

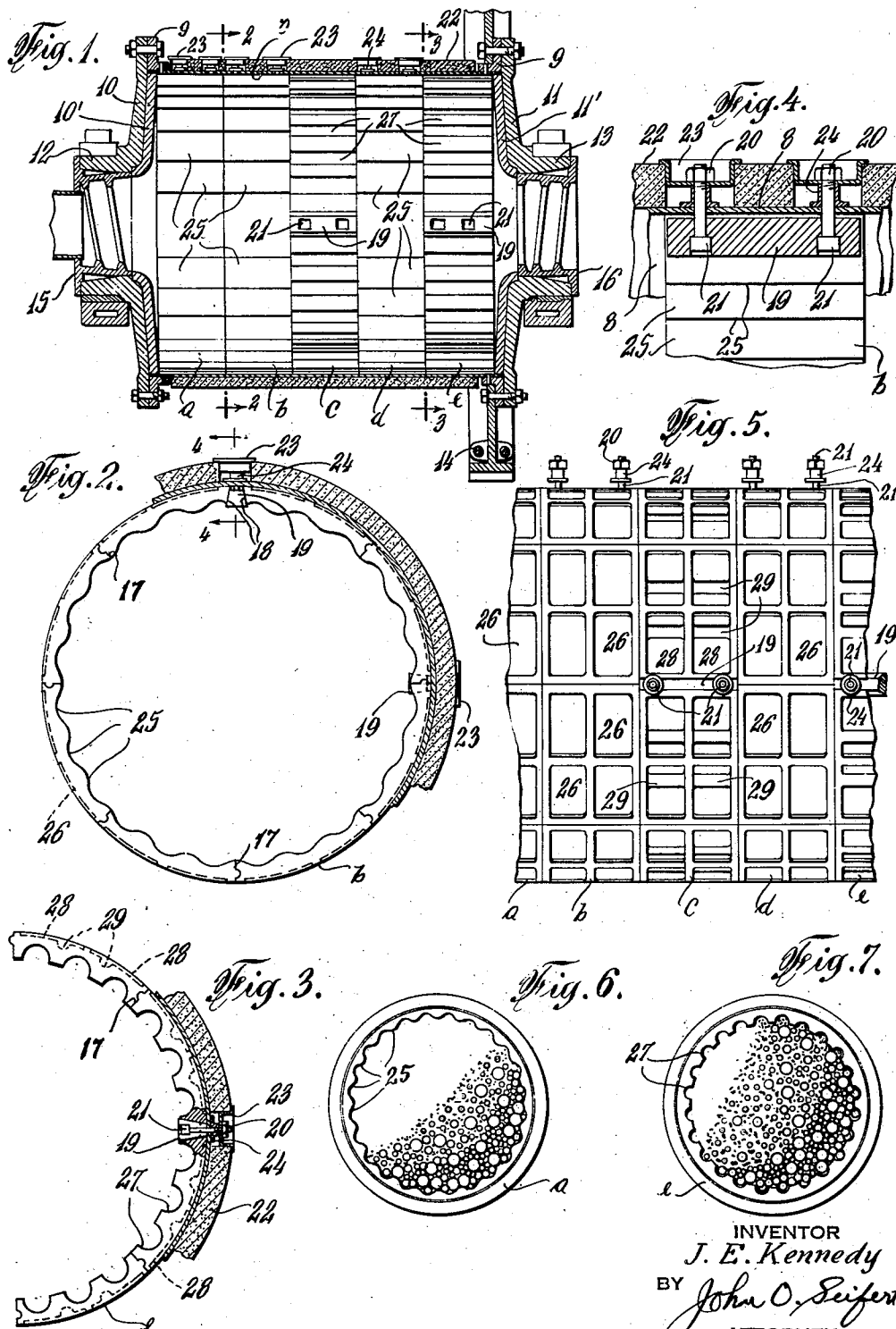
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TUBE MILL

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TUBE MILL

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This invention relates to tube mills for reducing and pulverizing material, and particularly to tube mills wherein the pulverized material is delivered from the mill in suspension in an air stream drawn from the mill, and including a rotatable drum having therein freely moving material reducing elements, such as balls or pebbles, cascaded with the material in the drum by the rotation thereof and reducing the material by impact of the balls thereon. To facilitate cascading the balls and material by the rotation of the drum and thereby effect separation and delivery of the pulverized material by the air drawn from the drum, the inner surface of the drum, or the surface of a liner of wear resisting material for the drum, is arranged of sinuous form disposed circumferentially about and extending longitudinally of the drum for the entire length thereof. The output capacity or tonnage of the tube mill depends upon the diameter and length of the drum and the volume of air required to deliver the pulverized material from the drum.

