in an operation requiring smaller abrasive. It should not be returned to the same machine. If it is necessary to return it to the same machine to economize on abrasion, the separator is improperly adjusted. If the discharge of the settled material is dusty, open the adjustable sleeve on the dribble valve just enough to offset this condition.

6.5.3.2 *Abrasive Elevators*—The blast gate in the duct from the elevator should be opened only enough to prevent escape of dust into the room.

6.5.3.3 *Abrasive Blasting Chamber*—There are three general types of exhaust arrangements for blast machines. These are:

a. Baffled outlet on top of the machine (self draining into the top of the cabinet) with the exhaust duct leading to the line-size abrasive trap installed in the horizontal run of the exhaust duct, the trap located to drain back into the machine through the dribble (airlock) valve and the flexible hose.
b. Tapered outlet (nonbaffled) on top of the machine with the exhaust duct leading to the oversize abrasive trap located as above.
c. Expansion box (usually internal) large enough to eliminate the need of auxiliary traps or baffles. The duct from the top of the expansion leads directly to the dust collector.

If abrasive traps are used, and if the internal baffle is adjustable, the bottom of the baffle should be one-fourth the diameter of the trap pipe opening above the bottom of the opening or collar. If an oversize trap is used, the inlet connection must be a long taper from pipe diameter to trap diameter. An identical taper should be used on the trap outlet, if space is available. The blast gate(s) should be open enough to provide clean surroundings during the blasting cycle. All trap reclaim should be returned to the machine.

6.5.3.4 *Blast Gates*—Standard slide type blast gates are usually used in all branch exhaust lines from blast equipment. These gates should always be as remote from the machine collar as possible, should never be located between machine collar and abrasive trap, and should always be installed with the slide travel horizontal. Usually, these branch gates are used only for balancing the exhaust between the various branch pipes. If closed more than halfway, abnormal wear on piping and elbows will result. They should never be used for throttling an abnormal capacity system. Either throttle the fan inlet or outlet or a separate collector system, or install a throttle gate in the machine main duct at its junction with the large main of a central exhaust system.

6.5.4 CARE OF A CLOTH-TYPE COLLECTOR—These instructions are necessarily brief and are recommended unless they conflict with the directions supplied by the manufacturer:

6.5.4.1 *Care—Daily Attention*

a. Hoppers should be emptied daily when the exhaust fan is not operating. Shaker devices should be operated before emptying the hoppers, not after. Make sure that the hoppers are clean; do not presume that the hoppers are empty just because dust stops flowing. Make sure that the hopper vales are closed after emptying, before the exhauster is started again.
b. Shaker devices should be operated every 4 h if possible, for about 21/2 min, when the exhaust fan is not operating. If your collector is equipped with an automatic shaker timer, the shakers will operate each time the exhauster is shut off; after an automatic time delay to allow the exhauster to coast to a stop. If you should start the exhauster before the automatic cycle is completed, the shaking will stop instantly, and the timer will reset for the next cycle.

If your collector is equipped with a draft gage indicating draft loss through the cloth, then, as a general rule, when the draft gage shows 2 in differential pressure through the bags (one side of the manometer to the clean air side and the other to the dirty air side), it is time to operate the shaker devices.

6.5.4.2 *Lubrication*—The fan and shaker device should be lubricated once a month (where lubrication fittings are provided), under normal service, with a good ball-bearing grease. The fan and shaker motors should be lubricated according to the maker's instructions, or according to your shop practice.

6.5.4.3 *General Attention*—It is well to inspect the interior of the collector at regular intervals, watching for worn bags or envelopes, and to check on the mechanical condition of the shaker device. Baffle plates should be replaced when worn appreciably.

6.5.5 CONCLUSION—The exhaust and collector system for an abrasive blast machine is necessary to achieve the maximum production, minimum costs and best quality of work.

Proper care of the exhaust and collector system is less expensive and provides more satisfaction than haphazard care.

7. ***Inspection—***Inspection for cleanliness of castings or forgings is a rather undefinable procedure. Cleanliness in itself is a relative matter, and the degree of cleanliness desired for a certain piece of work is reasonably indeterminate and not readily specified. However, before one can inspect, he must have some specification and idea of the actual requirements. This information is usually supplied by the process department or the division that will perform the next operation on the parts. There is no generalized specification that can be applied to suit any or all conditions.

The best and most widely used means of inspection for cleanliness of any type of work is visual inspection. Here, the inspector observes the surface conditions of the casting or forging or other type of work to see if they meet the established requirements. If the workpiece is a casting, visual inspection would consist of looking for sand on the critical areas or perhaps on all surfaces, depending on the nature of the end use. In intricate castings with considerable core work, it is sometimes possible to be lenient on the complete removal of sand from the hard-to-get-at-places, provided such leniency does not affect the final usage of the casting.

Certain methods of inspection are used other than visual observation. One of these is the scratch test. A chisel or sharp instrument is used to scratch a critical area of a casting to determine if the sand has been completely removed. Burned-in sand will appear as a white mark as the sharp instrument scratches over it, while the metal will appear in the normal dark color.

Another test used on ferrous castings or forgings or other types of work is the copper sulphate test. Here, a concentrated solution of copper sulphate in water is applied with an eye dropper or small brush to the surface of the work. Scale that has not been removed from the work will appear black, while a clean area will "plate-out" copper color. This test is rather widely used.

Another test commonly used for gray iron sand castings (especially bathtubs and other sanitary ware) is the heating up of the casting to a cherry red temperature and then allowing the casting to cool—this procedure is called "burning-in." Here, any sand that is left on the surface will appear very light gray, while the remainder of the casting will be black. This clearly indicates the amount of sand on the surface of the casting.

Other requirements for inspection may include surface roughness and type of etch. In castings (both ferrous and nonferrous), as well as forgings and roll-steel products, there are many instances where the surface roughness of the final cleaned product is of considerable importance. This is defined by the requirements of the parts in question, and it is a good idea to have a comparator sample to use. This specimen would be a sample of the type of surface desired that will permit visual inspection to see if it has been attained. Considerable care and judgment should be exercised in preparing the comparator so that it will properly serve its purpose. If the surface condition is of little or no importance, this should be disregarded.

It is important to remember that any inspection is no better than the inspector performing the operation, and he can only do a good job if he has a thorough knowledge of the requirements.

8. Maintenance of Blast Cleaning Equipment—Maintenance in manufacturing plants consists of keeping equipment in condition for efficient plant operation. In blast cleaning, maintenance costs may amount to one-third the total cost of the operation. Preventive maintenance is recommended on this equipment.

