

Nov. 25, 1947.

P. I. KLOCK
METHOD AND APPARATUS FOR WORKING PARTICLES, FOR
PRODUCTION OF METAL POWDERS OR PASTES
Filed May 19, 1943

2,431,565

3 Sheets-Sheet 1

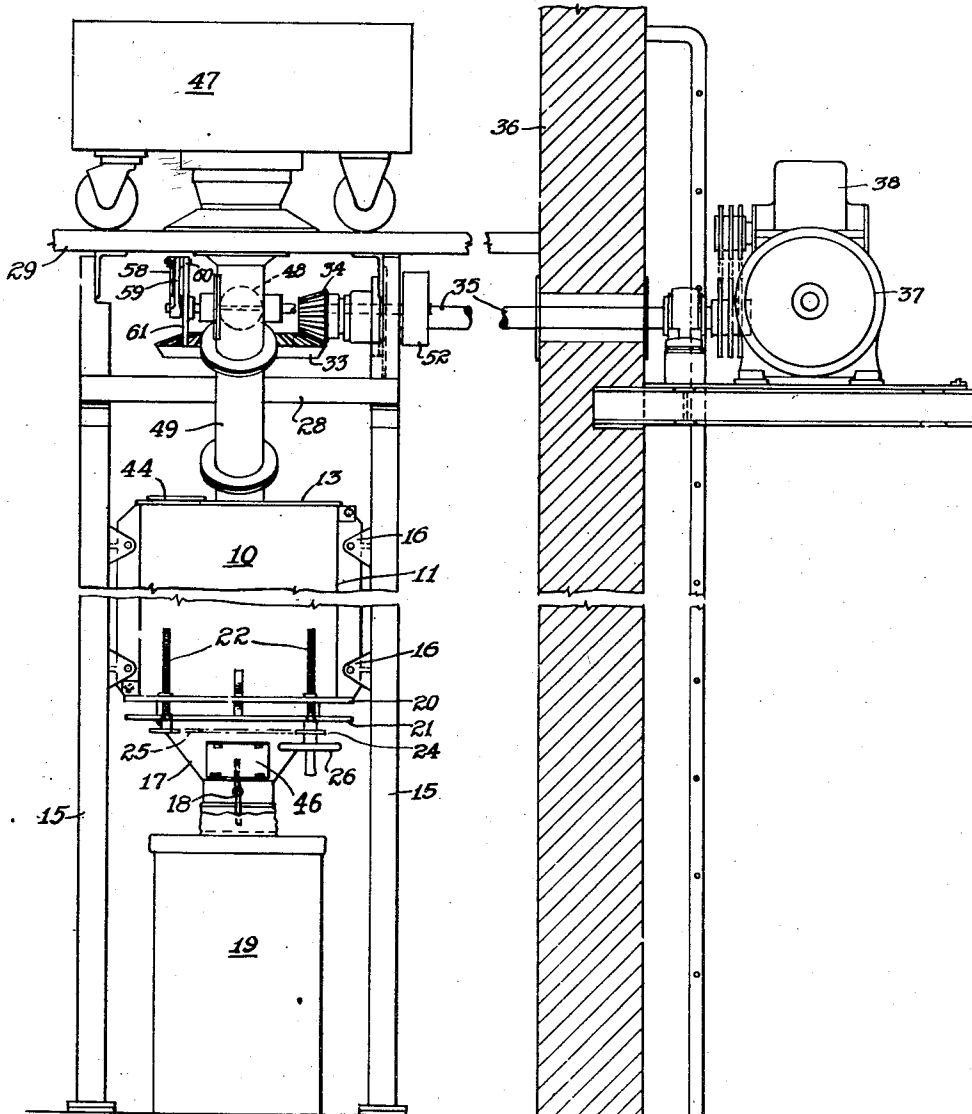


Fig 1

INVENTOR
PETER I. KLOCK
BY *Amos J. Bell*
ATTORNEY

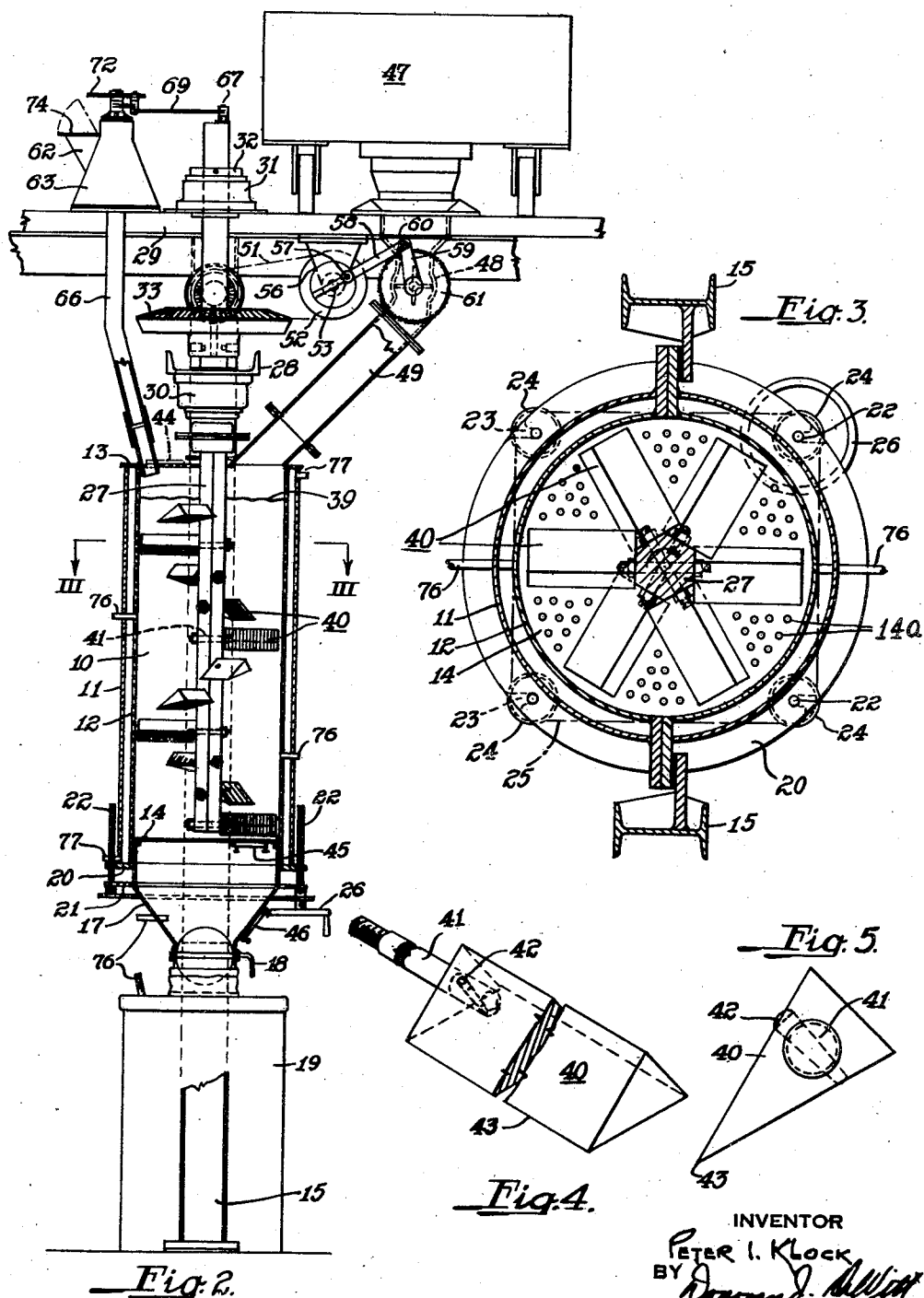
Nov. 25, 1947.

