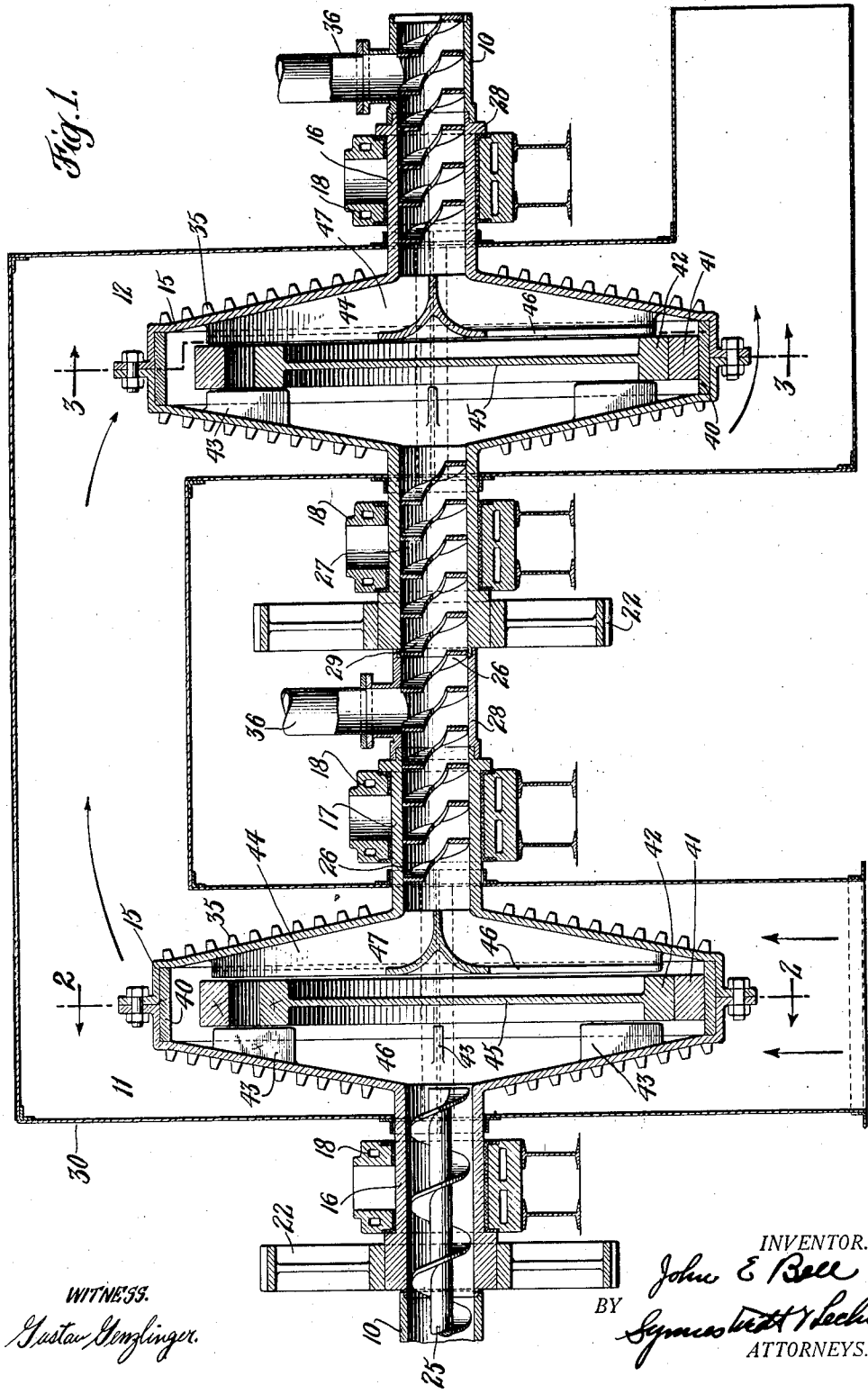
Sept. 6, 1927. 1,641,409

J. E. BELL

GRINDING AND DRYING APPARATUS

Filed Jan. 12, 1922 5 Sheets-Sheet 1

Fig. 1.



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GRINDING AND DRYING APPARATUS

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Fig. 2.

