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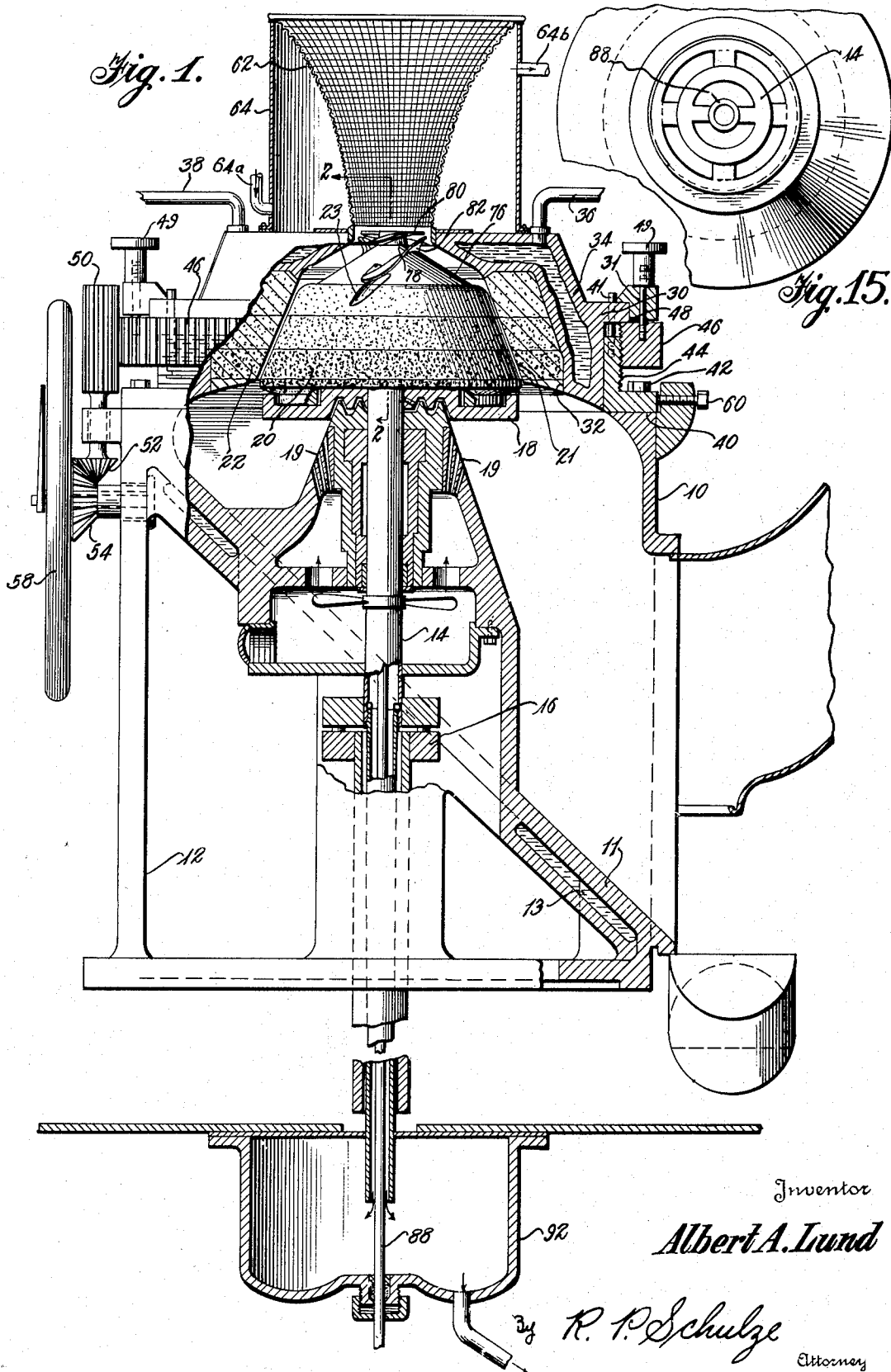
A. A. LUND