Some of the important items that should be checked regularly are as follows:

1. Any abrasive that has spilled or accumulated around the machine should be cleaned up and returned to use.
2. Keep the machine loaded so that this loading will protect exposed parts and reduce the wear on them. If the loading is not continuous the abrasive should be shut off.
3. Proper abrasive flow must be maintained for the type of abrasive used, and abrasives must be kept free of any particles which might clog the regular flow.
4. Set up cleaning cycles, whenever possible, so that the parts are not run longer than necessary.
5. The abrasive should be added at regular intervals and in relation to the amount of fines rejected. Keep the abrasive supply hopper full.
6. In wheel type equipment the blades should be checked regularly and replacements made so as not to cause the wheel to become unbalanced.
7. Ventilating and dust systems must be properly adjusted for good operation. When dust is not controlled it will create hazardous working conditions, possibly damage other equipment in the vicinity and reduce the cleaning efficiency of the machine. The exhaust system should be finely adjusted so that all the dust is removed but none of the abrasive is carried out.

8. The shell of the machine should be kept tight to prevent loss of abrasive and damage to other parts.
9. An inspection chart can be kept on the job to remind those responsible what attention should be given to the machine regularly.

9. Testing of Shot Life in the Laboratory—During the past few years, there has been a good deal of work done on the problem of life testing of shot particles. This work covers not only the mechanics of testing, but the pooling of ideas of various users, so as to establish a common understanding and a common language as regards shot testing.

It is generally agreed that breaking the shot up by subjecting it to repeated impacts under its own momentum gives results most likely to correlate with service performance. Accordingly, drop-hammer impact tests, ball mill tests, crushing tests, etc., are regarded as unsatisfactory.

Testing machines, devices to subject the shot particles to impacts due to their own momentum, have been developed and are described later.

It is the purpose of this section to describe how these machines may be used.

All these machines have a means of accelerating the shot particles to velocities likely to be encountered in service, (about 200 fps), and some sort of target, which the shot particles strike. The sample to be tested, therefore, is repeatedly accelerated to some velocity and subjected to the impact of striking a target. The number of times that the shot particle can be subjected to such punishment before failure is the value that is measured.

What constitutes failure is a question that is answered by definition. Needless to say, this definition has gradually changed and is still subject to debate. Its importance, however, is not great unless comparative data with other laboratories are intended.

The punishment that a particular single shot particle can endure before failure is easy enough to determine. One would simply count the number of times that this particular particle could be subjected to a given number of impacts without failure. In this case, however, we are confronted with a sample that has hundreds or even thousands of particles. So it is necessary to determine the average life of the group of particles.

The procedure usually follows this pattern:

1. A sample that is as nearly representative of the whole as possible is obtained.
2. This sample is put through standard sieves and separated into the various sizes.
3. A sample of 100 gr is taken from the sieve holding the largest proportion of the original sample.
4. This 100 gr is then put into the shot tester. As it passes through the tester, it is subjected to several impacts. In the case of the American Wheelabrator machine or the Pangborn machine, the sample is collected in a cup after making one pass. It is then hoisted, either mechanically or manually, to the feeding funnel and introduced for the second pass, etc. The number of passes is counted. In the case of the Alloy Metal Abrasive machine, the repetition of blows is automatic and is proportional to time. The number of passes is counted.
5. After a predetermined number of passes or time, the sample is removed from the tester and screened, using screens with selected opening sizes. The selection of screen opening size depends upon the definition of failure. Since shot is used mainly for blast cleaning purposes and shotpeening purposes, we use the following definitions of failure:

   a. For blast cleaning, the shot particles are considered broken when they pass through a screen with an opening of 0.0117 in, (No. 50 U.S. standard sieve), for shot of sizes SAE 230 and over. For the smaller sizes of shot, a screen with an opening of 0.0049 in, (No. 120 U.S. standard), is used. The choice is made because some production machines discard material when such degree of smallness is reached.

b. For shotpeening, the particles are considered broken when they pass through a screen with an opening next in line smaller in the U.S. standards than the sieve that held the material at the beginning of the test. For example, suppose the 100 gr sample to be tested was held initially on a sieve with an opening of 0.033 in; then the sieve to be used for measuring the breakdown would be one with an opening of 0.028 in. The choice of this definition of broken material for peening is based on the premise that full sized and uniform particles are wanted in a controlled peening operation, though it is acknowledged that this is sometimes impractical.

If shot testing is to be done with some particular production machine in mind, the definition of failure, and hence the size of "breakdown" screen used in the test, should correspond with the size of the material being discarded as useless by the machine.

6. The data obtained from the sieve analysis are plotted on a chart such as Figure 19, which shows the per cent broken versus the life in passes or time.
7. Repeating the testing and separation of broken particles from the good particles, as many points as desired can be obtained to establish this curve.

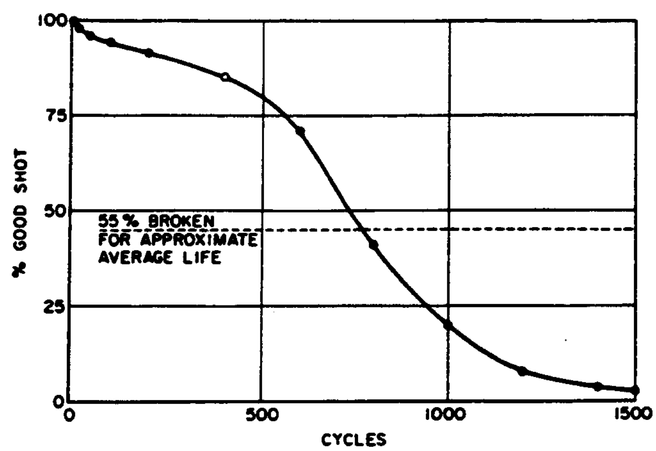

FIGURE 19—TYPICAL BREAKDOWN CURVE

Now comes the question of how this curve should be interpreted. We want an expression for the average life, because shot is fed into the production machine on the basis of average life. For a true value of the average life, this curve must be established accurately and completely—that is, until all the particles are failed (see peening breakdown curve, Figure 19). From the curve, one can see that some of the particles are weak and break down quickly, while others last a long time. To find the average life, it is necessary to add up the individual lives of all the particles and to divide by the total number of particles. This can be done by measuring the area under the curve and dividing by the height of the diagram.

Since curves for different shot materials are quite similar in nature, an approximation of the average life can be obtained by determining the life at the point where 55% of the sample is broken.[3] The value of 55% was established experimentally by measuring a number of typical diagrams.

To continue, there are definite liberties which can be taken, deviating from what has been said. For example, for testing incoming shipments of material, it would only be necessary to run the sample for some predetermined number of passes and measure the percentage of shot that is still good, provided that the selected number of passes is near the 55% breakdown point. A specification can be readily set up for this type of inspection.