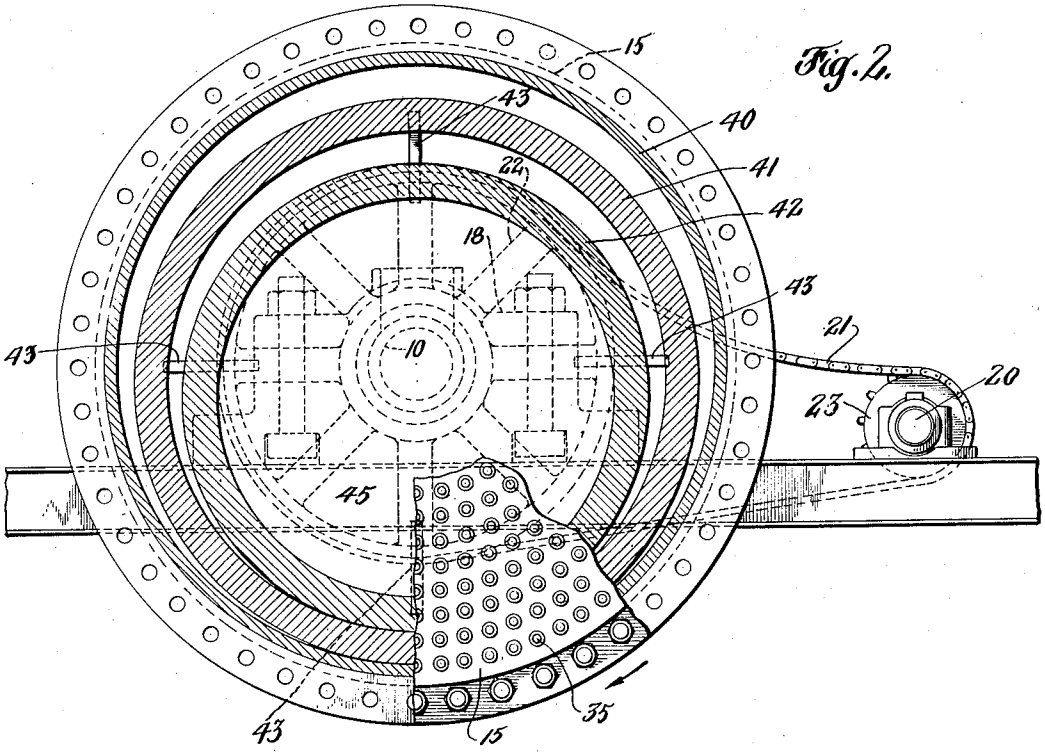
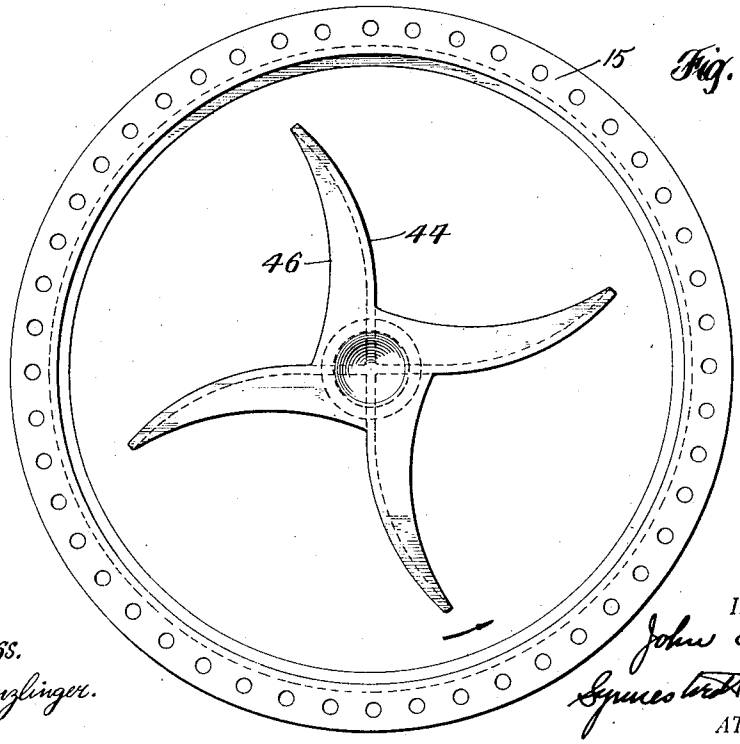


Fig. 3.



