Jan. 3, 1956 L. A. YESBERGER ET AL 2,728,940

BALLING APPARATUS AND PROCESS

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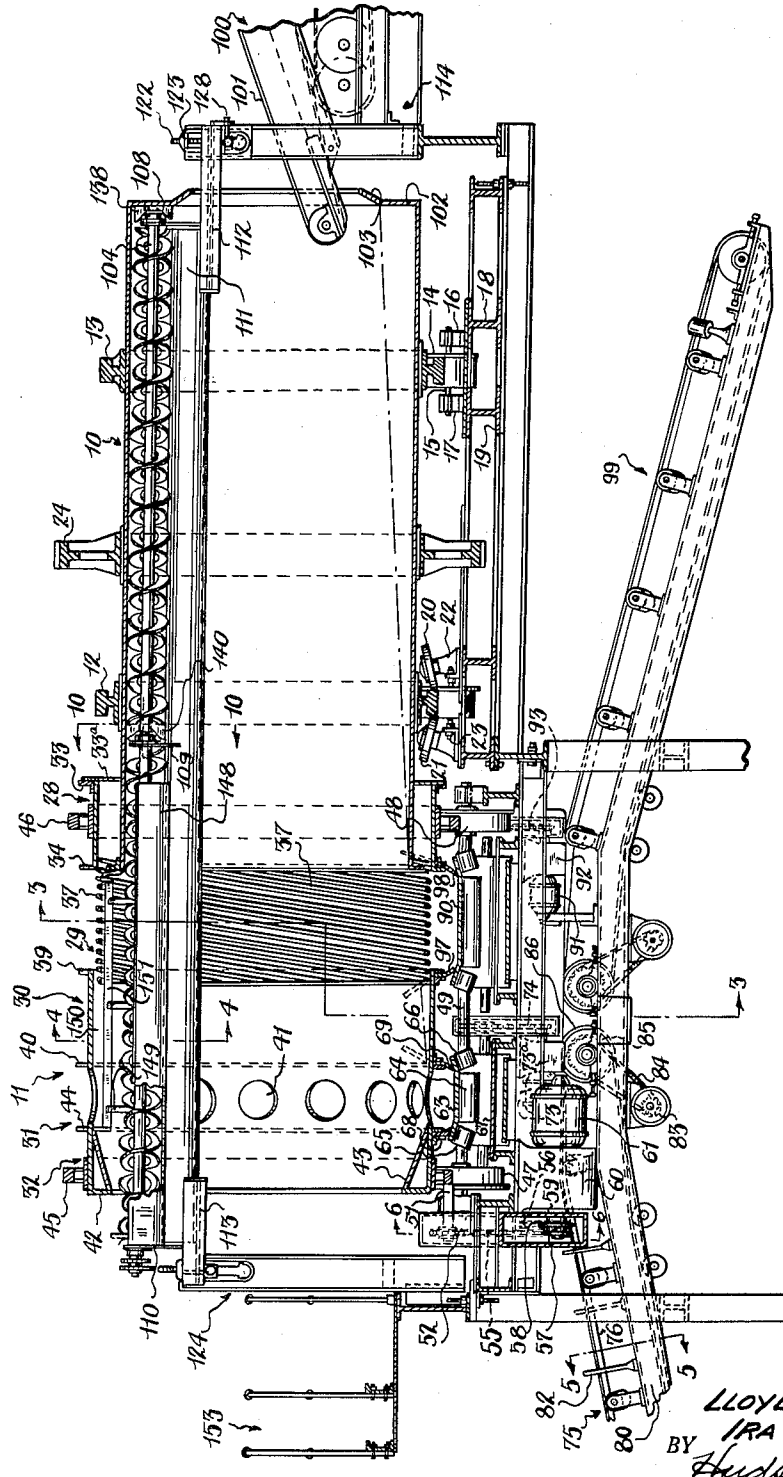


FIG. 1

INVENTORS
LLOYD A. YESBERGER
IRA H. WYNNE
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

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BALLING APPARATUS AND PROCESS

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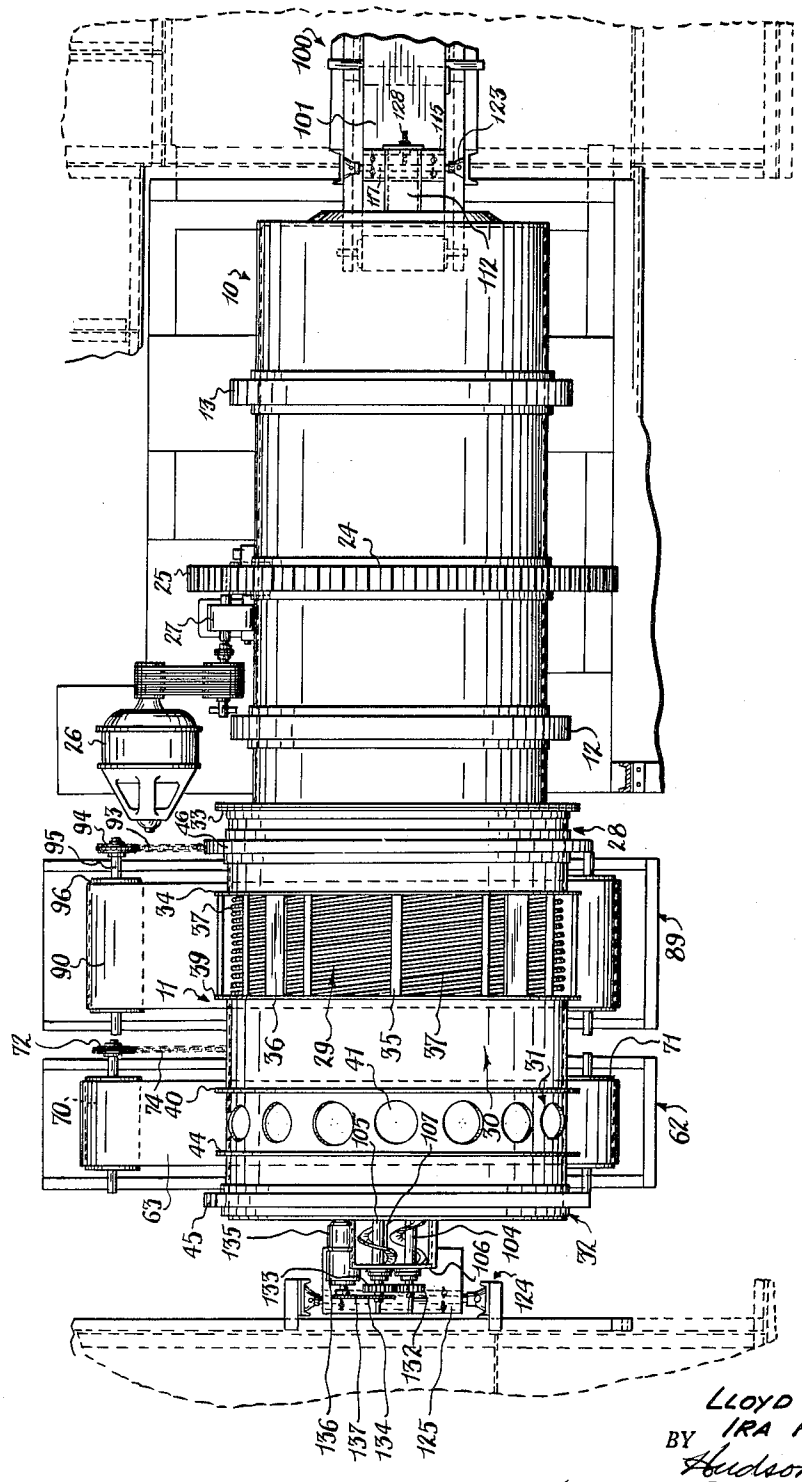


