BOULTON BALL AND PEBBLE MILLS FOR BATCH GRINDING AND MILLING

METICULOUS CARE IN DESIGN AND CONSTRUCTION ENSURES MAXIMUM EFFICIENCY AT MINIMUM COST

Mixing and grinding of a wide variety of materials for many different industrial purposes have exercised the minds of William Boulton engineers for more than 80 years.

Their accumulated knowledge and experience in the design and construction of machinery for these processes has conferred upon William Boulton unique qualifications to advise upon the problems arising.

The purpose of this brochure is to examine in some detail, the most important problems to be considered in relation to batch grinding and mixing of different materials in William Boulton Ball and Pebble Mills.

First, what does the mill look like? Turn to the photograph on the back page of this brochure and you will see that a ball and pebble mill is a machine which comprises a steel cylinder which rotates upon its horizontal axis. Thus, outwardly, it looks quite simple.

Experience has shown, however, that meticulous care in design and construction of individual parts is essential to ensure trouble-free service and convenience in handling. The most important points here are:

1. **The choice of lining materials and the method of fixing the linings. The most commonly used linings are Porcelain, Silex and Steel.**
2. **The fittings which enable charge and discharge to become easy operations.**
3. **Support bearings, drive, etc.**

PORCELAIN LINING

Mills lined with porcelain are probably the most common type, comprising blocks between $1\frac{1}{2}''$ and $3''$ thick depending on the size of the mill. The blocks are manufactured with special faces to key them together and secured in position by cement. Mills lined in this way are extremely easy to clean, which is important when used in the paint and printing ink industries. Mills lined by this method would use selected flint pebbles or porcelain balls as grinding media.

SILEX LINING

Silex lined mills are most common in the mineral dressing industry. Silex is a natural rock, about 99% pure Silica, with very hard wearing qualities. The blocks are rough hewn and $3''$ to $6''$ thick. The blocks, as with porcelain, are secured in the mill by cement. Silex lined mills use selected flint pebbles as grinding media, keeping contamination down to a minimum. As the silex has a rough face, this makes the lining more difficult to clean and therefore is not used in processes involving frequent changes of colour or material.

STEEL LINING

Where there is no objection to slight metallic contamination, steel lined mills may be used with steel balls as grinding media. The linings generally comprise manganese steel, special hard iron or steel sections bolted into the shell.

When steel lined mills are used, considerably more mechanical work is done in grinding or dispersing. Consequently the temperature rise of the contents is increased. In certain processes excessive temperature may be objectionable. It is then necessary to arrange for the temperature to be controlled, by means of a water cooling jacket.

In mills lined with steel, and using steel media, the coefficient of friction is considerably less than between mills lined with porcelain or silex. There is a tendency for more slip to occur between the grinding media and lining of steel mills. Also, when processing liquids having high lubricating properties, this may allow practically no transfer of movement between the mill and the grinding media.

The way to overcome this is to fit lifter bars on the shell to key the media and so produce a normal grinding action. The shape and size of the lifter bar is extremely important and should be sized, taking into account the diameter of the grinding media to be used. In general, the depth of the lifter bar should be sufficient to lift the media to produce a normal grinding action, but should not be so deep that they prevent the movement of the outer layer of grinding media where maximum pressures occur and a considerable amount of shearing takes place.
See Figures 1, 2 and 3.

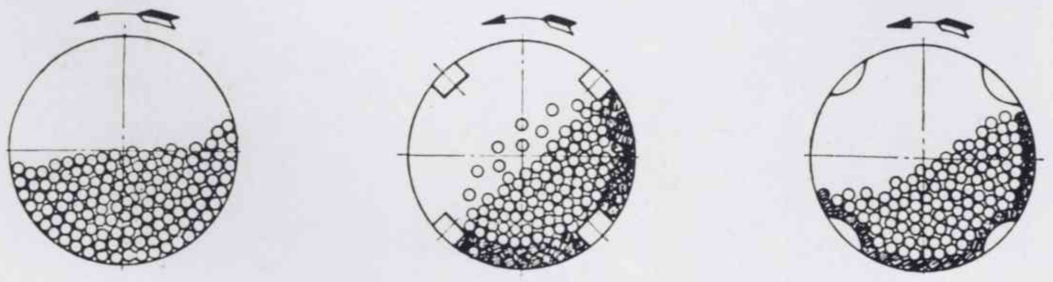


Figure 1 Figure 2 Figure 3

THE IMPORTANCE OF MEDIA SELECTION

To obtain maximum performance from the mill, it is important to select the correct type and size of grinding media. All the research which has gone into ball milling in recent years has been aimed to achieve the following ideal operating conditions.

Shorter dispersion time

Greater quantity production

Lower finished product cost

Lower maintenance cost

Better product quality

In studying how improvements have been made, and others can be achieved, we divide the media into three categories: Shape, Size and Density.

SHAPE

There is no doubt that where processes permit, the ideal shape is the round ball. Many tests have been made with cylinders and flat or so called 'natural' shapes. It has been shown that heavy density ceramic balls can produce the same dispersion in 75 per cent of the time taken by cylinders, with slight increases in power. When the ball mill is operated at its correct speed, and when all other conditions are equally correct, the balls follow roughly concentric and parabolic lines of motion. In so doing, and via their own natural rotary motion, they subject the material under process to three distinct assaults:

Repeated impact, Abrasion and Shear

The superiority of the ball over the cylinders is explained by the obviously greater degree of spin that can be imparted to a ball than to a cylinder. The process time taken with flat or natural shapes falls between that of the ball and the cylinder. This is probably because the 'natural' shape is closer to the ball than is a cylinder.

SIZE

The size of the ball will be determined by the mill duty, ball mills being most suitable for several duties:

Particle size reduction, Dispersion and Mixing.