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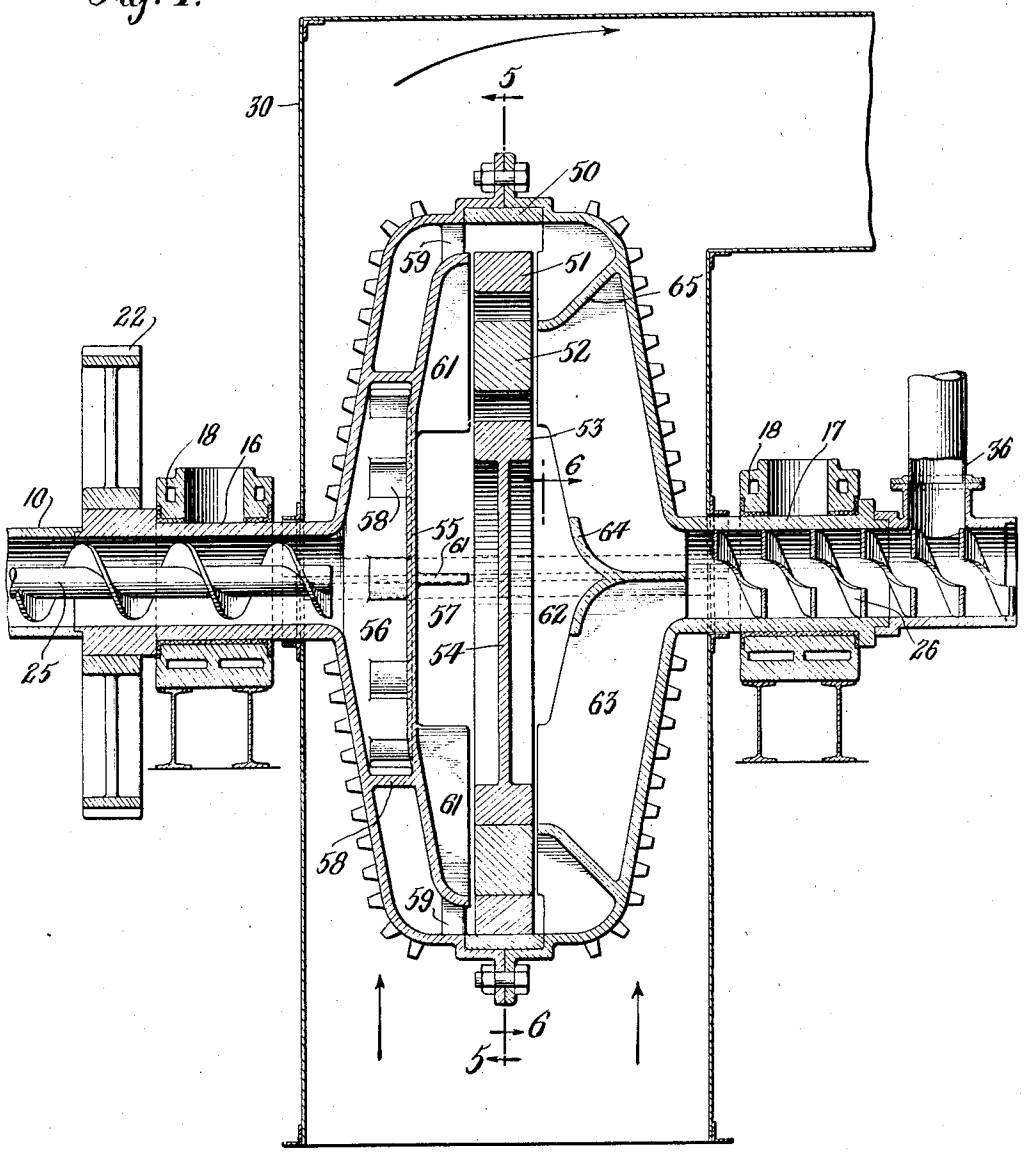
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Fig. 4.



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Sept. 6, 1927. 1,641,409

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GRINDING AND DRYING APPARATUS

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Fig. 5.

