May 6, 1941. S. K. WELLMAN 2,240,971

METHOD AND APPARATUS FOR SPREADING POWDERED MATERIAL

Filed March 1, 1939 3 Sheets-Sheet 1

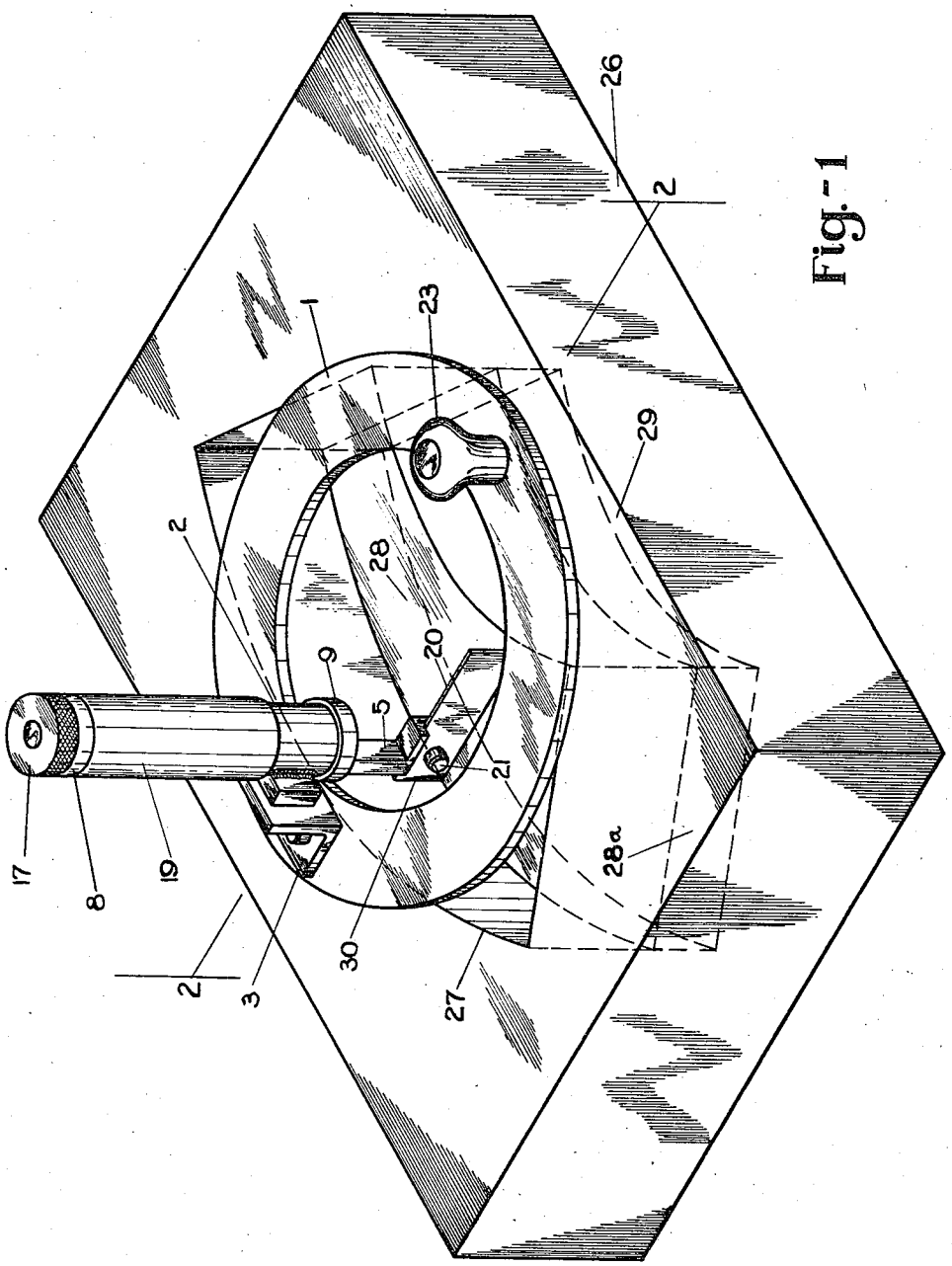


Fig. 1

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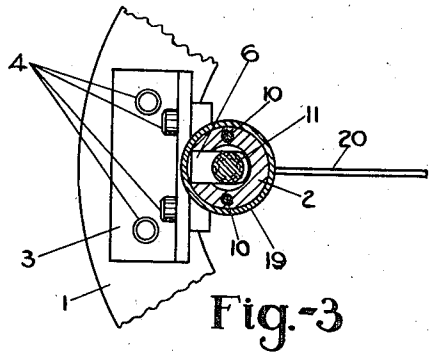