P. I. KLOCK
METHOD AND APPARATUS FOR WORKING PARTICLES, FOR
PRODUCTION OF METAL POWDERS OR PASTES

2,431,565

Filed May 19, 1943

3 Sheets-Sheet 2



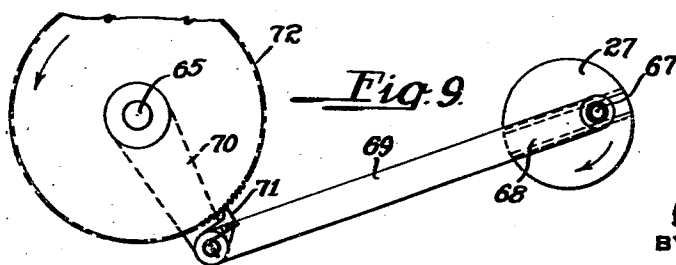
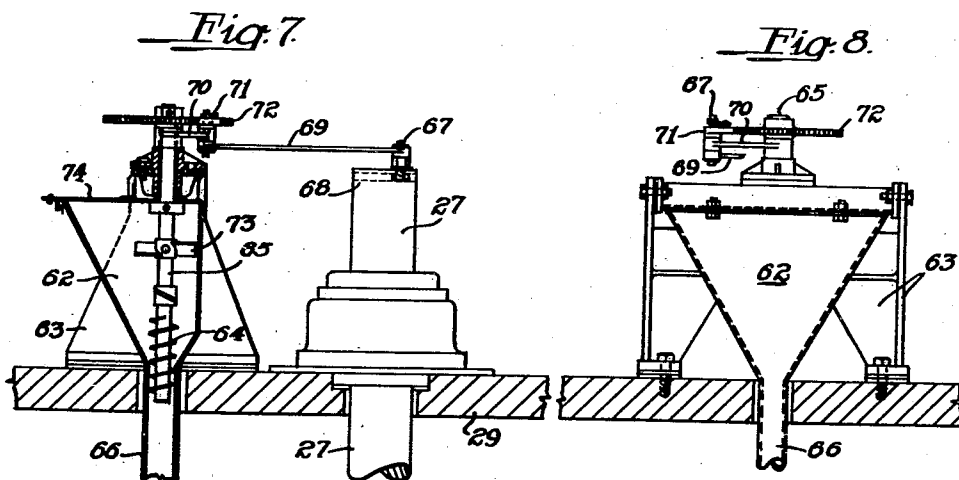
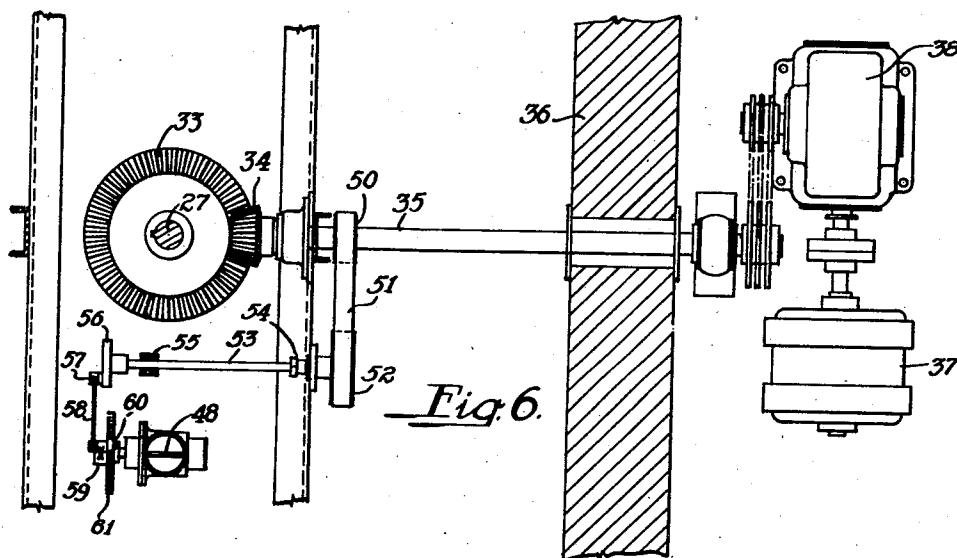
INVENTOR
PETER I. KLOCK
BY *Donovan J. Allen*
ATTORNEY

