W. FENNELL.

TUBE MILL.

APPLICATION FILED APR. 25, 1913. RENEWED JUNE 2, 1915.

**1,154,981.** Patented Sept. 28, 1915.

Fig. 1.

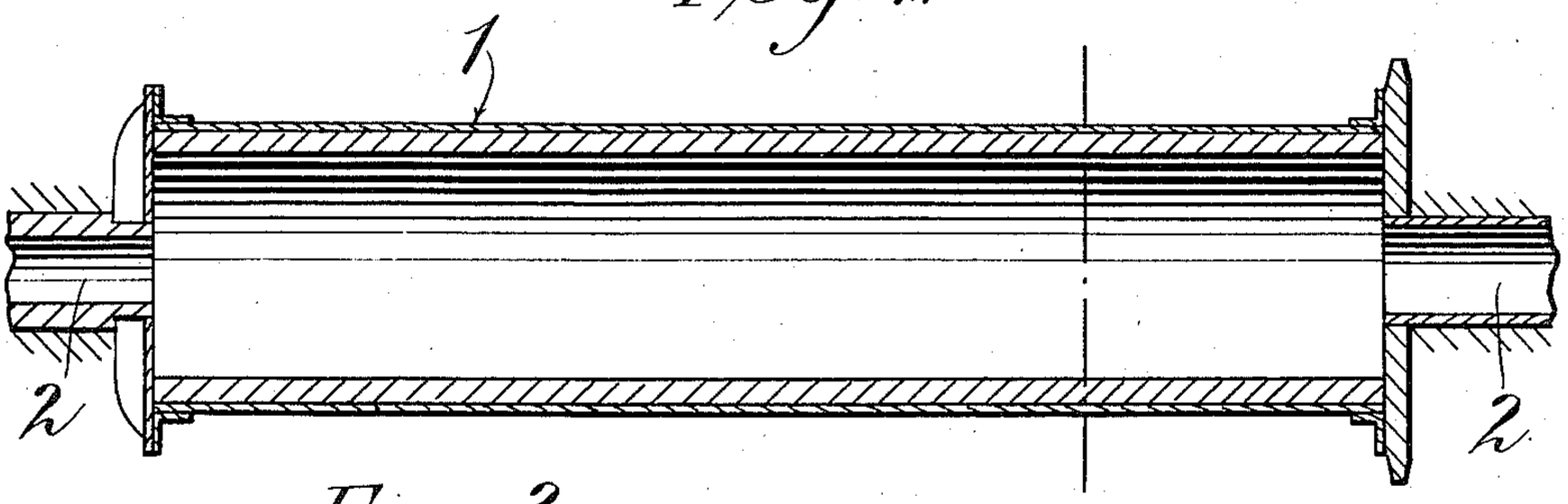


Fig. 3.

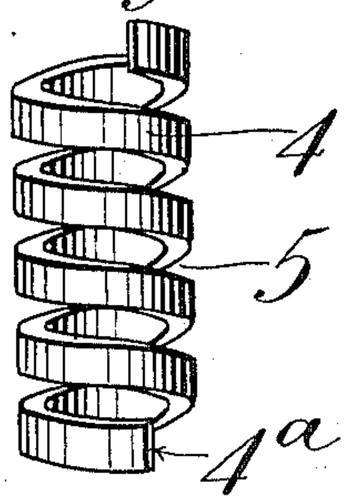


Fig. 4.

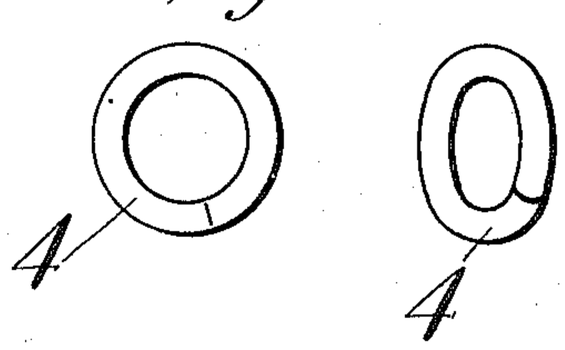


Fig. 5.