2,402,170

COLLOID MILL

Filed Oct. 13, 1939

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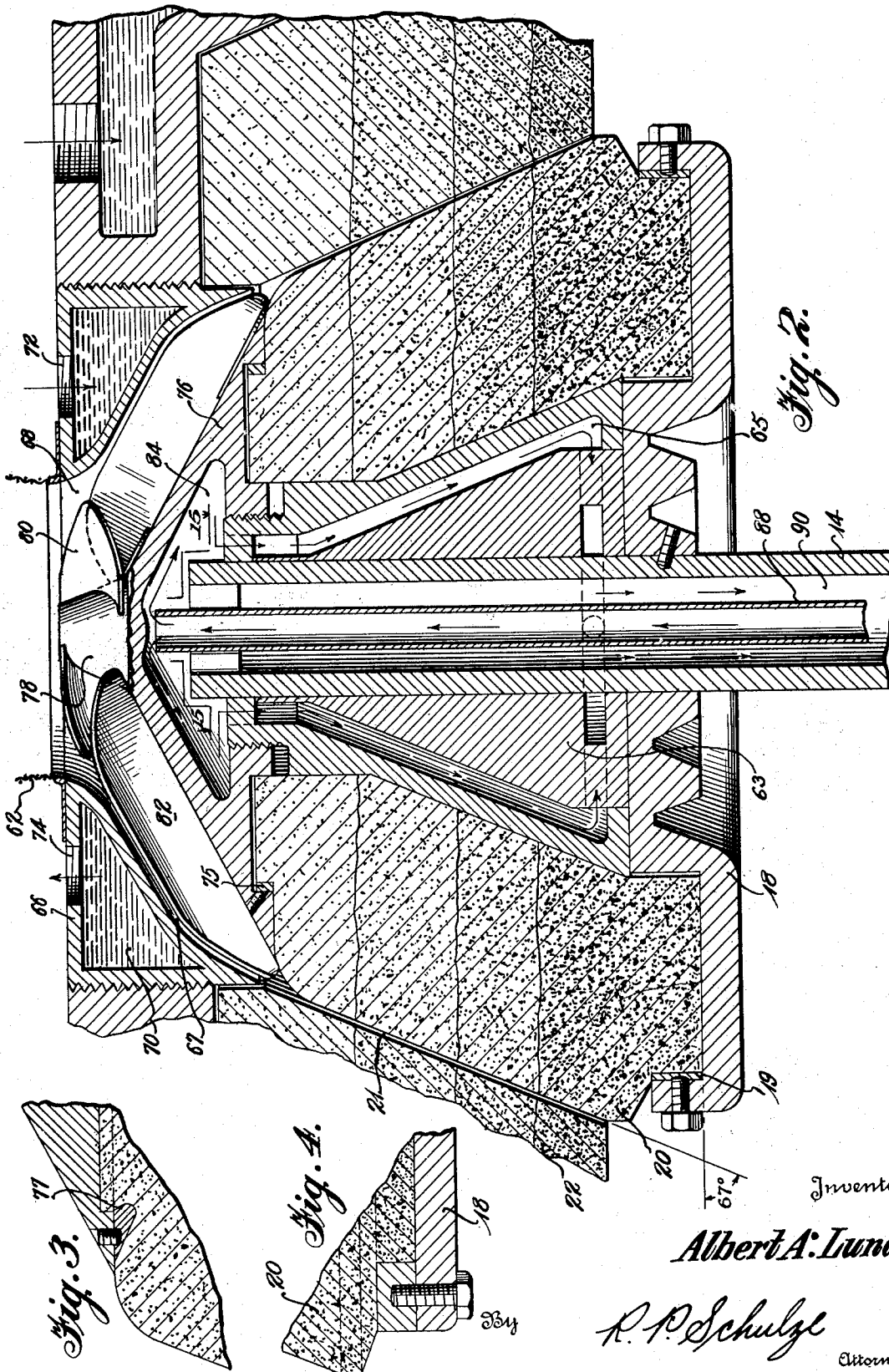
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Fig. 5.