Fig.-3

Fig.-2

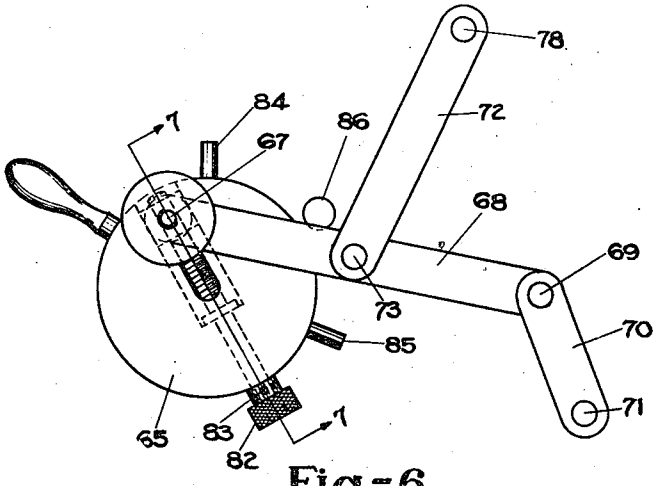


Fig.-6

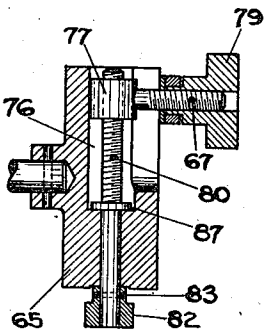


Fig.-7

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METHOD AND APPARATUS FOR SPREADING POWDERED MATERIAL

Filed March 1, 1939 3 Sheets-Sheet 3

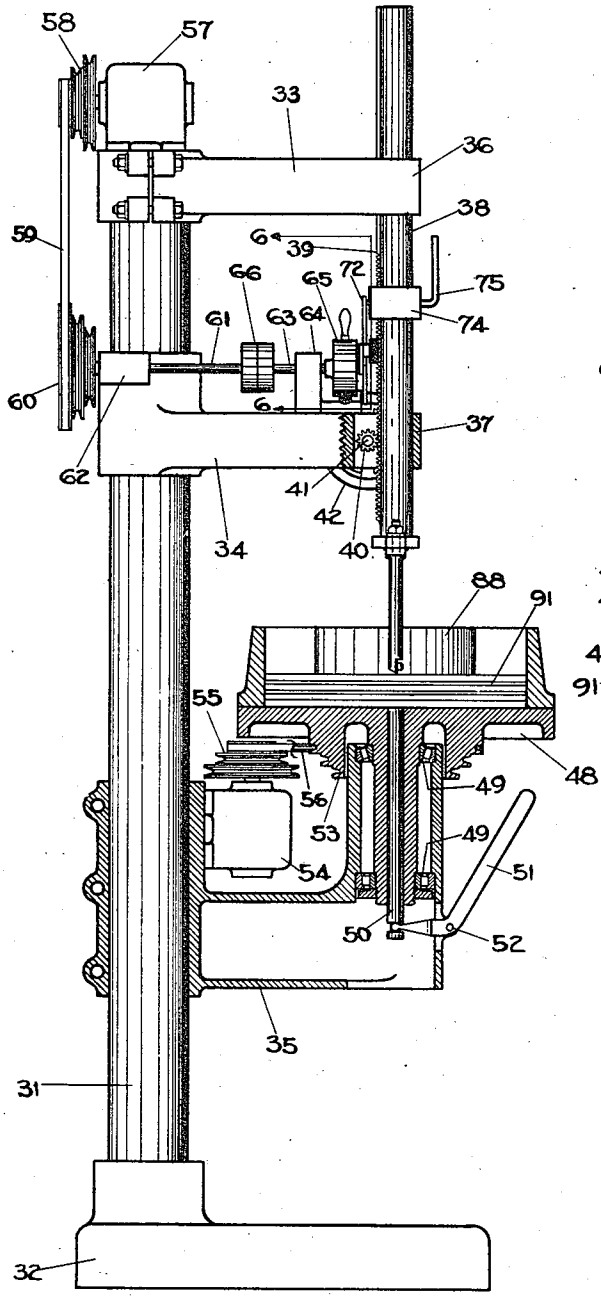


Fig.-4

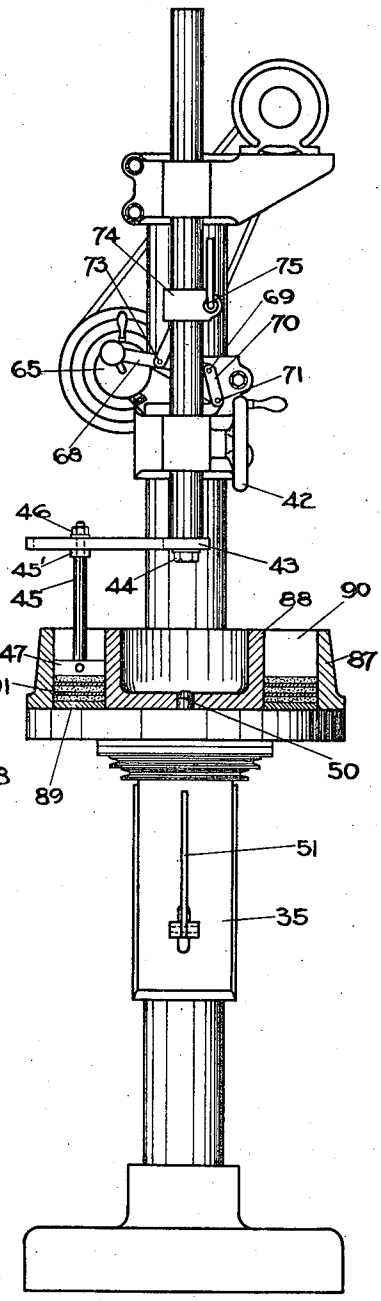


Fig.-5

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UNITED STATES PATENT OFFICE

2,240,971

METHOD AND APPARATUS FOR SPREADING POWDERED MATERIAL

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Application March 1, 1939, Serial No. 259,237

9 Claims. (Cl. 75—22)

This invention relates to a process and apparatus for spreading powdered material in a mold, and relates more particularly to a process and apparatus adapted to spread metal powder into layers in such a manner that coherent articles may be formed from them, either by compacting the layers under heavy pressure followed by sintering, or by sintering without the application of pressure, or by compacting and sintering in the same operation.

The invention relates especially to the class of processes in which the powder layers are compacted under heavy pressure with or without subsequent sintering, since it is in this type of process that the defects which my invention overcomes are most objectionable. When subsequent sintering is involved, this class of process ordinarily includes the steps of introducing a quantity of loose powder into a compression die, spreading it therein into a layer of uniform thickness, compacting it into a briquette by the application of heavy pressure, removing the briquette from the mold and introducing it into a furnace where it is sintered by heat-treatment at an elevated temperature. While operating this process in the past, it has been observed that the briquettes produced by the compacting steps have often contained such defects as cracks, wrinkles, bulges, thin spots, undue segregation of the heavy constituents, etc., which have made them unsuitable for further processing into sintered articles and which in some cases have weakened them so much that they could not be recovered from the mold. On some occasions these defective briquettes have constituted so large a proportion of the production that they have materially impaired the successful operation of the process.

