March 19, 1940. H. H. MANDLE 2,194,026

PULVERIZING SYSTEM

Filed Nov. 16, 1936 4 Sheets-Sheet 1

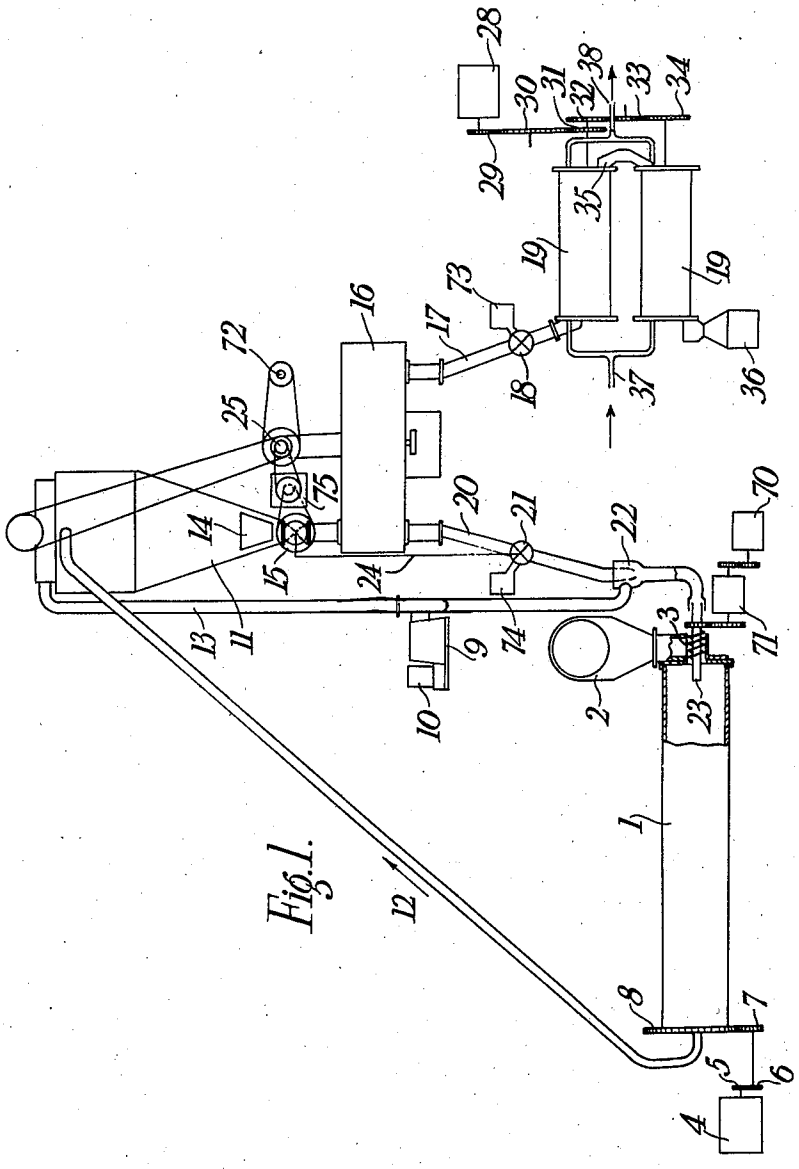


Fig. 1.