FIG. 2

INVENTORS
LLOYD A. YESBERGER
IRA H. WYNNE
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

Jan. 3, 1956 L. A. YESBERGER ET AL 2,728,940

BALLING APPARATUS AND PROCESS

Filed Jan. 23, 1952 4 Sheets-Sheet 3

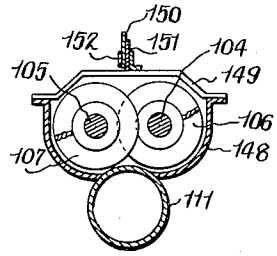


FIG. 4

FIG. 3

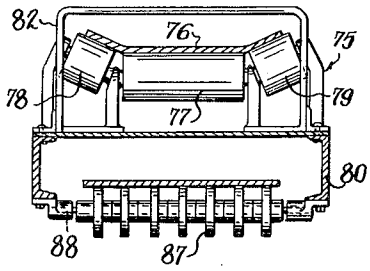


FIG. 5

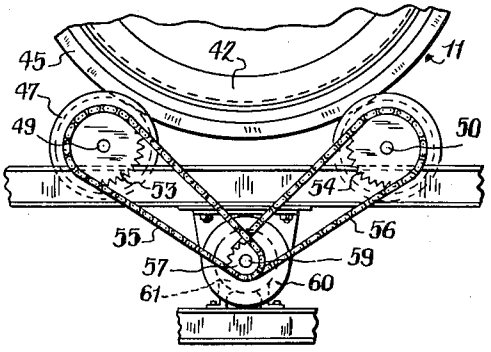


FIG. 6

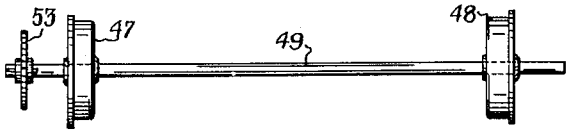


FIG. 7

INVENTORS
LLOYD A. YESBERGER
BY IRA H. WYNNE
Houdson, Boughton,
Williams, David & Hoffmann
ATTORNEYS

Jan. 3, 1956 L. A. YESBERGER ET AL 2,728,940

BALLING APPARATUS AND PROCESS

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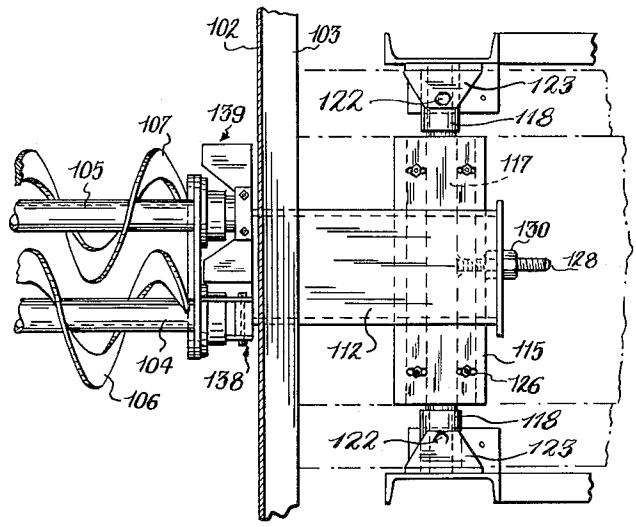


FIG. 8

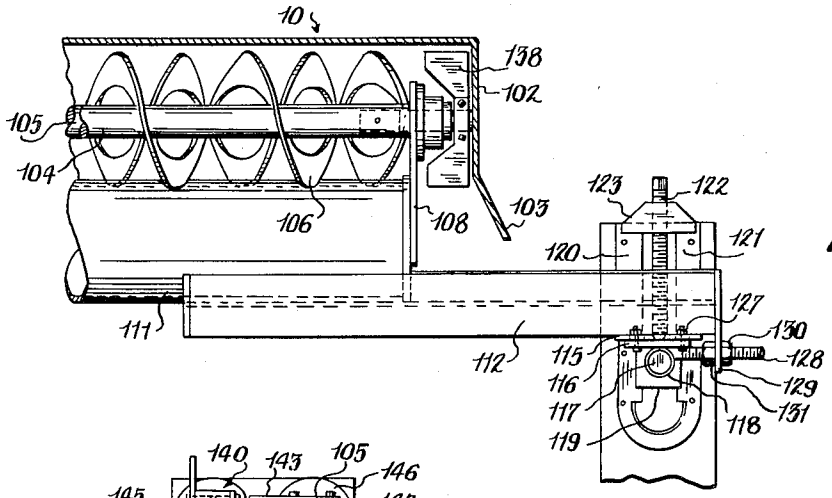


FIG. 9

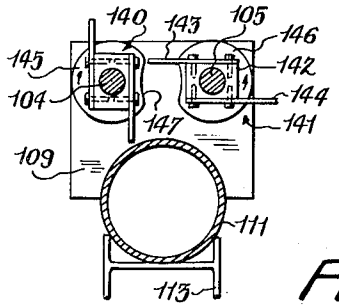


FIG. 10

INVENTORS
LLOYD A. YESBERGER
BY IRA H. WYNNE
Hudson, Boughton,
Williams, David & Hoffmann
ATTORNEYS

United States Patent Office

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BALLING APPARATUS AND PROCESS

Lloyd A. Yesberger and Ira H. Wynne, Duluth, Minn., assignors to Oglebay, Norton and Company, Cleveland, Ohio, a corporation of Delaware

Application January 23, 1952, Serial No. 267,842

20 Claims. (Cl. 18—1)

This invention relates to an apparatus for use in agglomerating finely divided solid material and, more particularly, to an apparatus for forming such material into pellets or balls.

It is frequently necessary to agglomerate finely divided material into larger size particles or pellets. For example, iron ore concentrates, flue dust, and the like cannot be utilized as a substantial part of the charge of a blast furnace until they have been formed into lumps or pellets many times the size of the individual particles thereof. One convenient mode of agglomerating or pelletizing materials of this nature is to roll or tumble them in a drum or cylinder while in a moist state, thereby forming balls which, in the case of ore concentrates or the like, may be subsequently hardened by heating. In conventional apparatus of this nature, however, difficulties have been encountered in attempting to produce balls of desired size and having the requisite strength for the necessary handling preceding the hardening operation.