3. From SAE Iron and Steel Technical Committee, Division 20.

It is not to be construed that these life tests tell the whole story about the performance of shot in blast cleaning operations. Proper consideration must be given to hardness. No specific tests have been devised to measure the influence of hardness on cleaning ability because no one knows how to measure cleaning ability. However, there have been experiences in the field that indicate the importance of hardness. When malleablized iron shot first made its appearance, there was some dissatisfaction with its performance as a cleaning medium because it did not knock the material off that was to be removed. A similar experience was had with the early cast steel shot. It can be appreciated that, in order to break or cut the scale from the surface, the stress at the instant of contact must be great enough to exceed the breaking strength. If a particle flattens out when it hits the work surface, it cannot produce the same stress as a particle that stays reasonably sharp. Long fatigue life can be obtained with relatively soft material, but its cleaning ability is also low. A compromise, then, must be made between the life and the hardness. Good results seem to be obtained with shot of "spring" hardness.

9.1 Shot Testing Machines—As a result of committee activities directed toward establishing a common testing procedure for shot quality, there are at present four testing machines. These are described here in the order in which they appeared.

9.1.1 AMERICAN WHEELABRATOR SHOT TESTER—The shot tester developed and used at American Wheelabrator and Equipment Corp. consists of a centrifugal wheel 4 5/16 in. in diameter. The wheel is driven by a 1/2-hp electric motor by means of an adjustable-speed belt drive. The wheel speed is adjustable between 5000 and 10,000 rpm in order to obtain the influence of wheel speed on the life of shot. The handle at the rear of the tester is attached to an adjusting screw for selecting the desired speed.

Surrounding the wheel is a specially designed, hardened-steel target. This target is provided with internal teeth, somewhat like an internal gear. Figure 20 shows a cross section of the wheel and target. The teeth of the target are inclined at a helix angle of 15 deg for the purpose of deflecting the shot into the hopper below, to prevent rebound of shot back into the wheel.

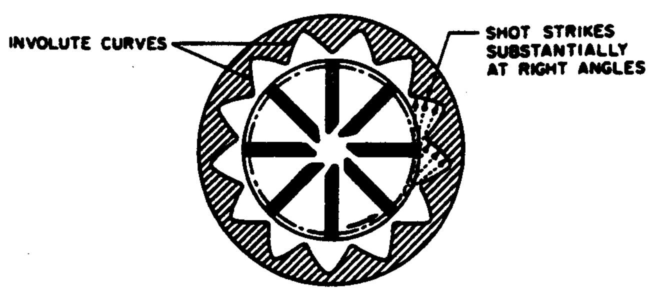

FIGURE 20—SHOT TESTER—WHEEL AND TARGET

9.1.2 PANGBORN EV-1 SHOT TESTER—The Pangborn shot tester (Figure 21) is a small laboratory machine developed for the purpose of comparing different types of abrasive by means of a breakdown test.

It is a vertical type of tester with a centrifugal wheel 4-1/2 in. in diameter mounted on a vertical spindle, which runs on ball bearings. The wheel rotates counterclockwise (when looking into the wheel from the top of the machine).

The speed of the wheel is adjustable from 0–10,500 rpm. At 9315 rpm the abrasive is propelled at a speed equal to that of a standard 19-1/2 in wheel running at a standard speed of 2150 rpm.

The drive for the wheel is mounted in the bottom of the cast-aluminum housing of the machine. The blasting compartment, which is lined with rubber, is in the top.

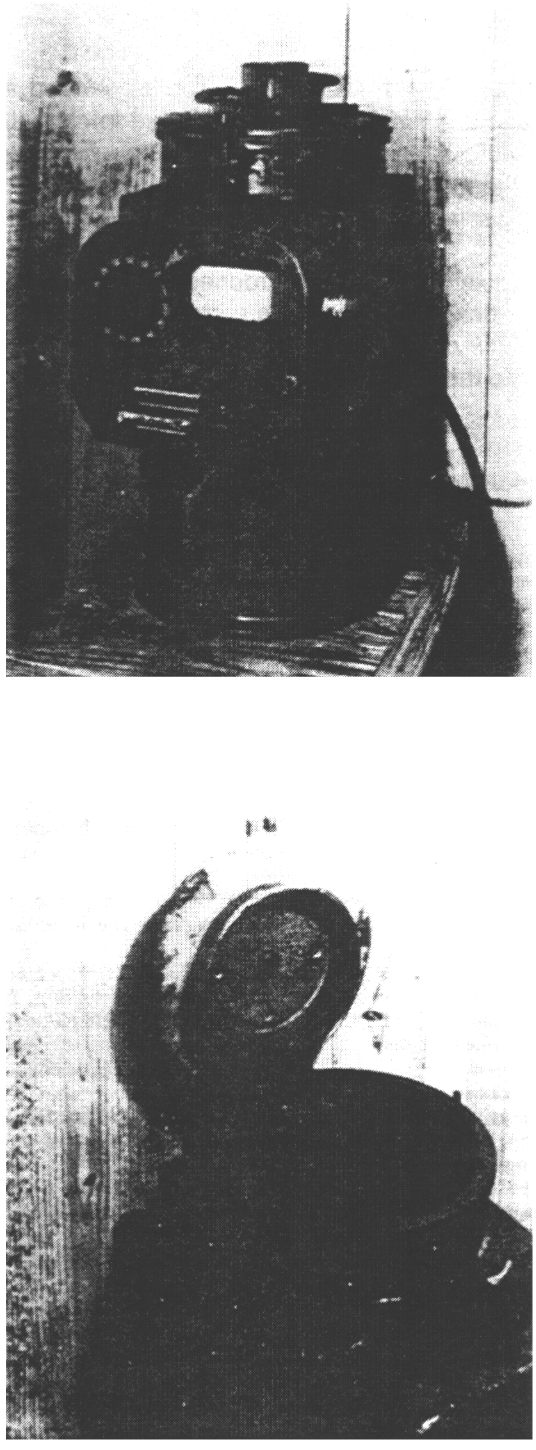

FIGURE 21—PANGBORN SHOT TESTER

The blasting compartment has a bottom, which slopes 45 deg into an outlet spout, on the end of which is inserted the receptacle receiving the abrasive after it has passed through the wheel.

A 1/3 hp, 12,000 rpm Universal motor drives the wheel. It is located directly under the spindle and connected to it by a flexible coupling. A pickup unit, driven from the vertical spindle through a belt, is also mounted in the bottom of the housing. This pickup unit registers the speed of the wheel on a speed indicator mounted on the front of the machine.