In grinding (as opposed to dispersion) the size of the grinding media is determined by the size of the particles to be broken up. For example, if one attempted to break large lumps of rock by a small hand hammer no reduction in size would occur, no matter how much energy was expended. A mill then used for particle size reduction with a feed material say minus $\frac{1}{4}$", and a product size of 200 mesh required, would be loaded with balls graded from $1\frac{1}{2}$", to $\frac{3}{4}$".

The balls would be proportioned as follows: 20% $1\frac{1}{2}$" diameter, 25% 1" diameter, 55% $\frac{3}{4}$" diameter. For the dispersion of paint, for example, the paint pigments are already in a very finely divided state, then generally speaking it would be an advantage to use small diameter media. Again, in selecting the size, the following points should be considered.

(a) **Is the media heavy enough to move freely in the paint?**

(b) **Are they large enough to break down the larger agglomerates at the beginning of dispersion?**

(c) **They should not be so small as to prevent easy discharge of the mill by blockage of the media retention grid.**

Generally speaking, mills used for paint dispersion would be loaded with balls of between $\frac{5}{8}$" to 1" diameter.

DENSITY

Obviously the higher the density of the balls, the quicker the particle will be reduced in size, but the power required to lift the more dense balls will be greater, and therefore the power consumption must be closely studied. Balls of the highest density are made from steel and, where lack of contamination risk permits their use, are highly satisfactory.

Hardness should be between 63 and 64 Rockwell C. If they are any harder they become subject to damage by chipping and splitting; a drop to only 62 Rockwell C results in excessive ball wear.

So far as paints, pigments, ceramic and chemical products are concerned, ceramic balls are widely used, particularly high density ceramics with specific gravities in the region of 3·3 to 3·6.

In the previously mentioned fields the ceramic ball has rapidly replaced the more traditional selected flint pebbles, which, incidentally, slow wear rates from 2 to 20 times greater than high density ceramic balls. Well made ceramic balls have another distinct advantage over pebbles, they have a low colour penetration quality and this is one of the major reasons for the change from pebbles. This does not in any way mean that grinding with pebbles is out of date. Numerous ceramic and mineral dressing processes still use them with complete satisfaction.

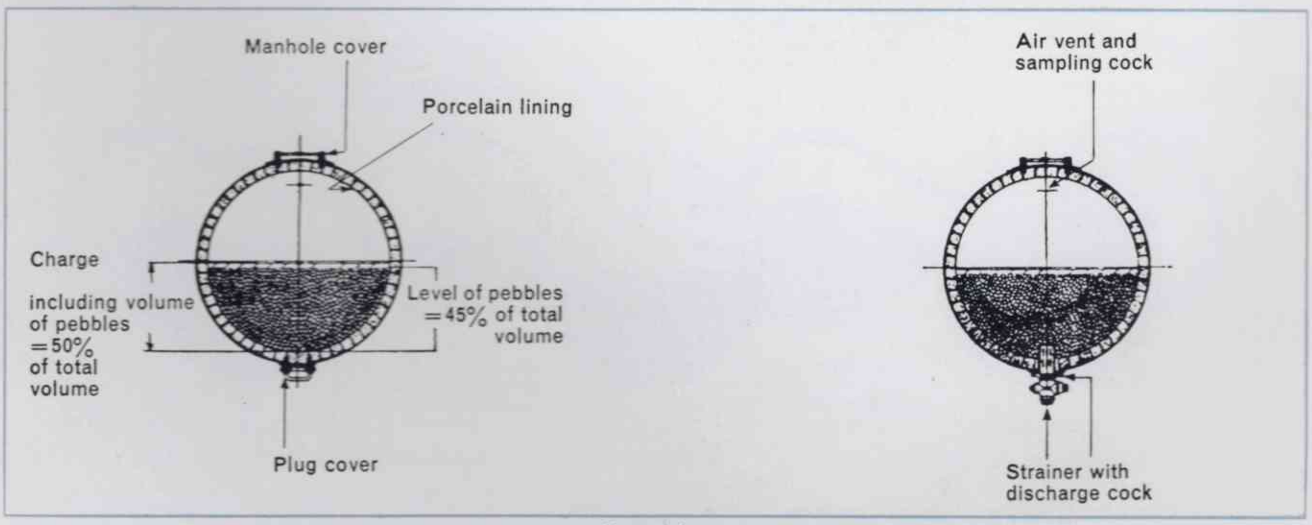


Figure 4

CORRECT MILL LOADING & SPEED

MILL LOADING

To obtain maximum efficiency from a mill when running at its correct speed the ball load should be approx. 45%—55% of the total mill volume. With steel ball mills, the volume of the ball charge is sometimes reduced below the optional because of the weight involved.

Optimum milling efficiency is achieved when the total volume of the charge corresponds to, or slightly exceeds, the void space in the media. For spherical grinding balls the volume of the void space is equal to approximately 40% of the apparent volume of the balls, which is 18% of the volume of the mill. For practical reasons, most users suggest that the volume of charge should be approximately 23% of the internal volume of the mill. **See figure 4.**

If the volume of the charge should exceed this volume, the time required for correct dispersion or grinding will accordingly increase. On the other hand, the labour charges associated with loading and discharging will be proportionately decreased, and the best economic efficiency will be obtained by striking the correct compromise between power costs, labour costs, and the quantity of product produced per hour, per working cycle.

In some cases where a dispersion or milling operation is not difficult the volume of the charge may be raised to as much as 50% of the mill volume. **See Figures 5, 6 and 7.**

MILL SPEED

The speed of a mill is expressed as a percentage of the critical speed. The critical speed is defined as the lowest rpm necessary to centrifuge the media next to the mill lining. The formula for calculating critical speed being

$$Nc_1 = \frac{54{\cdot}18}{\sqrt{R}}$$

where R is the internal radius in feet and Nc_1 = r.p.m.