An object of this invention is to provide an improved balling apparatus which, while not limited thereto, is especially useful for agglomerating fine ore particles, such as iron ore concentrates or the like, into pellets or balls of predetermined diameter and having sufficient strength prior to hardening to withstand sizing by screening and distribution by conveyors of the endless type.

Another object of the invention is to provide an improved balling apparatus comprising two separate rotatable drums so arranged that finely divided material introduced into one drum is formed into balls therein, which balls are then transferred into the second drum where they are compacted and polished by rerolling, screen means being provided adjacent the discharge end of the first drum to remove balls and particles smaller than a predetermined size.

A further object of the invention is to provide an improved balling apparatus as defined in the preceding paragraph and wherein separate variable speed means are provided to rotate the said drums so that the latter may be rotated at different preselected speeds.

A more specific object of the invention is to provide an improved balling apparatus comprising a pair of rotatable drums so arranged that material introduced into one drum is formed into balls by rotation therein and are then delivered into the other drum, there being a continuous means in said drums, acting in said one drum to scrape therefrom material adhering thereto and to convey material scraped from the other drum back into said one drum, whereby nuclei are provided for ball formation in said one drum and the ball contacting surface of said other drum is kept clean so that the balls do not grow in size while rolling therein but are polished and compacted by rerolling.

A further object of the invention is to provide an improved balling apparatus as defined in the preceding paragraph and wherein the said scraping and conveying means comprise helical means rotatably mounted adjacent the tops of the said drums interiorly thereof and adapted to scrape material from the wall of the said one drum, the said helical means extending in spaced relationship with respect to the interior wall of the other drum with a trough extending therebelow in a manner such that the helical means extends longitudinally therethrough and serves as a conveyor therefor, a stationary scraper means being provided above said helical means in the said other drum to remove material from the interior wall thereof, which material drops into said trough and is returned to said one drum.

The invention further resides in certain novel features of construction and combination and arrangements of parts, and further objects and advantages thereof will be apparent to those skilled in the art to which the invention pertains from the following description of the present preferred embodiment thereof, described with reference to the accompanying drawings in which similar reference characters represent corresponding parts in the several views and in which:

Fig. 1 is a longitudinal sectional view taken through the present preferred embodiment of a balling apparatus constructed in accordance with this invention, certain parts being shown in elevation and others broken away for the sake of clarity of illustration;

Fig. 2 is a top plan view of the balling apparatus shown in Fig. 1, certain parts being omitted;

Fig. 3 is a transverse sectional view taken substantially on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary sectional view taken through the means for scraping the rerolling drum and for conveying the scraped material back to the balling drum, the view being taken substantially on the line 4—4 of Fig. 1;

Fig. 5 is an enlarged fragmentary sectional view through the delivery conveyor for the balls, the view being taken substantially on the line 5—5 of Fig. 1;

Fig. 6 is a fragmentary sectional view taken on the line 6—6 of Fig. 1 showing the drive for the wheels or rollers which effect rotation of the rerolling drum, the chain guard being removed;

Fig. 7 is a detached fragmentary view showing one of the pair of wheels or rollers for supporting and rotating the rerolling drum;

Fig. 8 is an enlarged fragmentary plan view of the supports for the helical members adjacent the entrance to the balling apparatus with the shell of the latter broken away;

Fig. 9 is a side view of that portion of the apparatus shown in Fig. 8; and

Fig. 10 is an enlarged transverse sectional view taken substantially on the line 10—10 of Fig. 1.

Briefly stated, the balling apparatus of this invention comprises two hollow cylindrical members or drums with open ends. One of these cylinders or drums is termed the balling drum and it is into this cylinder or drum that the finely divided materials are initially introduced, preferably in a moist state, so that when the drum is rotated the material is rolled or tumbled about therein forming ball-like bodies or pellets. The second of the drums is hereinafter referred to as the rerolling drum and is a cylindrical member into which the balls, discharged from the ball drum, are received for compacting and polishing by rolling upon a substantially smooth surface. Intermediate the region in which the balls are originally formed and the rerolling region, balls and/or particles having dimensions smaller than a predetermined desired size are removed. The balls which are polished and compacted by rerolling are then discharged and conveyed to a point of utilization or further treatment.

Preferably the balling drum, generally designated 10 in the drawings, is of smaller diameter and of greater length than the rerolling drum, generally designated 11, and the

discharge end of the balling drum projects into the interior of the rerolling drum so that the balls and other material from the drum 10 directly enter the rerolling drum 11. The drums 10 and 11 are preferably formed of curved metal plates welded or otherwise connected together so as to provide substantially smooth interiors and in the present preferred embodiment these drums are supported for rotation substantially coaxially and with their axes extending substantially horizontally, although it will become apparent that the axes of the two drums need not be coextensive nor do the axes need to be substantially horizontally disposed.

The balling drum 10 is preferably provided with a pair of circular tracks 12 and 13 on the external surface of the drum which provide means for rotatably mounting the latter and also serve as reinforcing for the drum. These tracks 12 and 13 may be in the form of I-beams or other structural members having cross sections similar to railroad rails and are adapted to be supported upon suitable rollers or wheels, such as 14, there preferably being two such wheels 14 for each of the rails 12 and 13 disposed at either side of the vertical center line of the drum 10 thereby providing a cradle-like support. The wheels 14 are shown as similar in nature to flanged car wheels and each is mounted with its axle 15 supported by suitable bearings 16, 17, the latter being in turn supported upon structural members 18 and 19 of a building or other supporting structure.

Endwise movement of the drum 10 may be prevented by any suitable means, but as herein shown a pair of thrust rollers 20 and 21 is provided to act on opposite sides of the rail or track 12, the rollers 20 and 21 being rotatably supported upon suitable brackets 22 and 23 with the axes of the rollers substantially vertical so that any tendency of the drum 10 to move axially is prevented.

Intermediate the tracks 12 and 13, the drum 10 is provided with a ring gear 24 which meshes with a driving gear 25 disposed at one side and adjacent the bottom of the drum, see Fig. 2, the gear 25 being driven by a variable speed electric motor 26 through a suitable drive comprising a conventional speed reduction means 27. It will therefore be apparent from the structure thus far described that energization of the motor 26 will effect rotation of the drum 10 at a speed determined by the speed of the motor and the rate of reduction in the unit 27.

The rerolling drum 11 is, as previously mentioned, preferably of larger diameter than the balling drum 10 and of shorter length, the rerolling drum 11 being preferably formed in a plurality of separate portions or sections united together. These sections comprise an entrance end portion 28, a screening portion generally designated 29, a rerolling or polishing portion 30, a ball discharge portion 31 and an outer end portion 32. The entrance end portion 28 of the drum 11 is of cylindrical configuration and has the discharge end of the balling drum extending therein, the exterior of the portion 28 being provided with circular flanges 33 and 34 serving as strengthening ribs. Attached to the flange 33 is an annular plate 33*a* extending radially inwardly to a point adjacent the exterior of drum 10.