A hinged cover, mounted on the top of the housing, allows access to the blasting compartment. The anvil is mounted on the bottom side of this hinged cover and has a 17-1/2 deg angle surface on which the shot, hurled from the wheel, is impacted.

Mounted on the outside and in the center of the hinged cover is a cone-shape receptable with a removable orifice in the bottom for feeding the abrasive uniformly to the center of the wheel.

Several instruments and controls are mounted on the front of the machine: a speed indicator for registering the speed of the wheel, a voltage controller for adjusting the speed of the wheel, a counter for registering the number of passes of shot or abrasive through the machine, an on and off switch for starting and stopping the motor, and a fuse to protect the motor.

The machine is equipped with an extension cord, which can be plugged into any 110 V light circuit.

9.1.3 ALLOY METAL ABRASIVE CO. SHOT TESTER—This machine was developed to give accurate breakdown results and do the job automatically and obtain accurate results in a comparatively short time. It has a recycling device that returns the material to the beater wheel, which is used for accelerating the shot against an anvil. This machine is shown in Figures 22 and 23; it operates automatically. The shot particles are accelerated by means of a belt-driven wheel, and the axis of rotation is horizontal. The target is inclined at a slight angle to the direction of discharge from the beater wheel. This anvil is driven by a separate motor by means of a belt and rotates about the same axis as the beater.

The Alloy Metal Abrasive shot tester machine has the following features:

9.1.3.1 All the small broken down material is removed from the machine by an air circulating device.

9.1.3.2 The machine approximates the same conditions as are experienced in the commercial blasting machine.

9.1.3.3 It has a positive feed control, which automatically passes the material through a definite cycle without variations.

9.1.3.4 The machine is powered to maintain constant speed, which discharges the shot at approximately 200 fps, which corresponds to the same velocity as experienced in the commercial blasting machine.

9.1.3.5 This machine will make a complete and accurate breakdown test in a comparatively short time, even for long life materials.

9.1.3.6 The machine is equipped with a counter register, which records the number of material passes through the machine.

9.1.3.7 The operation other than charging and discharging the material is automatic.

9.1.3.8 The charging and discharging the material from the machine requires only the removal of a rubber plug.

9.1.3.9 The machine will operate under normal conditions for many months without altering the test results.

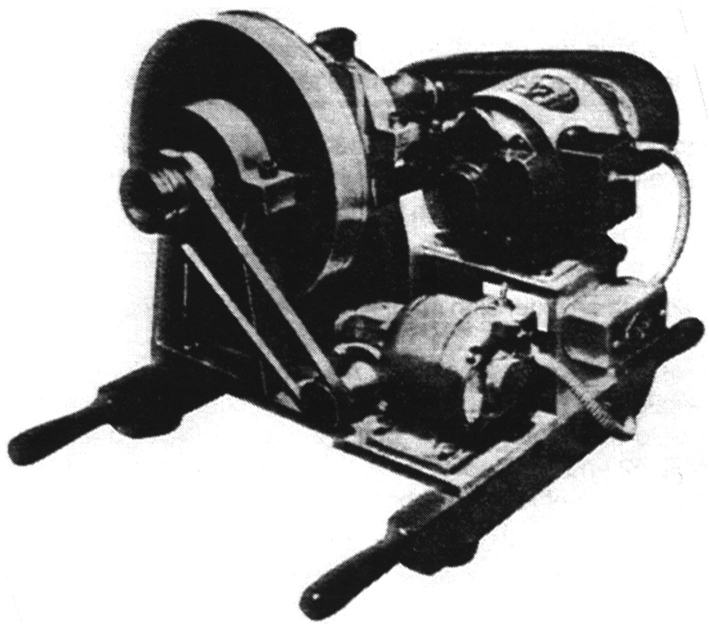

FIGURE 22—ALLOY METAL ABRASIVE CO. SHOT TESTER

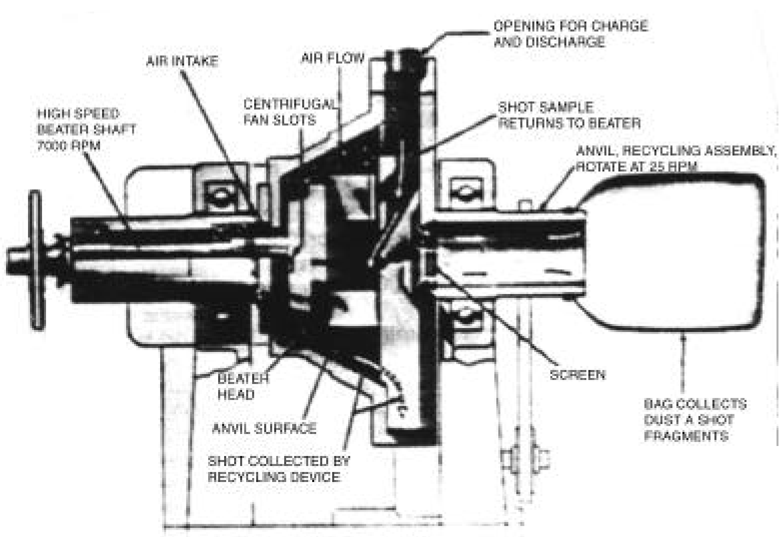

FIGURE 23—ALLOY METAL ABRASIVE CO. SHOT TESTER

9.1.3.10 The energy delivered by throwing 100 g at 200 fps, 25 times/min, approximates 60 ft-lb/s. This machine is powered with a 1/2 hp, 110 V motor.

9.1.3.11 The machine is hand portable and equipped with attached handles for easy carrying.

9.1.3.12 The approximate machine time required for the test of a 100 g sample broken down to a 0.010 size is as follows:

a. Hard iron: 7 min.
b. Steel: 60 min.

For a 50 g sample, the machine speed can be increased from 7000 rpm spindle speed to 10,000, and the time required reduced to one-half, which shows machine breakdown time for:

a. Hard iron: 3-1/2 min.
b. Steel: 30 min.

9.1.3.13 This machine minimizes all the variables that are experienced when attempting to make the test in commercial blasting equipment.

9.2 Shot Acceptance Testing Method—The following shot testing method was developed by Division XX, Mechanical Prestressing of Metals, of the SAE Iron and Steel Technical Committee as a means of measuring the relative quality of shot materials used for blast cleaning and shotpeening. In this test, the particles are subjected to repeated impact in a manner similar to that in production shotpeening and blast cleaning machines, and the resulting failure of the shot particles is similar in nature. In actual shotpeening and blast cleaning machines, however, there are many additional factors that influence the useful life of these materials—hence, this property alone should not be considered as the sole criterion of the utility of any particular shot material.

The test is primarily designed to serve as one of the tests in a more general acceptance testing procedure. Accordingly, it is rapid and essentially simple to perform.