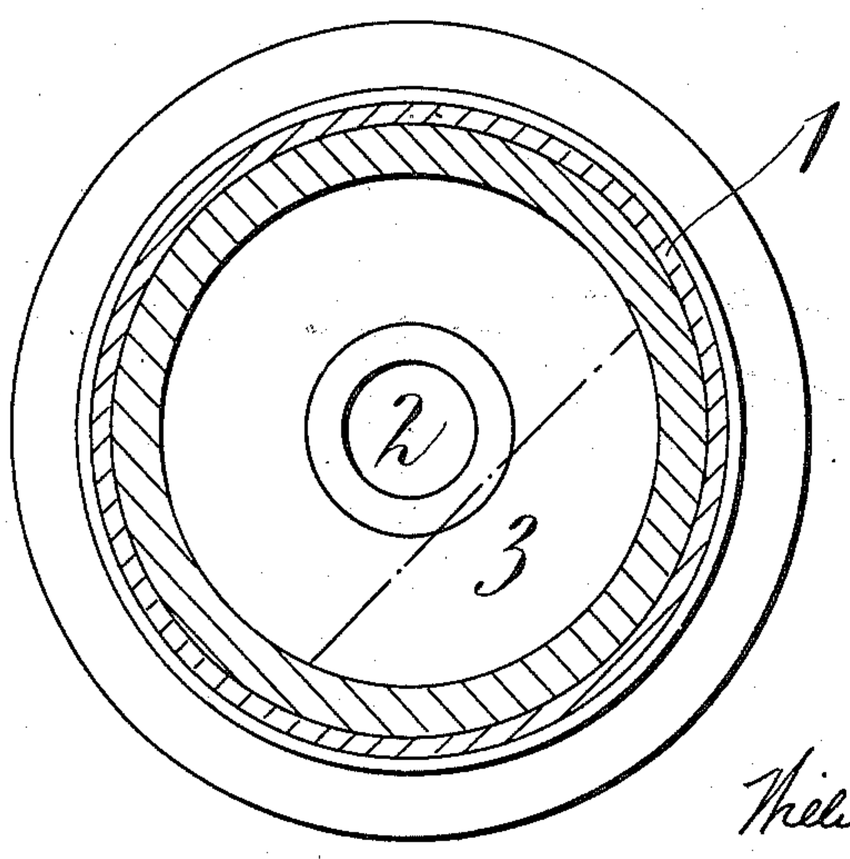


Fig. 2.

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## TUBE-MILL.

1,154,981. Specification of Letters Patent. Patented Sept. 28, 1915.

Application filed April 25, 1913, Serial No. 763,524. Renewed June 2, 1915. Serial No. 31,792.

*To all whom it may concern:*

Be it known that I, WILLIAM FENNELL, a subject of the King of Great Britain and Ireland, residing at Southam, near Rugby, in the county of Warwick, England, have invented Improvements in or Relating to Tube-Mills, of which the following is a specification.

In the specification of another application for Letters Patent filed by me the 16th November 1912, Serial No. 731861, I have described the use in tube mills for grinding and pulverizing cement, slag, limestone, ore, coal, and other materials, of grinding bodies each made hollow or partly hollow for the reception and movement of material to be ground and made of comparatively small length in relation to the length and diameter of the mill but of greater length than diameter or width, the relative dimensions being such that the several grinding bodies when in use will not roll upon each other but will, under the action of centrifugal force, set themselves lengthwise in planes at right angles, or approximately so, to the axis of the rotating mill and will circulate in an endwise direction, in an alternately upward and downward direction, in curved paths in such planes, with a sliding motion, material that enters the bodies when these are at the lower part of the mill being carried upward and discharged among the bodies so as to become effectually ground between adjacent sliding surfaces thereof, the object of using such bodies being to reduce their weight, as compared with solid metal cylinders of the same dimensions, so as to enable a greater number of them to be used than of solid cylinders, without unduly loading the rotating drum, to enable a better distribution of the load in the drum to be obtained and a saving in power to be effected, and to insure a better distribution of the cement or other material between the sliding surfaces of the bodies. In the said former specification, the grinding bodies described by way of example, comprised short elongated bodies of circular, oval or equivalent curvilinear shape in cross section and having a hole extending centrally and lengthwise therethrough.

Now according to the present invention, the hollow grinding bodies used in tube mills are each made in the form of a helix or spiral, like a helical spring, so that a helical groove or recess extends between the convolutions of the body, the outer surface of the convolutions being preferably straight or flat as seen in longitudinal section.

Grinding bodies of the improved kind hereinbefore described may be of circular, oval or other curvilinear shape in cross section, and of uniform or nearly uniform cross sectional dimensions through their length and, as in the said former specification, be made of such dimensions that when in use they will move endwise and slide in contact with one another. Such bodies may be of hardened and tempered steel or of other metal or material according to the nature of the material to be ground.

In the accompanying drawings, Figure 1 shows in central longitudinal section, and Fig. 2 in cross section, to a larger scale, a tube mill, and Figs. 3 and 4 show respectively in side elevation and end view, to a still larger scale, one of the improved grinding bodies for use in such mill. Fig. 5 shows in end view a modified form of the grinding body.

1 is a tube mill of any ordinary construction having hollow trunnions 2 and in which a mass 3 of loose grinding bodies constructed according to the present invention with intermixed cement or other material to be ground is placed for the purpose of grinding such cement or other material when the mill is rotated.