Tube mills of this character are utilized to pulverize coal in pulverized coal firing systems for furnaces of steam generators and of billet heating furnaces, the pulverized coal being delivered from the mill directly to the furnace in suspension in an air stream and constituting with the air a fuel. In utilizing a tube mill in a pulverized coal firing system for furnaces the capacity output of the mill may not be required for firing the furnace. However, in a mill wherein the drum has or is provided with a liner having such a sinuous form of surface should the speed of rotation of the drum be reduced with the object of reducing the output of the mill the reduction in the output of the mill will be so much greater in proportion to the reduction in the speed of rotation of the mill that it is not possible to control the output of the mill. It is, therefore, required that the drum be rotated at the high speed required to produce the output capacity or tonnage of the mill and a consequent large amount of power is required to rotate the drum at all times.

It is the primary object of the invention to provide an improved arrangement of the inner surface of the drum, or drum liner, in tube mills to increase the cascading movement of the material and balls in the mill and an increase in the output capacity or tonnage of the mill without any increase required in the volume of air to deliver the material from the drum, and that will cause the mill to function as efficiently with a reduction in the speed of rotation of the drum as at full speed and produce a reduction in the output of the mill corresponding to the reduction in the speed of rotation of the drum, and a reduction in the power required to rotate the drum proportional to any reduction in the speed of rotation of the drum, as well as a reduction in the

volume of air required to deliver the material from the drum.

A further object of the invention is the arranging of the inner surface of the drum of a tube mill with sections of different forms of irregular surfaces disposed about the drum, one section of said surface at the outlet end of the drum being arranged to cause the material and material reducing elements to be lifted to a higher level and effect a greater cascading of the reducing elements and material in said portion of the drum by the rotation thereof.

It is another object of the invention to arrange the inner surface of the drum of a tube mill with circumferential sections disposed longitudinally of the drum with different forms of surfaces, the surface of one section at the inlet end of the drum being arranged of sinuous or sinusoid form disposed circumferentially about the drum, and the surface of a section at the outlet end of the drum arranged with pockets of arcuate form equidistantly spaced about and extending longitudinally of the drum and being of increased depth relative to the inwardly curved portions of the sinuous surface.

It is a further object of the invention to provide an improved construction and arrangement of a liner for the drums of tube mills, comprising segments of equal length and width and curved to conform to the inner surface of the drum and said segments disposed in sections circumferentially of and spaced longitudinally of the drum, the concave surface of the segments of certain of the sections being arranged of sinuous form circumferentially of the drum having uniform inwardly and outwardly curved portions, and the concave surface of the segments of another section arranged with pockets spaced circumferentially of the drum having arcuate portions of increased depth and width relative to the inwardly curved portions of the sinuous surface of the other sections.

In the drawing accompanying and forming a part of this application, Figure 1 is a longitudinal sectional view of the drum of a tube mill showing an embodiment of my improved liner applied thereto.

Figure 2 is a cross sectional view taken substantially on the line 2—2 of Figure 1.

Figure 3 is a cross sectional view taken substantially on the line 3—3 of Figure 1.

Figure 4 is a sectional view, on an enlarged scale, taken on the line 4—4 of Figure 2 and showing the means for securing the liner to the cylindrical wall of the drum.

Figure 5 is an elevational view looking at the rear of a portion of the assembled liners.

Figure 6 is a diagrammatic view to show the movement of the material and reducing elements by the rotation of the drum from below the axis

of the drum and imparting cascading movement thereto by the form of surface shown in Figure 2; and

Figure 7 is a diagrammatic view to show the movement of the material and reducing elements by the rotation of the drum from below the axis of the drum and imparting cascading movement thereto by the form of surface shown in Figure 3.

An embodiment of the invention is shown in the drawing in connection with the drum of a tube mill having a cylindrical body 8 of uniform internal diameter secured at the ends by annular members 9 of angle form in cross section to heads 10, 11 and securing said heads to the body, the heads having axial hollow trunnions 12, 13 constituting inlet and outlet openings for the drum and whereby the drum is supported to rotate on a horizontal axis. The drum contains material to be reduced and pulverized and material reducing elements, such as balls or pebbles, adapted by the rotation of the drum to reduce and pulverize the material. The pulverized material is delivered from the drum in suspension in an air stream caused to flow into the drum through one trunnion and from the drum through the other trunnion by a fan, not shown. The drum is rotated from a suitable source of power through a gear 14 disposed about and secured to the drum and shown as secured to the peripheral portion of the head 11 by the annular member 9 securing the head 11 to the body 8. A sleeve 15 is mounted in the trunnion 12 constituting the charging opening of the drum and the sleeve is provided with an internal spiral rib operative to convey material through the sleeve into the drum. A sleeve 16 is secured in the trunnion 13 having an internal spiral rib arranged to reenter into the drum material and reducing elements passing therein from the drum. The inner surfaces of the heads are provided with liners of wear resisting material 10' and 11'.