10. Measuring Shot Blasting Machine Efficiency—A test method has been developed to aid in the evaluation of the operation of blast machine when using the various shot on the market today. The test is based on the measure of shot consumption versus time, tonnage cleaned, or wheel hours. The significant figures are pounds of shot consumed per hour of operation, pounds per ton cleaned, pounds per wheel hour; or the reciprocals of these figures. At the same time that shot consumption is being recorded, the amount of maintenance is usually recorded. Maintenance variations with different shots are as important, costwise, as shot consumption variations.

The test method has been designed to show the rate of shot consumption versus the previously mentioned units as a plotted curve. This graphically plotted curve, under ideal cleaning conditions, is a straight line. The usual curve measured under normal operating conditions with normal variables, etc., gives an excellent approximation of a straight line with the daily and weekly variables being evident; this feature being desirable in that the variables are apparent as to when they occur. The steps involved in developing such a curve are as follows:

1. Record each addition of shot by recording the weight of the addition and the operating hours since the last addition. If shot is added every day, record daily shot additions and daily hours of operation. This is simplified if an elapsed-time recording clock is connected to the shotblast equipment so that the clock operates when the machine operates. Clock readings taken when shot is added will show hours of operation between additions.
2. On a computation sheet accumulate the daily shot additions and the elapsed times, so that the latest figure in each column shows the total shot added since the test began, and the total hours of operation since the test began.

3. On graph paper, plot these accumulated shot totals versus the respective accumulated hours of operation. This will generate a rate curve. Dips and jumps in the curve indicate the effects of machine conditions, operating personnel, etc. The "straightness" of this rate curve generally indicates that the test is accurate. The idiosyncrasies that cause the curve to veer show up as soon as they occur and also show to what extent they alter the rate of shot consumption. Because one knows when they happen they can be quickly and effectively dealt with.

Figure 24 shows a typical methods test. This test was run on a 5-wheel cabinet cleaning complex, large, cored gray-iron castings. The manner in which this machine was operated involved the use of an inventory of 20 tons of shot in and about the machine. As you will note from the curve, it took approximately 20 tons of addition of new material before the old shot has been completely "flushed" and the effect of the new was felt. Within a week after the "turn" the lower usage of the new material was evident. The minor dips and curves show mainly the inaccuracy of the operator in judging the amount of shot necessary to add. The major jump at 600 h was due to the addition of a second shift on the cleaning operation. The work of the second shift was stacked until the next day and in that stack was a considerable amount of carryout. This carryout is all reclaimed and will be returned to the system when this type of two-shift operation ceases. You will note that the new rate of shot consumption continues after this large jump.

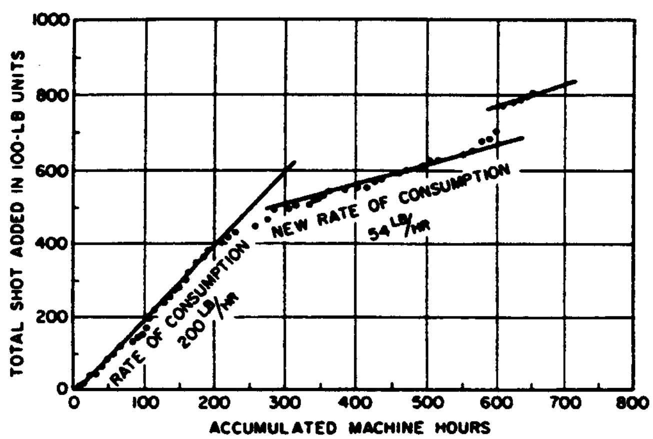

FIGURE 24—TYPICAL METHODS TEST

Figure 25 shows the operating curve of two identical shot peening machines operating side by side on different shots. The machines are 2-wheel automatic conveyor machines. These curves show that shot breaks down at a definite rate, regardless of operating disturbances. Rate of breakdown A is constant regardless of the two gaps where no record was made of shot additions. These gaps are so wide that if no shot had been added, as it appears, the machine would have exhausted itself and ceased to operate. Rate B is the effect of a new shipment of the same type of shot that was used during rate A. Rate C is from the second machine, which used a premium shot. The erratic behavior of the beginning of the curve was due to the shot stabilizing and the flushing of the previous shot. The jump just before rate C starts was due to an arbitrary raising of the shot level in the equipment. The level was arbitrarily raised again by 400 lb midway along the rate C line.

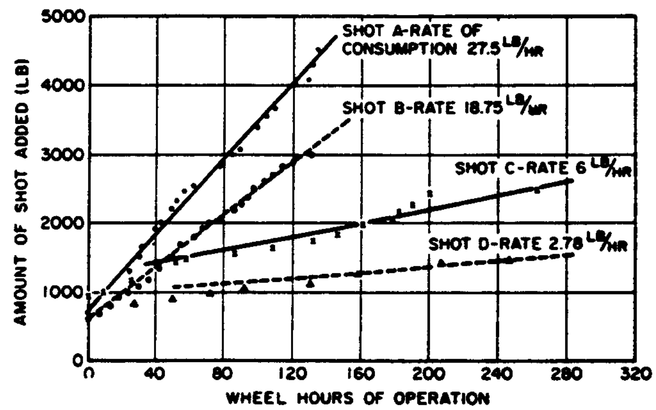

FIGURE 25—CURVE OF IDENTICAL SHOT PEENING MACHINES OPERATING ON DIFFERENT SHOTS

Figure 26 shows the comparison of operating features using four different shots in the same machine. A batch type airless blast machine was used to clean miscellaneous forgings.

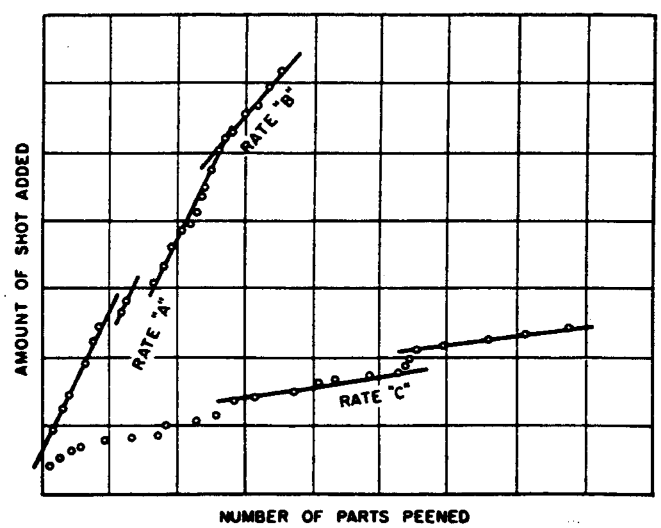

FIGURE 26—COMPARISON OF OPERATING FEATURES OF 4 DIFFERENT SHOTS

This was a straightforward, easily and quickly determined test, using various sizes of shot, and consumption rates for cleaning a variety of forgings. On the shot C curve around 180 h there was a quick rise in shot consumption. Upon inspection of the equipment a large leak was found. The leak was plugged and the shot reclaimed. The next point fell on the curve where it belonged.