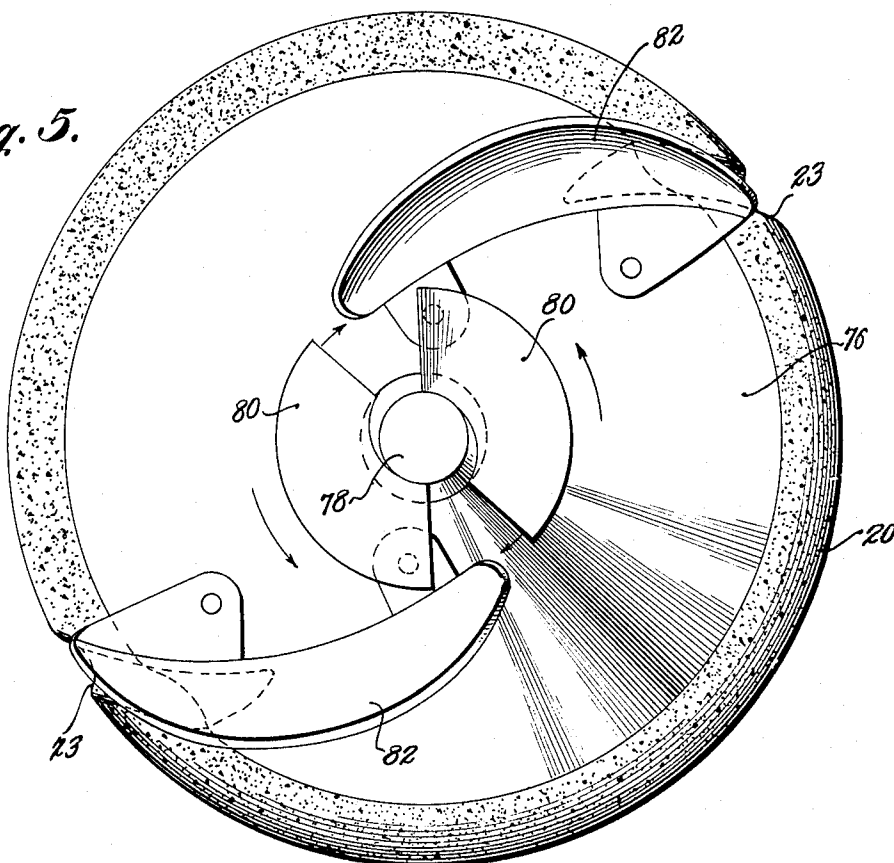
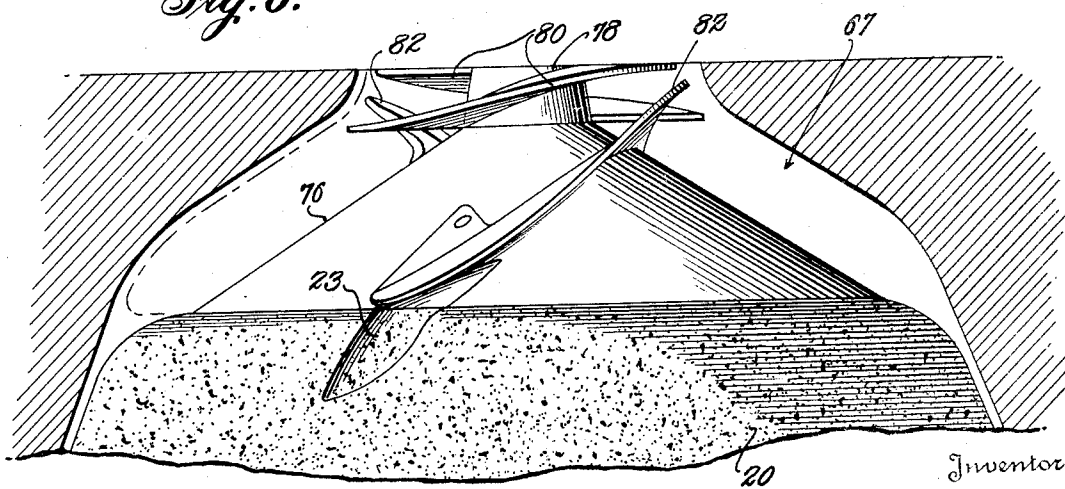


Fig. 6.



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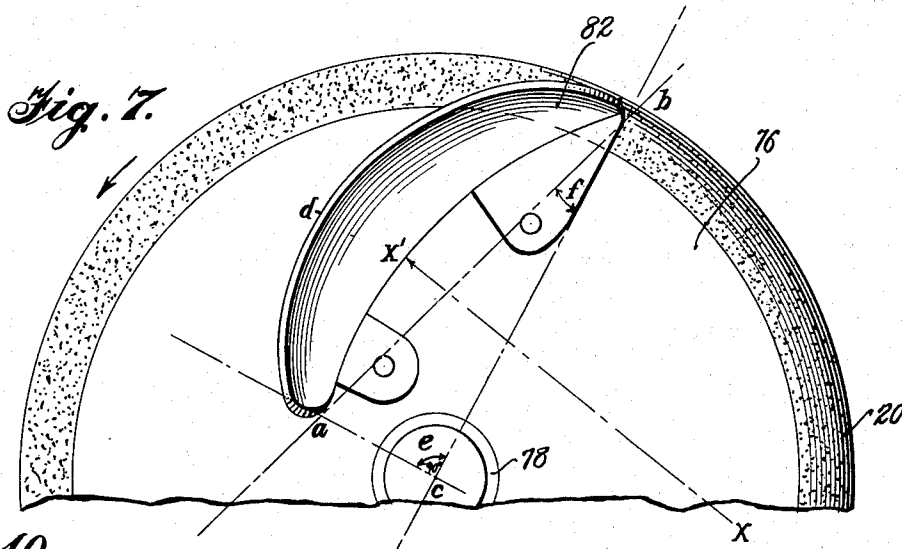
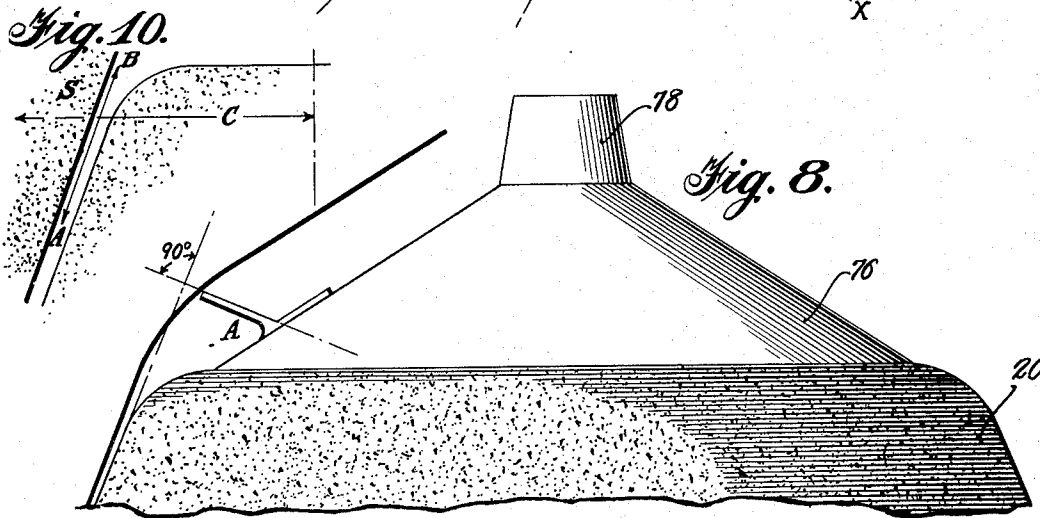
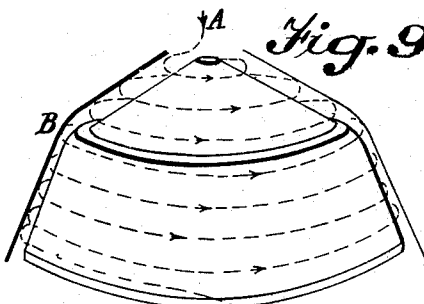