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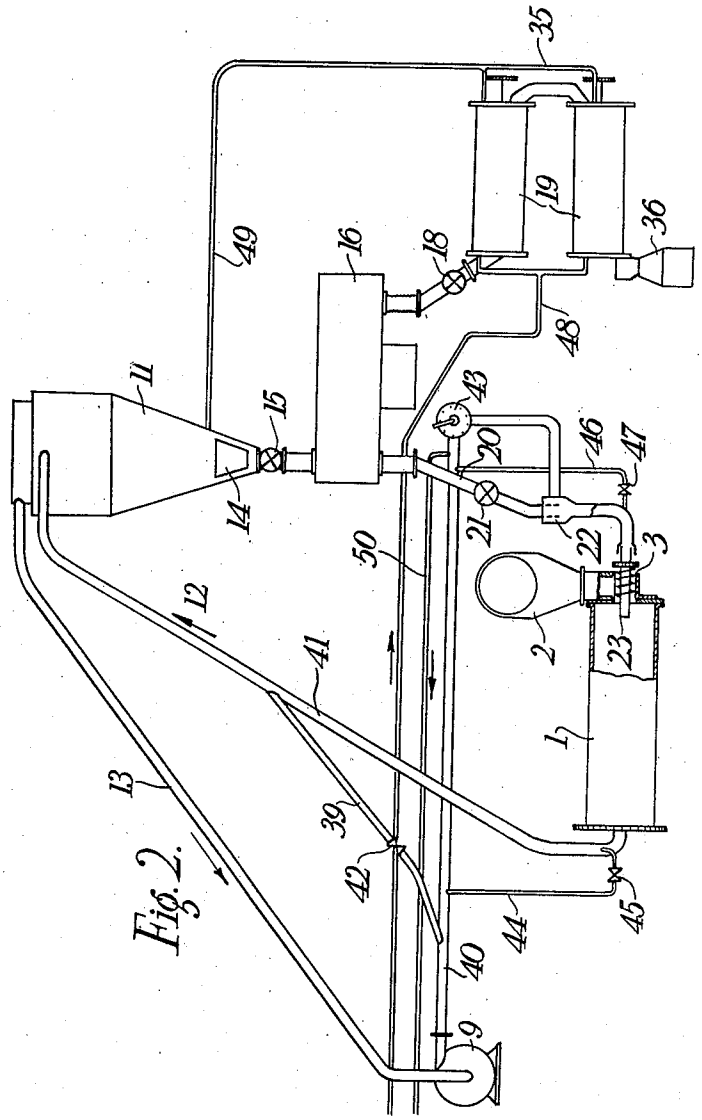


Fig. 2.

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PULVERIZING SYSTEM

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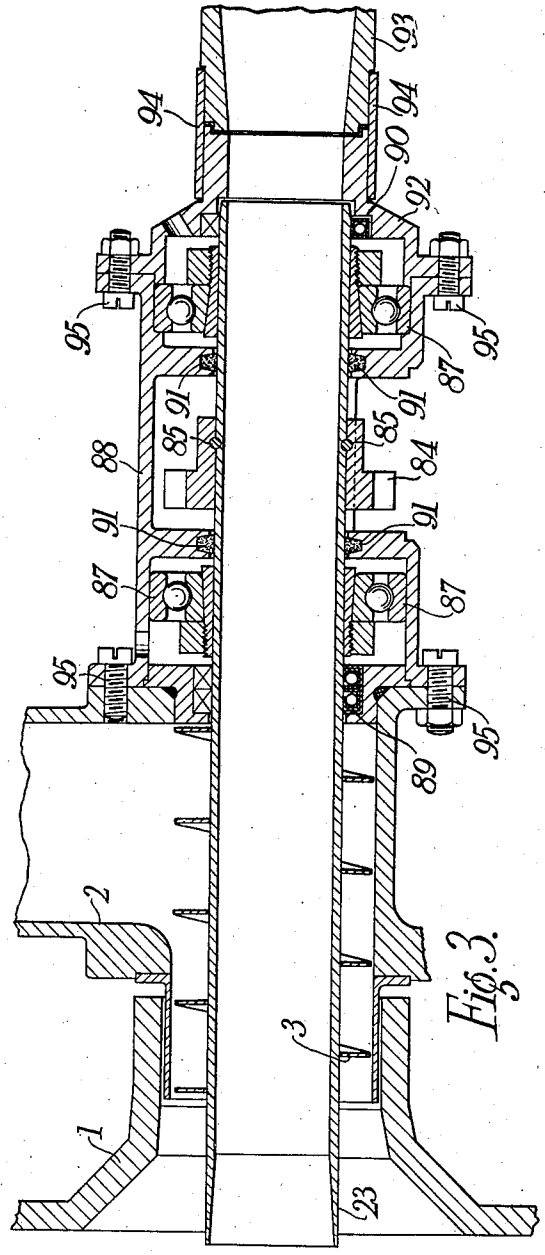


Fig. 3.