The screening portion 29 comprises a plurality of circumferentially spaced, axially extending plates 35 and bars or lengths of pipe 36 secured to the entrance section 28 and to the rerolling section 30 thereby providing a skeleton-like section having a generally cylindrical configuration with the majority of the circumference open. Supported upon the plates and bars or pipes 35, 36 of the screening portion 29 is a removable trommel or cylindrical screen 37 formed of a helically wound rod or wire having spacing between the convolutions thereof such as to allow passage therethrough of balls and other particles of lesser size than that which it is desired to produce. The screen or trommel 37 may be secured in place by any suitable means but, as mentioned heretofore, should be readily removable so as to permit substitution of a screen having openings of different size when it is desired to produce balls having a different minimum diameter.

The rerolling or polishing portion 30 of the drum 11 is preferably formed of one or more curved metal plates secured together to provide a smooth interior, circular flanges or ribs 39 and 40 being provided between the said screening section 29 and the rerolling section 30 and between the latter and the discharging portion 31, respectively, to provide strengthening of the drum.

The discharge portion 31 is preferably constructed of one or more apertured plates secured together in a substantially cylindrical configuration coextensive with the remainder of the drum thus providing a plurality of substantially equally spaced openings 41 about the entire circumference of this portion of the drum, the number and spacing of the openings preferably being such as to permit substantially unimpeded discharge of material therethrough while retaining sufficient strength in the drum to prevent bending or deflection thereof in this region.

The outer end section 32 of the drum 11 comprises a cylindrical portion formed of one or more curved plates secured together, the outer edge of this portion, and hence the outer end of the drum, being provided with an annular ring 42 secured to the section 32 and having a portion extending radially inwardly of the drum a short distance. Between the ring 42 and the edge of the discharge section 31, the section 32 is provided with a lining 43 having an inclined surface. This lining may be formed of suitable material such as cement, asphalt, or the like or may, as shown, be a metal plate or plates secured in the drum. The purpose of this lining 43 is to direct any balls passing between the discharge openings 41 back to such openings and thereby prevent their discharge through the open end of the drum 11. Intermediate the section 32 and the discharge portion 31 may be provided one or more strengthening ribs each of which is in the form of a circular flange as indicated at 44.

The rerolling drum 11 is rotatably supported, as heretofore mentioned, and for this purpose the exterior surface thereof is provided with a pair of circular rails or tracks 45, 46 similar to the rails or tracks 12, 13 for the balling drum 10. Cooperating with the rails or tracks 45, 46 are suitable driving wheels forming the support and driving means for the drum. These driving wheels are preferably flanged and are connected in pairs on two axles extending on either side of the vertical center line of the drum 11. Thus, the wheels 47, 48 are connected for rotation with an axle 49 which extends parallel with the axis of the drum 11 adjacent the bottom and at one side thereof, the wheel 47 having the rail 45 resting thereon, while the wheel 48 has the rail 46 resting thereon. An axle 50 provided with a similar pair of driving wheels is disposed at the other side of the vertical center line of the drum, the flanged wheels on this axle 50 likewise cooperating with the rails 45, 46 of the rerolling drum, as will be apparent from Figs. 1 and 3. The flanges on the wheels such as 47, 48 cooperate with the exterior surface of the rails 45, 46, respectively, to thereby prevent axial movement of the drum. In addition, one or more thrust rollers may be provided for this purpose and arranged to cooperate with the rails 45, 46. As shown in Fig. 1, a thrust roller 51 is rotatably mounted on a bracket 52 with the axis of the roller vertical, the roller cooperating with the outer face of the rail 45. A similar roller may be provided for cooperation with the outer face of the rail 46 if necessary or desired.

The rollers or wheels such as 47, 48 provide both the support and the driving means for the drum 11. Therefore, as mentioned heretofore, these wheels are connected with the axles 49 and 50 which axles are journalled for rotation in suitable bearings mounted upon a portion of the supporting structure. The axles 49, 50

project forwardly beyond the wheels and are each provided with a sprocket wheel such as 53 and 54 about which pass driving chains 55 and 56, respectively, see Fig. 6. The chain 55 is engaged about a sprocket wheel 57, while the chain 56 is engaged about a sprocket wheel 58, both of the latter being connected with a shaft 59 forming the output shaft of a speed reduction unit 60, the input shaft of which is connected with a variable speed motor 61. It will be apparent, therefore, that when the motor 61 is energized it will drive the chains 55, 56 thereby rotating the wheels 47, 48, which being in frictional engagement with the tracks 45, 46, rotate the drum 11.

Supported below the rerolling drum 11, and extending transversely with respect to the axis thereof, are conveying means to remove both the compacted rerolled balls of predetermined or larger size and the uncompacted balls or other particles having sizes less than the predetermined value. Thus, a conveyor of the endless belt type, generally designated 62, is disposed below the discharge openings 41 and extends transversely of the drum 11 to carry away the compacted rerolled balls discharged through the openings 41. In the form shown, the conveyor 62 comprises an endless belt 63, the upper flight of which is supported for movement and troughed by rollers 64, 65 and 66 which are supported from frame members such as 67 for the conveyor, the supports for the rollers being omitted from Fig. 1 for the sake of clarity but are similar to those shown in Fig. 5.

The upper flight of the conveyor 62 is preferably provided with side boards or members 68, 69 to prevent balls from being discharged from the sides of the conveyor. These side boards or members extend longitudinally of the conveyor beneath drum 11 and are so spaced as to receive therebetween the ribs 40, 44 of the drum in a substantially sealing relationship so that any balls passing out of the drum must be received upon the trough-shaped conveyor. The conveyor 62 is driven in a conventional manner by having the belt 63 thereof provided with a driving drum 70 and an idler drum 71 adjacent the ends of the conveyor structures, the drum 70 having its axle connected with the drum and provided with a sprocket wheel 72 which is driven by a motor 73 connected with the sprocket 72 through a speed reduction unit 73a and a chain 74.

The conveyor 62 discharges the balls carried thereon into a conveyor, generally designated 75, which is adapted to carry the balls to a point of utilization or of subsequent treatment as, for example, to a furnace for hardening or the like. As shown in the drawing, the conveyor 75 extends substantially at right angles with respect to the conveyor 62 and at one side of the drum 11. This conveyor 75 is likewise of the endless belt type comprising a belt 76 supported on rollers 77, 78 and 79 providing a trough-like configuration for the upper flight of the belt as is well known in the art, see Fig. 5. The conveyor 75 is supported upon suitable structural members such as 80 and has a major portion thereof inclined downwardly with respect to the axis of the drum. In order to prevent the balls from running ahead of the conveyor or forming piles thereon, a plurality of ball retarding brackets 82 are provided to cooperate with the upper flight of the belt 76 as will be seen from Figs. 1 and 5. These ball retarding brackets are substantially U-shaped members secured to the frame member 80 at spaced points and extending a predetermined height above the upper flight of the belt 76. They, therefore, serve to level off any piles of balls on the belt 76 and maintain the level of balls at a predetermined maximum height above the belt. This makes for a more uniform movement of the balls and hence a more uniform delivery thereof to the point of utilization. The conveyor belt 76 is driven by a motor and speed reducer assembly 83 connected by a chain 84 with a sprocket 85 provided on the shaft of the belt drum 86.

