Jan. 27, 1953 S. L. ABBOTT 2,626,746

CENTRIFUGE

Filed Oct. 25, 1946 4 Sheets-Sheet 1

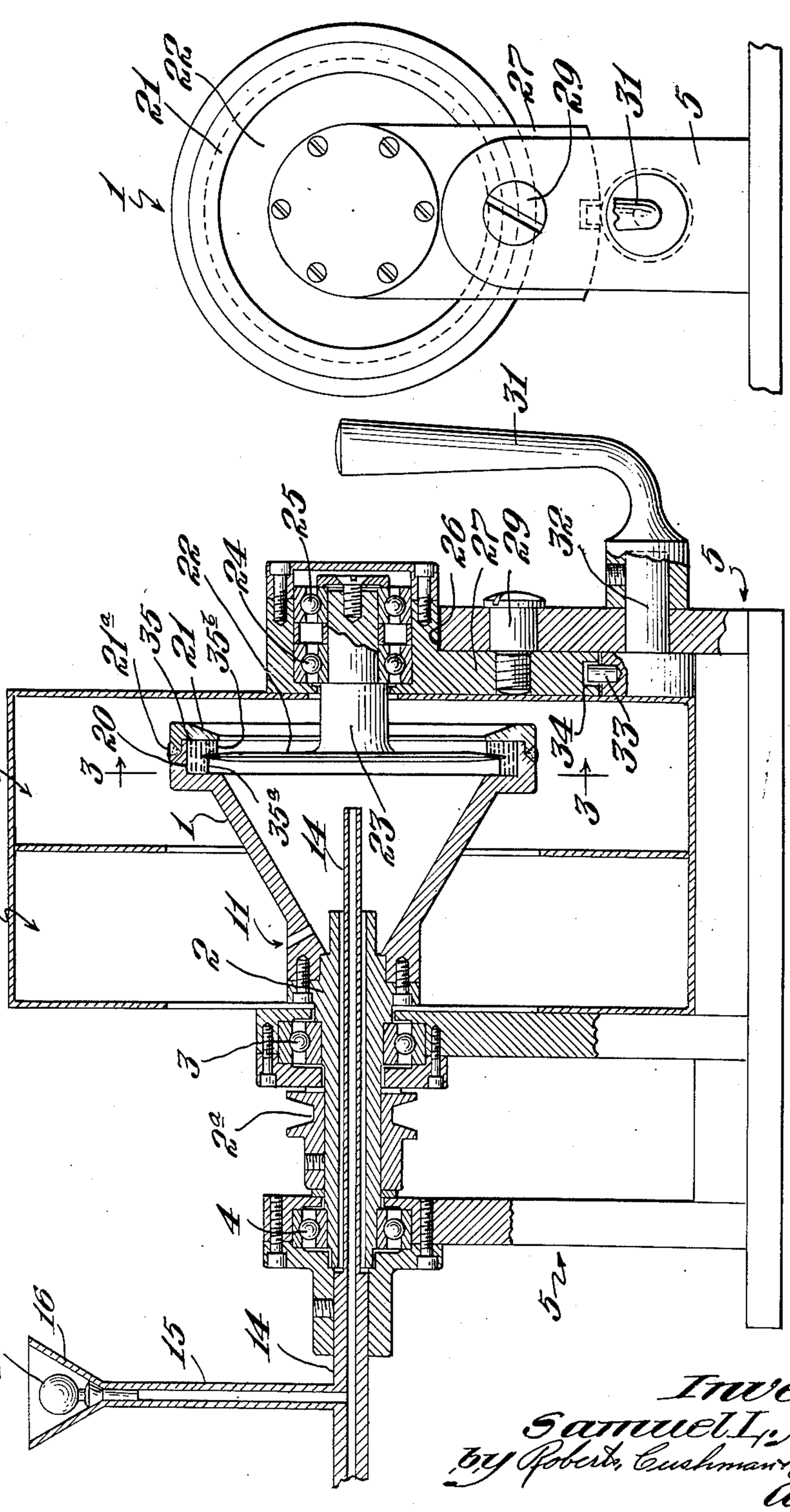

Fig. 1