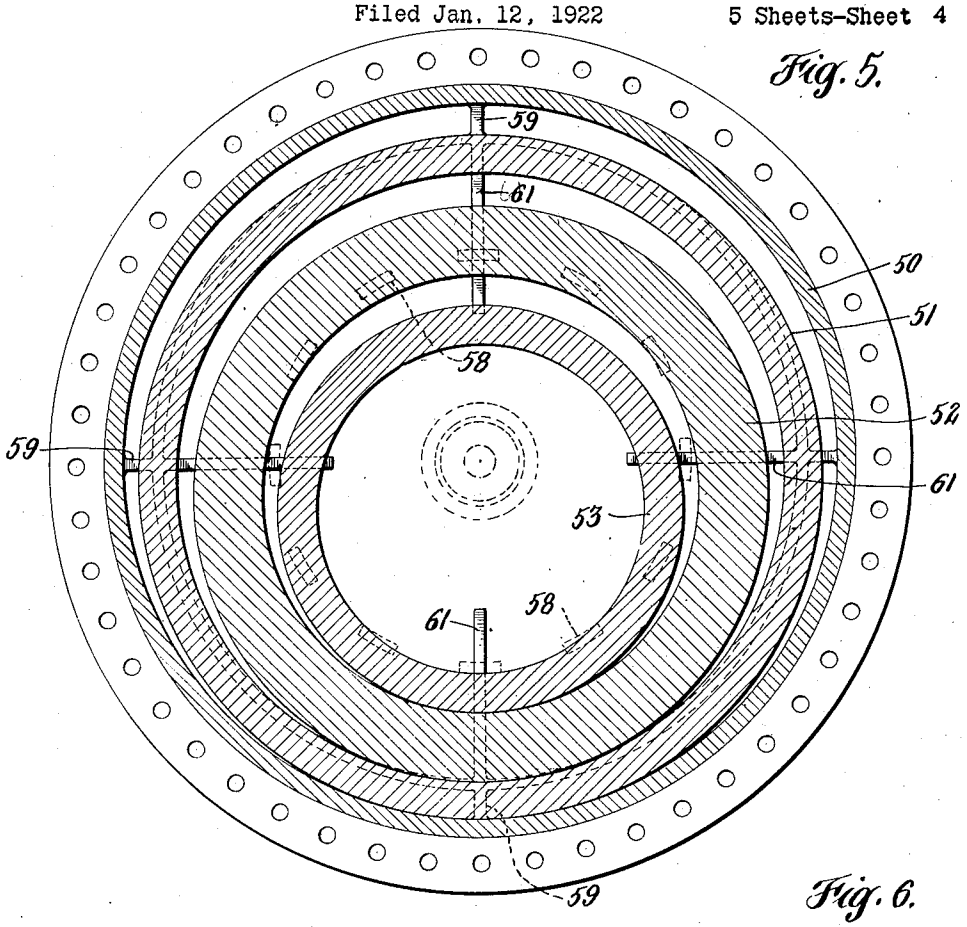
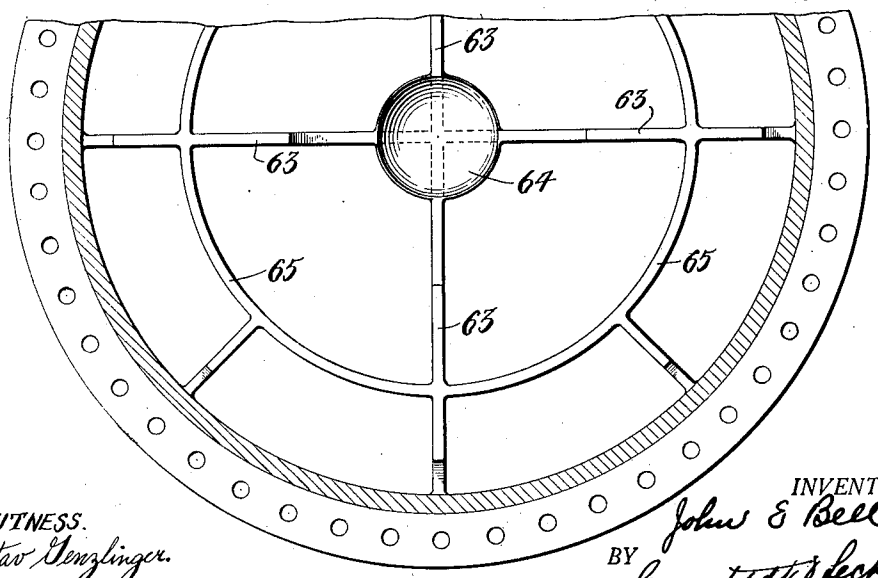


Fig. 6.



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GRINDING AND DRYING APPARATUS

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Fig. 7.

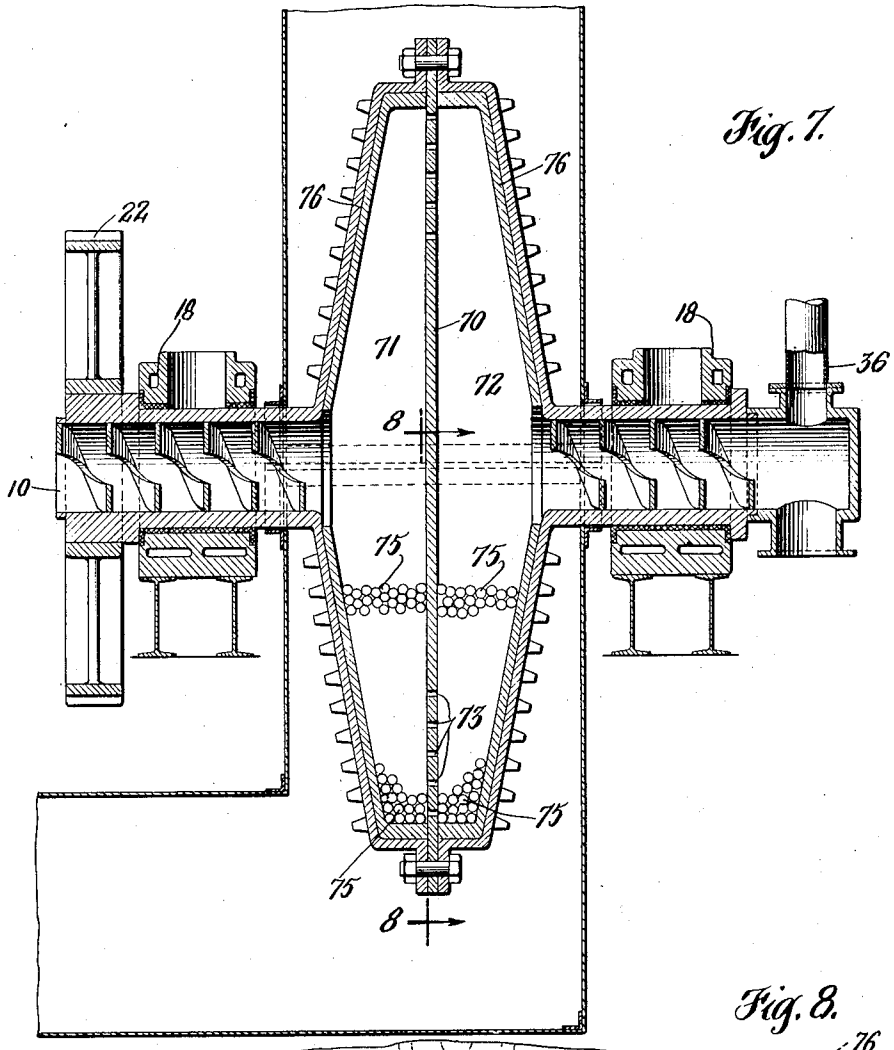
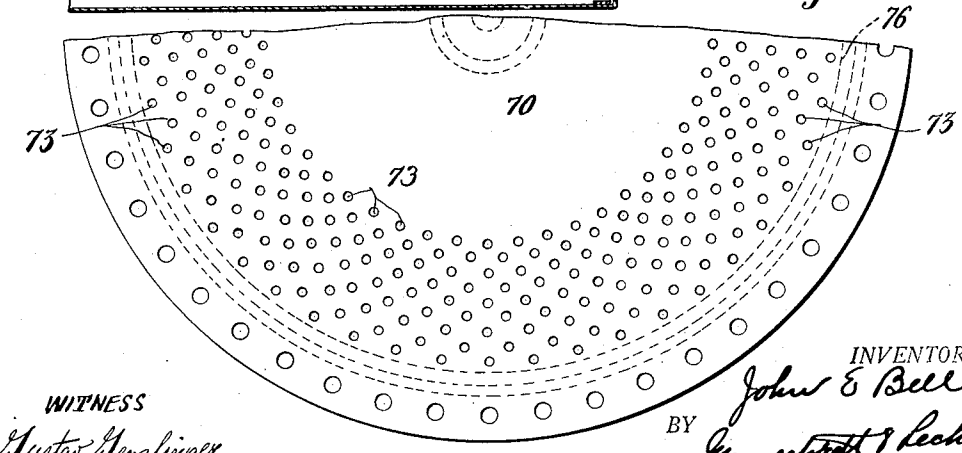