Nov. 25, 1947.

P. I. KLOCK
METHOD AND APPARATUS FOR WORKING PARTICLES, FOR
PRODUCTION OF METAL POWDERS OR PASTES
Filed May 19, 1943

2,431,565

3 Sheets-Sheet 3



INVENTOR
P. I. Klock
BY *Rosenberg*
ATTORNEY

UNITED STATES PATENT OFFICE

2,431,565

METHOD AND APPARATUS FOR WORKING PARTICLES FOR PRODUCTION OF METAL POWDERS OR PASTES

Peter I. Klock, New Kensington, Pa., assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

Application May 19, 1943, Serial No. 487,676

8 Claims. (Cl. 241-3)

1 This invention relates to a method and apparatus for the disintegration, polishing, or dispersion of metallic particles or aggregates thereof, the contemplated usage being principally concerned with the production of metal powders and pastes. Aluminum is widely used for these purposes and is exemplary of the other metals which find employment in this same fashion. Accordingly, aluminum powders and pastes will be referred to herein for purposes of illustration.

Metal powders and pastes are customarily produced by subjecting small pieces of metal, such as sheet or foil, to the action of a stamp mill or a ball mill. In some cases, small metal particles, such as those produced by atomizing molten metal, may be employed as the starting raw material. In the processes involving a stamp mill operation, the metallic powder is usually maintained in dry form, and accordingly the process is referred to as a "dry" one. Some ball milling processes have also been employed with the powder dry, but the more successful "wet" processes have employed a volatile vehicle to form with the metallic particles a fluid charge or paste of proper consistency.

While many of the known processes for producing metal powders and pastes have been employed with successful results, no commercial method has as yet been proposed which will permit of operation in a continuous manner, that is, with further quantities of raw material being charged into the apparatus as it processes, or works, the raw material introduced, and discharges, in continuous fashion, the desired finished product without the aid of auxiliary equipment. A dry process is available which permits of continuous operation through the medium of an auxiliary suction system; however, the product exhausted from the apparatus in this fashion is not a finished product and must be subjected to an additional treatment in a standard brush type polisher in order that the resulting powder have proper leafing qualities. By the term "finished product" I mean material which has been subjected to sufficient working action that it may be employed in the normal fashion, as a bronze or metallic pigment, for example, without further processing.

It is a general object of this invention to provide an economical process for the production of small particles of material, and more particularly, of metal powders and pastes. Another object is to provide a process for producing such materials which permits of working the raw ma-

2 terial with simultaneous discharge of the desired product.

More particularly, it is an object to provide a process for the continuous production of metal powders and pastes, characterized by the simultaneous working of the raw material and discharge of the desired finished product, with further additions of raw material being made without interruption to said working and discharge steps.

Still another object is to provide a process by which aluminum raw material may be worked into the form of a powder or paste wherein the aluminum particles have lamellar, or flake-like, form, said powder or paste exhibiting good covering and leafing qualities when employed as a pigment.

It is also an object of my invention to provide suitable apparatus for carrying out the said processes.