Fig. 2

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CENTRIFUGE

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4 Sheets-Sheet 2

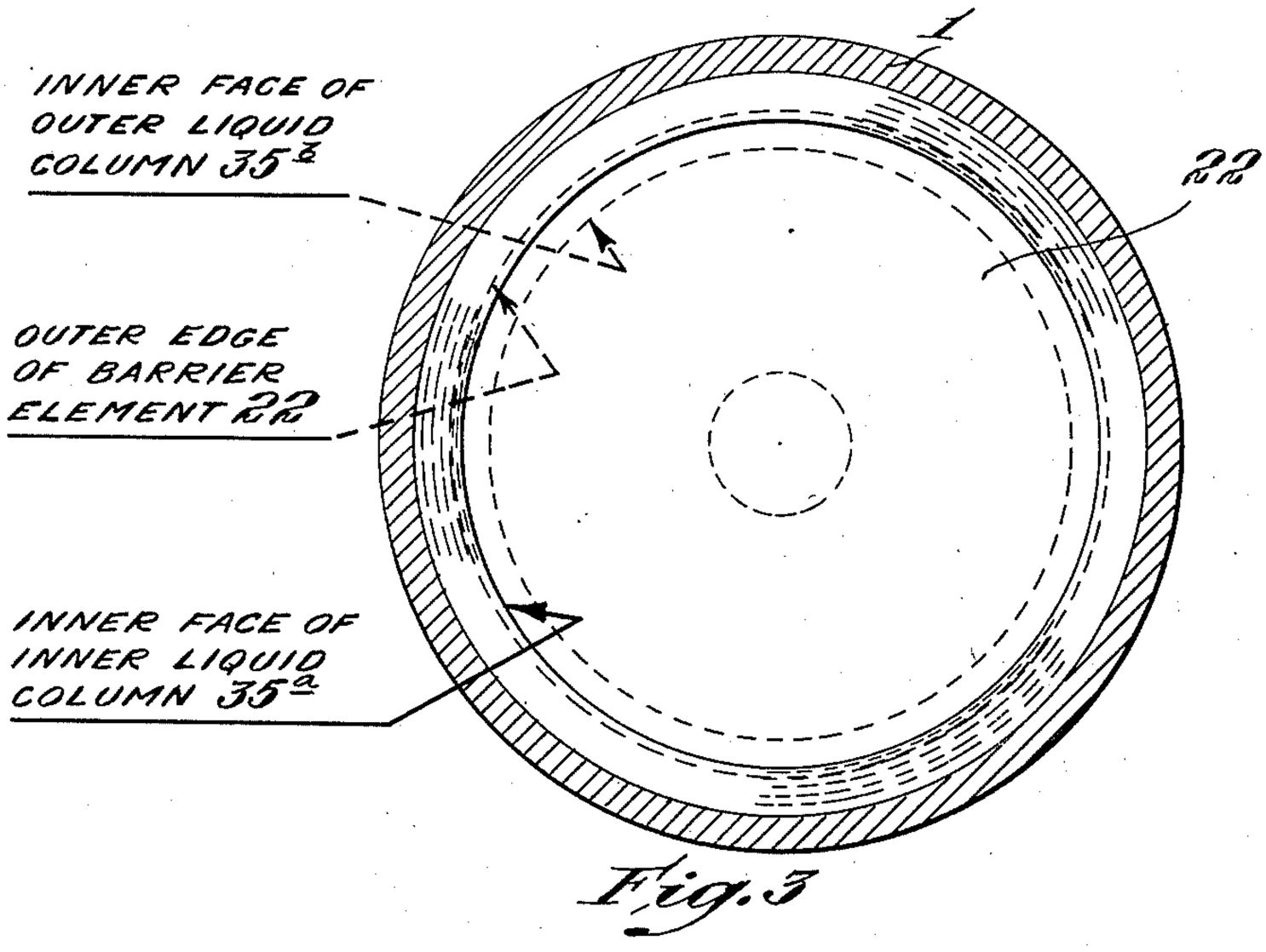

Fig. 3

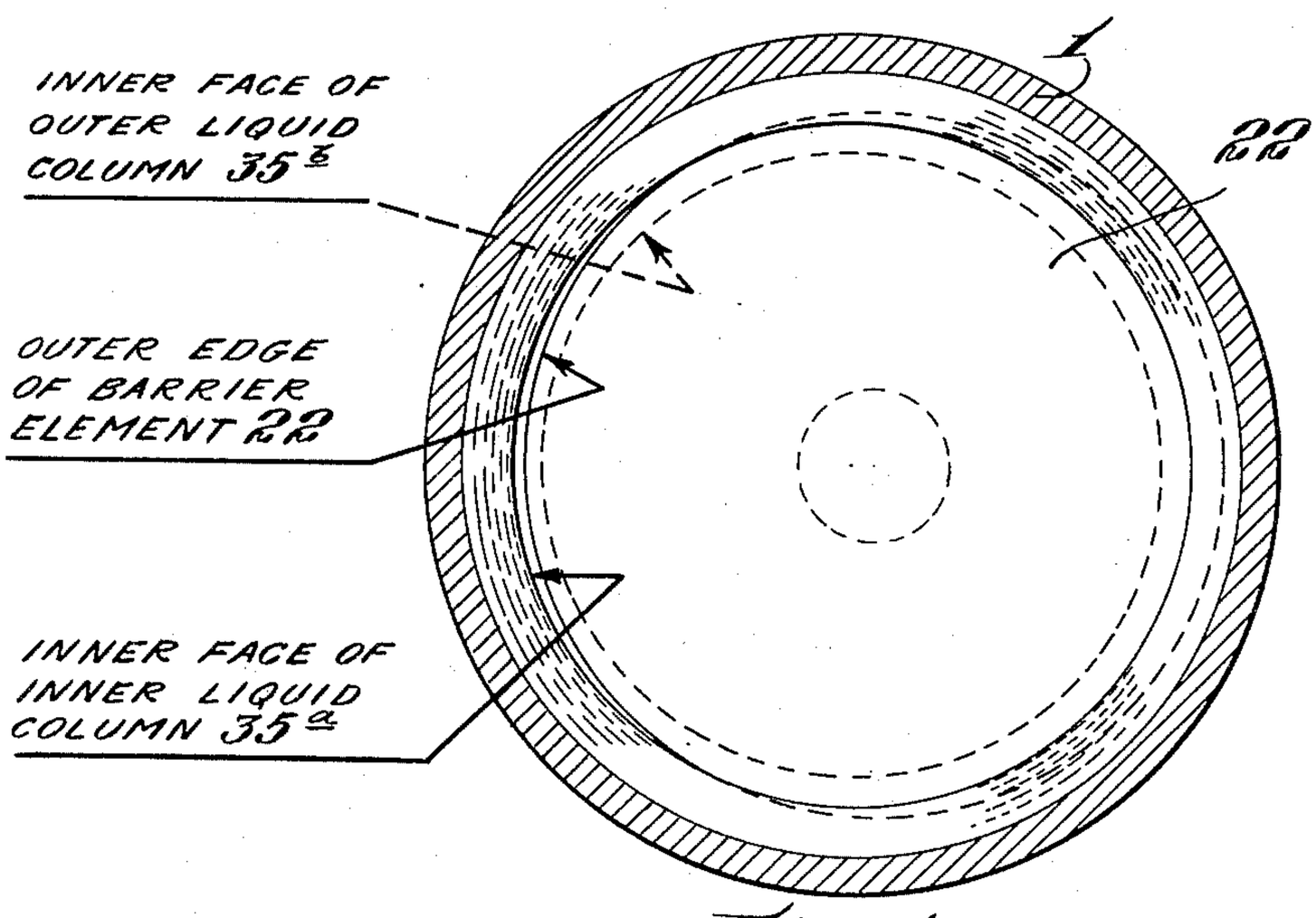

Fig. 4