Fig. 8.



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Patented Sept. 6, 1927. 1,641,409

UNITED STATES PATENT OFFICE.

JOHN E. BELL, OF BROOKLYN, NEW YORK, ASSIGNOR TO COMBUSTION ENGINEERING CORPORATION, A CORPORATION OF NEW YORK.

GRINDING AND DRYING APPARATUS.

Application filed January 12, 1922. Serial No. 528,668.

My invention relates to grinding and drying apparatus especially useful for pulverizing and drying fuel such as coal that is to be burned in powdered form. I aim to make both the crushing or grinding and the drying operations rapid, continuous efficient, and economical, and to enable them to be carried on concurrently. I also aim to make the apparatus itself simple, durable, and relatively inexpensive. How these and other advantages can be realized through the invention will appear from my description hereinafter of the best forms of embodiment at present known to me.

In the drawings, Fig. 1 shows a vertical axial section through an apparatus conveniently embodying my invention and comprising a couple of similar grinding and drying mills or units arranged and connected to operate upon the same coal successively.

Fig. 2 is a transverse view showing one of the grinding units opened up, with certain parts in section as indicated by the line 2—2 in Fig. 1,—a fragment of the casing in front of the plane of section appearing.

Fig. 3 is a transverse view of the interior of a unit opened up, taken as indicated by the line 3—3 in Fig. 1.

Fig. 4 shows a vertical axial section, on a larger scale, through a single grinding and drying unit of somewhat different construction from those shown in Figs. 1, 2 and 3.

Figs. 5 and 6 show transverse vertical sections through this grinding unit, taken as indicated by the lines 5—5 and 6—6 in Fig. 4.

Fig. 7 shows a vertical axial section through still another form of grinding and drying unit.

Fig. 8 is a fragmentary side view of a partition shown in Fig. 7, taken as indicated by the line 8—8 in that figure.

The apparatus shown in Fig. 1 comprises a conduit, comprehensively indicated by the numeral 10, in which grinding mill units 11, 12 are serially arranged. The conduit 10 may be extended to include any desired number of grinding mills by simple cumulation of units, or a single grinding unit may be used by itself,—since each one may be intrinsically complete. The units 11, 12 shown being almost exact counterparts of one another, it will suffice to describe in full detail only the unit 11.

The grinding mill 11 comprises a casing or shell 15 having at its opposite sides hollow journals 16, 17 by means of which it is supported for rotation in water-cooled bearings 18. Since the hollow journals 16, 17 form part of the conduit 10 and serve for entrance and discharge of material to and from the casing 15, I ordinarily prefer not to make them stationary axles, but rather to construct them as trunnions united and turning with the casing. The casing 15 may be driven (see also Fig. 2) from a countershaft 20 at the rear of the conduit 10, by means of a sprocket chain connection 21 between a sprocket wheel 22 fast on the journal 16 and a sprocket wheel 23 on the shaft 20.