Now in seeking a remedy for this condition, I have discovered that variations resulting from non-uniform distribution of the powder in the uncompacted layer are largely responsible for the defects. As a result of this discovery, I have found that when care is taken to distribute the powder uniformly upon a compression surface, the defects may be avoided entirely. It will, therefore, be understood that the primary object of this invention is to provide a method and apparatus adapted to distribute the metal powder in such a way that harmful variations in the distribution are eliminated.

In seeking to accomplish this object, I have found that it is essential merely to have the same weight of powder within each unit of area which is to be compacted. It should be understood that the weight referred to here is the weight of a column of powder of unit cross section extending from one compression surface of the layer to the other. When the weight of the powder in such columns is the same in all parts of the layer, irrespective of the thickness of the layer, the layer may be compacted without the occurrence of any of the defects mentioned above. For convenience, it is desired that the above condition be expressed hereafter by the term "uniform column density."

It will be recognized that when a powder layer has both a uniform column density and a uniform thickness, then the average density of the powder in any column is the same in all parts of the layer. On the contrary, when the thickness varies, a uniform column density will occur only when the average density of each column varies inversely as the height (thickness) of that column; that is, it is then necessary that the product obtained by multiplying the average density of any column by the height of that column be constant in order to produce a uniform column density in the layer.

It will be understood that when a powder layer has a uniform column density it need not necessarily have a uniform actual density as measured by the weight of powder in each unit of volume therein. The actual density of the powder in one part of the column may be different from that in some other part of the same column as a result of the stratification of the powder, so that the actual density prior to compacting may vary from top to bottom; but even then if the column density is uniform in all parts of the layer, the layer may be compressed into a sound coherent body of uniform thickness and density. For the same reason it is not necessary that the actual density of the powder be the same in the corresponding location of all columns, although it may often be advantageous to have this type of distribution in the layers. This latter condition might be described by the term "uniform horizontal density", since the actual density of the powder would then be uniform on any plane extending through the layer parallel to the horizontal compression surface.

I have found that it is possible to use a variety of methods in producing layers having uniform column density and uniform thickness, but I prefer to use a process in which a quantity of powder is kept thoroughly mixed by stirring and turbulence while at the same time that it or a portion thereof is spread into a relatively thin layer. My preferred process may be performed

by hand, but I have found that more consistent results may be obtained by using apparatus designed to distribute the powder in accordance with the above principle. Two forms of suitable apparatus are shown in the accompanying drawings and reference is now made to them since explanation of their operation at this point will aid in explaining the whole invention more fully.

In the drawings

Figure 1 is an isometric view showing a hand device mounted for operation in a suitable mold cavity.

Figure 2 is a sectional view taken on the vertical plane passing through line 2, 2 of Figure 1.

Figure 3 is a horizontal sectional view taken on line 3, 3 of Figure 2.

Figure 4 is a side elevation, partly in section, of a power operated device for spreading powder in a circular or annular cavity.

Figure 5 is a front elevation partly in section of the same device as shown in Figure 4.

Figure 6 is a side elevation showing the crank and linkage arrangement used in raising the spreader blades, the parts being viewed as indicated by line 6, 6 of Fig. 4.

Figure 7 is a sectional view taken along the line 7, 7 of Figure 6.

Referring now to Figures 1 thru 3 illustrating a type of hand apparatus which is suitable for spreading powder in a mold cavity of either regular or irregular shape, but which is especially useful in the latter, the device will be seen to consist of a base or guiding support 1 to which a barrel 2 is attached, as through angle bracket 3 and screws 4. The barrel is shaped internally, as shown in Fig. 3, to receive a stem 5 having a cranked portion 6, which is provided with a threaded hole 7. The barrel is closed top and bottom with caps 8 and 9 respectively secured thereto as by means of screws 10. The caps are drilled so as to provide bearing supports for screw 11 as shown at 12 and 13.