This invention contemplates a method whereby suitable raw materials, in either dry or paste form, are charged either continuously or periodically into a vertical processing chamber, preferably cylindrical in shape, provided with a rotating bladed shaft through its central axis and substantially filled with a processing medium. This processing medium may consist of flattened steel or aluminum balls, for example, though other materials and other shapes may be employed. These various types of processing materials are herein, and in the appended claims, generally referred to as "pellets." Under the effect of the paddling action of the blades on the rotating shaft, the metallic particles in the raw material are constantly subjected to rubbing action between adjoining pellet surfaces as these particles move downwardly by gravity toward openings provided in the lower portion of the chamber. By the time the particles being worked have reached the bottom of the chamber, they are fully processed, whereupon they fall downwardly through these openings into a suitable container. As the particles of raw material move downwardly through the chamber in this fashion, they are subjected to an increasing pressure as the weight of pellets above them increases; but since each particle introduced into the machine pursues a generally similar downward course at approximately the same rate, and since each particle is continuously and uniformly subjected to approximately the same degree of processing between the pellets, material of uniform quality is produced. Preferably, the additions of raw material are made so as to maintain a con-

3

or at least a minimum, level of said material in the processing chamber. This level is usually slightly above that of the processing medium.

The term "working" is employed herein and in the appended claims to describe the action to which the particles of raw material introduced into the apparatus are subjected as they proceed downwardly between the processing pellets as the latter are stirred. This working may include, for example, disintegration, polishing, or dispersion of the particles being worked or of aggregates or agglomerates thereof, all as more fully explained hereinbelow.

The nature and extent of the working accomplished within the processing chamber is affected by a variety of factors. For a given depth of processing medium, the density of the pellets which make up the same largely determines the pressure exerted against the particles of the charge, and the resulting degree of disintegration thereof. Other factors are the degree of agitation of the mass and the general rate of downward progression of the charged raw material through the chamber. All of these factors may be varied at will, and by controlling them, one may establish the degree of disintegration, polishing, dispersion, or other working effected. By disintegration is meant action that reduces the size of the particles longitudinally and in thickness, generally measured by screen test, or covering, power. By polishing effect is meant the imparting of a sheen to the particles; when aluminum powder is polished with a leafing lubricant, such as stearic acid, the particles acquire leafing power as measured by various leafing tests. By dispersion is meant the breaking apart of agglomerates of individual particles.

It will be noted that in the process which is here described, the necessary working of the particles constituting the charge of raw materials is effected by the rubbing action exerted on the particles by adjoining working elements, i. e., pellets of whatever nature employed. All previous attempts to utilize processes of this nature in the production of metal powders or pastes have been unsuccessful because of failure to obtain uniform processing of the raw material; as a result, some particles received excessive disintegration, with the production of undesirable material called "fines," while others received little or no treatment. This contrasts with the controlled nature of my process wherein such non-uniformity of product cannot result inasmuch as all particles undergoing treatment follow a similar downward course during which they are continuously and uniformly subjected to approximately the same degree of working between the pellets employed. There is thus no general commingling of all the contents of the chamber, but rather a controlled commingling of any given stratum of material as it moves downwardly through the chamber. Accordingly, no one particle may receive appreciably more working action than another.

The nature of the raw materials charged into the apparatus may be varied. Any material previously comminuted to a suitable size can be reduced to particles having the desired fineness and shape as well as polish in my apparatus. When dealing with aluminum, atomized material may be used. Aluminum foil or other thin gauge material can also be used if it is first shredded or otherwise reduced to small pieces. However, heavier gauge material such as conventional sheet may not usually be employed in the apparatus without previous comminution in a

4

suitable stamp or ball mill. Whatever the nature and shape of the aluminum raw material employed, the resulting worked particles are characterized by a lamellar, flake-like form. This is important when producing aluminum powders or pastes which are to be used for paint purposes, for otherwise the pigment will not have the requisite covering and leafing powers.

The various functions of the method and apparatus can best be described with reference to the drawings in which:

Fig. 1 is a side elevation of the apparatus;

Fig. 2 is a front elevation of the apparatus, partly in section;

Fig. 3 is an enlarged sectional view of the apparatus taken along the lines III—III of Fig. 2;

Fig. 4 is a view in perspective of one of the stirring or agitator blades of the apparatus;

Fig. 5 is an end view of one of the agitator blades;

Fig. 6 is a plan view showing the apparatus drive and main feeding mechanism;

Fig. 7 is a front elevation, partly in section, showing the lubricant feeding mechanism;

Fig. 8 is a side elevation of the lubricant feeding mechanism; and

Fig. 9 is an enlarged plan view of the driving portion of the lubricant feeding mechanism shown in Figs. 7 and 8.

Referring now to the drawings, and more particularly to Fig. 2, the apparatus includes a vertical mixing chamber 10 defined by outer and inner spaced cylindrical walls 11 and 12, a top plate 13, and a perforated discharge plate 14. The mixing chamber is maintained in position by upright supports 15 through suitable connecting plates 16 seen in Fig. 1. The discharge plate 14, having perforations 14a therein, as shown also in Fig. 3, is carried at the upper, or open, end of a discharge cone 17 slidably supported in the lower end of the chamber 10 for vertical adjustment therein, as described below. A shutter 18 is provided at the bottom of cone 17 so that the powder or paste may be temporarily retained in the cone while an exchange of receiving vessels 19 is made. The lower end of the walls 11 and 12 is provided with a flange 20, and a flange plate 21 is secured to the discharge cone 17. This flange plate 21 rests on the heads of a series of screws 22 that have threaded engagement with the flange 20 and are accommodated by slots 23, shown in Fig. 3, in the plate 21. Sprockets 24, connected by a chain 25, are secured to the lower ends of the screws 22, and a hand wheel 26 is also attached to one of the screws. As a result of the screws 22 being connected with each other by the sprockets 24 and the chain 25, rotation of the hand wheel 26 and the screw to which it is attached effects rotation of all of the screws, thereby raising or lowering the discharge cone 17 and the perforated plate 14.