Coal is continuously fed into and through the casing 15 and the grinding devices therein by means of a rotary screw conveyor 25 in the entrance journal 16,—which conveyor (especially since the grinder and drier 11 is shown as the first of the series in the conduit 10) may be driven separately from the rotary parts of the mill 11,—either by a special connection from the countershaft 20, or quite independently. It is shown as of relatively coarse pitch, so as to handle readily the coarsest material that it can handle,—or that the mill 11 is intended to operate on. For reasons which will appear hereinafter, I generally prefer not to rely on the incoming coal to crowd the ground coal leaving the mill 11 along through the discharge journal 17 and the rest of the conduit 10 leading to the unit 12, but (as here shown) to make special provision for feeding along and discharging the ground coal by means of a rotary screw conveyor 26 in said journal 17. For reasons which will presently appear, this screw conveyor 26 is not made with a solid central shaft like that of the conveyor 25, but consists simply of a helically twisted strip of metal open through its center and secured at its outer edge to the interior of the journal 17.

The rotating discharge trunnion 17 of the mill 11 is connected with the rotating entrance trunnion 27 of the mill 11 by means

of a short stationary section 28 of the conduit 10 which has a close fitting rabbeted joint with each of said journals, but really belongs to the unit 11 rather than to the unit 12. The screw conveyor 26 of the journal 17 extends clear through the stationary conduit section 28 just about flush with its further end, and so carries along and delivers the coal to the journal 27, where it is, in turn, taken and carried along by means of a rotary screw conveyor 29 in said latter journal. Functionally, this conveyor 29 corresponds to the conveyor 25; but in form and construction it is like the conveyor 26. It extends just about flush with the receiving end of the journal 27. Aside from the difference between the rotary conveyors 25 and 29 just described, the mill unit 12 is shown as the exact counterpart of the unit 11, and may be individually driven from the countershaft 20 in the very same manner.

Since the coal entering the conduit 10 is likely to contain more moisture than it is desirable to have present in the final powdered product, and since the grinding of the coal tends to facilitate disengagement of moisture (and other gases or vapors), it is often advisable to heat the coal during its passage through said conduit. This I prefer to do while it is being ground in the mills 11 and 12. Accordingly, I have shown a serpentine heater casing 30 surrounding and enclosing the casing 15 of each of said mills 11 and 12, for the passage of heating medium over them. As shown, the journal bearings 18 for the various journals are excluded from the casing 30, and also their driving means 21, 22, etc., and the stationary conduit sections 28 with their rabbeted joints above mentioned, so as not to expose any of these parts to the heating medium. As here indicated, the heating medium traverses the mills 11, 12 in series, first making an upward pass around the mill 11, then an idle longitudinal pass, then a downward pass around the mill 12, and then a longitudinal pass which may lead either to another mill unit or to a stack or other means of discharge. To aid in the transmission of heat from the flowing gaseous or vaporous heating medium to the coal in the casings 15, the latter are provided with external heat-transmitting projections in the form of a great many frustro-conical protuberances 35 on their opposite sides.

The ground coal being carried along in the lower portion of the journal 17 by the conveyor 26 instead of being forcibly crowded through so as to fill the journal completely, and the center of the conveyor being open, space is afforded for passage and collection of vapor disengaging from the coal during and after the grinding operation. This vapor is drawn off from the discharge journal 17 through a pipe 36 connected to the upper side of the conduit section 28 whereby the ground coal is discharged from the mill 11 to the mill 12. A moderate suction should be employed for thus separately withdrawing the vapor, in order to avoid drawing the coal off with it. The vapor, therefore, is drawn through a mill toward its fuel discharge end, and is drawn off from the conduit 10 at intervals, from just beyond each grinding mill included in said conduit.

At the periphery of the two-part casing 15 is a circular liner band or track 40 on which a couple of tire-like annular members 41, 42 roll free and upright, one within another, under lateral guidance of members 43, 44 (see also Figs. 2 and 3) on the sides of the casing. The track 40 should preferably be of very hard steel (such as manganese steel), and the tires 41, 42 of ordinary tire steel such as used for the tires of wheels for railway rolling stock. With track 40 and tires 41, 42 substantially cylindrical and relatively smooth, as shown—rather than conical or transversely toothed or serrated,—the particles of material being ground can move freely across and along the track, so as to be more readily and certainly acted on at each revolution of the track. The interior of the tire (and, in the present instance, the whole center of the casing 15) is occluded by a transverse central partition or web 45 across the inside of the inner steel tire 42. The four members 43 are in the form of flange webs or vanes extending more or less nearly radially in the entrance side of the casing 15. The four members 44 are in the form of slightly curved flange webs or vanes, extending more or less nearly radially in the discharge side of the casing 15 and coming together at its discharge opening through the journal 17. The webs or vanes 44 have transverse flanges 46 which extend forward in the clockwise direction of rotation (speaking with reference to Fig. 2) of the casing 15, and increase in width toward the center,—where they curve toward the discharge opening at their merger with the axially extending portions of the webs, so as to assist in guiding and directing the ground coal to said opening.