Since the balling operation as a whole is generally quite dusty in nature, belt cleaning means may be provided for the lower flight of the several conveyor belts to remove any dust or other material adhering thereto and thereby eliminate "tracking" problems of the conveyors. One form of suitable belt cleaning means may comprise a plurality of rubber spools or wheels 87 supported upon shafts, such as 88, beneath the conveyor with the peripheries of the spools or wheels riding upon the return flight of the conveyor belt, see Fig. 5. If desired, these wheels may be given an endwise movement, may be eccentrically mounted for imparting slight repeated flexing movements to the belt, or may have other types of movements in addition to simple rotation to further facilitate loosening material adhering to the underside of the belt.

Beneath the screen 37 and extending laterally with respect to the axis of the reroll drum 11 is a conveyor, generally designated 89, for removing material passing through the openings of the screen. This conveyor 89 is constructed substantially identically with the conveyor 62 and hence will not be described in detail. Suffice it to note that the belt 90 of the conveyor 89 is driven by a motor 91 through a speed reduction unit 92, the output shaft of the latter being connected through a sprocket chain 93 to the sprocket 94 mounted on the axle 95 of the belt drum 96. The conveyor 89 is provided with side board or members 97 and 98 beneath the reroll drum to prevent material from passing over the edges of the conveyor belt 90. These side members or boards 97, 98 are spaced apart a distance such that the ribs 34, 39 on the drum 11 can pass therebetween and sufficiently close thereto to prevent escape of material at this point. Consequently, when fine material fragments of balls, or balls of a diameter less than that of the openings between the screen 37 are discharged through the latter, they are carried on the belt 90 to one side of the drum 11. The discharge end of the conveyor 89 is positioned over a portion of a conveyor, generally designated 99, which is constructed substantially similar to the conveyor 75 but extends in the opposite direction. The conveyor 99 carries the material received from the belt 90 to other conveyors, not shown, for introducing the material thereon into the inlet end of the balling drum 10 for recirculation through the latter.

A conveyor, generally designated 100, and comprising a power-driven belt 101 is provided in alignment with the inlet end of the balling drum 10. This conveyor is preferably formed substantially like the other conveyors previously described and hence the details thereof need not be specifically mentioned. The forward end of the conveyor 101 extends into the inlet opening of the drum 10 so that the material carried by the belt 101 is all deposited inside the balling drum adjacent the inlet opening thereof. In order to prevent the material introduced into the drum, and that being rotated therein, from coming out the inlet opening, the latter is provided with an annular ring 102 extending radially inwardly, the inner edge of which is provided with an outwardly flared portion 103 which may be integral with the annular ring 102 or a separate member connected thereto and cooperates with the ring 102 to prevent improper discharge of material.

The material carried by the belt 101 of the conveyor 100 comprises finely divided material which is to be agglomerated or balled. Preferably this material is in moist condition and with it may also be carried fragments of balls and balls of small diameter which have been discharged through the screen means 37 and returned to the conveyor 100 by means of the conveyors 89, 99 and other suitable conveyors not shown. The material thus introduced into the balling drum 10, by virtue of its moist nature, tends to cling to the inner surface of the drum as the latter is rotated and is carried therewith through at least a part of the rotation thereof thereby tending to form a layer of the finely divided material upon the inner surface of the

drum. As the drum 10 rotates, however, portions of this layer of finely divided material will break off and drop into the lower part of the drum and these portions together with the small balls and fragments from screen 37 are rolled upon the layer of material in the drum thus forming substantially spherical agglomerates or balls, the action being similar to the formation of snowballs. Due to the rotation of the drum 10 and/or a slight inclination of the axis thereof towards the left as viewed in the drawings, the balls formed therein move towards the discharge end of the drum.

It has been found that if the drum 10 has a smooth interior without other expedient, such drum is relatively inefficient in formation of balls of desired characteristics since an undue amount of the material tends to build up in a thick layer upon the entire interior of the drum. As a result, the fragments breaking away and falling therefrom are frequently of larger size than is desirable for formation of balls so that the balls produced by the drum tend to be of irregular size and shape and the operation of the drum is in general unsatisfactory. In order to overcome these defects, it has been found that a means is necessary to scrape a portion of the interior of the drum as the latter is rotated to thereby prevent the layer of finely divided material from becoming too thick and to insure that a sufficient quantity of the material breaks off in pieces of desired size and at the desired time to provide nuclei for formation of the balls or agglomerates. Heretofore, stationary scraper blades have been employed for this purpose, but these have not proved entirely satisfactory since they simply tend to maintain the material within the drum as a smooth layer of predetermined thickness and do not insure that the portions of the layer breaking away shall be of the proper size or properly distributed throughout the length of the drum to result in the desired ball formation.

In accordance with this invention a novel scraping means is employed which not only prevents the formation of a layer of the finely divided material of too great a thickness within the drum but also insures that portions of that layer are removed substantially uniformly through the entire length of the drum, which portions are of similar size, thereby providing nuclei of the desired amount, distribution and size for formation of balls within the drum. This scraping means is helical in nature and in the disclosed embodiment comprises two screw-like members supported adjacent the top interior of the drum 10 and rotated by a power means exteriorly of the drum.

As shown in Fig. 1 of the drawings, the helical scraping means comprise screw-like members of the type frequently used for conveying material and known in the trade as "ribbon flight" conveyors. Each of the helical means comprises a central shaft or axle 104, 105 about which is disposed a ribbon-like metallic member in helical configuration, the helical or screw member 106 having a right-hand thread and the helical or screw member 107 having a left-hand thread. The ribbon or helical portions of the members 106 and 107 are connected with their respective axles at spaced points so as to provide a substantially rigid construction and the two scrapers or helical members are mounted adjacent each other so that their convolutions interfit without contact therebetween. Moreover, the screws or helical means are rotated in opposite directions so that they tend to be self-cleaning; that is, the convolutions on one of the members tends to remove material adhering to adjacent convolutions of the other member and conversely.

The two helical members or means 106, 107 extend through both the drum 10 and the drum 11 and are supported at spaced points by suitable bearings carried by plates such as 108, 109 and 110 extending upwardly from a tubular supporting member 111, the helical members 106 and 107 being discontinuous substantially medially of their lengths to accommodate the supporting plate 109.

The tubular supporting member 111 extends through both of the drums adjacent the tops thereof and is in turn supported adjacent its ends by channel members or I-beams 112 and 113 secured to the underside of the tubular member. The member 112 extends beyond the inlet opening of the balling drum 10 and is adjustably supported exteriorly of this drum upon a suitable framework, generally designated 114, extending upwardly from the floor or other support upon which the balling drum and rerolling drums are mounted.