A shaft 27 is located in the center of chamber 10 and extends substantially the full length thereof and upwardly through a cross beam 28 and through a floor 29, each of which carries a suitable bearing, 30 and 31 respectively, in which the shaft is journaled. A collar 32 on the shaft cooperates with the bearing 31 to prevent endwise shifting of the shaft. The shaft 27 carries a bevel gear 33 that is driven by a pinion 34 on a shaft 35, the shaft 35 extending through an exterior wall 36 as is shown in Figs. 1 and 6. The shaft 35 is driven by a motor 37, operating through a suitable speed reducer 38, which is placed outside the wall 36 for reasons of safety.

The portion of the shaft 27 within the chamber 10 is provided along its length with a plurality of spaced transverse holes in which stirring blades 40 are mounted by means of threaded pins 41, as seen in Fig. 4. Pins 41 may be fixed to the blades 40 by taper pins 42 (see also Figs. 4 and 5). The blades are preferably wedge shaped and are customarily mounted on shaft 27 in an upward spiral, with the edge 43 of each blade leading in the direction of rotation of the shaft. I prefer to use the upward spiral, counterclockwise arrangement of the blades on the shaft, as best shown in Fig. 2, when the direction of motion is clockwise, or in reverse order when the direction of rotation is changed. The blades are preferably set at an upwardly inclined angle so as to avoid compressing downwardly and jamming the pellets placed in chamber 10. It will be noted that in the apparatus as described, each blade moves in a generally horizontal plane.

The processing pellets, usually in the form of flattened steel or aluminum balls, or other shapes, are charged into the chamber 10 to a required height through an opening, provided with a cover 44, in top plate 13. The chamber 10 is usually substantially filled with the pellets, whereupon the cover 44 is applied. The approximate pellet level is shown by line 39 in Fig. 2. To permit the removal of the balls or pellets from the cylinder, the perforated discharge plate 14 is provided with an opening normally closed by cover 45. This opening is accessible through an aperture in the side of cone 17, which in turn is provided with a tightly fitted plate 46.

The raw material to be worked is charged into the chamber 10 from a hopper 47 through an adjustable feed valve 48 and chute 49. In order that the raw material may be fed during the time the apparatus is in operation, a mechanism is provided to actuate the valve 48 during the time the shaft 27 is being revolved, as best illustrated in Fig. 6. Shaft 35, there shown, is provided with pulley 50 which, by means of a belt 51, actuates pulley 52 attached to one end of shaft 53, which shaft is in turn journaled within bearings 54 and 55, and is supported by means of a suitable hanger from floor 29, as seen in Fig. 2. A driving disc 56 is attached to the other end of shaft 53. This driving disc is provided with a T-slot adjustably carrying a crank 57. One end of a crank arm 58 is pivotally mounted on said crank, while the other end is similarly connected to one end of arm 59, to which pawl 60 is also pivotally mounted. The other end of arm 59 is pivotally mounted on the shaft of feed valve 48. This valve shaft fixedly carries a ratchet wheel 61 which is engaged by the pawl 60 and intermittently turned upon rotation of the disc 56 and operation of the crank arm 58, thereby feeding raw material through the chute 49 into the chamber 10. By changing the position of the crank 57 in the T-slot, it is possible to increase or decrease the movement of the ratchet wheel 61, and consequently to control the rate at which the raw material is fed through the valve, for any given speed of the apparatus.

In producing bronze powders and pastes, it is customary to incorporate with the charge a lubricating material, such as stearic acid. In the present apparatus, provision is made to feed this lubricant directly and continuously into the chamber 10 at the same time that the raw material is added, if that be desired. For this purpose a hopper 62 is provided, which is supported by members 63. This hopper is provided with a

screw feed 64 carried on shaft 65, and turning of this screw forces the lubricating material into the chute 66. As shown in Figs. 7, 8 and 9, this feeding mechanism is actuated by a crank 67 adjustably carried in a T-slot 68 provided in the upper end of shaft 27. With rotation of shaft 27, this crank 67 operates a crank arm 69 which impels the screw 64 through arm 70 and pawl 71 as said pawl engages ratchet wheel 72 fixedly mounted on the end of shaft 65. Shaft 65 also carries a suitable agitator 73 within hopper 62. The hopper 62 may be charged with the lubricant through a suitable trap door 74. The rate of introduction of the lubricating fluid into the chamber 10 may be varied for any given speed of the apparatus by adjusting the position of the crank 67 in the T-slot 68.

The lubricant need not, however, be introduced into the processing chamber by means of the apparatus described above. In many cases it will be more convenient to mix it with the raw material to be processed, such as aluminum powder or paste, before such material is introduced into the feed hopper 47.