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CENTRIFUGE

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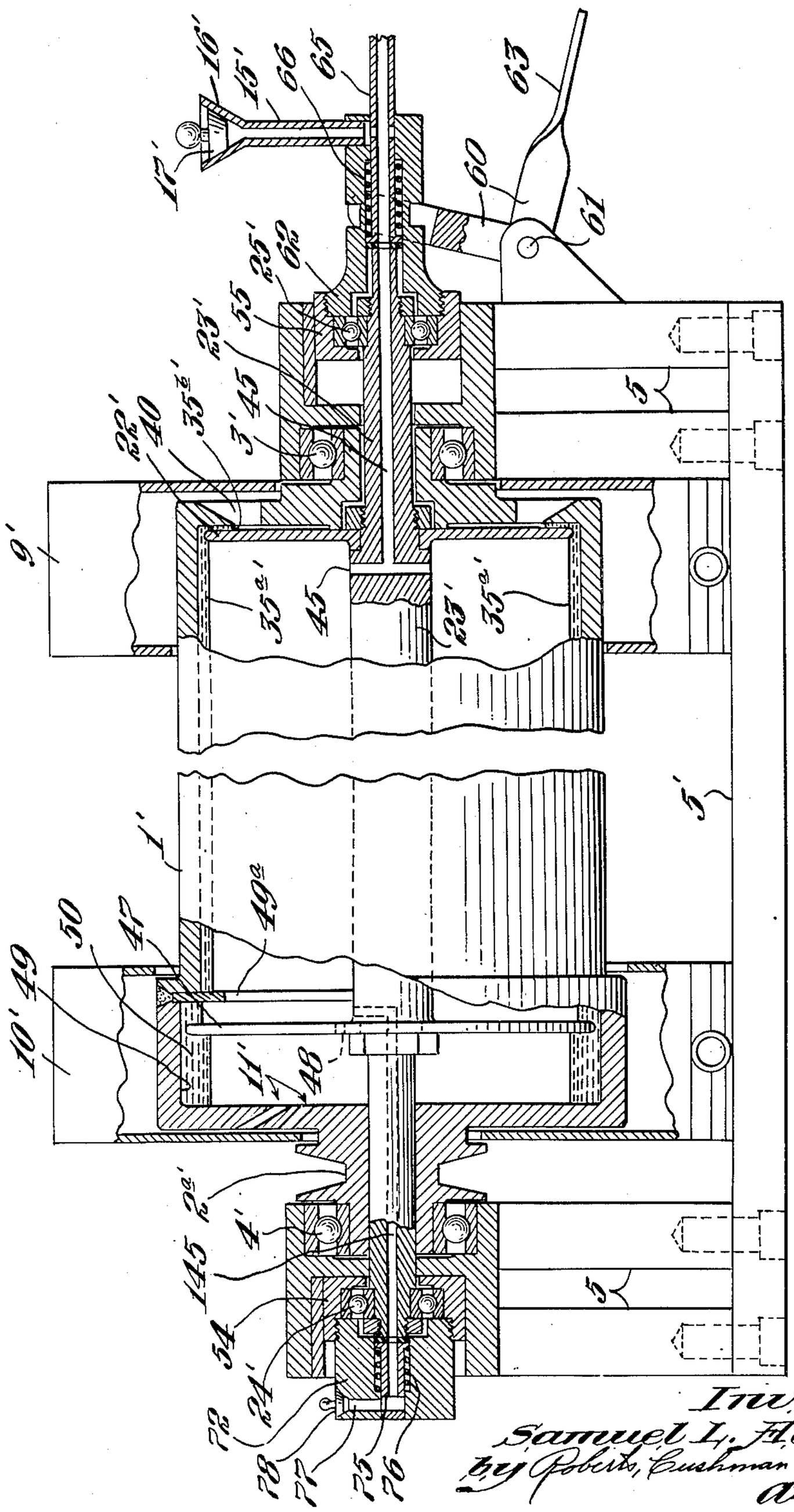