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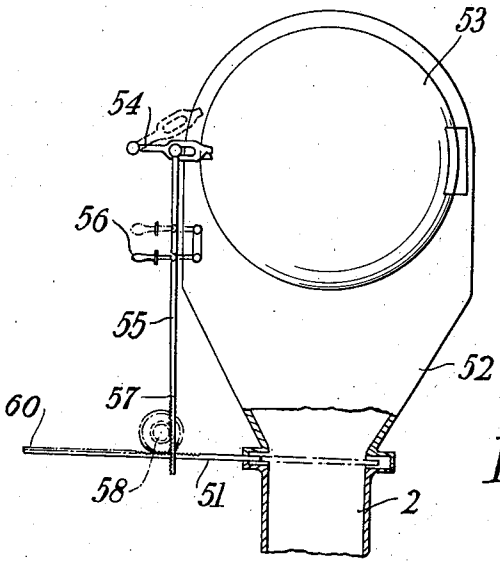


Fig. 4.

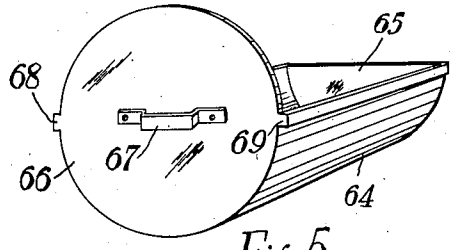


Fig. 5.

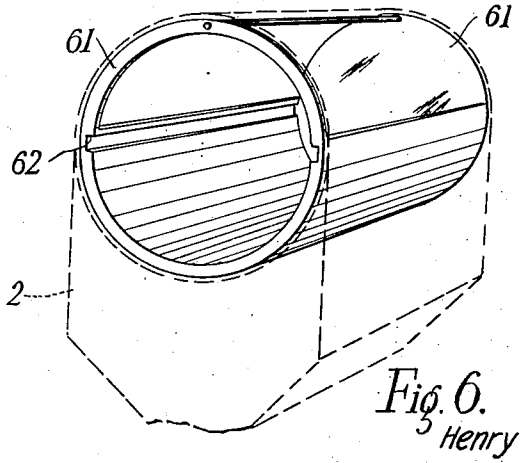


Fig. 6.

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UNITED STATES PATENT OFFICE

2,194,026

PULVERIZING SYSTEM

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Application November 16, 1936, Serial No. 111,021
In Great Britain September 9, 1936

5 Claims. (Cl. 83—93)

In the combination of solid materials, for example in the reduction of metal to powder, it is usually difficult to obtain a high yield without excessive comminution of part of the material. Moreover, for economical working it is necessary to reduce the bulk of the charge of raw material to powder before removing it from the pulverizing mill. If the pulverizing operation is continued until the bulk of the charge has been comminuted, i. e. a high yield of powder is obtained, then it is inevitable that a material proportion of the resultant powder will be reduced to a very fine dust and there will be a continuous range of particle sizes within relatively wide limits. Thus the resultant powder will in no way be uniform and in some cases such as the production of so-called bronze powders the fine dust can only be regarded as waste. On the other hand, if the pulverizing operation is interrupted before there is any excessive comminution, i. e. comminution beyond the desired lower limit, then the yield is small. If then further raw material is introduced to maintain a constant quantity of material under treatment, there is a danger during the next pulverizing operation of excessive comminution of the material which has already been partially pulverized, whereas, if after the comminuted material of the desired size has been withdrawn, the pulverizing operation is continued with the remaining material, the quantity of material being subjected to comminution progressively decreases and the pulverizing mill is not utilized up to capacity. Whatever mode of operation is employed, provision must be made for the very complete separation of the product of the desired fineness from the coarser material.

The present invention has for its object to provide methods and apparatus enabling a far-reaching control of the pulverizing operation, and whereby solid material can be comminuted without the production of excessively fine particles and with the continuous utilization of the full capacity of the pulverizing mill. A further object is to provide a method and apparatus for the complete separation of the desired comminuted material from the coarser material.

With these objects in view, the present invention makes use of the following considerations which have been confirmed by experiment.

The treated material can be withdrawn from the action of the mill before excessive reduction of any appreciable proportion by following the well known method employed in ball mills in the production of metal powders, more particularly the so-called "bronze powders," namely by passing a gas stream through the mill at an appropriate speed. Substantially complete separation of the product of the desired degree of fineness from the coarser material can be attained satisfactorily by mechanically sifting the material withdrawn from the mill, while for the coarser product to be further comminuted but to a lesser extent than fresh material it is necessary to use a separate mill for the further reduction of the partially reduced material unless provision is made for causing the partially reduced material to be exposed to a part only of the action of the mill to the full action of which the fresh material is subjected.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings which show apparatus suitable more particularly for the production of lamellar metal powders (bronze powders).