It has been found that for most batch ball milling processes, the best all round speed is approximately 60% of the critical speed. Mills operating in the mineral dressing fields are usually run at speeds up to 70% of the critical speed. In mills operating at this percentage critical speeds, the balls are carried up almost to the top of the mill, after which they will leave the side of the mill and are projected into the void above the bulk of the grinding media on to which they descend with considerable force. This type of action is required when particle size reduction is the requirement.

The ideal technique for paint manufacture and other processes, where severe wear and contamination are kept to a minimum, is to run the mill at the slower speed.

The ball will then leave the lining at a much lower point and can then roll down the sloping face of the mass of the charge. In this way the whole mass of balls is in motion, each rolling over and rubbing against its neighbours, at different speeds.

In certain specialised product fields, operators are running mills as high as 90% critical speed. Such mills are usually steel lined and use steel media, this type of construction being necessary to withstand the high stresses that such speeds involve. The power-consumption of such mills is higher than the slower machine, but where mills are being operated in this way the increased power costs are more than offset by a substantial reduction in grinding time. It should be noted however that the choice of such high speed mills is largely dependent on the material being processed, as it has been found that few materials respond satisfactorily to high speed processing.

It is possible to determine the power applied to a ball mill shell by measuring the electrical input and making some allowance for mechanical and electrical losses. It is, however, more convenient to deduce the power from a knowledge of the torque which corresponds to the displacement of the centre of gravity of the charge. The power can then be found from the relation:

$$\frac{(\text{Weight of Charge tons} + \text{media}) \times (\text{Mill speed}) \times (\text{Horizontal displacement of c.g. in ft.})}{3{\cdot}14}$$

= *KW input to shell to maintain displacement of charge.*

DRY VERSUS WET GRINDING

Although our previous comments were directed mainly to wet grinding process, a high percentage of ball mill users process their material by dry grinding.

The general principle of operation of dry grinding mills is similar to that of wet mills. Owing to the high internal friction of the dry material, ball charges carry higher on the upcoming side of a dry ball mill than in a wet mill. As a result, dry mills are operated at a lower peripheral speed than wet mills, usually around 10%. Ball loads are smaller than in the wet mill and would occupy between

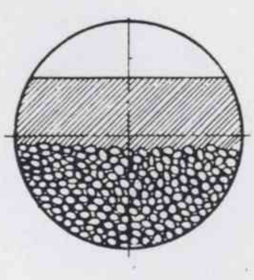


Figure 5

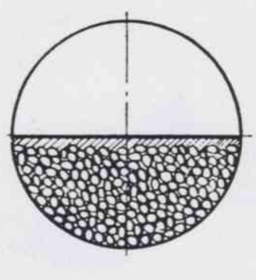


Figure 6

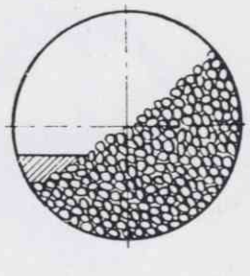


Figure 7

35%—45% of the mill volume to prevent cataracting. Power consumption for dry grinding mills is from 20% to 30% higher than for wet mills.

Wet grinding is usually preferable in cases where a wet product is acceptable, even when the dust nuisance in dry grinding is not considered.

Dry grinding always requires more work input to the mill than wet grinding to the same product size. In many fine dry grinding installations particularly when grinding rather soft materials, the balls and the mill lining become coated with fine material to an extent that particle reduction virtually stops after a certain limiting size has been reached.

Advantages of WET GRINDING:

1. Lower power consumption per ton of product.
2. Higher capacity per cu.ft. of mill volume.
3. Makes possible the use of wet screening or classification for close product control.
4. Elimination of the dust problem.
5. Makes possible the use of simple handling methods, such as pumps, pipes and launders.

Advantages of DRY GRINDING:

1. Lower wear rate of mill liners and grinding media.
2. Higher percentage of fines in milled product. In many cases this is very desirable.

CONTINUOUS MILLS

Continuous ball or pebble milling is employed mainly in the Mineral Dressing fields where large quantities of ore require reducing in size. Continuous milling systems are operated on both dry and wet basis in open and closed circuit. Continuous mills generally falls into two categories: Tube mills and conical hardinge mills.

Open and Closed Circuit grinding could be defined as follows:

OPEN CIRCUIT GRINDING is that method where the material is fed into the mill at one end and the product discharged at the other end in a finished state. It is the most simple system and is generally employed for relatively coarse products, although it is also used where a reasonably fine product is required at a sacrifice of power consumption and general overall efficiency, with the sole advantage of simplicity.

CLOSED CIRCUIT GRINDING is so termed when the product of the mill is sent to a sizing device and the oversize material is returned to the mill for re-grinding. When mills are operated in this way they have a greater capacity and the product contains little or no oversize, this depending on the efficiency of the sizing equipment. When grinding to 60 mesh it is almost essential to use a closed circuit system, if the mill is to be operated economically.

The tube mill is a long cylinder with a length-diameter ratio usually greater than 2. The linings of such mills would usually be steel or silex blocks with the grinding media being steel balls or flint pebbles. The simplest form of tube mill is the type arranged for gravity discharge. The rate of discharge is controlled by the rate of feed, which is in turn related to the fineness of product as the feed rate will control the retention time of the material within the mill. The length of the mill is also an important factor in determining the fineness of the product. Where a product having a large specific surface area is required, this method of operation would be an advantage but it is possible in this system for a percentage of oversize material to be discharged from the mill. This system is called open circuit.