Generally speaking, the chamber 10 is charged with the processing pellets to a depth sufficient to cover the topmost blade on the shaft 23, as seen in Fig. 2, line 39 indicating the upper pellet level. The shape, size, weight and surface finish of the processing pellets should be such as to provide easy sliding action between them and the material to be treated when the entire charge is in motion; otherwise excessive friction results. Commercial round balls can be used satisfactorily, but I have found that flattened pellets are more efficient because this shape gives a better sliding, or rubbing, action and offers a larger area of contact. As stated above, the weight, that is, the density of the pellets, other conditions being equal, will determine the intensity of the rubbing action between them. Steel pellets, for instance, will produce higher attritive forces than will aluminum pellets of the same size. Accordingly, when it is desired to disintegrate the particles as well as to polish them, pellets of heavier density, such as those made of steel, are employed; when polishing action is that chiefly desired, or dispersion of agglomerates, pellets of lighter density, such as those made of aluminum, can be used. In general, selection of the density of the processing medium will depend on the type of material to be treated as well as upon the nature of the processing action, or working, desired. Conceivably, non-metallic balls or pellets would be of utility in certain circumstances. The finish of the balls or pellets should be smooth.

Once the apparatus is charged with the processing medium, it is put in motion by starting the motor 37. This causes the bladed shaft 27 to revolve and initiates feeding of raw material from hopper 47. It also may initiate feeding of the lubricant from hopper 62 if desired. During the first few minutes of operation, it is desirable to speed up the introduction of raw material so as to raise the level thereof to a proper height as soon as possible, this level usually being slightly above that of the pellets. Since the level of raw material in the machine affects the discharge rate, and consequently the extent of working of the raw material, it is important to maintain said level approximately the same once it be established.

It may sometimes be necessary to reprocess the initial product discharged by the machine since this portion of the charge may fall too

rapidly through the processing chamber for effective working.

The rate at which the material is discharged through plate 14 determines the length of time a given amount of material remains in the machine subject to working between the processing pellets. By varying this time, one may control the degree of disintegration and/or polishing accomplished. This discharge rate may be governed by various factors, one of which is the amount of clearance between the bottom blade or blades and the perforated plate 14. Adjustment of this clearance is effected by means of hand wheel 26. By increasing this clearance, the discharge rate decreases, and vice versa. Likewise, when but one blade is placed at the bottom of shaft 27, the discharge rate is less than that obtained when two or more blades are placed there. The rate may also be increased, other conditions being equal, by increasing the speed of rotation of shaft 27. These various factors are thought to be effective for increasing or decreasing the discharge rate as they cause more or less agitation of the processed material in the immediate vicinity of the orifices 14a in discharge plate 14.

The size of the perforations 14a in plate 14 may also have an important bearing upon the rate of production as larger openings would tend to facilitate passage of the worked material. Ordinarily, however, I employ a plate having a large number of such openings, as shown in Fig. 3, which are smaller than the smallest of the processing pellets introduced into the machine, yet not so small as to unduly impede the fall of the material reaching this level. For most satisfactory operation, I prefer to have the holes 14a in plate 14 tapered outwardly toward the bottom. Obviously, it would also be possible to control the rate of discharge of the worked product by providing a shutter device to regulate the size of the perforations in plate 14.

The shape, size, number and arrangement of blades 40 must be such as to produce uniformly satisfactory agitation of the contents of the machine. The action of the blades in motion should preferably be such as to move the pellets in a generally horizontal direction. The pellets should not be pressed downwardly as that will have a tendency to jam the machine. The height of any blade at any set angle determines its vertical effective agitation area, and a sufficient number and distribution of blades should be used to eliminate any "dead" areas of no agitation. The length of the blades is governed to some extent by the size of the balls or pellets used, for it is desirable that there be enough clearance between the extreme end of the blade and cylinder wall 12 to let the balls or pellets employed pass freely. The same is true of the clearance between the lower edge of the bottom blade or blades and the discharge plate 14.

The method and apparatus employed in the present invention are adapted to the production of materials either by wet or dry processes, and are therefore adapted to the production of either powders or pastes. Sometimes it may be found beneficial, either from the standpoint of quality or for safety reasons, to carry on these processes in a controlled atmosphere. Suitable gases may be continuously fed into the apparatus through openings 76 provided through the walls of the chamber 10 and of cone 17, as well as in the wall or cover of vessel 19. When not in use, openings 76 are plugged. In other operations it is

necessary to control the temperature of the chamber 10 and its charge of processing medium and raw material. For this purpose, other openings 77 are provided in the outer wall 11 through which the heating or cooling medium may be introduced into the space between walls 11 and 12. When an explosion hazard is involved in processing certain types of powders or pastes, all of the parts within the chamber 10 may be made of non-sparking material.

To illustrate the manner in which this invention finds practical application, several examples are given below. It will be noted that when it is desired to effect both disintegration and polishing of the aluminum particles introduced as raw material into the chamber, as well as to disperse agglomerates thereof into the constituent particles, steel balls are employed. On the other hand, when it is desired to effect little reduction in particle size but only to polish the particles, or to break up agglomerates thereof, or to effect both said results, aluminum processing pellets are utilized.