The inner surface of the body 8 is provided with a liner of wear resisting material, such as manganese steel, and which as shown, comprises a series of annular sections of successively abutting segments of equal length and width and conforming to the curvature of the inner surface of the drum, and the sections being arranged edge-wise longitudinally of the drum, the liner being shown in the present instance as comprising five sections of substantially equal length, *a*, *b*, *c*, *d* and *e*, and each section including eight segments, as shown in Figure 2. To mount and secure the segments of the annular sections upon the inner surface of the body 8, the segments of each section have a tongue and groove connection, as at 17, with the exception of two of the segments, the adjacent edges of which are arranged to diverge from the outer to the inner surface of said segments, as at 18, and adapted for the engagement of a wedge shaped key 19 drawn between the ends of said segments by nuts 20 threaded onto the ends of bolts 21 extended through countersunk openings in the keys and openings in the body 8, said bolts being adapted to secure sheathing of noise deadening material 22 to the exterior of the body by laterally flanged cup members 23, the bolts being extended through openings in said members 23 and spacing sleeves 24 interposed between the body 8 and said cup members 23 with a flange at one end of the sleeves abutting the body of the drum, as shown in Figures 2 and 4. The securing keys 19 for certain of the sections are circumferentially spaced from such securing

means for segments of adjacent sections, as shown in Figure 5.

The concave or front surface of the segments of certain of the sections exposed to the interior of the drum, and shown in the present instance as the section *a* at the inlet end of the drum, the section *b* adjacent of the section *a* and the section *d* between the section *c* and section *e* at the outlet end of the drum, are arranged of uniform sinuous or substantially sinusoid form, as shown at 25 in Figure 2, and the ridges and the dales of said surface of the segments of the respective sections *a*, *b* and *d* being circumferentially spaced about and extending in alinement longitudinally of the drum, as shown in Figure 1, the dales or inwardly curved portions and the ridges or outwardly curved portions of said surfaces of the segments being in arcs of a circle struck from radii of equal length. The rear or convex face of the segments of said sections *a*, *b* and *d* is in an arc concentric with the inner surface of the drum and recessed, as at 26, for the engagement of a noise deadening and cushioning material, such as cork, interposed and clamped between the segments and the wall of the body 8. The concave or front surface of the segments of the other sections *c* and *e* are arranged with pockets in the form of equidistantly spaced arcuate recesses 27 extending transversely of the segments, as shown in Figure 3, and said recesses of the sections *c* and *e* extending in alinement longitudinally of the drum, as shown in Figure 1. The pockets or recesses 27 are of greater depth and area than the inwardly curved portions of the sinuous surface 25 of the sections *a*, *b* and *d*. The rear or convex face of the segments of the sections *c* and *e* is also in an arc concentric with the inner surface of the drum and recessed, as at 28, and arranged with inwardly curved recesses 29 opposed to the wall portions between the recesses 27 in the concave face and said recesses being adapted for the engagement of a noise deadening and cushioning material, such as cork, interposed between said segments and the body 8 of the drum.

In Figure 6 there is shown in a diagrammatic manner the movement of the material from below the axis of the drum and the cascading of the material by the rotation of the drum in the portions of the drum arranged with the sections *a*, *b* and *d* having the sinuous surface 25. In such movement and cascading of the material and the reducing elements the air drawn through the drum to serve as the conveying vehicle for the pulverized material from the mill is caused to pass above the material in the drum and reduced material is picked up only by such air as comes in contact with the material.

In Figure 7 there is shown in a diagrammatic manner the movement of the material from below the axis of the drum and the cascading of the material and reducing elements by the rotation of the drum in the portions of the drum arranged with the sections *c* and *e* having the arcuate pockets 27. It will be noted that the material and reducing elements are moved from below the axis of the drum and lifted to a higher plane than the material lifted by the sections with the sinuous surface 25 and causing a greater cascading of the material and the reducing elements in the drum, and as the material as it is reduced and pulverized has a tendency to move toward the outlet end of the drum, the cascading material has a greater quantity of fines than the remaining portion of the drum and the air just prior to its passage from the outlet of the drum is caused to

pass through the cascading material and thereby separating and picking up an increased quantity of the fines or pulverized material and conveying the same from the drum.