Figure 27 shows the cost per ton cleaned when using four shots whose rates where shown by Figure 26. During the time the four shots were run tabulations were kept on the amount of material cleaned, the amount of maintenance on the machine, and the cleaning rates of the shots. It was then an easy matter to gather the cost per ton cleaned.

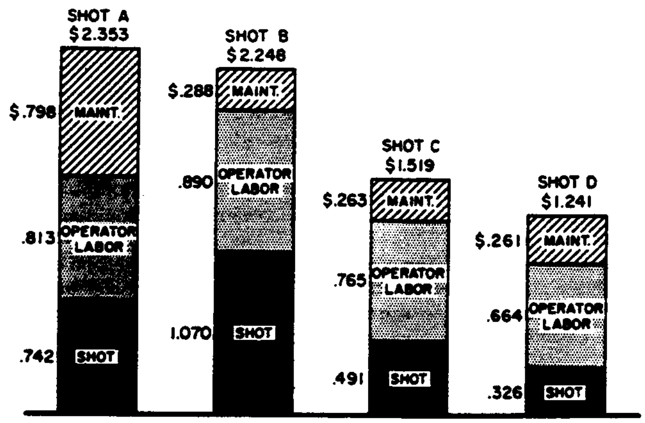

FIGURE 27—COST PER TON USING VARIOUS SHOTS

These four illustrations and the data shown by each are an accurate representation of the operating conditions of these machines. None of the tests took an extremely long time to show the change in costs due to a change in shot. This test method can be used to show the effects of change in wheel speed, change in shot size, change in materials handling techniques, etc. It is not limited to showing effects of change in shot only.

11. ***Wet Blasting with Fine Particles*[4]—**Blasting with fine particles suspended in a liquid has become an important process in cleaning and producing better finishes on many products these days. The functional finishes produced by this process have aided in the development of improved tool performance, better lubrication, better plate adherence, and improvements in many processing techniques.

The development of a wide range of compositions, types, and sizes of abrasive has been a feature of the process. Beginning with river sands and normal silicas, investigators discovered and produced finer and better cutting and longer lasting abrasives in quartz, novaculite, and manufactured abrasives.

The abrasive, together with approximately double its volume of water, forms a slurry which is fed to the blast gun. In the gun, the liquid stream joins with a high pressure air stream which projects the mixture against the workpiece at high speed.

One of the first types of wet and blasting machines merely added inhibited water to dry blasting. This proved unusually acceptable and was the pioneer equipment in this field. This type of equipment has recently been modernized and is expected to have many fields of application. Another type of wet sand blasting, employing coarser particles, uses water at high pressure to supply the force and injects sand into this stream to clean castings and knock out cores.

Fine particle wet blasting, known by various trade names such as "Fluid Honing," "Hydro finishing," "Liquamatting," and "Vapor Blasting" or "Liquid Honing," generally uses finer particles and produces finer finishes than the dry blasting process.

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4. Based on papers, "Hydro-Finish and Hydro Sandblast," by W. I. Gladfelter, Pangborn Corp.; "Fine Particle Blasting or MicroBlast Fluid Honing and Finishing," by E. E. Hawkinson, MicroBlast Mfg. Corp.; and "Fine Particle Blasting—Wet," by A. P. Neumann and V. W. Nichols, Vapor Blast Mfg. Co. These papers were presented at a meeting of Division 20—Shotpeening, Hot Springs, Va., Sept. 25, 1952. Division 20 is a part of the SAE Iron and Steel Technical Committee. Article reprinted from SAE Journal, October, 1953.

The art of blasting, both wet and dry, dates back into the 1800's. Fresh impetus was given wet blasting with fine particles in 1934 by A. H. Eppler, who pioneered in the development of special equipment for this purpose. Working with C. T. Strauss, who owned Arkansas mines of novaculite, Eppler found new and valuable applications for the process as finer and finer abrasives became available. Industrial acceptance was so enthusiastic that production wet blasting equipment soon appeared on the market. Now American Wheelabrator and Equipment Co., MicroBlast Mfg. Co., Pangborn Corp., and Vapor Blast Mfg. Co. all make wet blasting equipment for use with fine abrasives.

Novaculite, the most widely used fine abrasive for wet blasting, is very hard quartzose rock analyzing 99.4% silicon dioxide. Nature has produced it in very firm strata, which man uses for whetstones, and in naturally decomposed veins. From this powered state it is dried and separated according to particle sizes. It is available in many sizes ranging from 100 mesh (150 microns) down to a nominal 5000 mesh (2-1/2 microns). The particles are pseudo-cubical—that is, they are six-faced crystals with rounded corners. Makers of wet blasting equipment market novaculite under such trade names as "Aweco Liquabrasive," "Microbrasive MNH," "Pangbornite," and "Vapor Blast NVB." At the present rate of consumption, the supply is adequate for many hundreds of years.

Quartz, the best of which comes from the famous Wausau deposit in Wisconsin, is available for wet blasting in mesh sizes from 60–300. It is a sharp-angled crystal silicon dioxide of good lasting quality. This also is in adequate supply, being so plentiful that the owners donated half of the deposit to the city of Wausau, Wisconsin, to make the famous Rib Hill recreation grounds and Ski Hill.

Other natural siliceous abrasives, made from pulverized silicas and river sands, are also used in wet blasting and are in ample supply. Manufactured abrasives such as aluminum oxide and silicon carbide are also used for fast cutting and other special requirements.

All fine particle abrasives used for wet blasting tend to settle out and pack, when not being recirculated. So abrasive suppliers provide additives to help keep the abrasives in suspension, and to keep the slurry wet enough to drain rapidly from blasted surfaces and equipment walls. They also provide inhibitors to retard corrosion of equipment and ferrous parts being processed.

Figure 8 shows a schematic diagram of wet blasting equipment for fine abrasives. A centrifugal pump recirculates the abrasive mixture to maintain suspension and delivers the slurry to the blast gun. Here the slurry joins a compressed air stream at 80–100 psi pressure. The gun shoots the stream a the work piece, usually from 1–3 in away, with the blast impinging on the surface to be treated at an angle of from 45–60 deg. The slurry drains off the work piece and equipment to the hopper for reuse.