As the casing 15 revolves, the tires 41, 42 roll on the internal track 40 and one on the other (the interior of one tire being a track to that inside it) under the influence of gravity, always remaining substantially at the low point of the track. The portion 45 keeps the accumulation of coal falling into the entrance side or chamber 46 of the casing 15 from passing freely inside the tires 41, 42 to the discharge side or chamber 47, and thus coacts with the revolving vanes 43

in causing the coal to be carried up and directed across the internal track 40 and the peripheries of the tires, through the gaps that exist between them everywhere above the low points. The coal progressively crushed under the weight of the tires is fed across the track 40 and the inner surface of the tire 41 by the pressure of fresh coal continually entering between the tires. The ground coal thus fed through the gravitational grinding means just described drops in the discharge chamber 47, and is caught by the revolving discharge vanes 44,—either directly, or after some accumulation has occurred. By these vanes 44, the ground coal is lifted until it slides down and out into the discharge journal 17.

The gravitational tire grinding mill shown in Figs. 4, 5 and 6 differs from that just described in having on its track 50 three tires, 51, 52, 53, rolling upright one within another, instead of two. Its really important difference, however, is in the provision of partition means, etc., for directing the coal to be ground back and forth across the peripheries of different tires in succession. Besides being occluded by the central partition 54 in the inner-most tire 53, the interiors of the tires and the center of the casing are also occluded by a transverse dished partition 55 in its entrance side which divides the latter into two chambers 56, 57. This partition 55 is attached to its side of the casing by circumferential spaced webs 58 at an intermediate point and by radial webs 59 at its periphery. The webs 58 assist in distributing the entering coal more or less uniformly, and the webs 59 in carrying it up as the casing or shell revolves and directing it across the track 50. The annular opening around the partition 55 is of such width relatively to the outer tire 51 that the partition itself directs the coal across the track 50 and the periphery of the tire 51. On the hollow side of the partition 55 are four radially extending vanes or webs 61 whose arrangement and functions are similar to those of the vanes 43 in Figs. 1 and 2,—as will presently appear. In the discharge side or chamber 62 are four radially extending webs or vanes 63 which differ from the discharge vanes 44 in Figs. 1 and 3 principally in not being curved and in having transverse flanges 64 that do not extend far outward from their merger at their intersection. In the outer portion of the casing is a sloping partition 65 that extends circumferentially from one vane 63 to another, and serves as a reguide for directing back across the inner surface of the outer tire 51 (between it and the periphery of the tire 52) ground coal that has crossed the track 50. The coal thus directed between the tires 51 and 52 against the hollow side of the dished partition 55 is by the latter redirected back again between the tires 52 and 53 to the discharge chamber 62. It is there caught by the discharge vanes 63 and by them raised until it slides down and out into the discharge journal 17. In this mill, therefore, the coal is ground and reground in a succession of distinct operations.

In the gravitational grinding mill shown in Figs. 7 and 8, a transverse central partition 70 clamped between the halves of the casing or shell divides it into entrance and discharge chambers 71 and 72. The central portion of this partition 70 is solid and occludes the center of the casing completely, so as to prevent the coal entering from passing directly through. In the outer zones of the partition 70, adjacent the peripheries of the chambers 71 and 72, are openings 73 (consisting of a great number of small holes) for the passage of coal ground in the chamber 71 to the chamber 72. The gravitational grinding means here employed comprises a quantity of balls 75 in each chamber, of such sizes that they are incapable of passing through the holes 73 from one chamber to another. As the casing revolves, the balls 75 are continually tumbled about with the coal and effectively pulverize it. As the coal enters and is ground in the entrance chamber 71, it works its way radially outward therein and through the holes 73 into the discharge chamber 72, where it is reground. It then works its way (or is displaced) into the discharge journal 17. In this mill also, therefore, the coal is ground and reground in a succession of distinct operations.

The balls 75 may be of any suitably hard material, such as cast iron. The partition or diaphragm 70 may be of manganese steel, and the halves of the casing or shell may have dished linings 76 of the same material.

It will be noted that in all the forms of mill described above the chambers at opposite sides of the central partition are of relatively narrow width and convergent toward their peripheries, and that their sloping outer sides tend to crown the material toward the center and so help in feeding it along or in insuring its being picked up by the various revolving vanes. In addition, the convergence of the narrow chambers outward in Fig. 7 crowds the falling balls together and so makes their action on the material more effective.

What I claim is:

1. A continuous grinding mill comprising a rotary casing with means for entrance and discharge of material; gravitationally movable grinding means in said casing; means for heating the material while being ground; and means for drawing vapor disengaging from the material toward the fuel discharge end of the apparatus, and withdrawing and separating it.

2. A continuous grinding mill comprising a rotary casing with means for entrance and discharge of material; gravitationally movable grinding means in said casing; means for continuously feeding material into and out of said casing, and through said grinding means; means for heating the material while being ground; and means for withdrawing vapor from the material discharging means.