Example I

Using an apparatus such as is illustrated in the drawings and embracing a processing chamber having an inside diameter of about 6", approximately 135 pounds of flattened steel balls varying in size from .25" to .375" were charged into the chamber to a depth of about 30". The bladed shaft was rotated at a speed of about 100 revolutions per minute. During the processing of the powder, the temperature was controlled between 90 and 100° F., and an atmosphere containing about 5 per cent oxygen was fed continuously through the apparatus. The raw material processed was unpolished Standard Varnish Grade of dry aluminum powder which in general exhibited little, if any, leafing properties. A quantity of stearic acid equivalent to about 2 per cent by weight of the powder was added and the resulting mixture was fed constantly into the processing chamber. The powder discharged at the bottom of the apparatus showed substantial increase in covering power, was finer, and had good leafing qualities. In general, the processed powder had the characteristics of Standard Lining Grade.

Example II

In this case the conditions of operation were the same as those described above for Example I. However, instead of dry powder, a paste was employed as raw material which contained about 3 parts by weight of unpolished Standard Varnish Grade of aluminum powder, together with about 4 parts by weight of a liquid made up of mineral spirits containing 3 per cent stearic acid. The processed paste discharged at the bottom of the apparatus showed substantial increase in covering power, finer screen test, and good leafing qualities. In general, the finished paste had the characteristics of Standard Lining Grade.

Example III

The operating conditions of this test were again the same as those described in Example I above. In this case, however, the raw material introduced into the chamber was atomized aluminum of approximately 100 mesh. This material, together with approximately 3 per cent stearic acid, was processed through the apparatus. The resulting powder showed good leafing and covering qualities.

Example IV

Under the same conditions of operation as were described in Example I above, a paste made up of 10 parts by weight of 100 mesh atomized aluminum, together with about 7 parts by weight of mineral spirits containing 3 per cent by weight of stearic acid, was processed through the machine. The resulting paste showed high covering power, fine screen test, and good leafing properties. In general, the finished paste had the characteristics of Standard Lining Grade.

Example V

In this test the apparatus described in Example I above was charged with a processing medium consisting of burnished, granulated aluminum pellets instead of the flattened steel balls. Each aluminum pellet being about .15" thick and from .25" to .5" in diameter. Approximately 80 pounds of pellets were employed, which furnished a head of processing medium of about 40". The raw material employed in this test was unpolished Standard Varnish Grade of aluminum powder, which had been produced by a dry stamping process. This powder, which exhibited little, if any, leafing properties, was mixed with about 1 per cent by weight stearic acid and processed through the apparatus. Flue gas was fed continuously through the processing chamber and the temperature was held between 100 and 105° F. The resulting powder, which exhibited little change with respect to covering power, now showed excellent leafing characteristics and had the general qualities of the polished Standard Varnish Grade of aluminum powder.

Example VI

The apparatus used in this test was one which employed a processing chamber having an inside diameter of approximately 20". Approximately 750 pounds of burnished, granulated aluminum pellets, each pellet being about .15" thick and from .25" to .5" in diameter, were charged into the apparatus, giving a "head" of about 40". The bladed shaft was rotated at a speed of about 30 revolutions per minute. Flue gas was fed continuously through the processing chamber and the temperature was held at about 90° F. Extra Fine Lining aluminum powder, as obtained by drying paste produced by a wet process in a ball mill, was processed through the machine, with the continuous addition of approximately 1 per cent by weight stearic acid. The resulting powder showed an appreciable increase in apparent covering power and a corresponding decrease in quantity of agglomerates. The processed powder showed excellent leafing characteristics and had the general characteristics of Extra Fine Lining aluminum powder polished in standard brush polisher equipment.

In the interests of economy and efficiency of operation it may sometimes be desirable to employ more than one machine in carrying out the process of my invention. This can be accomplished without interrupting the continuity of the process, for when two or more machines are employed, the processing chambers may be connected with one another in such fashion that the material discharged from the first machine is fed continuously into the feeding hopper of the adjoining apparatus, and the material discharged from the second machine may in turn be fed continuously into the feeding hopper of a third machine. This operation is continued until the material dis-

charged from the last machine is a finished product.

While the invention has been described with respect to the production of bronze pigments, the method and apparatus are obviously adapted for other uses wherein it becomes necessary to effect disintegration, burnishing, dispersion, and mixing or blending of small particles.

I claim:

1. In a method of producing aluminum particles, such as powders or pastes suitable for paint pigments, the improvements comprising introducing comminuted aluminum particles, together with a leafing lubricant, into the top portion of a column of flattened metallic processing pellets, each pellet being about 0.25 to 0.5 inch in diameter, allowing the particles to proceed downwardly through the column by gravity while subjecting them to substantially uniform amounts of working by rubbing action between adjoining pellets, effecting the aforesaid working by the paddling action of stirring blades set at an upwardly inclined angle to avoid downward compression and jamming of the pellets and particles and rotating horizontally through the column at a plurality of levels, and discharging out of the bottom portion of the column the particles processed, said steps being characterized by the production, from the materials introduced, of small flake-like particles in the form of powders or pastes exhibiting substantial covering and leafing power when employed as a paint pigment.

2. In an apparatus for working small particles of material, a chamber containing a column of processing pellets, said chamber being provided with an opening to permit the introduction of said particles into said column; stirring means distributed throughout and adapted to stir substantially uniformly said column of pellets, whereby substantially uniform working of said particles between adjoining pellets is effected as said particles fall downwardly by force of gravity through the pellets in said column; and means fixed against rotation at the lower end of said chamber on which said column of pellets is supported, said means being provided throughout with evenly distributed perforations of such size as to permit of downward passage therethrough of said worked material, but not of said processing pellets.