Fig. 1 is a diagrammatic view showing a complete installation in accordance with the invention.

Fig. 2 is a diagrammatic representation of an alternative form of installation in accordance with the invention.

Fig. 3 shows on an enlarged scale the construction of the arrangement for the simultaneous and separate introduction of coarse and partially pulverized material into the pulverizing mill.

Fig. 4 is a detail view of the feed hopper for coarse material.

Figs. 5 and 6 are further details showing a preferred arrangement for introducing coarse material into the feed hopper.

In Fig. 1 the material to be pulverized is introduced into the ball mill or other rotary pulverizing mill 1 by way of the hopper 2 and the worm conveyor 3. The ball mill 1 is driven by the motor 4 by way of the gear train 5, 6, 7, 8, while the worm conveyor 3 is driven independently by the motor 10 by way of the variable speed transmission 11. A fan or blower 9 driven by a motor 10 causes a current of air to circulate through the ball mill 1 and a filter 11, cyclone or like device for separating solid particles from a gas stream. The direction of circulation of the air stream is indicated by the arrow 12.

The material pulverized in the ball mill 1 is carried by the air current to the filter 11 where it is entirely separated from the air stream which latter is directed back to the drum 1 through the conduit 13.

The solid material separated from the air stream in the filter 11 drops to the lower part of the filter housing which is provided with a

sight glass 14 so that the quantity of pulverized material present within the housing can be determined by inspection. Beneath the sight glass the housing is connected by way of a rotary valve 15 to a sifter 16 which by a mechanical screening operation separates the material which has attained the desired degree of comminution from the material which is not sufficiently comminuted. The material which is sufficiently fine is discharged from the pulverizing system by way of a conduit 17 which passes by way of a rotary valve 18 to polishing drums 19. The material which is too coarse passes from the sifter 16 by way of conduit 20 to a rotary valve 21 whereby the material can be re-admitted in regulated quantity into the pulverizing system. The material admitted by the rotary valve 21 is introduced into the air stream by means of the mixing tube 22 and enters the ball mill 1 together with the gas current through the hollow shaft 23 of the worm conveyor 3. The rotary valves 15, 18 and 21 are of the type provided with a number of peripheral pockets so that in the rotation of the valves the material introduced into the pockets on one side is discharged on the other side without any direct connection being produced between the two sides.

As the partially pulverized material is re-introduced into the ball mill 1 with the gas current through the hollow shaft 23 the gas current carries it beyond the range of action of the balls nearest the hollow shaft 23. The greater the strength of the gas current through the shaft 23, the farther the partially pulverized material is injected into the ball mill 1 and the less it is subjected to the pulverizing action of the ball mill. In addition there will be a tendency for the lighter components of the partially pulverized material returned to the ball mill to be carried farther into the mill than the heavier components and thus subjected to a lesser pulverizing action, as is desirable. This effect can be augmented by making use of the known ball mill of tapering cross section furnished with balls of different weights. The maximum cross section and heaviest balls are at the inlet end, where in consequence the maximum pulverizing action is exerted.

To maintain a constant quantity of material under treatment in the pulverizing system so as to ensure a high degree of uniformity in the product, the worm conveyor 3, which is driven by the independent motor 70 and the variable transmission 71, is driven at such speed as to introduce into the ball mill 1, the same quantity of material as is discharged from the pulverizing system to the polishing drums 19 by way of the rotary valve 18. At the same time the rotary valves 15 and 21 must be actuated at such speed that material is discharged from them at the same rate as it is supplied to them. The sight glass 14 provided on the filter 11 enables the level of the material to be observed so that by appropriate control of the valve 15 the level can be kept constant and as for given working conditions the proportion of sufficiently finely divided material will be constant, the valve 21 can be geared with the valve 15 so as to rotate at the appropriate speed. A transmission mechanism between the two valves 15 and 21 is indicated at 24. Alternatively, the valve 21 could be controlled independently with the aid of a sight glass in the same way as the valve 15.