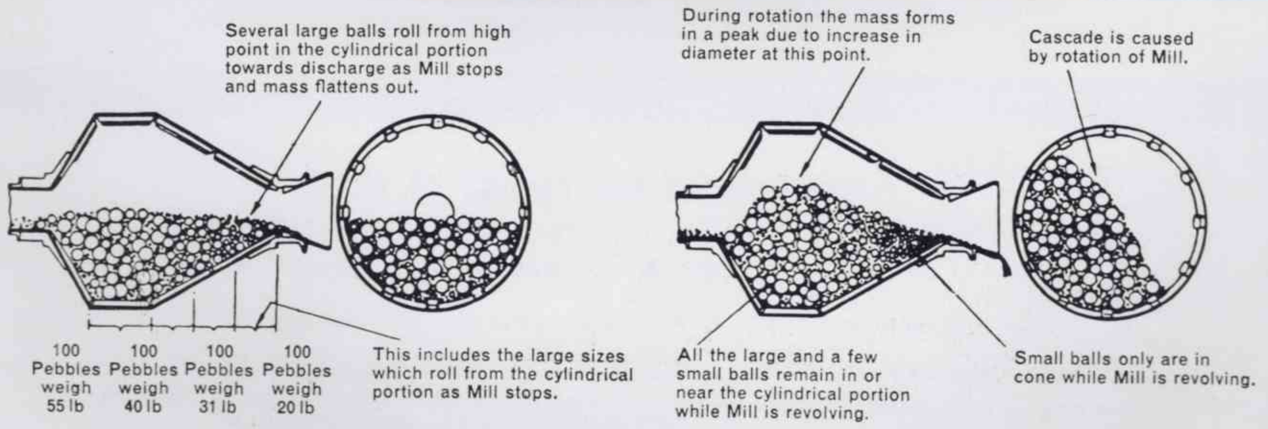
A more controlled system can be arranged where external classification is employed, this system being called closed circuit.

TWO OR THREE COMPARTMENTS

Tube mills, if required, may be divided into compartments to allow the mill to receive a large feed size. In this type of mill the initial or primary compartment is loaded with large diameter balls, followed by one or more secondary compartments provided with smaller grinding media. A three compartment mill for example could receive material having a feed size of minus 1″ and grind to 250–300 mesh using balls of 4″ to $\frac{3}{4}$″ diameter.

A single compartment ball mill would have a limited feed size of about $\frac{1}{2}$″ or finer.

Continuous tube mills are operated at speeds between 65% and 80% critical speed. Generally, the smaller diameter mills operate at a higher percentage critical speed than the larger mills. Ball charges range from 35% to 50% of the mill volume. The air classification system of a closed circuit dry grinding mill would be similar for both tube mills and conical mills. The system comprises a fan, separator, cyclone and dust collector. It is essential with this system to fit an adequate seal between the revolving ends of the mill and the stationary air conveying pipes. The pipe conveying the material from the mill is connected to the fan and the bottom of a special double cone separator. This separator is fitted with dampers and flaps that allow the oversize material to return to the mill for regrinding.

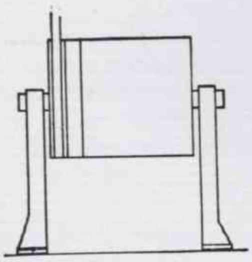


CONICAL MILL STANDING IDLE   Figure 8   CONICAL MILL IN ROTATION

TYPES OF DRIVES

Various types of drives are fitted to Boulton ball and pebble mills. The standard range is detailed below, but drives to suit any site conditions can be incorporated.

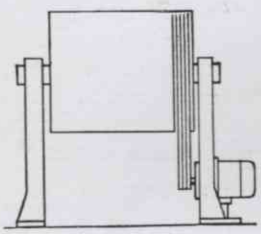
A



Flat belt drive from line shafting.

Not recommended on sizes above 3′ 6″ dia.

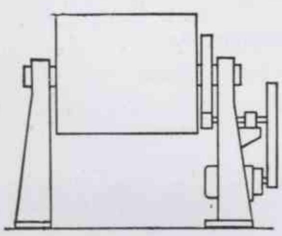
B



High torque motor geared unit, 'V' flat drive direct to cylinder shell.

Not recommended above 4′ 0″ dia.

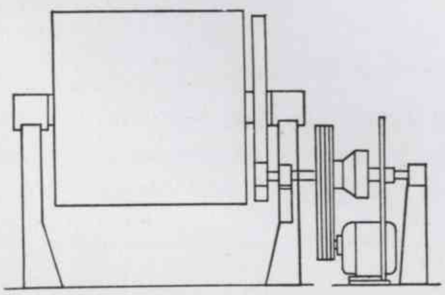
C



High torque motor drive with inch button, through 'V' drive and spur gears. Very compact. Complete driving unit housed in one "A" stand.

Up to 3′ 0″ dia. only.

D

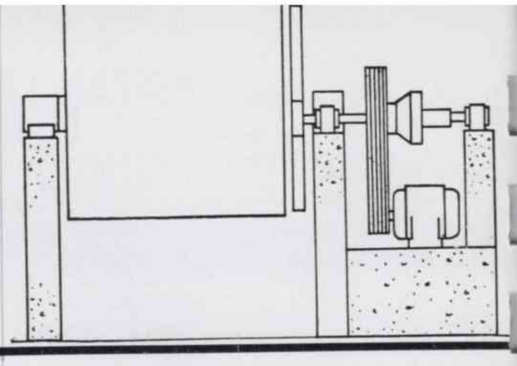


Squirrel cage motor drive, friction clutch, 'V' drive and spur gears.