Fig. 11.

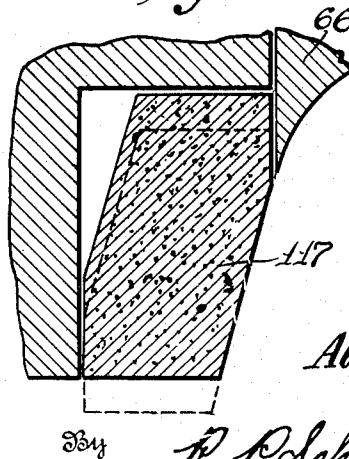
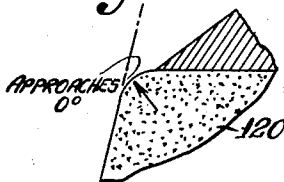


Fig. 12.



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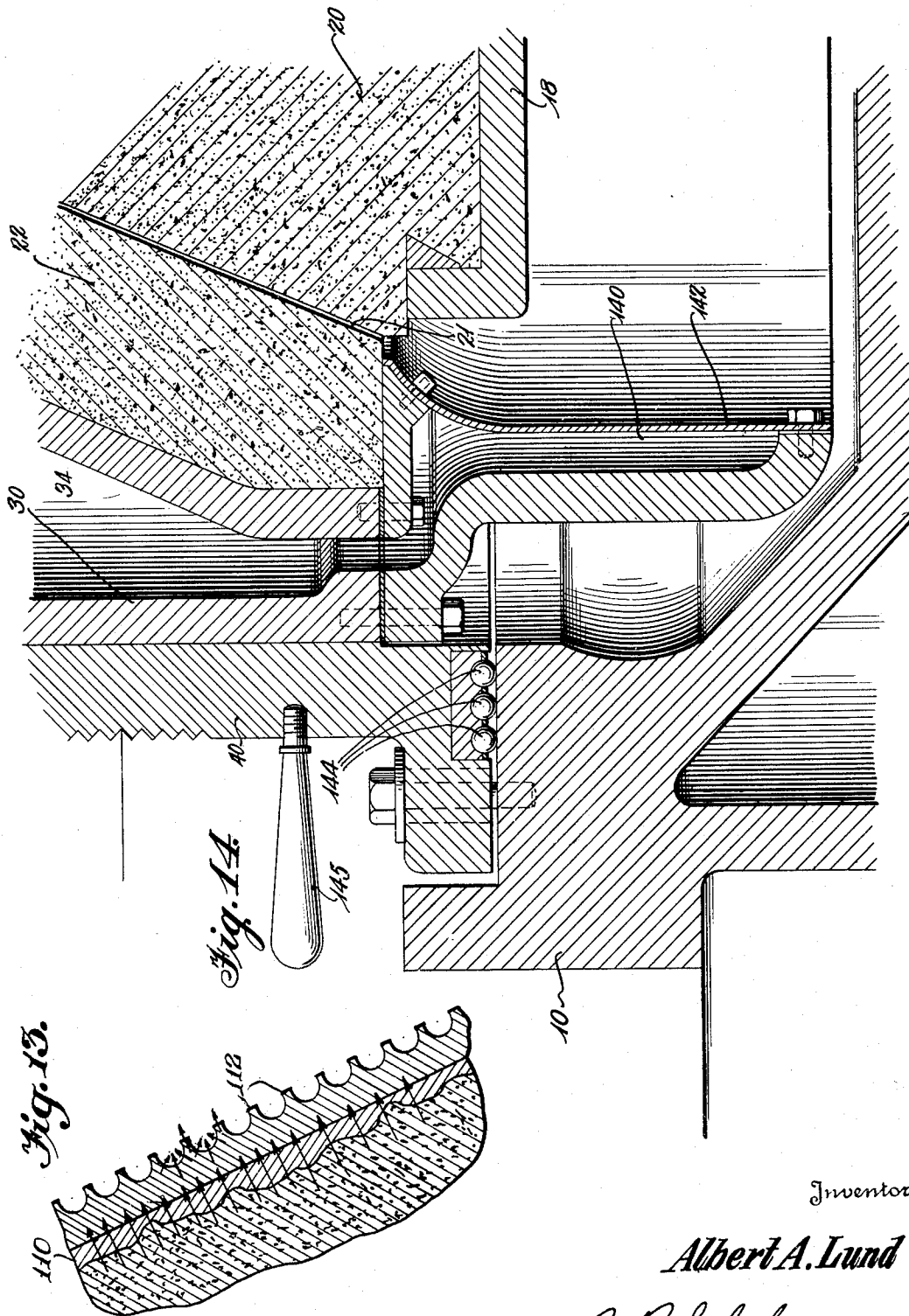
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UNITED STATES PATENT OFFICE