The mechanical sifter 16 and the rotary valve 15 can conveniently be driven from a common shaft 25, the drive to the rotary valve 15 preferably including a variable transmission 75 so that the valve can be controlled without interfering with or modifying the operation of the mechanical screen 16. Where the device for separating the solid material from the air stream involves moving parts, these may be driven from the same shaft 25 as indicated in Figure 1. If a number of systems as illustrated in Figure 1 are arranged side by side, a common drive shaft 72 may be provided from which the individual shafts 25 are driven.

The polishing drums 19 shown are of the customary type consisting of stationary cylinders within which brushes are rotated by means of a motor 28 and a gear train 29, 30, 31, 32, 33, 34. The powder passes from the upper to the lower polishing drum by a pipe 35 and the polished powder is discharged from the lower polishing drum into the collecting receptacle 36.

It is frequently necessary to provide an inert gas atmosphere in the polishing drums and provision is therefore made for passing gas through them by means of the pipe system 37, 38. These pipes do not form part of the main circulatory system as the pressure and rate of flow of the gas in the polishing drum is small in comparison with the pressure and rate of flow in the pulverizing system. In order to obtain satisfactory polishing it is frequently desirable to introduce a lubricant into the polishing drums 19 with the powder to be polished. For this purpose a lubricant dispensing device indicated at 73 in Fig. 1 is preferably associated with the rotary valve 18, so that each time a given quantity of powder is introduced by the valve 18, a corresponding quantity of lubricant is simultaneously introduced from the dispensing device 73.

When it is necessary to supply lubricant to the pulverizing mill 1, the lubricating material may be introduced with the coarse material by way of the hopper 2. In many cases, however, it is unnecessary to lubricate the coarse material and in most cases it is advantageous to introduce the lubricant into the pulverizing system together with the partially pulverized material which is re-introduced for further treatment. To enable this to be done a lubricant dosing device 74 is associated with the rotary valve 21 so that each time the valve admits a predetermined quantity of partially pulverized material a corresponding quantity of lubricant is admitted simultaneously.

The association of the dispensing devices 73, 74 with the rotary valves 18, 21 not only enables an accurate dosing of the lubricant to be effected, but in addition ensures the uniform distribution of lubricant among the material to which it is added.

Fig. 2 shows an arrangement which in its essential components is the same as that shown in Figure 1 and corresponding reference numerals are employed to indicate corresponding parts. Certain elements of Figure 1 which may be employed in conjunction with Figure 2 are not shown, more particularly the mechanism for driving the rotary valve 15, the transmission between the rotary valves 15 and 21 and the lubricant dosing devices associated with the valves 21 and 18. The arrangement according to Figure 2 differs primarily from that of Figure 1 in that the gas circuit for the pulverizing system and the gas circuit for the polishing drums are interconnected so that the constitution of the gas can be controlled from a common point. In addition a conduit 39 is provided leading from the

pressure conduit 40 of the blower to the conduit 41 leading from the drum 1 to the filter 11 so that if necessary the entire gas current from the blower 9 can be directed solely through the filter and not through the drum 1 by closing the valves 42 and 43. In the normal course the current of gas passing through the drum 1 is regulated by means of the valve 43. In addition a conduit 44 is provided between the pressure conduit 40 and the lower end of the conduit 41 to enable a powerful jet of gas to be injected into the conduit 41 in the upward direction to assist the conveyance of pulverized material to the filter 11. A valve 45 serves to control the passage of gas through the conduit 44. A further conduit 46 exists between the pressure conduit 40 and the lower part of the mixing tube 22. This conduit 46 is provided with a valve 47 and can serve two purposes. It may be utilized to clear any obstruction of material in the hollow tube 23 forming the shaft of the worm 3 and in addition it may be employed for controlling the composition of the atmosphere within the pulverizing mill 1. By associating the valve 47 with a mixing tube device of the same character as the mixing tube 22 a volatile liquid such as furfural, furfuryl alcohol or varnolene, can be introduced into the pulverizing apparatus to reduce the oxidizing tendency of or the proportion of oxygen in the gas atmosphere in the apparatus. The volatile liquid is preferably introduced in such proportions that under the conditions obtaining in the mill it is completely volatilized. For certain purposes more particularly when the apparatus is employed for the production of metal powder such as bronze powders, it is necessary to reduce the oxidizing tendency of the atmosphere.