Shoulders 14 and 15 are provided on the screw 11 to bear against caps 8 and 9 respectively to provide thrust bearings for the screw. A shank 16 is provided on the screw to extend beyond cap 8, and a hand wheel 17 is secured thereto, as by means of a set screw 18. A sleeve 19 is positioned around barrel 2 so as to rotate freely thereon. Cap 8 retains it in place. At the lower end of stem 5 is secured a spreader blade 20 which may be removed readily by removing screw 21. Diametrically opposite the barrel assembly just described, on the support 10, is positioned a knob composed of a core member 22, about which revolves roller 23. A washer 24 rests on core 22 to retain roller 23 in position, the whole assembly being secured to support 2 by means of screw 25.

The operation of this device may be understood more fully by reference to Fig. 1 which shows it positioned on a mold 26 having a compression cavity 27 recessed therein to extend between the opposite faces of the mold. The base 28 of the compression cavity is parallel to the upper face 29 of the mold and preferably is separable from the body of the mold. For example, a plate 28a may be inserted in the cavity to form the compression surface 28. The spreading device described above is positioned on the mold with support 1 resting upon surface 29. By rotating hand wheel 17 blade 20 can be forced downwardly so as to contact the surface of base 28, or so as to be spaced vertically therefrom any desired amount.

In use, a charge of the powder is placed into the mold cavity. The spreading device is then laid upon the upper surface 29 with stem 5 and blade 20 within the mold cavity. Handwheel 17 is rotated so as to force the blade against the base surface 28. With the blade in this position, the spreader is grasped by sleeve 19 and knob 23 and traversed upon surface 29 in such manner that the edge 30 of blade 20 contacts the wall of the cavity at all times. After a complete circuit about the cavity, and if the blade 20 is proportioned in length so as to be more than half the width of the cavity, the whole charge will have been thoroughly stirred. Of course, if the blade is less than one-half the width of the cavity, additional circuits must be made to stir the whole charge. Handwheel 17 is then rotated so as to raise blade 20 slightly above base surface 28, and another complete circuit is made. This procedure is repeated, the blade being raised slightly after each circuit, until the powder has been distributed into a layer of uniform thickness upon the base surface 28 of the compression cavity. The spreader may then be removed, and the mold with its charge of powder positioned in a press for compressing the powder.

The purpose of this procedure is to equalize the density of the powder introduced upon the compression surface, and then to maintain a portion of the powder in a state of moderate turbulence while it is being spread in the thin layer. When the powder is first introduced upon the compression surface, some portions, in falling thereon, become compacted more than others. If the pile of powder is merely smoothed off from the top downwardly until a layer of uniform thickness has been formed, parts of these more dense portions in the base of the original pile will not have been disturbed and consequently will retain their greater density. When such a layer is compressed under heavy pressure, the briquet will exhibit the defects described above. It will be seen however, that when the spreading device is operated in the manner described above, all of the powder resting upon the compression surface is stirred so that its density is equalized. The powder is then spread into the desired layer. As the blade 20 is moved thru the powder, a quantity of the powder accumulates in front of it in the form of a small pile which is churned over and over as the blade moves along. This churning action should not be so violent as to produce dust, but should be maintained in such state as to cause moderate turbulence of the material. This turbulence maintains the equalized density and prevents non-uniformity of density in the formed layer.

The principles of operation illustrated by the hand device may be utilized in a machine which is particularly adapted to spread powder in a circular or annular cavity. Figures 4 through 6 illustrate such a machine and reference is now made to them. The machine consists of a column 31 set in a base 32 and carrying brackets 33, 34 and 35 at spaced intervals along its length. Brackets 33 and 34 terminate in guides 36 and 37 respectively through which stem 38 is adapted to slide. A rack 39 is secured to stem 38 and is used not only in raising and lowering the stem but also is used as a positioning key to prevent rotation of the stem. The rack meshes with a pinion 40 which is secured to shaft 41 passing transversely through bracket 34. A hand wheel 42 is secured to the outer end of shaft 41. An arm 43 is secured to the lower end of stem 38 by means