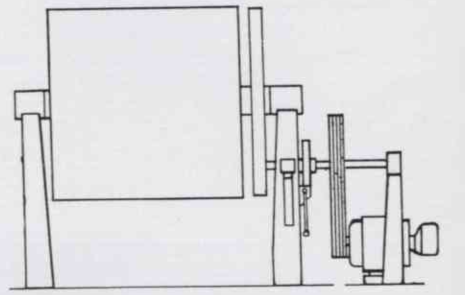
Mounted on cast iron stands.

All sizes above 3′ 0″ dia.

E



F



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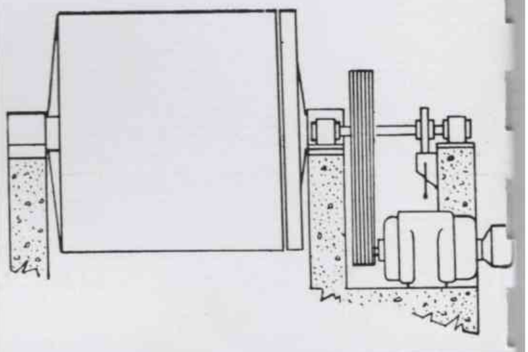

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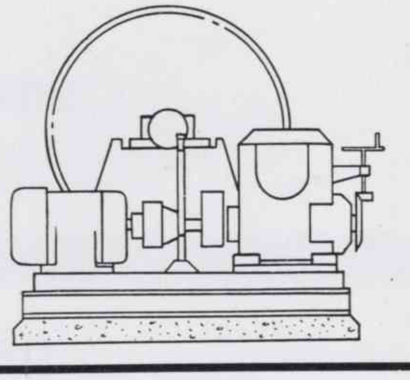

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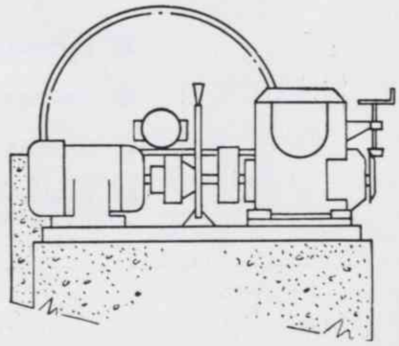
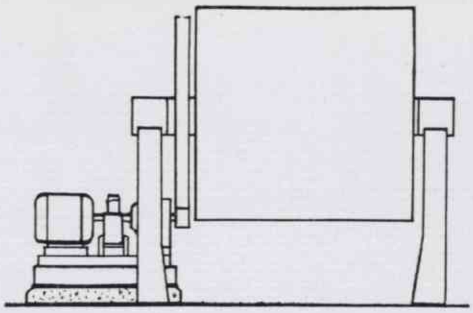


Squirrel cage motor drive. friction clutch and spur gears.

Mounted on cast iron soleplates, brick or concrete piers.

All sizes above 4′ 6″ dia.

J



High torque geared motor unit drive, spur pinion fitted to outpuc shaft of geared unit. Magnetic brake and inching device fitted. Mounted on cast iron "A" stands.

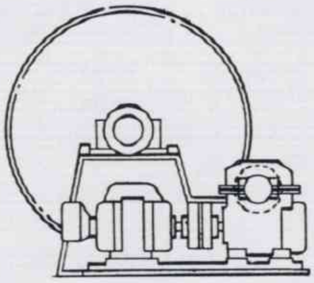
Up to 4′ 6″ dia. only.

Slip ring motor drive, inching device, 'V' drive and spur gears.

Mounted on cast iron stands.

All sizes.

K



Slip ring motor drive direct coupled to worm reduction gear. The output shaft of the worm reduction gear carrying the pinion of the spur drive. Magnetic brake and inching device fitted.

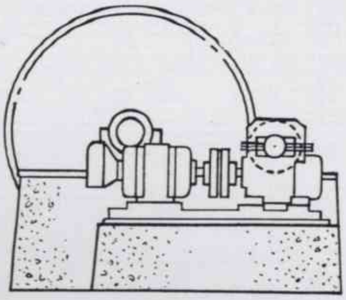
Mounted on cast iron "A" stands.

All sizes above 3′ 0″ dia.

Slip ring motor drive, inching device, 'V' drive and spur gears. Mounted on cast iron soleplates, brick or concrete piers.

All sizes above 4′ 6″ dia.

L



Slip ring motor drive direct coupled to worm reduction gear. The output shaft of the worm reduction gear carrying the pinion of the spur drive. Magnetic brake and inching device fitted.

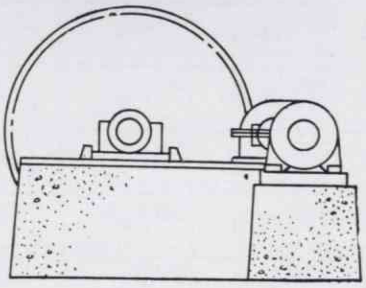
Mounted on cast iron soleplates, brick or concrete piers.

All sizes above 4′ 6″ dia.

Squirrel cage motor drive, direct coupled through disc type friction clutch to a worm reduction gear. The output shaft of the worm reduction gear carrying the pinion of the spur drive. Magnetic brake and inching device fitted. Mounted on cast iron "A" stands.

All sizes above 3′ 0″ dia.

M



Slip ring motor drive, direct coupled to spur reduction gear, the output shaft of the spur reduction carrying the pinion of the main spur drive.

Mounted on cast iron soleplates, brick or concrete piers.

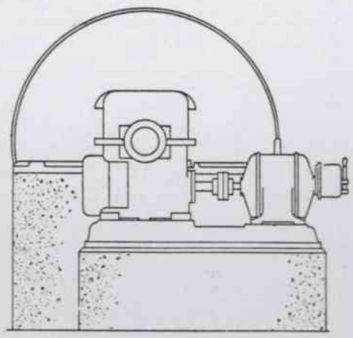
All sizes above 4′ 6″ dia.