The details of the adjustable support for the helical means are illustrated in Figs. 8 and 9. As shown therein, the member 112 has a plate 115 secured to the underside and adjacent the outer end thereof. The plate 115 rests upon a plate 116 which is secured, by welding or the like, to a rod or shaft 117. The rod or shaft 117 extends beyond the ends of plates 115 and 116 and the ends of this rod or shaft are received in socket members 118 which have enlarged rectangular portions 119 slidably guided for vertical movement on ways 120 and 121 provided upon vertical members of the framework 114. The socket members 118 for the ends of the rod or shaft 117 each have a screw 122 projecting upwardly therefrom and passing through a nut member 123. The screws 122 are secured to the socket members 118 in a manner permitting rotation but preventing axial movement relative thereto while the nut members 123 cooperate with the ways 120, 121 to prevent rotation. The outer end of the screws 122 are preferably polygonally shaped or otherwise formed to receive a tool for rotation of the screw to thereby change the elevation of the member 112 and the helical means or members supported thereby. The other end of the helical means or members 106, 107 are similarly adjustably supported upon frame members, generally designated 124 by having the member 113 projecting outwardly of the reroll drum 11 and supported by a plate 125 which is in turn supported for vertical adjustment in the same manner as is plate 115.

Longitudinal adjustment of the helical means or members relative to the drums 10 and 11 is permitted by providing the plates 115 and 125 with slotted openings 126 through which extend the bolts 127 that secure the plates to their supporting plates, such as 116. By loosening the bolts 127 the members 112, 113 together with the tubular member 113 and the helical members 106 and 107 may be adjusted longitudinally as a unit and then clamped in the new position. To facilitate this adjustment the rod or shaft 116 has a screw 128 secured thereto substantially centrally thereof and projecting beyond the adjacent end of the member 112. The latter has a plate 129 secured to the end thereof and extending downwardly therefrom with the screw 128 passing through an opening thereof. Nuts 130 and 131 are provided on screw 128 on either side of the plate 129 and hence by operating these nuts the helical means may be moved longitudinally as above mentioned.

Mounted upon the supporting plate 125 of the helical means is a driving mechanism for effecting rotation thereof. This driving mechanism comprises intermeshing gears 132 and 133 connected with the shafts or axles 104, 105 of the helical members, respectively, one of these shafts or axles as, for example, 105 being provided with a sprocket wheel 134 which is driven by a motor 135 through a speed reduction unit 136 and chain 137. Since only one of the shafts or axles of the helical means or members is driven directly by the motor 135 and the other is driven through intermeshing gears upon the two shafts or axles, it will be apparent that the helical means rotate in opposite directions.

As will be apparent from Fig. 1 of the drawings, the portion of the helical members 106, 107 within the balling drum 10 are so disposed as to extend closely adjacent the interior surface of the balling drum to thereby scrape and remove at least a portion of the material, adhering thereto which material as mentioned here-

tofore, falls within the drum and forms nuclei for formation of agglomerates or balls. Due to the action of the numerous convolutions of the helical means upon the entire interior of the drum, the layer of finely divided material adhering thereto is broken into relatively small chunks or portions of substantially the same size, thus providing nuclei of the desired characteristics while at the same time preventing the formation of a layer of undue thickness upon the interior of the drum. Moreover, since the helical means are rotated in opposite directions, as mentioned heretofore, any of the finely divided material adhering to the helical means is cleaned therefrom by the joint interaction thereof.

In addition to the helical members **106** and **107** on the axles **104** and **105**, the latter are each provided with rotary scrapers **138** and **139** intermediate the mounting plate **108** and the adjacent end of the balling drum **10**. Similar scrapers **140** and **141** are provided adjacent the supporting plate **109** near the discharge end of the balling drum **10**. The scrapers **138**, **139** prevent the material being balled or agglomerated from building up adjacent the ring **102** at the entrance of drum **10** while the scrapers **140** and **141** prevent building up of the material adjacent the plate **109** where the helical members are discontinuous.

As shown in Fig. 10 the rotary scrapers each comprise a rectangular hub **142** suitably secured to the axle or shaft upon which the scraper is carried and secured to opposite sides of the hub are generally trapezium shaped blades **143** and **144** extending in opposite directions from the hub. The bushings or bearings **145** and **146** for the axles or shafts **104** and **105** are recessed as indicated at **147** to permit free passage of the blades **143** and **144**.

The drum **11**, as has been mentioned heretofore and as is shown in the drawings, is preferably of larger diameter than the drum **10** and hence the helical means **106**, **107** extend in spaced relationship with respect to the top of the interior surface of the drum **11** and perform no scraping action with respect to the interior of this drum. Instead the portions of the helical means or members within the drum **11** serve as conveyors to remove scraped material from the interior of this drum back into the drum **10** without rolling of the scraped material within the drum **11**. For this purpose, the support such as the tubular member **111** for the helical means is provided with curved plates forming a trough **148** about the portion of the helical members within the drum **11**, the inner end of this trough extending into the interior of the drum **10**. Supported from the sides of the trough **148** as, for example, by means of brackets **149** see Fig. 4, is a scraper blade **150** which is stationarily mounted and extends axially within the drum **11** in scraping relationship with the interior thereof. The scraper blade **150** is preferably formed of flexible material and is held between a back-up bar **151**, secured to the brackets **149**, and a clamping bar **152**, see Fig. 4.

It will now be evident that any material adhering to the screen **37**, the rerolling surface **30**, or to the portion of drum **11** between the discharge openings **41** is removed by the scraper blade **150** and falls within the trough **148** from whence it is carried by the helical members **106**, **107**. Material thus scraped and conveyed, after travelling through the trough **148**, drops within the balling drum **10** and is rotated therein to form balls in the same manner as does the material scraped from the interior of the drum **10**.

In operating the balling apparatus of this invention the finely divided material which is to be agglomerated into balls is delivered by the conveyor **100** into the interior of the balling drum **10** which is rotated by the motor **26**. As the drum is thus rotated, the material delivered thereto tends to be carried around upon the inner side of the drum in the form of a layer with parts of this layer breaking way from time to time and rolling on the layer retained, picking up additional material and thereby forming balls. The thickness of the layer is maintained within predetermined limits and/or removed adjacent the top of the drum by action of the helical means **106**, **107** which break portions of the layer into substantially uniformly distributed and uniformly sized particles that drop into the drum and form nuclei of agglomerates or balls. In the event the material supplied to the drum is deficient in moisture content, a suitable spray or sprays may be provided within the drum **10** by extending a pipe or pipes therein through the entrance opening.

As the drum **10** is rotated the nuclei repeatedly dropping from the top thereof, and other nuclei which may be introduced along with the finely divided material, rotate and grow by rotation to form the balls as aforesaid. During this rotation the balls tend to move towards the discharge end of the drum due to the rotation of the latter, this movement of the balls being assisted if necessary by disposing the axis of the drum at a slight angle to the horizontal. As the balls are discharged from the drum **10**, they pass over the screen means **37** in the drum **11** at which time any balls smaller than a predetermined diameter, broken balls, or unpelletized material drop through the screen upon the conveyor **89** and are delivered by the latter to the conveyor **99** and thence back to a point of storage or to the inlet conveyor **100** as desired.