of a screw 44. The outer end of this arm is slotted so as to receive a threaded rod 45 having a shoulder 45', which may be clamped against arm 43 by means of nut 46. Rod 45 carries at its lower end a spreader blade 47 replaceably secured thereto. Lower bracket 35 carries a turntable 48 which is rotatably mounted therein as in bearings 49. A centering pin 50 passes axially through the turntable and protrudes slightly above its upper surface. The pin is slideably mounted in the turntable and can be raised or lowered by means of hand lever 51 pivoted with respect to bracket 35 at pivot 52. A stepped pulley 53 is provided on turntable 48. An electric motor 54 is secured to bracket 35 in any suitable manner and is provided with a stepped pulley 55 which is connected by means of belt 56 with the pulley 53 on turntable 48. The belt may be changed to extend between different sized pulleys so as to permit limited variation in the speed of rotation of the turntable. A variable speed motor may be used.

It will be observed that the position of stem 38 and its attached rod 45 may be controlled primarily by the hand wheel 42, but since a slow and controlled rate of rise is to be preferred, a powered raising mechanism is provided. This raising mechanism may of course take many forms, utilizing mechanical, electrical, magnetic, pneumatic, or hydraulic control units, producing uniform or non-uniform rates of rise of blade 47. A constant and uniform rate of rise is sometimes desirable, although for most purposes I have found that a non-uniform rate of rise is preferable. A crank and linkage mechanism is shown here to represent just one form of mechanism which may be used to produce this type of movement. This mechanism consists of a motor 57 which drives a stepped pulley 58. A belt 59 drives stepped pulley 60 which is secured to shaft 61 extending through bearing 62 secured to bracket 34. A second shaft 63 in axial alignment with shaft 61 passes through bearing 64 and has an adjustable crank disc 65 secured to one end thereof. The two shafts 61 and 63 are connected through a friction clutch 66. Now as will be seen better in Figure 6, crank disc 65 is provided with an adjustably positioned crank pin 67. Pivotally positioned on pin 67 is a link 68 which is pivoted at 69 with another link 70 which in turn is pivoted at 71 to any convenient portion of bracket 34. A third link 72 is pivotally connected with link 68 by pivot 73 intermediate the ends of the latter link. The other end of link 72 is pivotally connected at pivot 78 to a clamp 74 which is slidably mounted on stem 38. The clamp consists of a spring collar, the two free ends of which may be drawn toward each other by a screw 75. It will be understood that by tightening the screw the clamp may be removably secured to the stem.

The construction of the adjustable crank disc 65 is shown in Figure 7. A radial recess 76 is provided in the disc 65 and a block 77 carrying a threaded crank pin 67 and nut 79 is slidably positioned in the recess. A screw 80 is rotatably mounted in the block so that upon rotation of the screw the block may be moved radially in the recess toward or away from the center of rotation of disc 65. It will be seen that the length of the crank arm may be varied by rotation of the screw 80. The screw is provided with a shoulder 81 which serves as a thrust bearing in one direction, while a knob 82 secured to the screw by means of pin 83 serves as a thrust bearing in the opposite direction. The knob 82 is also secured to screw 80 to facilitate rotation of the latter. Stops 84 and 85 may be provided at some convenient point in the linkage, as on disc 65, to limit the rotation of crank arm 65 to about 90° of angle, the stops being positioned to limit the rotation by striking against any convenient stop pin such as 86. It will be recognized that the stepped pulleys 58 and 60 permit adjustment of the rate of rotation so that the time required for the crank to move thru its allotted angle of motion may be varied to some extent. As will later be explained, adjustability is thus provided by which the rate of rise of blade 47 may be timed with respect to the rotation of table 48.