In the arrangement shown in Figure 2 the supply of gas to the polishing drums is effected by way of the conduit 48 and after passing through the polishing drums the gas enters the main circulating stream of the pulverizing system by passing through the conduit 49 to the lower part of the filter 11. A further conduit 50 leads from the pressure conduit 40 to the point at which the constitution of the gas for the polishing drums is controlled and completes the conduit system for the circulation of gas through the polishing drums. In this way the control of the gas atmosphere is more precise in the polishing drums than in the pulverizing system where an equally high degree of precision is in general not necessary. In addition the pressure at which the gas is supplied to the polishing drums and the rate of flow of the gas through the polishing drums can be much lower than the corresponding valves in the main pulverizing system. In particular it is necessary that there should be a slower rate of flow in order that the fully pulverized material which is being polished should not be swept out of the drums by the gas current which is provided essentially for the purpose of ensuring the correct constitution of the atmosphere within the polishing drums.

The preferred construction of the worm conveyor 3 and of the associated hollow shaft 23 which forms the subject matter of my co-pending application of even date is shown on a larger scale in Figure 3 where the hopper 2 and the pulverizing mill 1 are indicated in fragmentary manner.

The shaft 23 is rotated by means of the gear wheel 84 keyed to the shaft by the pins 85. The mechanism for imparting the drive to the gear wheel 84 is not shown in Figure 3. The rate at which the material is fed from the hopper 2 to the interior of the drum 1 is determined by the rate at which the worm 3 is caused to rotate by means of the gear wheel 84. The right hand end (Figure 3) of the shaft 23 is mounted in spaced bearings 87 accommodated in the fixed housing 88. Packing rings 89 are provided between the fixed housing and the shaft adjacent the hopper 2 and a similar packing ring 90 is provided at the extreme right hand end of the shaft 23. On either side of the gear wheel 84, felt washers 91 or the like are provided between the housing 88 and the shaft 23 to prevent the lubricant supplied to the bearings 87 from escaping. At the outer end of the shaft 23 the housing 88 has an extension 92, to which the supply conduit 93 is attached by means of a clamping band 94. The extension 92 is secured to the fixed housing 88 and the latter is secured to the hopper 2 by means of bolts 95. The conduit 93 serves for the re-introduction of the partially comminuted material into the drum 1.

Particularly when the gas circulating in the pulverizing system is not atmospheric air, it is advisable to prevent any escape of gas from the system when the hopper 2 is being recharged. For this purpose a slide valve 51 (Figure 4) is provided at the lower end of the hopper and is adapted to be positioned across the conduit leading from the bottom of the hopper so as to isolate the hopper 2 from the main pulverizing system. The hopper itself is constructed in the form of a housing 52 provided with a filling aperture closed by a door 53. To ensure that the door 53 is not opened before the hopper 2 has been isolated from the main pulverizing system by closing the slide valve 51, the catch 54 serving to hold the door 53 in the closed position is preferably linked with the valve plate 51 so that the door cannot be opened unless the valve plate 51 is in the closed position which is indicated in broken lines in Figure 4. For this purpose, in the construction shown in Figure 4 the catch 54 is provided with a downwardly extending rod 55 carrying the operating handle 56. The lower part of this rod 55 is constructed as a rack bar 57 which engages with a pinion 58. Rigidly connected with the pinion 58 is a further pinion 59 which engages in a rack 60 formed on or associated with the valve plate 51. Thus when the catch is raised into the dotted line position to enable the door 53 to be opened the plate 51 is automatically interposed to isolate the hopper from the main pulverizing system. Similarly when the catch 54 is lowered to retain the door 53 in the closed position the plate 51 is automatically withdrawn so that the contents of the hopper can pass to the pulverizing mill 1 by way of the worm conveyor 3.