Squirrel cage motor drive, direct coupled through disc type friction clutch to a worm reduction gear. The output shaft of the worm reduction gear carrying the pinion of the spur drive. Magnetic brake and inching device fitted.

Mounted on cast iron soleplates, brick or concrete piers.

All sizes above 4′ 6″ dia.

N



Slip ring motor drive, direct coupled to worm reduction unit. The output shaft of the worm reduction unit coupled to mill trunnion by flexible coupling.

Mounted on cast iron soleplates, brick or concrete piers.

All sizes above 4′ 6″ outside dia.

MILL SIZES AND SPECIFICATIONS

PORCELAIN-LINED BALL MILLS FOR THE CERAMIC INDUSTRY

Mill size External (inches)	Total capacity		Operating capacity		Grinding media		H.P.	Speed r.p.m.
	Gallons	Cu. ft.	Wet galls.	Dry (lb)	Balls (lb)	Pebbles (lb)		
24 × 24	18	2·78	9	73	140	160	2	63
24 × 33	27	4·3	14	100	210	240	2	63
30 × 30	36	5·8	18	144	300	340	3	50
30 × 39	52	8·3	26	210	420	470	3	50
36 × 36	73	11·7	37	296	550	620	3	42
36 × 42	88	14·1	44	352	635	710	3	42
36 × 45	97	15·5	50	400	680	760	3	42
42 × 42	126	21·0	63	500	920	1060	4	36
42 × 51	160	25·6	80	640	1200	1350	4	36
48 × 48	200	32·0	100	800	1410	1580	5	31
48 × 54	228	36·5	114	920	1610	1800	5	31
54 × 54	290	46·5	145	1200	2010	2250	7½	30
60 × 60	400	64·0	200	1600	2900	3250	12½	29
60 × 66	440	70·0	220	1760	3100	3470	12½	29
66 × 66	600	96·0	300	2400	4200	4700	20	27
72 × 72	740	118·0	370	2960	5200	5850	25	25
72 × 84	860	138·0	430	3440	6100	6700	25	25
84 × 84	1240	198·0	620	3760	9000	11000	35	22

VARIES WITH MATERIAL

The horsepowers and speeds given above are based on wet grinding and will require to be varied for dry grinding. This information can be given on request.

The operating capacity given in lb. is based on materials having a density of 100 lb. per cu. ft.

MILL SIZES AND SPECIFICATIONS

SILEX-LINED BALL MILLS FOR THE CERAMIC INDUSTRY

Mill size External (inches)	Total capacity		Operating capacity		Grinding media	H.P.	Speed r.p.m.
	Galls.	Cu. ft.	Wet galls.	Dry (lb)	Pebbles (lb)		
24 × 24	16·5	2·65	9	56	140	2	63
24 × 33	23·0	3·64	12	96	210	2	63
30 × 30	26·0	4·15	13	104	300	3	50
30 × 29	40·0	6·42	20	168	420	3	50
36 × 36	55·0	8·80	28	224	550	3	42
36 × 42	69·0	11·0	35	280	635	3	42
36 × 45	76·0	12·3	38	324	680	3	42
42 × 42	96·0	15·1	50	400	920	4	36
42 × 51	120	19·2	60	480	1200	4	36
48 × 48	150	24·0	75	600	1410	5	31
48 × 54	165	26·4	83	664	1610	5	31
54 × 54	230	36·8	115	1000	2010	7½	30
60 × 60	332	53·0	166	1300	2900	12½	29
60 × 66	360	57·5	180	1450	3100	12½	29
66 × 66	500	80·0	250	2040	4200	20	28
72 × 72	590	94·0	295	2400	5200	25	25
72 × 84	680	108·5	340	2720	6100	25	25
84 × 84	1020	163·0	510	4080	9000	35	22

VARIES WITH MATERIAL

The horsepowers and speeds given above are based on wet grinding and these will require to be varied for dry grinding. This information can be given on request.

The operating capacity given in lb. is based on materials having a density of 100 lb. per cu. ft.

MILL SIZES AND SPECIFICATIONS

STEEL-LINED BALL MILLS

Mill size External (inches)	Total capacity		Operating capacity		Grinding media Balls lb	H.P.	Speed r.p.m
	Galls.	Cu. ft.	Wet galls.	Dry (lb)			
24 × 24	24	3·80	12	—	374	3	34
24 × 33	32	5·10	16	—	512	3	34
30 × 30	60	9·70	30	—	960	4	32
30 × 39	82	13·1	41	—	1310	4	32
36 × 36	98	15·6	50	—	1560	5	28
36 × 42	118	18·9	60	—	1890	5	28
36 × 45	127	21·9	65	—	2190	5	28
42 × 42	175	28·0	90	—	2800	7½	24
42 × 51	240	38·5	120	—	3850	7½	24
48 × 48	270	43·5	135	—	4350	10	22
48 × 54	300	48·0	150	—	4800	12½	22
54 × 54	390	62·5	195	—	6250	15	20
60 × 60	540	86·0	270	—	8600	20	18
60 × 66	596	95·5	300	—	9550	25	18
66 × 66	820	131	410	—	13100	30	17
72 × 72	940	150	470	—	15000	40	16
72 × 84	1020	163	610	—	16300	40	16
84 × 84	1480	236	740	—	23600	50	15

VARIES WITH MATERIAL

For dry grinding: Information given on request.