Balls having a size at least equal to or greater than the openings in the screen **37** pass thereover and are received upon the rerolling surface in the section **30** of the drum **11**. Here the balls are rerolled due to the rotation of the drum **11** through operation of the motor **61**. Any particles of material which may tend to be deposited upon this rerolling surface from breakage of the balls or otherwise are continuously removed therefrom by the scraper blade **150**. The material thus removed by the blade **150** drops into the trough **148** and is carried back into the balling drum **10** by the helical means **106**, **107**. Consequently, the screen **37** and the rerolling surface **30** are both kept substantially free of the material being agglomerated so as to prevent formation of layers of material thereon. Thus the rerolling surface of the section **30** is a clean, bare surface free from the presence of fine material. During this rerolling operation, the balls are compacted and/or polished thereby making them firmer and less liable to breakage during subsequent handling.

As the drum **11** continues to rotate the balls therein move from the rerolling surface **30** to the discharge openings **41** being assisted in this movement, if necessary, by a slight inclination of the axis of the drum towards the left as viewed in the drawings. The balls therefore now fall through the openings **41** upon the conveyor belt **63**, any balls which tend to pass between the openings **41** being redirected back to this portion of the drum by the inclined surface **43** so that none of the balls are discharged through the open outer end of the drum. The balls passing through the openings **41** are carried by the conveyor belt **63** to the conveyor **75** and from the latter are delivered to a furnace for heating and hardening, or may be carried to a place of storage or of utilization as may be desired.

The balling and reroll drums may be operated at any desired speed depending upon the characteristics of the materials handled, the relative sizes of the drums and like considerations. It has, however, been found desirable in certain instances to have the reroll drum rotated at a different speed than that of the balling drum, for example, somewhat slower, and consequently separate drive motors are provided for the two drums to facilitate selecting the desired respective speeds of operation. Other means may, of course, be provided for this purpose; for example, a single prime mover may be employed for both drums with the desired speeds for each drum being attained through suitable change speed mechanisms. With the drums constructed in substantially the relative proportions shown, it has been found desirable to operate the rerolling drum at approximately half the speed of the

balling drum. This is not, however, critical and is cited only by way of example and is not intended to be a limitation upon the invention.

By virtue of the open ends of the balling and reroll drums, support of the helical means **106**, **107** is facilitated. In addition, the open ends of the drums facilitate feeding of material into the balling drum and observance of the action therein. If desired, a platform, generally designated **153**, may be provided adjacent the open outer end of the reroll drum **11** to enable an operator to gain access to the drum when stationary and to observe its operation when in rotation.

While the invention has been disclosed primarily with respect to agglomerating finely divided material such as iron ore concentrates, flue dust and the like, it will be apparent that the apparatus is not limited to use with such material but may be employed wherever similar problems exist with respect to the nature of the material and the manner in which it is to be used. It will also be apparent that details of construction of the device may be altered from those specifically shown and described. For example, it is not necessary that the screen **37** be in all cases a part of the rerolling drum but may in certain instances be a separate member or may be a part of the balling drum adjacent the discharge end. Likewise, in some cases, the separate discharge openings such as **41** may be eliminated together with the annular ring and inclined surface **43**, the discharge of the drum then being through the outer end thereof to a suitable conveyor. These and other changes will readily occur to one skilled in the art after having had the advantages of this disclosure. Consequently, the invention is not to be considered as limited to the specific details of construction illustrated and described.

Having thus described the invention we claim:

1. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a rotatable drum, means to introduce finely divided material into said drum, means to rotate said drum to thereby produce balls of the finely divided material introduced therein, means to scrape material from the wall of said drum with the said scraped material dropping into the drum and being rolled therein, screening means adjacent the point of discharge of said balls from said drum to remove particles of the material smaller than a predetermined size, a rotatable smooth surfaced rerolling means independent of said drum receiving the balls passing over said screening means, means to remove material adhering to the surface of said rerolling means, means to convey the said removed material from said rerolling means to said drum, and means to rotate the said rerolling means to thereby effect compacting and discharge of said balls.

2. An apparatus as defined in claim 1 wherein the means to rotate said drum and the means to rotate said rerolling means comprise separate variable speed motors.

3. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums so arranged that material is discharged from the one drum into the other drum, means to introduce finely divided material into said one drum, means to rotate said drums, means to scrape material from the inner wall of said one drum with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, the said other drum including a surface for polishing and compacting balls of material delivered thereto, means to scrape the inner wall of said other drum and to convey the material scraped from the said other drum into the said one drum, and means in said other drum adapted to remove therefrom particles of material smaller than a predetermined size.

4. An apparatus as defined in claim 3 and further comprising means to adjust said scraping and conveying means relative to said drums.

5. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums so arranged that material is discharged from the one drum into the other drum, means to introduce finely divided material into said one drum, means to rotate said drums, means to scrape material from the inner wall of said one drum with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, the said other drum including a surface for polishing and compacting balls delivered thereto, means to scrape the inner wall of said other drum and to convey the material scraped from the said other drum into the said one drum, and means in said other drum adapted to remove therefrom particles of material smaller than a predetermined size, the said other drum having a plurality of openings at points spaced around the circumference thereof for discharge of the balls therefrom which have been polished and compacted by rotation of said other drum.

6. An apparatus as defined in claim 5 wherein the said means for removing particles smaller than a predetermined size comprises screening means adjacent the point of introduction of material into said other drum with the said discharge openings being adjacent the other end of that drum, and the said surface for polishing and compacting the balls is a substantially smooth circumferential wall portion intermediate the said screen means and discharge openings.

7. An apparatus as defined in claim 5 and wherein the means to rotate said drums comprise separate variable speed driving means for each drum.

8. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums so arranged that the material is discharged from the one drum into the interior of the other drum, means to introduce finely divided material into said one drum, means to rotate said drums independently of each other, means to scrape material from the inner wall of said one drum with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, the said other drum including a surface for polishing and compacting balls delivered thereto, means to scrape the inner wall of said other drum and to convey the material scraped from the said other drum into the said one drum, and means in said other drum adapted to remove therefrom particles of material smaller than a predetermined size, the said other drum having a plurality of openings at points spaced around the circumference thereof for discharge of the balls therefrom which have been polished and compacted by rotation of said other drum.

9. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums arranged with their axes substantially horizontal in a manner such that material is discharged from an open end of one drum into the interior of the other, means to introduce finely divided material into the other end of said one drum, means to rotate said drums, means to scrape material from the wall of said one drum with the said scraped material dropping into the drum and being rolled therein, a scraper means cooperating with the interior of said other drum, means spaced from the interior of said other drum to remove from the latter the material scraped from the interior thereof, cylindrical screen means forming a part of said other drum adjacent the discharge end of said one drum permitting passage therethrough of particles of material smaller than a predetermined size, the said other drum having at least a portion of the interior surface thereof smooth whereby material introduced into said one drum is rolled into balls with those balls which do not pass through said screen means being polished and compacted by rotation on the said smooth surface of said other drum and then discharged therefrom.