To facilitate the introduction of the charge of untreated material into the hopper 2 use is preferably made of the arrangement illustrated in Figs. 5 and 6. Rotatably arranged within the hopper in alignment with the opening closed by the door 53 is a cylindrical cage 61 which may be closed over half its periphery as shown in Fig. 6. Provided in the cylindrical cage are two grooves 62 and 63 which are disposed diametrically opposite one another and extend parallel to the axis of the cylinder. A semicylindrical tray 64 provided at one end with a corresponding semicircular end plate 65 and at the other end with a circular end plate 66 on which a handle 67 may be provided, is filled with the material which is to be introduced into the hop-

per. The tray 64 has lateral rails 68 and 69 which are adapted to engage in the grooves 62 and 63 in the cylindrical cage 61. The filled tray can thus be inserted into the rotary cage 61 and thereafter the cage and tray rotated in common within the housing 2 so as to empty the contents of the tray 64 into the hopper. If desired provision may be made for rotating the cage and tray after the door of the hopper has been closed. In this way any desired quantity of raw material can be introduced into the hopper in a simple and convenient manner.

I claim:

1. An apparatus adapted for powdering metal comprising, in combination, a ball mill having inlet and outlet ports at opposite ends thereof, a screw conveyor for delivering primary raw material to be powdered to the inlet port, a closed conduit system including a separator connecting the outlet and inlet ports of said mill, the inlet end of said conduit system terminating in spaced relationship inwardly of the inner end of said screw conveyor of the raw material, means for causing a flow of gas through said conduit system and mill, said conduit system including means for pneumatically returning the inadequately powdered portion to the inlet end of the mill and for pneumatically projecting the material into the mill by a gas blast of sufficient intensity to deposit the material along the mill according to its size.

2. An apparatus adapted for powdering material, more particularly metal, comprising, in combination, a ball mill having inlet and outlet ports at opposite ends thereof, mechanical feeding means for delivering primary raw material to be powdered, to and through the inlet port, a closed conduit system including a separator connecting the outlet and inlet ports of said mill, the inlet end of said conduit system terminating in spaced relationship inwardly of the inner end of said feed means of the raw material, the separator serving to separate the inadequately powdered portion from the remainder, said conduit system including means for pneumatically returning the inadequately powdered portion to the inlet port and for pneumatically projecting the material into the mill by a gas blast of sufficient intensity to deposit the material along the mill according to its size.

3. An apparatus adapted for powdering metal comprising in combination, a ball mill having inlet and outlet ports at opposite ends thereof, mechanical feed means for delivering primary raw material to be powdered to and through the inlet port, a closed conduit system connecting the outlet and inlet ports of said mill, the inlet end of said conduit system terminating in spaced relationship inwardly of the inner end of said feed means of the raw material, means for causing a flow of gas through said conduit system and mill, a separator, means for discharging the powdered material from the conduit system into the separator so arranged that the gas stream is prevented from passing through the separator, said conduit system including means for pneumatically returning the inadequately powdered portion from the separator to the inlet port of the mill and for pneumatically projecting the material into the mill by a gas blast of sufficient intensity to deposit the material along the mill according to its size, and means for independently regulating the rate of delivery of primary raw and inadequately powdered material to the mill.

4. An apparatus adapted for powdering metal comprising, in combination, a ball mill having inlet and outlet ports at opposite ends thereof, mechanical feed means for delivering primary raw material to be powdered to and through the inlet port, a closed conduit system including a separator connecting the outlet and inlet ports of said mill, the inlet end of said conduit system terminating in spaced relationship inwardly of the inner end of said feed means of the raw material, means for causing a flow of gas through said conduit system and mill, said conduit system including means for pneumatically returning the inadequately powdered portion to the inlet end of the mill and for pneumatically projecting the material into the mill by a gas blast of sufficient intensity to deposit the material along the mill according to its size, and means for independently regulating the rate of delivery of primary raw and inadequately powdered material to the mill.

5. An apparatus adapted for powdering material, more particularly metal, comprising, in combination, a ball mill having inlet and outlet ports at opposite ends thereof, mechanical feeding means for delivering primary raw material to be powdered to and through the inlet end, a closed conduit system including a separator connecting the outlet and inlet ports of said mill, the inlet end of said conduit system terminating in spaced relationship inwardly of the inner end of said feed means of the raw material, the separator serving to separate the inadequately powdered portion from the remainder, said conduit system including means for pneumatically returning the inadequately powdered portion to the inlet port and for pneumatically projecting the material into the mill by a gas blast of sufficient intensity to deposit the material along the mill according to its size, means for indicating at the outlet end the total rate of delivery of material from the mill, and means for independently regulating the rate of delivery of primary raw and inadequately powdered material to the mill.

HENRY HAYMAN MANDLE.