The operator manipulates the gun and work piece through armholes in the front of the machine with gloved hands. To keep his vision port or window clear from abrasive-laden fog, he presses a knee control which activates a clear water spray. The filter in the exhaust system is also spray washed to keep it functioning at good performance levels. To start or stop the blast and to control the air pressure, the operator presses another knee valve.

Machines have been built using several differing techniques, such as air agitation for abrasive suspension and venturi action for delivery of slurry to gun, but pumps have proved more efficient and economical for both purposes.

Delivery of the slurry to the gun under pressure (from pressurized tank or by pressure pumping) has been employed with success for spray head nozzles, long nozzles, small diameter nozzles, and for other special guns. Although design and function of manual machines has been pretty well standardized, many special machines for unusual and high production uses are continually being designed, developed, and built.

Users can procure fine particle machines with tracks, turntables, rotating devices, multiple gun manifolds, special guns for angle or lance blasting, gun oscillating mechanisms, and automatic rubber lined tumbling barrels.

11.1 Applications—Fine particle blasting guns benefit a great variety of products. They are used to clean off heat treat scale and corrosion, remove fine burrs, blend tool marks, smooth turbine blades; produce special lustrous or frosted finishes, and make micro-rough surfaces.

Fine particle blasting can remove some types of heat treat scale with only infinitesimal dimensional change on precision parts. Even heat treat salts in small amounts disappear. The process is often used before shot peening to prevent contamination of shot by scale. After shot peening, parts can again be blasted without losing effects of the peening.

Cleaning and finishing plastic molds and dies by fine-particle blasting is relatively fast, too; users report as much as 95% reduction in bench time. What's more, blasted molds release castings more easily than hand finished ones.

11.2 Results of Vapor Blast's Research

11.2.1 RELATION OF PERCENTAGE OF ABRASIVE TO METAL REMOVAL (FIGURE 28)

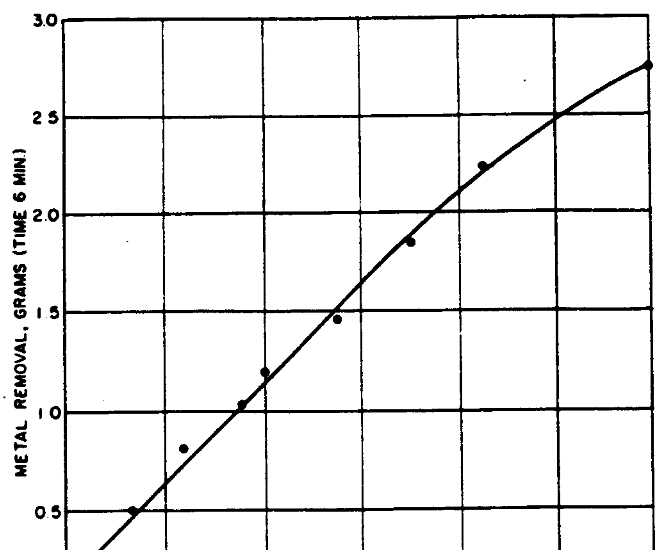

FIGURE 28—RELATION OF PERCENTAGE OF ABRASIVE TO METAL REMOVAL

11.2.1.1 Conditions—Duration of blasting, 6 min; angle of impingement, 90 deg; work-to-gun distance, 2 in; material used, SAE 1010; air pressure, 80 psi; type of gun used, V-B angle gun; diameter of nozzle, 1/2 in; diameter of air jet, 1/4 in.

11.2.1.2 Conclusions—An increase in the volume of abrasive, in the water-abrasive mixture, increases the cutting action of the blast.

A 68%-by-volume mixture was obtained before excessive settling occurred. This was decided to be the stopping point from the practical standpoint of using field equipment.

The data obtained show a straight-line relation between the amount of metal removed and the percentage of abrasive used up to 43% abrasive by volume. Any further increase in the amount of abrasive used causes the slope of the curve to decrease. This flattening of the curve could be credited to the settling of the abrasive. At these high percentages, the total amount of abrasive in the machine was not circulating properly.

11.2.2 EFFECTS OF CUTTING ANGLE ON WEIGHT REMOVAL (FIGURE 29)

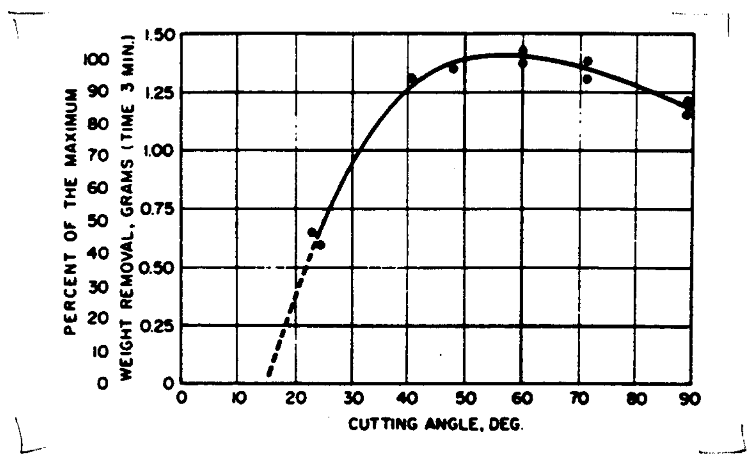

FIGURE 29—EFFECTS OF CUTTING ANGLE ON WEIGHT REMOVAL

11.2.2.1 Conditions—Duration of blasting, 3 min; angle of impingement, 90 deg; work-to-gun distance, 2 in; material treated, SAE 1010; air pressure, 85 psi, type of gun used, V-B angle gun; diameter of nozzle, 1/2 in; diameter of air jet, 1/4 in.

11.2.2.2 Conclusions—Cutting action increases gradually as the cutting angle decreases from 90 to 60 deg.

This increase can probably be accounted for by two facts:

a. The rebound effect is reduced as the cutting angle approaches 60 deg.
b. There is more scouring and less peening action as the angle is decreased to 60 deg.

Angles more acute than 60 deg gave a decided decrease in cutting, and the slope of the curve at angles less than 60 deg is great. At these lower angles, the blast has a wearing action which is much slower in metal removal rates than the cutting or scouring type action obtained near 60 deg.