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COLLOID MILL

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8 Claims. (Cl. 241-66)

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This invention relates to improvements in colloid mills and more particularly embraces improvements upon colloid mills of the character disclosed in my co-pending application Serial No. 175,319, filed November 18, 1937, of which the present application is a continuation-in-part.

The colloid mills of the said application have as their general object the capturing of the frictional heat developed as the result of grinding and the controlled employment of such heat for treating material fed to the mill. It is an object of the present invention to provide a device designed to promote a more accurate control of frictional heat, more particularly, to concentrate the heat in the parts of the mill where the material is to be thereby treated and dissipating the same in parts where its presence is not advantageous.

Another object is to provide improved apparatus for feeding material into the mill and into the working faces of the grinding elements and further objects include the provision of a rotor and stator of novel composition, construction and arrangement whereby the material may be readily received between the working faces thereof and therein subjected to the desired treatment.

It is also an object to provide for minute relative adjustment of the rotor and stator to prevent undue wear on these parts and to regulate the grinding area whereby to further control treatment of material passed to the mill.

Other objects and advantages of the invention will be apparent from the following detailed explanation taken in conjunction with the accompanying drawings wherein preferred forms of the invention are exemplified.

In the drawings:

Fig. 1 is a side elevational view of a colloid mill as contemplated by the present invention, partly broken away;

Fig. 2 is an enlarged sectional view of the rotor and fragments of adjacent parts;

Fig. 3 is a fragment representing a modified manner of connecting the cone and rotor;

Fig. 4 is a fragment representing a modified manner of connecting the driving head and base of the rotor;

Fig. 5 is a plan view on an enlarged scale of the cone and rotor of Figs. 1 and 2, including the impeller blades;

Fig. 6 is a side elevational view of Fig. 5;

Figs. 7 and 8 are fragmentary plan and elevational views, respectively, illustrating operation of the impeller blade;

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Fig. 9 is a diagrammatic illustration of the induced helical travel in the feeding and grinding systems of the present apparatus;

Fig. 10 is a diagrammatic illustration of the working area of the grinding elements showing the forces acting thereon;

Fig. 11 is a fragmentary section of a mill head and stator illustrating the provision for wear compensation;

Fig. 12 is a fragmentary section illustrating the novel rotor lead;

Fig. 13 is an enlarged fragmentary sectional view illustrating a preferred manner of joining a grinding element and its collar as contemplated by the invention;

Fig. 14 is an enlarged fragmentary section through the mill head and stator showing a preferred manner of adjustably supporting the head and further illustrating a modified form of head; and

Fig. 15 is a plan view looking through rotor and taken on line 15-15 of Fig. 2.

Referring more in detail to the drawings wherein like numerals refer to like parts, the mill housing 10 which is adapted to substantially enclose the interior operating portions of the mill may have any suitable support such as a framework 12. A vertical drive shaft 14 extends upwardly into the housing 10 and is suitably driven by a motor (not shown) whose drive shaft is connected with the rotor drive shaft 14 through coupling 16. At its upper extremity, the drive shaft 14 is operatively connected to a drive plate 18 which in turn carries and drives the rotor 20 in a counterclockwise direction axially of the stator 22 to provide a grinding area 21 between the rotor and stator. A gaseous treating agent may be injected into the material emerging from the grinding area through apertures 19.

A head 30 is removably secured to the housing 10 in a manner to prevent fluid leakage and the stator 22 is supported interiorly of the head in operative relationship with the rotor 20 by means of a cove ring 32. The head 30 may if desired be provided with a water jacket 34 having a liquid inlet 36 and outlet 38 to regulate the transfer of heat from the stator 22 and the feeding area above the grinding or working surfaces comprising the grinding area 21.