Fig. 5

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4 Sheets-Sheet 4

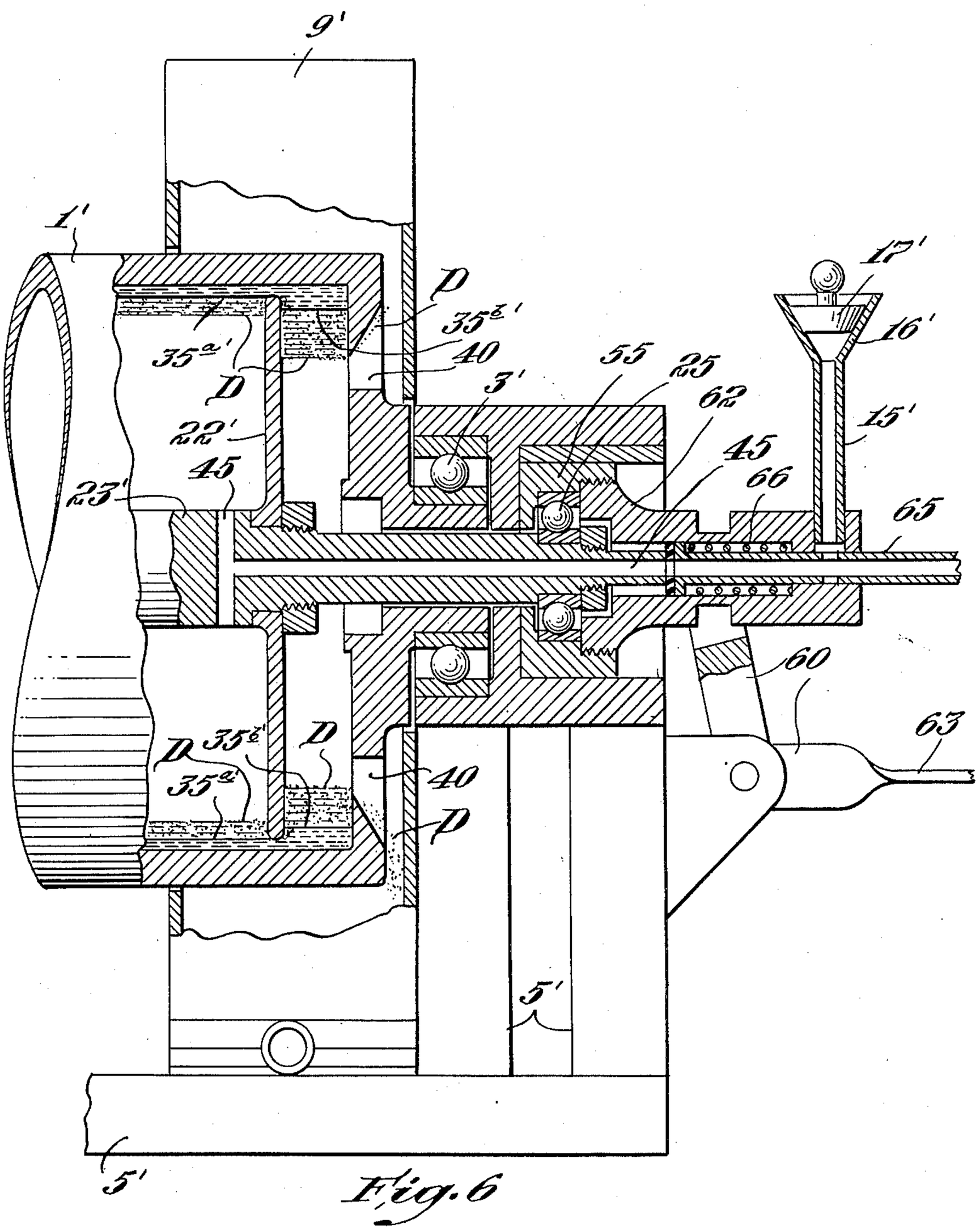

Fig. 6

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UNITED STATES PATENT OFFICE

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CENTRIFUGE

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Application October 25, 1946, Serial No. 705,664

11 Claims. (Cl. 233—14)

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This invention relates to a centrifuge of the type having a heavy liquid therein adapted to control the discharge of a separated component which has been separated by the centrifuge. It has previously been proposed to provide the container of a centrifuge with an annulus of a relatively heavy liquid of specific gravity greater than that of the heavier of the separated components, and to provide a disk or similar element extending into this liquid annulus so that the liquid annulus constitutes a seal consisting in effect of two liquid columns. Both of such liquid columns are subject to the action of centrifugal force, and the first or inner one of these columns is subject also to the pressure thereon of the heavier separated component within the container.

Such a construction embodying a liquid seal has the potential advantage of affording a way in which the separated component's exit from the container can be controlled without provision, in the rotating mechanism, of mechanical valves subjected to the destructive action of the separated component.

It is possible by suitable choice of the extent of penetration of the disk or similar element into the liquid annulus to obtain a sufficiently delicate balance between the net resistance to displacement of the two liquid columns of the annulus and the pressure within the container that the separated component will be more or less continuously discharged from the container through the liquid annulus. However, I have discovered that when such a delicate balance is secured there is a tendency for the liquid seal to separate the heavier component according to its particle size, discharging the finer particles of this heavier component while holding back the larger particles and thus causing these larger particles to accumulate in the container.