11.2.3 RELATION OF CUTTING ACTION TO AIR PRESSURE (FIGURE 30)

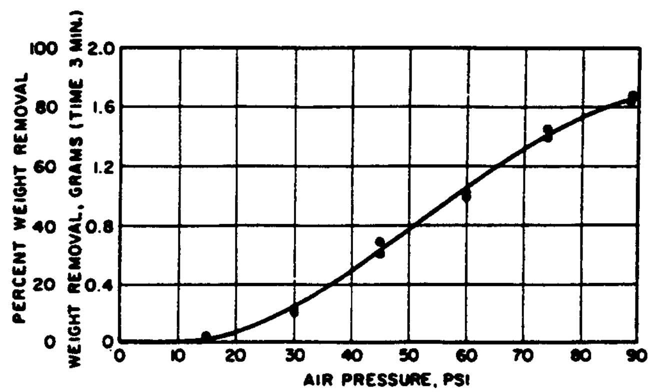

FIGURE 30—RELATION OF CUTTING ACTION TO AIR PRESSURE

11.2.3.1 *Conditions*—Duration of blasting, 3 min; angle of impingement, 90 deg; work-to-gun distance, 2 in; material treated, SAE 1010; air pressure, 85 psi; type of gun used, V-B angle gun; diameter of nozzle, 1/2 in; diameter of air jet, 1/4 in.

11.2.3.2 *Conclusions*—Between 30 and 75 psi the cutting action is almost directly proportional to air pressure.

At low pressure the kinetic energy of the particles is not sufficient to stress the surface of the steel beyond the failure point; hence the action is more wearing than cutting. Above 75 psi, a slight tapering off in the increase in cutting action was noted.

11.2.4 EFFECT OF GUN DISTANCE ON WEIGHT REMOVAL (FIGURE 31)

11.2.4.1 *Conditions*—Duration of blasting, 6 min; angle of blast impingement, 90 deg; material treated, SAE 1010; air pressure, 85 psi; type of gun, brass angle gun; diameter of nozzle, 1/2 in; diameter of air jet, 1/4 in.

11.2.4.2 *Conclusions*—No cutting action exists at distances less than 3/32 in. Optimum gun distance from the work is from 1.2-2.5 in.

At distances closer than 3/32 in, the back pressure reflected from the plate to the gun is sufficient to restrict flow of slurry. This rebound effect causes a rapid decrease in cutting action as the distance decreases. The cutting action falls off rapidly as the distance is increased beyond 2 in, but not proportionally to the square of the distance. Figure 31 would, of course, vary with changes in nozzle design. (Experiments have been performed only with a standard B-20 type brass angle gun.)

11.2.5 AIR REQUIRED FOR VARIOUS AIR JET DIAMETERS AT DIFFERENT PRESSURES (FIGURE 32)

11.2.5.1 *Conditions*—Type of gun used, V-B gun; abrasive used, 140 mesh, 40% by volume; air-measuring device, Fischer and Porter flowmeters; readings taken with slurry running through gun.

11.2.5.2 *Conclusions*—Air flow required is dependent on the abrasive flow, especially when the abrasive is under pressure greater than 3 psi.

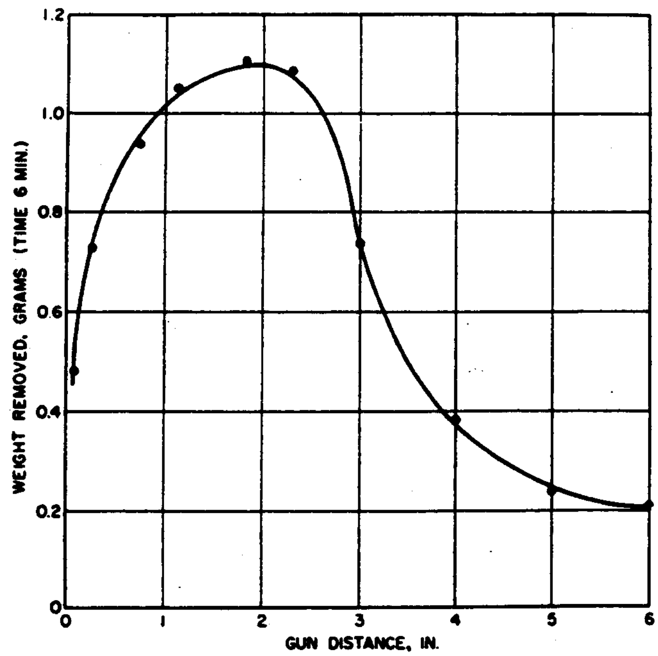

FIGURE 31—EFFECT OF GUN DISTANCE ON WEIGHT REMOVAL

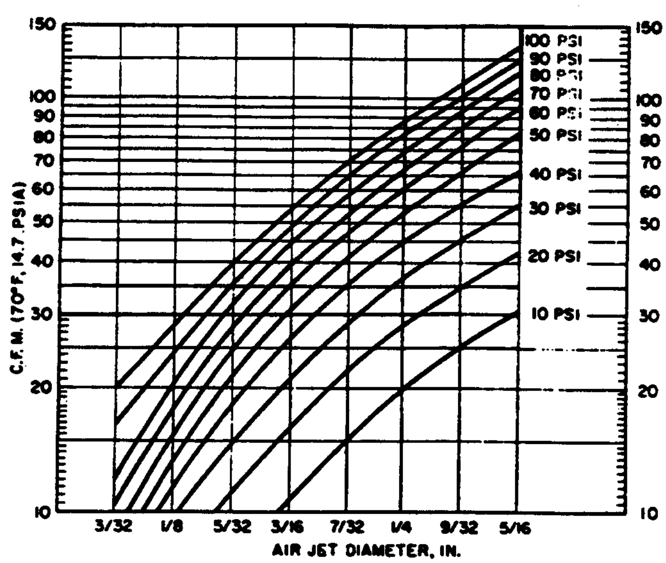

FIGURE 32—CFM OF AIR REQUIRED FOR VARIOUS AIR JET DIAMETERS AT DIFFERENT PRESSURES

12. Notes

12.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE IRON AND STEEL TECHNICAL COMMITTEE

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—This report on blast cleaning is a companion to the SAE report on Shot Peening. It is intended to help engineers, management, and shop personnel to increase their knowledge of the process. The information contained herein has been submitted and edited by a group that has had extensive and varied experience with blast cleaning and whose recommendations merit consideration.

Reference Section

SAE J441—Cut Wire Shot

SAE J444—Cast Shot and Grit Size Specifications for Peening and Cleaning

SAE J827—Cast Steel Shot

SAE Handbook

“Modern Blast Cleaning and Ventilation,” C.A. Reams, Cleveland, Ohio, Penton Publishing Company, 1939

“Simplified Practic Recommendation 118-50—Abrasive Grain Sizes,” U.S. Department of Commerce Bulletin, June 1, 1950

“Hyrdo-Finish and Hydro Sandblast,” W.I. Gladfelter, Pangborn Corporation

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“Fine Particle Blasting—A.P. Neuman and V.W. Nichols, Vapor Blast Manufacturing Company

Developed by the SAE Iron and Steel Technical Committee