The stator may be adjusted relative to the rotor by moving the head 30 both axially and transversely of the rotor whereby the desired clearance between the grinding surfaces may be maintained. For such axial adjustment of the stator, a threaded collar 40 is disposed annularly of the

head 30, generally in the plane of the stator and is secured to the housing 10 by bolts or the like 42 which pass through elongated slots arranged radially of the collar. The collar 40 is threaded at 44 to receive a micrometer ring 46 which ring may provide the sole support for the head. The periphery of the head 30 is seated in a groove 48 of the ring 31 and aligned by the pins 41. An oil film or other non-friction gaskets may be provided in the upper and lower portions of the groove 48 formed by the ring 31 and the micrometer ring 46 to facilitate sliding movement of the head periphery therein. The hand bolts 49 and ring 31 secure the head periphery 30 in adjustably fixed relationship to the micrometer ring 46 and thus to the collar 40 and housing 10. A spindle gear 50 and bevel gear 52, which meshes with a bevel gear 54 operated by a Vernier wheel 58 or the like, may be provided to control the micrometer ring 46 for effecting vertical adjustment of the stator relative to the rotor. Lateral adjustment of the stator may be effected through the medium of collar 40 and centering screws 60 to urge the collar 40 and the head 30 carried thereby in a horizontal plane transversely of the axis of the rotor 20.

Modified means for effecting lateral adjustment of the head eliminating the use of set screws 60 is illustrated in Fig. 14. Herein the head 30 may be mounted on ball bearings 144 and demountable handles 145 provided for engaging collar 40 for manually urging the head 30 in a direction to center the stator 22 relative to the rotor 20. Centering will be greatly facilitated if the rotor is revolving at a very slow speed, if necessary, by putting a pulley shaft on the motor or rotor shaft powered to a small variable speed motor.

The structure thus far described is generally as disclosed in my aforementioned co-pending application and is exemplary of a mill in which the improvements herein particularly contemplated and hereinafter described may well be embodied.

A feed funnel or hopper 62 is mounted on the head 30 above an opening leading into the grinding area of the rotor and stator and I have found that if a vase-shaped reticulated hopper having substantially parallel sides at its mouth immediately above the mill opening is provided, discrete material will not become caked along the side walls thereof where the flow is slow and the advantages of a straight sided cylindrical feed may thus be combined with the liberal head area of a conical hopper. If desired, a gas-tight jacket 64 may be secured to the head 30 surrounding the hopper and which may be supplied by means of inlet and outlet pipes 64a and 64b respectively with an inert gas such as CO₂ to perform the various functions of washing the material free of air, offsetting heat from the mill and cooling the entering material, and absorbing and removing any steam vapors which may rise from the mill into the entering material. Alternatively, steam and other vapors may be exhausted from the throat of the mill by creating a suction in jacket 64, such as at the pipe outlet 64b.

As shown in Fig. 2, head 30, may threadedly receive for axial adjustment a ceiling insert 66 which forms the ceiling of a feed chamber 67 disposed within the mill beneath an opening 68 in the insert communicating with the hopper 62. The member 66 is preferably hollow and provided with a passageway 70 for the circulation of a cooling medium through inlet 72 and outlet 74.

That part of the feeding system for force feed-

ing material into the grinding area includes a cone 76 mounted upon the table or top of the rotor and a smaller truncated supercone 78 above the cone 76 and positioned axially of the rotor. One or more spiral feeding knives 80 are carried by the frusto-cone 78 and corresponding thrust knives 82 are carried by the cone 76. The spiral knives 80 are positioned on the frusto-cone so as to parallel each other on opposite sides thereof and are inclined at an angle of approximately 60° to the axis of rotation. The knives 80 are further arranged so that their outer circumferences barely clear the sides of the mill inlet 68 and also so that their leading edges are approximately on a level with, but not projecting above, the head of the mill to avoid centrifugal throw against the hopper 62. Since the ceiling of the feed chamber 67 sharply inclines away from the inlet, the centrifugal throw of blades 80 causes the material to be deflected downwardly and prevents an upward creep which might contribute to clogging.

The spiral thrust knives 82 are so positioned below the spiral knives 80 that the trailing edges of each spiral knife immediately precedes the leading edge of a thrust knife whereby material is fed to the latter. The action is such that the spiral knives bite into the material entering the inlet 68 and force it downward under pressure in the path of the oncoming thrust knives which take the material from that point radially downward.

The outer edges of the knives 82 are arcuately contoured to clear substantially the entire area of the feed chamber 67, barely clearing the ceiling thereof so that material is prevented from riding over the knives and becoming compacted against the ceiling. As illustrated best in Figs. 7 and 8, the knife or knives 82 are positioned on the cone 76 in such a manner that at any point of elevation on the cone the arc of the knife meets the periphery of the cone plane taken horizontally at that point, at a substantially constant angle, which is always acute. In the preferred arrangement shown in Fig. 7, $a-x'-b$ represents the trailing edge of the blade in contact with the cone surface; $c-b$ is the generating line of the cone surface; d the leading edge of the blade contoured similarly to the ceiling; the distance $x-x'$ equals $a-b$; the angle e is about 90° but no more; and the angle f may be about 10° to about 30°. Fig. 8 shows at A a comparative preferred angular positioning of a knife 82. It will be apparent that a more upright positioning of the knife would provide excessive centrifugal throw and insufficient downward pressure.

At their lower edges, the knives 82 extend outwardly past the cone periphery and into the lead of the grinding area and may be arranged to feed directly into inclined feeder grooves 23 in the rotor with the upper portion of the latter rounded to meet the flow of material in a smooth continuous manner as shown in Fig. 6.