Now in preparing the device for operation, a suitable die assembly is positioned on the turntable 48. For purposes of illustration, an assembly is shown which comprises a shell 87 and a core member 88 spaced from each other by a spacer ring 89 to form a die cavity 90. This assembly is centered upon the turntable about centering pin 50. A blade 47 properly dimensioned so as to fit the die cavity closely, is now secured to rod 45. Stem 38 is now lowered by turning handwheel 42 and rod 45 is adjusted in the slot in arm 43 until it will enter the cavity 90 and may be lowered freely into the cavity to contact spacer ring 89. Rod 45 is then firmly clamped upon arm 43 by tightening nut 46. Now upon rotation of hand wheel 42 stem 38 together with blade 47 may be raised out of the cavity or reinserted thereinto to any desired depth. Considering now for purposes of illustration, that a layer of powder $\frac{1}{16}$'' thick is to be spread in the mold assembly, belts 56 and 59 will be placed upon the proper set of pulleys so as to give a suitable number of revolutions of turntable 48 while crank arm 65 is rotating thru the angle determined by stops 84 and 85. For example, the turntable may be caused to rotate at about 50 revolutions per minute, while crank disc 65 is caused to rotate from one stop to the other in about one minute. It should be understood that these values are merely illustrative and are in no sense critical. Both may be varied over rather wide ranges while retaining the principles of my method for spreading the powder. The length of the crank arm will next be adjusted by turning knob 82 so that when crank disc 65 is rotated thru its allotted angle, the blade 47 will be raised slightly more than $\frac{1}{16}$''. Now with clamp 74 in a loosened condition, the device is ready to be operated. Motor 57 may be started and a weighed charge of powder introduced into the cavity 90. Motor 54 may then be started and with turntable 48 rotating, handwheel 42 may be operated so as to bring blade 47 into contact with the upper surface of spacer ring 89. It is held in this position while turntable 48 makes at least one revolution thereby stirring all of the powder which was introduced into the cavity. It will be understood that as the turntable rotates under blade 47 the powder is churned over and over in front of the blade with the result that it soon attains a uniform density. At this point crank disc 65 is turned backward until stop 85 bears against stop pin 86, and while held in this position clamp 74 is tightened upon stem 38. It will be understood that friction clutch 66 permits this to be done without interfering with the rotation of motor 57. Crank disc 65 is now released and motor 57 is permitted to move it at a uniform angular velocity in a clockwise direc-

tion. As will be understood, this motion causes blade 47 to be raised at a slow variable rate of speed away from the surface of spacer 89. As the blade is slowly raised out of the powder a layer of powder accumulates under it between the surface of spacer ring 89 and the lower edge of blade 47, gradually increasing in thickness as the blade moves upwardly. Since the crank has previously been adjusted to raise the blade slightly above the powder layer, by the time stop 84 contacts stop pin 85, the charge of powder will have been fully distributed into a layer of uniform thickness. It should be noted that the linkage of Fig. 6 tends to move the blade upwardly at a decreasing rate of speed although crank 65 moves at a constant rate of speed. This action of the linkage tends to cause the blade to rise more slowly near the end of its stroke than near the beginning with the result that the upper surface of the layer which is formed is revolved under the blade a greater number of times for each unit of rise of the blade and consequently is gradually smoothed off to form a layer of uniform thickness.

After the crank has moved through its allotted angle of motion and stop 84 has been brought to rest against stop pin 86, clamp 74 may be loosened and handwheel 42 rotated so as to raise blade 47 out of the cavity, thus completing the operation for forming one layer of powder. If more than one layer of powder is to be spread in each mold, a metal separator 91 is eased into the cavity on top of the first layer of powder. Another charge may then be introduced on top of this separator and the above process repeated. Of course in lowering the blade into contact with the separator 91 when stirring this next charge, the operator must be careful not to strike the separator abruptly as that would disturb the powder layer underneath it. The process may be continued in the same manner until any desired number of layers have been formed. Blade 47 is then raised out of the cavity, and the mold assembly comprising ring 87, core 88, spacer 89, and the stack of alternating separators and powder layers, is slid off of the turntable and transferred to a suitable press where the powder layers are compacted into coherent rings. The mold may then be separated from them, and the compacted rings passed on to the next fabricating step.