In practice it has been found that by arranging the surface with the circumferentially spaced packets 27 substantially equal to one section, such as section c or e, of one-fifth the length of the drum, that the output capacity or tonnage of material delivered in suspension in the air stream is increased 16% without any increase in the volume of the air required to deliver the material from the mill over a type of mill wherein the entire interior surface of drum is provided with a surface such as the sinuous surface 25. Also that by reducing the speed of rotation of the drum 25% there is a corresponding reduction of 25% in the output capacity or tonnage of the mill and a decrease in the volume of air required to deliver the material from the drum and a corresponding reduction in the power required to rotate the drum, and there is a proportional reduction in the output of the mill when the drum is rotated at one-half or one-quarter speed and a proportional reduction in the air required to deliver the pulverized material from the drum as well as in the power required to rotate the drum. This is a great advantage where two, three or more mills are utilized in connection with the firing of the furnace or furnaces of a battery of boilers, since the mills may be normally operated to fire the furnace or furnaces, say at 75% of the capacity of the mills and a corresponding reduction in power required to operate the mills, and in case it may be necessary to shut down one mill the other mills may be operated at full capacity and serve to fire the furnace or furnaces, resulting in a great saving in the cost of power as well as in the maintenance of the mills.

Having described my invention, I claim.

1. In a tube mill, a drum including a cylindrical body of uniform internal diameter having closures arranged with axial hollow trunnions at the opposite ends to rotatably support the drum and through which trunnions material to be reduced is delivered into the drum and reduced material delivered from the drum in suspension in an air stream, and a liner for the cylindrical body of the drum, comprising arcuate segments curved to conform to the curvature of the drum, assembled edgewise and secured to the inner surface of the body in annular sections disposed longitudinally of the drum, the concave surface of the segments of the first two sections at one end of the drum and of the successive alternate section being arranged of sinusoid form disposed circumferentially about and extending parallelly of the axis of the drum and adapted by the rotation of the drum to move the material to be reduced and the material reducing elements in the drum from below the axis up the side of the drum and impart cascading movement thereto, and the concave surface of the segments of the section at the opposite end of the drum and of the successive alternate section being arranged with pockets of arcuate form in cross section circumferentially spaced about and extending parallelly of the axis of the drum, said pockets being of greater depth than and arranged in staggered relation to the inwardly curved portions of the sinusoid surface of the segments of

the other sections and the portions between the pockets being in arcs of a circle whose center lies in the axis of the drum adapted to move the material and material reducing elements from below the axis up the side of the drum to a higher level in the drum and impart greater cascading movement thereto than the surface of the segments of the sections with the sinusoid surface, and the convex surface of the segments of the respective sections arranged with recesses, and a noise deadening and cushioning material disposed in said recesses in interposed relation between the segments and cylindrical body of the drum.

2. In a tube mill, a horizontal axis drum including a cylindrical body of uniform diameter having closures with axial openings at the opposite ends, said body having an annular section of the inner surface at one end arranged of sinusoid form circumferentially of the body and adapted by the rotation of the drum to move material to be reduced and reducing elements in the drum from below the axis up the side of the drum and impart cascading movement thereto, and an annular section of the inner surface of the body at the opposite end arranged with pockets of arcuate form in cross section circumferentially spaced about and extending parallelly of the axis of the body, said pockets being of greater depth and of less width than the dales of the sinusoid surface of the first mentioned section and adapted by the rotation of the drum to move the material to be reduced and the reducing elements in said section of the body from below the axis up the side of the body to a higher level and effect greater cascading movement thereof than the material and reducing elements moved up the side of the body by the section of the drum having the sinusoid surface.

3. In a tube mill, a rotatable horizontal axis drum including a cylindrical body having closures with axial openings at the opposite ends adapted to contain the material to be reduced and freely moving reducing elements, and a liner for the cylindrical body comprising arcuate segments conforming to the curvature of the body arranged in annular sections disposed in endwise relation longitudinally of the body, the inner surface of the segments of the sections at one end and a section within the opposite end of the body being arranged of sinusoid form disposed circumferentially about and extending parallelly of the axis of the drum, and the inner surface of the segments of the annular sections at the opposite end and midway of the ends of the body arranged with pockets of arcuate form in cross section uniformly spaced circumferentially about the body and extending parallelly of the axis of the body, and said pockets being of greater depth than and arranged in staggered relation to the inwardly curved portions of the sinusoid surface of the other sections, and said sinusoid surfaces and pockets by the rotation of the drum adapted to move the material and reducing elements from below the axis up the side of the body and effect cascading movement thereof, and the sections with the pockets adapted to move the material and reducing elements to a higher level and effect greater cascading movement thereof than the sections with the sinusoid surface.

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