The cooling system of the mill is best shown in Fig. 2, wherein the rotor 20 may be axially bored to receive a core 63 preferably of a frusto-conical configuration corresponding with the rotor and of suitable material such as a metal of high heat conductivity. Formed within the core 63 is a continuous passageway 65 adjacent the interior wall of the rotor for the circulation of a cooling medium. The passageway 65 communicates with a passageway 84 formed in the cone 76 and a cooling liquid may be pumped upwardly or admitted under pressure through

a conduit 88 provided in the hollow drive shaft 14 into the cone passageway 84, thence into the rotor passageway 65 and out suitable openings into a return conduit 90 surrounding the conduit 88 to a sump 92 beneath the machine. If cold water were permitted to enter at the axis of the rotor, it would tend to emerge at the axis without displacing the centrifugally held wall of warm water at the outer surface of the core where cooling is needed and it is therefore important that the cooling liquid be forced into a passageway contiguous to the exterior of the core or rotor such as in the manner illustrated. Thus, frictional heat of the rotor may be dissipated and the cone 76, frusto-cone 78 and knives 80 and 82 in heat exchange relationship with the cone 76 and feed chamber 67 may all be cooled to prevent any deleterious results of the heat from grinding friction upon the material undergoing processing in the mill. While the rotor and cone cooling system is of utmost importance in controlling conditions within the mill, the ceiling heat exchange passageway 70, the stator cooling means 34 and the passageway 13 provided in the spillway 11 of the mill receiving treated material do contribute to successful operation.

The modification of Fig. 14 provides for a water jacket 140 depending from the head 30 and having a "Stellite" plate 142 or the like to serve as a chilling plate for material discharged from the grinding area. The entire jacket 140 may be bolted to the head 30 in communication with the cooling liquid circulating passageway 34 therein by means of bolts or the like with interposed gaskets. Fig. 14 illustrates another feature of the invention wherein the head 30 may be mounted on the housing 10 by means of ball bearings 144 in suitable races thus permitting the stator head 30 to be easily moved laterally in any direction with respect to the axis of rotation of the rotor by means of detachable handles 145 engaging collar 40, thus facilitating a direct manual centering of the rotor and dispensing with the mechanical set screws 60 of Fig. 1.

To promote conductivity between the stone rotor and stator and the metal wall of the heat exchange jackets, a feature of my invention illustrated in Fig. 13 provides for bonding the stone to the metallic wall by means of a relatively low melting point metal or metal alloy 110 which will fill the voids between the stone and the metal wall to securely bond the elements together and evenly distribute conductivity as indicated by the arrows in Fig. 13. In a modification incident to this feature fins or other projections 112 may be provided on the metal wall of the cooling jacket.

Colloid mill rotors are conventionally driven axially such that the driving stress is through metal inserts in the base of the rotor or on the stone adjacent a keyed-in drive shaft, the resulting torque making rotor breakage common. According to the present invention, the rotor may be driven peripherally and to further minimize breakage of the rotor, the cone 76 may be attached to the periphery of the rotor so that the rotor is banded both at the top and bottom and prevented from flying apart even if a crack should occur. This is best illustrated in Figs. 2, 3 and 4 wherein a band 19 is shrunk around the lower periphery of the stone and the drive plate is provided with a peripheral flange through which screws or the like may be passed to engage the band 19 and support the rotor 20 in driven position. In the modification of Fig. 4, a ring 75

11 may be shrunk on the stone and engaged at its bottom by screws passed through a flat drive plate. Similarly, a split ring or band 75 may engage the upper periphery of the rotor to provide support for the cone 76 and, if desired, an annular groove 77 may be provided in the rotor 20 below the table thereof to provide a peripheral seat for the cone 76.

As explained hereinbefore, the present invention provides for both axial and radial adjustment between the rotor and stator to control the grinding area between the working faces thereof and as a further feature of the invention shown in Figs. 11 and 12, provision is made for wear compensation in the rotor and stator to insure maintenance of a selected grinding area at all times. Fig. 11 represents a stator stone contemplated by my invention of the cross-sectional formation illustrated wherein lowering of the stone 117 from the solid to the dotted line position to compensate for wear on its working face leaves no gap in the continuity between the working face of the stone and the ceiling 66 and the effective working face remains normal. When the adjustable ceiling 66 hereinbefore described is employed it is possible to avoid lowering the entire head with resulting crowding of the impeller blades and the ceiling 66 may be raised to maintain normal impeller clearance.

Fig. 12 shows the present novel rotor lead whereby the feeding of the material into the working passage is facilitated by replacing the angle of the conventional bevel with an arc giving an entrance angle approaching 0°.

Fig. 9 will diagrammatically illustrate the very material difference in operation of the mill of the present invention over the operation of the normal vertical colloid mill whereby I am enabled to process liquids, oleaginous materials or solids, as for example, converting cocoa beans to chocolate liquor in a single operation. My rotor and cone are designed to effect a helical travel of the material being treated and as shown by the arrows in Fig. 9, there is an induced helical travel in the feeding system from A to B with the helix constantly expanding and an induced helical travel in the grinding system from B to C with the helix constantly expanding.