3. In an apparatus for working small particles of material, a chamber containing a column of processing pellets, said chamber being provided with an opening to permit the introduction of said particles into said column; stirring means adapted to stir substantially uniformly said column of pellets, whereby substantially uniform working of said particles between adjoining pellets is effected as said particles fall downwardly by force of gravity through the pellets in said column; adjustable means at the lower end of said chamber on which said column of pellets is supported, said means being provided throughout with evenly distributed perforations of such size as to permit of downward passage therethrough of said worked material, but not of said processing pellets; and means to control the distance between said adjustable means and the lowermost portion of said stirring means.

4. In an apparatus for producing metal powder and paste from metal particles, a chamber containing a column of metallic processing pellets, said chamber being provided with an opening in its upper portion to permit the introduction of said particles into said column; stirring

means moving in a generally horizontal plane adapted to stir said column of pellets, whereby working of said particles between adjoining pellets is effected as said particles fall downwardly by force of gravity through the pellets in said column; an adjustable perforated plate, at the lower end of said chamber, on which said column of pellets is supported, the perforations in said plate being of such size as to permit of downward passage therethrough of said worked particles but not of said processing pellets; and means to control the distance between said perforated plate and the lowermost portion of said stirring means.

5. In an apparatus for producing metal powder or paste from metallic particles, a vertical cylindrical chamber containing a quantity of metallic processing pellets, said chamber being provided, above the level of said processing pellets, with an opening to permit the introduction of said metallic particles into the chamber; a rotatable shaft mounted along the axis of said chamber and provided with spaced blades adapted to effect stirring of said pellets upon rotation of said shaft; means to effect rotation of said shaft; a perforated plate, adjustably mounted at the lower portion of said chamber, on which said pellets rest, the perforations in said plate being of such size as to permit of downward passage therethrough of said metallic particles, but not by said processing pellets; and means to control the distance between said perforated plate and the lowermost blade on said shaft.

6. In an apparatus for producing aluminum powder or paste, a vertical cylindrical chamber containing a quantity of metallic processing pellets, said chamber having an opening in its upper portion to permit the introduction of said particles into said chamber; means to effect introduction of said particles, at any desired rate, through said opening into the chamber; a rotatable shaft mounted along the axis of said chamber and provided with spaced blades adapted to effect stirring of said pellets upon rotation of said shaft, whereby working of said particles between adjoining pellets is effected as said particles fall downwardly by gravity through said processing pellets; means to effect rotation of said shaft; a perforated plate, adjustably mounted at the bottom of said chamber, on which said pellets rest, the perforations in said plate being of such size as to permit the continuous downward passage therethrough by the bronze material produced by said working, but preventing such passage by the processing pellets; and means to control the distance between said plate and the lowermost blade on said shaft.

7. In an apparatus for working aluminum particles in dry or paste form into bronze pigment of the desired grade, a vertical cylindrical chamber containing a quantity of metallic processing pellets, said chamber having an opening in its upper portion to permit the introduction of said particles into said chamber and a second opening in its upper portion to permit the introduc-

tion of a leaping lubricant into said chamber; means to effect substantially continuous introduction of said particles, at any desired rate, through said first opening into the chamber; means to effect substantially continuous introduction of said leaping lubricant, at any desired rate, through said second opening into the chamber; a rotatable shaft mounted along the axis of said chamber and provided with spaced blades adapted to effect stirring of said pellets upon rotation of said shaft, whereby working of said particles between adjoining pellets is effected as said particles fall downwardly by gravity through said processing pellets; means to effect rotation of said shaft; a perforated plate, adjustably mounted at the bottom of said chamber, on which said pellets rest, the perforations in said plate being of such size as to permit the continuous downward passage therethrough by the bronze material produced by said working, but preventing such passage by the processing pellets; and means to control the distance between said plate and the lowermost blade on said shaft.

8. In an apparatus for working small particles of material, a chamber containing a column of processing pellets, said chamber being provided with an opening to permit the introduction of said particles into said column; stirring means including a rotatable shaft provided with spaced blades arranged in an upward spiral therearound and moving in generally horizontal planes adapted to stir substantially uniformly said column of pellets, whereby substantially uniform working of said particles between adjoining pellets is effected as said particles fall downwardly by force of gravity through the pellets in said column; and means fixed against rotation at the lower end of said chamber on which said column of pellets is supported, said means being provided throughout with evenly distributed perforations of such size as to permit of downward passage therethrough of said worked material, but not of said processing pellets.

PETER I. KLOCK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,785,283	Podszus	Dec. 16, 1930
1,930,684	Kramer	Oct. 17, 1933
2,002,891	Hall	May 28, 1935
2,272,629	Arthur	Feb. 10, 1942
2,042,254	Goodinez	May 26, 1936
849,545	Hunt	Apr. 9, 1907
1,909,586	Kramer	May 16, 1933
1,956,293	Klein	Apr. 24, 1934

FOREIGN PATENTS

Number	Country	Date
233,164	Germany	Apr. 1, 1911
101,992	Germany	Jan. 28, 1898
592,105	Germany	Feb. 1, 1934