A principal object of the invention is to provide a centrifuge having a liquid seal adapted to control the discharge of a separated component, avoiding the disadvantages of prior liquid seals, and requiring, as the apparatus is set up for use, less delicate balance of the liquid columns of the seal and the pressure within the container, or less accurate regulation of the extent of contact of the disk or similar element with the liquid annulus.

A further object is to provide for accurate regulation of the discharge of a separated component from the container of the centrifuge while the apparatus is running.

Other objects of the invention and advantageous features will be apparent from this specification and its drawings wherein the invention is described by way of example.

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In the drawings:

Fig. 1 is a diagrammatic vertical cross sectional view of a centrifuge embodying this invention, the centrifuge being shown as rotating in the operation of separating the material in the container into the lighter and heavier components, but this material being omitted from the figure for clarity of illustration;

Fig. 2 is a right end elevation of the centrifuge of Fig. 1 with some of the parts omitted;

Fig. 3 is a diagrammatic view in the nature of a vertical section taken on the line 3—3 of Fig. 1 in one adjustment of the centrifuge;

Fig. 4 is a view similar to Fig. 3 showing a different adjustment of the centrifuge;

Fig. 5 is a view similar to Fig. 1, showing another form of centrifuge embodying the invention. In Fig. 5 the centrifuge, though shown as rotating, is shown as adjusted to shut off discharge of the heavier separated component which is omitted from this figure; and

Fig. 6 is a vertical cross sectional view of the right end of the centrifuge of Fig. 5, to a larger scale, showing the heavier separated component and showing the centrifuge adjusted to cause discharge of this component.

The invention is applicable to the separation of various mixtures of liquids, gases, solids and any of these. In this application the invention will be described by way of example as applied to a centrifuge for separating dirt from the other components of wool scouring liquor.

It is an advantage of the invention that wool scouring liquor can be effectively treated by the improved centrifuge even though the liquid contains a large quantity of dirt. It is thus unnecessary to employ preliminary settling of the liquor for the purpose of eliminating part of the dirt before the centrifuging operation.