Figs. 3 and 4 show one of the grinding bodies made of hollow helical shape, like a helical spring, of hardened and tempered steel, and having its convolutions 4 spaced apart to form a helical shaped groove 5 between them, the said body being of circular cross section and of uniform diameter throughout, the outer periphery of such body being straight or flat in a longitudinal section thereof, as shown at $4^a$. Such hollow cylindrical grinding bodies can be made in the same manner as ordinary helical metal springs, and preferably of metal wire or rod of substantially rectangular section, as shown.

The grinding bodies instead of being of circular cross section, as shown in Fig. 4, may each be of other shape in end view or cross section, for example of hollow oval shape, as shown in Fig. 5.

In order that the new grinding bodies may move endwise and slide in contact with each other as described, they must each be made of a length that is a small fraction of the radius of the mill and of greater length

than diameter as in the case of the grinding bodies described in the said former specification.

The new grinding bodies may advantageously be made about 2 inches in length, about ¾ of an inch in external diameter and about $\frac{7}{16}$ of an inch in internal diameter. Consequently it will be understood that a very large number of such grinding bodies are required in the mill, each being free to move endwise, that is to say, in the direction of its length, in a plane transverse, or nearly so, to the axis of the mill.

Grinding bodies according to the present invention are used in the manner described in my said former specification, the helical groove or recess between the convolutions of each body serving, in addition to the hole or passage extending through the center of the body, to further lighten the body as compared with its bulk and also to raise material to be ground and distribute it among the mass of grinding bodies in such manner that a greater output of ground material is obtained from a mill of given size in a given time charged with such grinding bodies than with the same weight of grinding bodies previously used. Furthermore, by making the grinding bodies of helical shape as described, they have a greater overall bulk for a given weight than hollow grinding bodies such as described in my said former specification, and a far greater overall bulk for a given weight as compared with solid metal cylinders, each having the same area of grinding surface, so that the volume or bulk of the load, composed of cement or other material to be ground and grinding bodies, in the mill will be increased as compared with a load comprising the same weight of cement or other material and grinding bodies of either of the other forms referred to, with the result that not only will the output of the mill be considerably increased but the power required to drive the mill and its load will be decreased.

In order that the grinding bodies may slide one over the other and grind material between their adjacent surfaces as described, the convolutions of each body must of course be arranged near together, as shown, that is to say, the axial width of each convolution must be greater than the axial width of the helical groove between the convolutions so as to prevent the helical shaped grinding bodies becoming entangled with each other when in use.

What I claim is:—

1. The combination with a tube mill of a large number of loose freely movable grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has an open ended passage extending lengthwise therethrough and a hole in its peripheral surface of less width than that of the surface adjacent to said hole, substantially as and for the purposes set forth.

2. The combination with a tube mill of a large number of loose freely movable hollow grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has a hole extending laterally entirely through its peripheral wall.

3. The combination with a tube mill of a large number of loose freely movable hollow grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has in its peripheral surface an elongated hole of less width than the portions of the surface adjacent thereto.

4. The combination with a tube of a large number of loose freely movable hollow grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has in its peripheral surface an elongated hole that is inclined to its longitudinal axis and is of less width than the portions of the surface adjacent thereto.

5. The combination with a tube mill of a large number of loose freely movable hollow grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has in its peripheral surface an elongated hole that extends completely through its wall and is of less width than the portions of the surface adjacent thereto.

6. The combination with a tube mill of a large number of loose freely movable hollow grinding bodies each made of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter and has in its peripheral surface an elongated hole that is inclined to its longitudinal axis, extends completely through its wall and is of less width than the portions of the surface adjacent thereto.

7. The combination with a rotary tube mill of a large number of loose freely movable grinding bodies adapted to slide endwise against each other and each made of a helical spring-like shape of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter, substantially as described for the purpose set forth.

8. The combination with a rotary tube mill of a large number of loose freely movable hard metal grinding bodies adapted to slide endwise against each other and each made of a helical spring-like shape of a length that is equal to a fraction only of the radius of the mill but is of greater length than diameter, substantially as described for the purpose set forth.

9. The combination with a rotary tube mill of a large number of loose freely movable grinding bodies adapted to slide endwise against each other and each made of a helical spring-like shape and of substantially uniform cross section through its length, each of said bodies being of a length that is equal to a fraction only of the radius of the mill but is of greater length than radius and the convolutions of which are spaced at such a distance apart as to admit of such body sliding over and against adjacent bodies for the purpose set forth.

10. The combination with a rotary tube mill of grinding bodies each made of cylindrical helical spring-like shape of a length that is a small fraction only of the radius of the mill and of greater length than diameter and adapted to slide against other similar grinding bodies in the mill, substantially as described for the purpose set forth.

11. The combinations with a rotary tube mill, of a large number of small freely movable grinding bodies adapted to slide endwise against each other and each made of helical spring-like shape of a length that is a fraction only of the radius of the mill and of greater length than diameter, the convolutions of the body having outer surfaces that are flat or straight in longitudinal section.

Signed at London England this 14 day of April 1913.

WILLIAM FENNELL.

Witnesses:

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