The induced helical spin is largely attributed to the fact that the working surfaces of the grinding elements are disposed at a very acute angle to the axis of rotation, the angle preferably being such that the resolution at the stator surface of the centrifugal force acting upon the material being ground produces a relatively weak component acting downwardly of the working surfaces to an extent sufficient to induce helical spin but insufficient to cause the ejection of the material in a direct trajectory. The generating angle of the working faces with respect to the axis of rotation presently employed for an 8½" base diameter rotor operating at about 3425 R. P. M. is 23° but since the centrifugal force acting upon the material is increased as the diameter and speed of the rotor are increased, the generating angle should be changed in designing different grinding elements. The principle is best illustrated in Fig. 10 wherein C represents the centrifugal force; S the stator working surface; and A—B the force components resolved from C by impact with S. The force B acts as a retardant, keeping material in the grinding passage for a longer period, hence inducing helical travel and increased grinding.

It is understood that the various forms and

phases of my invention herein illustrated and described are exemplary only of the broad principles of the invention defined in the following claims.

What I claim is:

1. A colloid mill comprising, a housing including a ceiling having an opening therein, a rotor and stator of vitrified bonded abrasive material disposed within said housing beneath the ceiling to receive material fed through said opening between their working faces, said rotor being axially bored, and a member having a passage-way for the circulation of a heat exchange medium received in said bore, said member being bonded to said rotor by a layer of plastic metal substantially filling the voids between the member and the rotor.

2. A colloid mill comprising, a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor, a cone carried by said rotor and a smaller frusto-cone coaxially mounted on said cone, said cone and frusto-cone extending into said feed chamber, a spiral feed knife mounted on said frusto-cone at an acute angle to the direction of rotation, and a thrust knife mounted on said cone at an acute angle to the direction of rotation and disposed below said spiral knife in position to receive material therefrom and force the same into the grinding area of the rotor and stator.

3. A colloid mill comprising, a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor, a cone carried by said rotor and a smaller frusto-cone coaxially mounted on said cone, said cone and frusto-cone extending into said feed chamber, a spiral feed knife mounted on said frusto-cone at an acute angle to the direction of rotation, and a thrust knife mounted on said cone at an acute angle to the direction of rotation and having its leading edge disposed below and spaced laterally from the trailing edge of said spiral knife to receive material from the latter and force it into the grinding area of the rotor and stator.

4. A colloid mill comprising, a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor and having an upper opening, a vase-shaped hopper for said opening having a mouth of parallel sides immediately above said opening to deliver material thereto without caking, a cone carried by said rotor and a smaller frusto-cone coaxially mounted on said cone, said cone and frusto-cone extending into said feed chamber, a spiral feed knife mounted on said frusto-cone at an acute angle to the direction of rotation and rotatable beneath the mouth of the hopper, and a thrust knife mounted on said cone at an acute angle to the direction of rotation and having its leading edge disposed below and spaced laterally

from the trailing edge of said spiral knife to receive material from the latter and force it into the grinding area of the rotor and stator, the said thrust knife operating within substantially the entire area of said feed chamber to prevent deposition of material therein.

5. A colloid mill comprising, a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor, a cone carried by said rotor and a smaller frusto-cone coaxially mounted on said cone, said cone and frusto-cone extending into said feed chamber, a spiral feed knife mounted on said frusto-cone at an acute angle to the direction of rotation, a thrust knife mounted on said cone at an acute angle to the direction of rotation and disposed below said spiral knife in position to receive material therefrom and force the same into the grinding area of the rotor and stator, and means for circulation of a cooling medium within said rotor and cone whereby to dissipate grinding friction heat from said feed chamber the said thrust knife being mounted on said cone in heat exchange relationship therewith.

6. A colloid mill comprising, a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor and having an upper opening, impeller means mounted upon said rotor for rotation therewith, the said impeller means being curved in plan and inclined to the axis of rotation and to the surface of the rotor in the direction of rotation for forcing material fed through said opening into the grinding area of the rotor and stator, said impeller means extending into said feed chamber sufficiently to traverse when rotated at least a major portion of the area of the feed chamber.

7. A colloid mill comprising a stator, a rotor rotatable at high velocity within said stator, a feed chamber above said rotor, a cone carried by said rotor and extending into said feed chamber, and a thrust knife having a working surface curved in plane, said knife being mounted on said cone at an acute angle towards the downwardly inclined surface of said cone to force material in said feed chamber into the grinding area of the rotor and stator.

8. A colloid mill comprising a stator, a rotor rotatable at high velocity within said stator, said rotor having a rounded lead edge at the entrance to the grinding area of the rotor and stator, a feed chamber above said rotor, a cone carried by said rotor and extending into said feed chamber, and a thrust knife having a working surface curved in plane, said knife being mounted on said cone at an acute angle towards the downwardly inclined surface of said cone to force material in said feed chamber into the grinding area of the rotor and stator.

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