In addition to dirt, wool scouring liquor includes alkaline water, wool grease and soap fats. The dirt is the heaviest of these components, and in a centrifuge the dirt tends to occupy the outer portion in the rotating container, the water is lighter and tends to occupy a position inwardly of the dirt, and the grease and fats are still lighter and occupy the innermost position.

The centrifuge of Figs. 1 to 4, inclusive, is shown as comprising a rotating container 1 affixed to a rotatable tubular shaft 2 which is mounted in ball bearings 3 and 4 in a suitable frame indicated generally by the reference character 5.

The container and its tubular shaft 2 may be

mounted to rotate on whatever axis is desired, and by way of example, these are shown as mounted for rotation on a horizontal axis. The container may be rotated through a pulley 2a at the appropriate speed.

A suitable casing substantially surrounding the rotating container is divided into appropriate sections for reception of the separated components of the material as these leave the rotating container.

The container may have as many exits as there are components into which it is desired to separate the material, for instance, there may be exits adapted to discharge respectively the dirt, the water, and a mixture of the grease and fats, and the casing could then be provided with suitable compartments for the reception of these separated components. For simplicity of illustration, the container is shown as provided with exits for the dirt on the one hand and for the water and grease and fats on the other hand, the casing including a compartment 9 for reception of the dirt and a compartment 10 for reception of the water and grease and fats.

Thus one or more exits 11 (one being shown in Fig. 1), located relatively close to the axis of the container, discharge the water and grease and fats into the compartment 10. The dirt is discharged into the compartment 9 through a mercury seal at the larger diameter right-hand portion of the container, more fully described below.

The material to be treated may be continuously fed into the container through a stationary axially extending tube 14. A vertical branch 15 of the tube 14, provided at its top with a funnel 16 and removable stopper 17 is adapted for use in supplying the sealing liquid to the container at the beginning of a run, before material to be treated is fed in through the tube 14.

As shown in Fig. 1 the larger diameter right-hand portion of the container is shaped to provide an annular pocket 20 adapted to hold the sealing liquid. The outer margin of the pocket 20 is defined by an annular rim portion 21 which is securely welded to the container at 21a to prevent loss of the sealing liquid at this joint.

A generally circular barrier element 22 having for example a plate-like form as shown in Fig. 1 is adapted to make contact with the annulus of sealing liquid, and so prevent unrestricted exit of the material from the container.

Preferably the barrier element 22 is rotatably mounted, and as herein illustrated, is shown as integral with a shaft 23 which rotates in ball bearings 24 and 25 carried by a housing 26 on a plate 27. Rotation of the barrier element is most easily obtained by merely allowing it to be rotated by its frictional contact with the sealing liquid which in turn is rotated by the container.

The sealing liquid 35 which constitutes the annular seal in the pocket 20 has a greater specific gravity than the heavier component which is separated by the centrifuge, and in the typical case in which dirt is the heavier component, this sealing liquid may consist of mercury, carbon tetrachloride, or other suitable liquid that is heavier than the dirt.

The portion of the liquid annulus lying inside or to the left of the barrier element 22 of Fig. 1 constitutes in effect one liquid column 35a and the portion of the sealing liquid that lies outside or to the right of this barrier element 22 constitutes in effect another liquid column 35b, and these two liquid columns react in the manner of the two liquid columns of a U-tube. Both liquid columns are subject to and tend to be depressed by the action of centrifugal force, and inner column 35a, but not the outer column 35b, is subject also to the depressing action thereon of the contents of the container. The height of the inner column 35a with relation to the peripheral path of the barrier element determines at any given speed of rotation the amount of pressure that must be developed within the container in order to displace the inner face of the inner column radially outwardly to or slightly beyond the periphery of the barrier element 22. With such displacement of the inner column the heavier separated component can work outwardly beyond the periphery of the barrier element 22, pass the barrier element 22, and then, because of lesser specific gravity than the sealing liquid, float inwardly radially through the other column 35b.