When briquettes are formed in accordance with the process just described, the defects pointed out in the opening paragraphs may be avoided completely, and when the briquettes are subsequently removed from the mold in accordance with the disclosure of my copending application Serial No. 249,899, filed January 9, 1939, losses due to defective briquettes are substantially eliminated, while by the same process briquettes are produced which have consistently uniform mechanical properties.

Various modifications of the structures here illustrated will occur to those skilled in the art. For example various inversions will be obvious. Thus in the power machine, instead of moving the blade up and down, the blade may be held stationary while the turntable is moved up and down. Likewise instead of revolving the mold and turntable under a fixed blade, the blade may be revolved while the table remains stationary. Other modifications will also be apparent.

Having now described my invention, what I claim is:

1. The method of forming a layer which is composed of a mixture of loose, dry, free-flowing, non-plastic powder materials having a tendency to become segregated and stratified while being handled in a loose condition, and which may be compressed into a compact and coherent body free from defects resulting from segregation, stratification and variations in density, said method comprising the steps of disposing a quantity of said powder mixture upon the supporting surface on which it is to be spread into a layer and subsequently compressed; contacting said supporting surface with the bottom of a spreader; relatively laterally advancing the spreader and the powder mixture over the surface in front of the said spreader while maintaining the spreader in contact with the surface to churn the powder mixture while preventing the formation of a layer of powder behind the spreader; thereafter relatively laterally advancing the powder over said surface in front of said spreader while gradually raising the spreader upwardly to space it above the surface, thereby continuing the churning of the mixture and forming a gradually thickening unconsolidated layer of homogeneous powder mixture upon said surface and concurrently gradually decreasing the quantity of powder maintained in a state of turbulence in front of said spreader; and continuing to relatively advance the spreader and the gradually decreasing body of powder over the surface until the powder has all been spread thereupon into a layer of substantially uniform thickness.

2. The method as claimed in claim 1 wherein said spreader is stationary and wherein said supporting surface is a surface of revolution and is rotated about its axis beneath said spreader.

3. The method as claimed in claim 1 wherein said mixed powder is predominantly metallic.

4. The method as claimed in claim 1 wherein said spreader is raised at a non-uniform rate of speed, the rate being slowest at the end of the spreading action.

5. The method as claimed in claim 1 wherein said supporting surface is a bottom wall of a vertically-disposed cylindrical mold cavity, and wherein said mold and supporting surface are rotated about the axis of said cavity.

6. The method as claimed in claim 1 wherein said supporting surface is the bottom wall of a stationary mold cavity, and wherein said spreader is traversed over said surface.

7. The method as claimed in claim 1 wherein said supporting surface is a bottom wall of a vertically-disposed cylindrical mold cavity, and wherein said mold and supporting surface are rotated about the axis of said cavity, said method including the further steps of extracting said spreader from the cavity after said layer has been formed, disposing a plane parallel separator disc within said cavity flatwise on top of said formed layer, and repeating the method of claim 1 to form an additional layer upon said separator.

8. Apparatus for spreading powdered material comprising the combination of a member having a surface upon which the powdered material is to be spread, a horizontal platform adapted to rotate about a vertical axis and further adapted to support said member, means for rotating said platform, a spreader adapted to create a condition of moderate turbulence within a quantity of powdered material when said material is relatively advanced over the surface of said member in front of said spreader, a support for said spreader adapted to retain it in predetermined relationship with respect to the surface of said member, means for relatively moving said spreader downwardly into contact with the sur-

face of said member, and additional means for relatively moving said spreader upwardly at a non-uniform rate of speed.

9. Apparatus as claimed in claim 8 wherein said last mentioned means comprises a crank adapted to revolve through a quadrant with substantially constant angular velocity, and a linkage coupled thereto and to said spreader, said quadrant extending over an angle such that linear motion of said spreader in one direction is produced as the crank revolves therethrough.

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