MILL SIZES AND SPECIFICATIONS

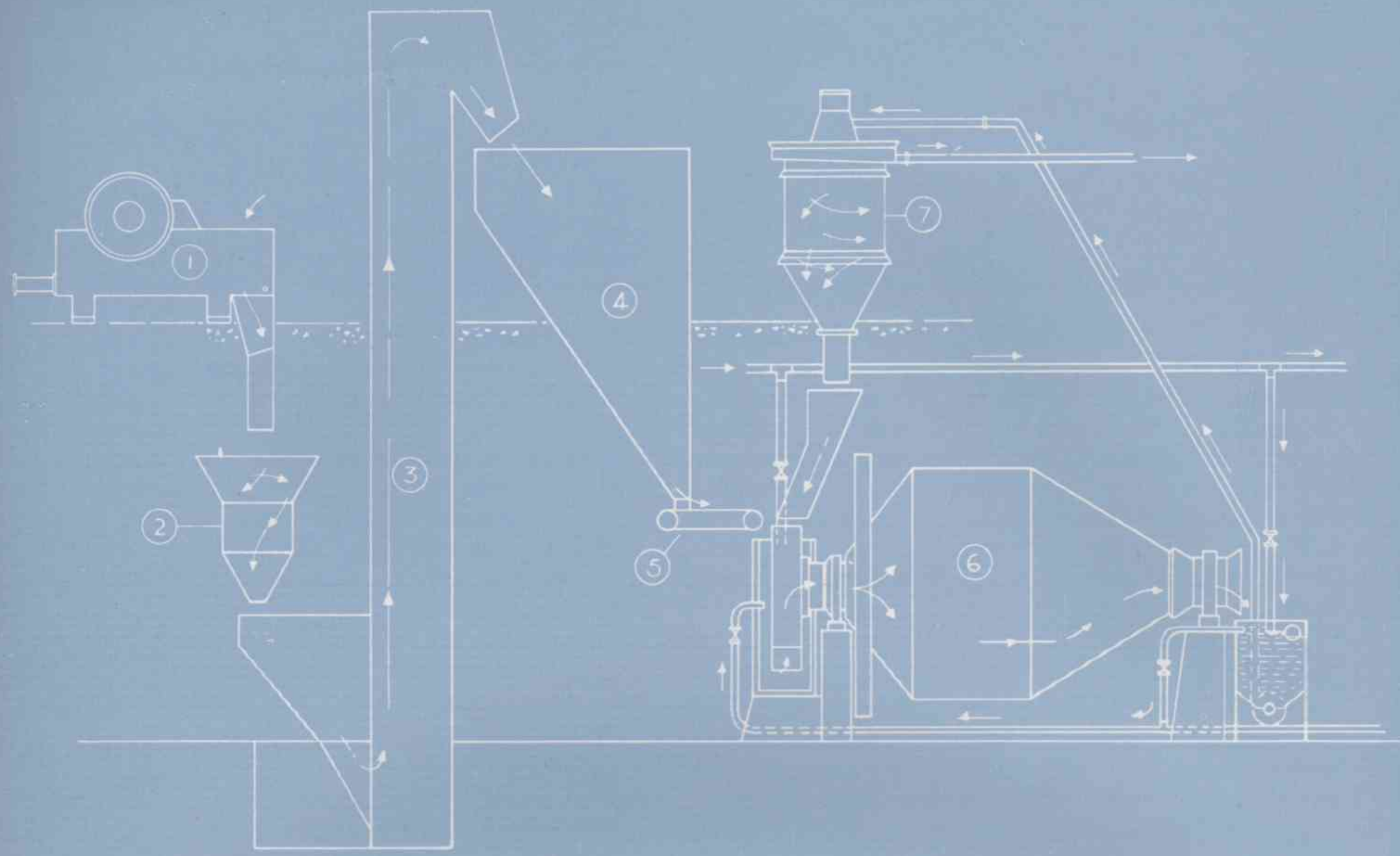
PORCELAIN-LINED BALL MILLS FOR THE PAINT INDUSTRY

Mill size External (inches)	Total capacity		Operating capacity		Grinding media		H.P.	Speed r.p.m.
	Galls.	Cu. ft.	Wet galls.	Dry (lb)	Balls (lb)	Pebbles (lb)		
24 × 24	18	2·78	9	73	120	140	2	38
24 × 33	27	4·3	14	110	180	210	2	38
30 × 30	36	5·8	18	144	255	300	3	34
30 × 39	52	8·3	26	210	360	420	3	34
36 × 36	73	11·7	37	296	470	550	3	30
36 × 42	88	14·1	44	352	540	635	3	30
36 × 45	97	15·5	50	400	585	580	3	30
42 × 42	126	21·0	63	500	800	920	4	28
42 × 51	160	25·6	80	640	1000	1200	4	28
48 × 48	200	32·0	100	800	1220	1410	5	26
48 × 54	228	36·5	114	920	1390	1610	5	26
54 × 54	290	46·5	145	1200	1760	2010	7½	25
60 × 60	400	64·0	200	1600	2420	2900	10	23
66 × 66	600	96·0	300	2400	3600	4200	15	21
72 × 72	700	118·0	370	2960	4500	5200	25	19
72 × 84	860	138·0	430	3440	5250	6100	25	19
84 × 84	1240	198·0	620	3760	7800	9000	30	16

VARIES WITH MATERIAL

The horsepowers and speeds given above are based on wet grinding and these will require to be varied for dry grinding. This information can be given on request.

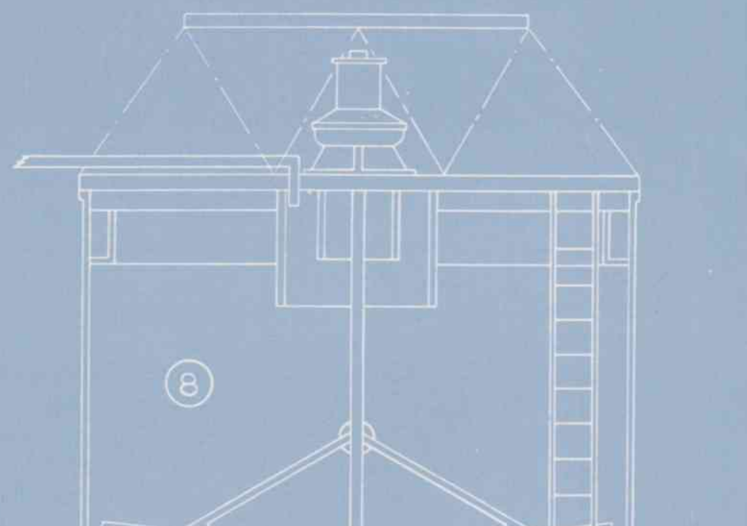
The operating capacity given in lb is based on material having a density of 100 lb. per cu. ft.