10. An apparatus of the character described for pro-

ducing ball-like bodies from finely divided material comprising a pair of rotatable drums arranged with their axes substantially horizontal in a manner such that material is discharged from an open end of one drum into the interior of the other, means to introduce finely divided material into the other end of said one drum, means to rotate said drums, helical means rotatably mounted adjacent the tops of said drums interiorly thereof and adapted to scrape material from the wall of said one drum with the said scraped material dropping into the drum and being rolled therein, the said helical means extending in spaced relationship with respect to the interior side wall of the said other drum and having a trough extending therebelow in a manner such that the said helical means extends longitudinally therethrough and acts as a conveying means therein, means to rotate said helical means, and scraper means cooperating with the interior side wall of said other drum above said helical means so that material scraped from the side wall of said other drum drops into said trough and is returned therethrough to said one drum by said helical means, whereby material introduced into said one drum is rolled into balls which are polished and compacted by rotation in said other drum.

11. An apparatus as defined in claim 10 wherein said helical means comprises a pair of screw-like members mounted adjacent each other and rotated in opposite directions to thereby effect self cleaning.

12. An apparatus as defined in claim 10 and further comprising means to adjust said helical means relative to said drums.

13. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums arranged with their axes substantially horizontal in a manner such that the material is discharged from an open end of one drum into the interior of the other, means to introduce finely divided material into the other end of said one drum, means to independently rotate said drums, helical means rotatably mounted adjacent the tops of said drums interiorly thereof and adapted to scrape material from the wall of said one drum with the said scraped material dropping into the drum and being rolled therein, the said helical means extending in spaced relationship with respect to the side wall of the said other drum and having a trough supported therebelow in a manner such that the said helical means extends longitudinally therethrough and acts as conveying means therein, means to rotate said helical means, scraper means cooperating with the side wall of said other drum above said helical means so that material scraped from the side wall of said other drum drops into said trough and is returned therethrough to said one drum by said helical means, screen means in said other drum adapted to remove therefrom particles of material smaller than a predetermined size, and a ball rerolling surface in said other drum whereby material introduced into said one drum is rolled into balls with those balls which do not pass through said screen means being polished and compacted by rotation on the said rerolling surface of said other drum and then discharged therefrom.

14. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums coaxially arranged with their axes substantially horizontal in a manner such that the material is discharged from an open end of one drum into the interior of the other, means to introduce finely divided material into the other end of said one drum, means to independently rotate said drums, helical means rotatably mounted adjacent the tops of said drums interiorly thereof and adapted to scrape material from the wall of said one drum with the said scraped material dropping into the drum and being rolled therein, the said helical means extending in spaced relationship with respect to the side wall of the said other drum and having a trough supported therebelow in a manner such that the said helical means extends longitudinally therethrough and acts as conveying means therein, means to rotate said helical means, a scraper means cooperating with the side wall of said other drum above said helical means so that material scraped from the side wall of said other drum drops into said trough and is returned therethrough to said one drum by said helical means, screen means in said other drum adjacent said discharge end of said one drum adapted to remove particles of material smaller than a predetermined size, the said other drum having a plurality of openings around the circumference thereof and spaced from said screen means by a region having a substantially smooth ball rerolling surface, whereby material introduced into said one drum is rolled into balls with those balls which do not pass through said screen mean being polished and compacted by rotation on the said smooth surface of said other drum and discharged therefrom through said openings.

15. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums of different diameters arranged with an end of the smaller drum discharging into the interior of the larger drum, means to introduce finely divided material into the other end of said smaller drum, means to rotate said drums independently of each other, means to scrape from the inner wall of said smaller drum material adhering thereto with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, means to scrape the inner wall of said larger drum and to convey the material scraped from the larger drum into the smaller drum, the said larger drum including a screening portion adjacent the discharge end of the smaller drum and a substantially smooth ball rerolling surface for polishing and compacting balls of material passing over the screening portion, the latter portion having a plurality of openings spaced around the circumference thereof for discharge of the balls therefrom, and means adjacent said openings directing the rerolled balls thereto.

16. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums of different diameters arranged with an end of the smaller drum discharging into the interior of the larger drum, means to introduce finely divided material into the other end of said smaller drum, variable speed means connected to each of said drums for independent rotation thereof, a helical means to scrape from the inner wall of said smaller drum material adhering thereto with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, means to scrape the inner wall of said larger drum, the said helical means extending into said larger drum and acting therein to convey the material scraped therefrom into the smaller drum, the said larger drum including a screening portion adjacent the discharge end of the smaller drum and a substantially smooth ball rerolling surface for polishing and compacting balls of material passing over the screening portion, the latter portion having a plurality of openings spaced around the circumference thereof for discharge of the balls therefrom, and means adjacent said openings directing the rerolled balls thereto.

17. An apparatus of the character described for producing ball-like bodies from finely divided material comprising a pair of rotatable drums of different diameters arranged with their axes substantially horizontal with an end of the smaller drum discharging into the interior of the larger drum, means to introduce finely divided material into the other end of said smaller drum, variable speed means to rotate said drums independently of each other, helical means rotatably mounted adjacent the tops of said drums interiorly thereof and adapted to scrape

from the inner wall of said smaller drum material adhering thereto with the said scraped material dropping into the drum and being rolled therein thereby forming balls of the finely divided material, the said helical means extending in spaced relationship with respect to the inner wall of the larger drum, a trough extending below said helical means in a manner such that the helical means extends longitudinally therethrough and acts as a conveyor therein, means to rotate said helical means, and scraper means cooperating with the inner wall of said larger drum above said helical means so that material scraped from the larger drum drops into said trough and is returned therethrough to the smaller drum by said helical means, the said larger drum including a screening portion adjacent the discharge end of the smaller drum and a substantially smooth ball rerolling surface for polishing and compacting balls of material passing over the screening portion, the latter portion having a plurality of openings spaced around the circumference thereof for discharge of the balls therefrom, and means adjacent said openings directing the rerolled balls thereto.

18. An apparatus as defined in claim 17 wherein said helical means comprises a pair of screw-like members

mounted adjacent each other and rotated in opposite directions to thereby effect self cleaning.

19. An apparatus as defined in claim 1 wherein the said rerolling means has a plurality of discharge openings therethrough in a region thereof remote from said screening means.

20. The method of making essentially spherical balls or pellets from moistened fine metalliferous material which consists in delivering said material at one end of a rotating cylindrical drum, then separating the balls or pellets which have been formed in the said drum, from any admixed fine material, rerolling the balls or pellets upon a clear and bare inner surface of a cylindrical rotating drum and discharging the balls or pellets from the second drum.

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