3. A continuous grinding mill comprising a rotary casing with hollow journals at opposite sides thereof for entrance and discharge of material, respectively; gravitationally movable grinding means in said casing; and means for drawing off from the discharge journal vapor disengaging from the ground material.

4. A continuous grinding mill comprising a rotary casing with hollow journals at opposite sides thereof for entrance and discharge of material, respectively; gravitationally movable grinding means in said casing; means for discharging the ground material through a portion of the discharge journal, leaving space therein open for vapor disengaging from the ground material; and means for drawing off such vapor from such open space separate from the ground material.

5. A continuous grinding mill comprising a rotary casing with hollow journals at opposite sides thereof for entrance and discharge of material, respectively; gravitationally movable grinding means in said casing; discharge means for the ground material including a rotary screw conveyor in the discharge journal; and means for drawing off from the upper side of said discharge means vapor disengaging from the ground material.

6. The combination of a continuous grinding mill comprising a rotary casing with hollow journals at opposite sides thereof for entrance and discharge of material, respectively, and gravitational grinding means in said casing; and a heater casing for passage of heating medium over said casing surrounding and enclosing the same to the exclusion of its journal bearings.

7. A continuous grinding apparatus comprising a conduit with rotary gravitational grinding mills therein, including hollow journals for said mills; and rotary means in said journals for continuously feeding material from mill to mill through said conduit.

8. A continuous grinding apparatus comprising a conduit with rotary gravitational grinding mills therein; means for heating the material ground during its passage through the conduit; and means for drawing off from said conduit, at intervals, vapor disengaging from the ground material.

9. A continuous grinding apparatus comprising a conduit with rotary gravitational grinding mills serially arranged therein; means for heating said mills; and means for drawing off from said conduit, beyond each mill, vapor disengaging from the ground material.

10. The combination of a continuous grinding apparatus comprising a conduit with rotary gravitational grinding mills serially arranged therein and journal bearings for supporting said mills; and a serpentine heater casing for passage of heating medium in series over said mills surrounding and enclosing them to the exclusion of their aforesaid journal bearings.

11. The combination of a continuous grinding apparatus comprising a conduit with rotary gravitational grinding mills serially arranged therein and journal bearings for supporting said mills; means for driving said mills individually; a serpentine heater casing for passage of heating medium in series over said mills surrounding and enclosing them to the exclusion of their aforesaid journal bearings and individual driving means; and means for drawing off from said conduit beyond each mill vapor disengaging from the ground material.

12. A grinding mill comprising a rotary casing with an internal track; a rotary tire adapted to roll on said track as said casing revolves; another rotary tire adapted to roll upright inside the one aforesaid; transverse partition means occluding the interior of said tire and serving to direct material entering the casing across said track; and reguide means at the far side of said track for directing material crossing the same back across the inner surface of the first-mentioned rotary tire.

13. A grinding mill comprising a rotary casing with means at opposite sides thereof for entrance and discharge of material, respectively, and an internal track; a transverse dished partition in the entrance side of the casing occluding its center and serving to direct material entering it across said track, said partition having radially extending webs or flanges at its own hollow side away from the casing entrance; a plurality of radially extending webs or flanges in the discharge side of said casing coming together at its discharge opening; and rotary tire crushing and grinding means adapted to roll upright on said track under guidance of the aforesaid webs at opposite sides thereof.

14. A grinding mill comprising a rotary casing with means at opposite sides thereof for entrance and discharge of material, respectively, and an internal track; a transverse dished partition in the entrance side of the casing occluding its center and serving to direct material entering it across said track, said partition having radially extending webs or flanges at its own hollow side

away from the casing entrance; a plurality of radially extending webs or flanges in the discharge side of said casing coming together at its discharge opening; rotary tires adapted to roll upright one within another on said track under guidance of the aforesaid webs at opposite sides thereof; and circumferentially extending reguide means at the discharge side of said tires for directing material back between them against said transverse partition means for re-direction back again to the discharge.

15. A continuous grinding ball mill comprising a rotary casing with means at opposite sides thereof for entrance and discharge of material, respectively; transverse partition means in said casing dividing the same into a plurality of chambers of narrow width with sides convergent toward their peripheries, and having openings therethrough adjacent the peripheries of the chambers for passage of ground material from chamber to chamber; and grinding balls in said chambers of such dimensions as to be incapable of passing from one to the other through said openings.

16. A continuous grinding ball mill comprising a rotary casing with hollow journals at opposite sides thereof for entrance and discharge of material, respectively; transverse partition means in said casing dividing the same into a plurality of chambers of narrow width with sides convergent toward their peripheries, and having openings therethrough adjacent the peripheries of the chambers for passage of ground material from chamber to chamber; grinding balls in said chambers of such dimension as to be incapable of passing from one to the other through said openings; rotary means in said entrance journal for feeding the material through said chambers; and rotary means in said discharge journal for withdrawing the material from said casing.

In testimony whereof, I have hereunto signed my name.

JOHN E. BELL.