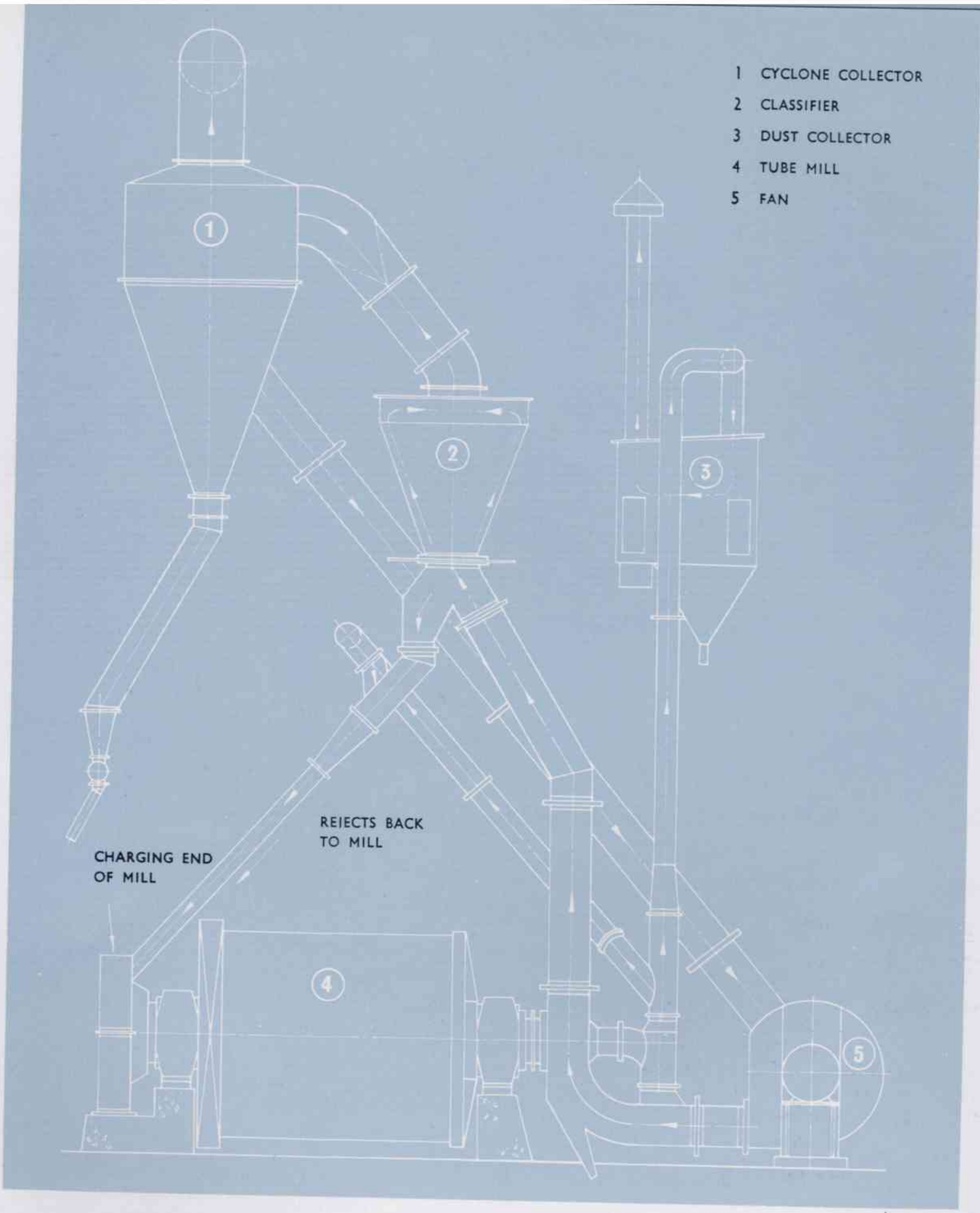
CONTINUOUS WET GRINDING SYSTEM

This system is capable of wet grinding and classifying to tight specifications. The mill is fed by an automatic weight feeder which can be accurately controlled. Oversize particles are returned automatically from the classifier to the mill feed.

1 PRIMARY CRUSHER
2 SECONDARY CRUSHER
3 ELEVATOR
4 STORAGE HOPPER
5 CONTINUOUS WEIGHT FEEDER
6 CONICAL PEBBLE MILL
7 WET CLASSIFIER
8 THICKENER



FULL RANGE OF SPARE PARTS
ALWAYS IN STOCK
FOR IMMEDIATE DELIVERY



CLOSED CIRCUIT DRY GRINDING SYSTEM

This system is capable of grinding and accurately classifying to tight specifications where close control is required. Elevation, classification, are all pneumatic, thus all mechanical wear and depreciation are reduced to a minimum. The mill is fitted with automatic feeding device which can be controlled accurately. The fines are collected and conveyed to collector and classifier, tailings returning automatically to the mill for re-grinding. Dust collectors can be introduced if required.

For dry grinding of coal, chemicals, clays, enamel frit, graphite, limestone, metals, refractories, silica, slag, oxides, Fuller's earth.