Each of the illustrated embodiments of the invention provide means operable during rotation of the container and independently of the degree of pressure within the container, for causing a relative lowering of the inner column of the sealing liquid with relation to at least a portion of the barrier element, permitting discharge of the separated component past the sealing liquid and barrier element to be accurately regulated.

In the device of Figs. 1 to 4 such means involves provision for establishing a non-concentric relation between the rotating container and the barrier element. A relatively small amount of non-concentricity is effective for the purposes of this invention.

Referring to Figs. 1 and 2, the plate 27, carrying the bearings in which the barrier element rotates, carries a stud 29 adapted to rotate or pivot in a vertical portion of the frame 5. A handle 31 is fixed to a stub shaft 32, rotatable in the frame 5 and carrying a pin 33 which engages in a recess 34 in the plate 27. Tilting of the handle 31 will thus tilt the plate 27 slightly about the axis of stud 29 and thus cause a relative displacement of the centers of the container and barrier element.

In normal running, when the handle 31 is not engaged by the operator, the barrier element 22 assumes a concentric relation to the rotating container, as shown diagrammatically in Fig. 3. By means of the handle 31 the barrier element 22 can be held in more or less non-concentric positions with respect to the container, such for instance as shown diagrammatically in Fig. 4.

Although in its broader aspects the invention is not limited to operating with such height of sealing liquid with respect to the barrier element as to prevent discharge of the heavier separated component when the container and barrier element are in their normal relative positions, it is an advantage of the invention that it can be thus used. Thus in the device of Figs. 1 to 4, the amount of sealing liquid and the height of its inner column with respect to the periphery of the barrier element in normal running is preferably, although not necessarily, sufficient to prevent exit of the heavier separated component when the container and barrier element are in their normal concentric relation.

Tilting of the handle 31 of the device of Figs. 1 to 4 then establishes a non-concentric relation between the container and barrier element, such for instance as diagrammatically shown in Fig. 4, with the result that in one arc of the path of the annular sealing liquid the extent of contact of the barrier element with the sealing liquid is reduced and there is thus a relative lowering of the level of the inner column 35a with relation to a portion of the path of the periphery of

the barrier element. When this relative lowering has been carried far enough, the arc where this takes place can then constitute a zone of continuous exit of the heavier separated component from the container. By suitable adjustment of the handle sufficient flow of the heavier separated component can be caused through this place of exit to insure departure of the entire heavier separated component without holding back the larger sized particles of this heavier separated component.

All particles of the heavier separated component, urged by centrifugal force against the wall of the container, come in turn to this place of discharge where the relative lowering of the inner column of liquid with relation to the path of the periphery of the barrier element has taken place. Thus, without the use of valves or unduly restricted passages, that are subject to becoming plugged by the material being separated, there is provided a place of discharge for the heavier separated component where this component may leave the container without any substantial tendency to be subdivided according to its particle size.

It should be understood that while Fig. 4 shows diagrammatically one of the possible non-concentric relations between the barrier element **22** and bowl **1**, this figure should not be taken as showing accurately the exact position of the sealing liquid in the pocket of the container, because this is variable. Also some turbulence probably develops in the sealing liquid, especially in the region of the discharge of the heavier separated component.

In the centrifuge of Figs. 5 and 6 the relative lowering of the inner column of sealing liquid is a relative lowering with respect to the whole of the peripheral path of the barrier element, instead of only a portion of such path as in Figs. 1 to 4, and is brought about by temporarily drawing off liquid from the inner column into the outer column. A preferred form of mechanism for this purpose includes provision for causing a relative displacement of the barrier element and the container for the sealing liquid in an axial direction.

The device of Figs. 5 and 6 includes many parts which are similar to and correspond to those of the device of Figs. 1 to 4, and these parts in general are indicated by the same reference characters with primes added thereto.

In the device of Figs. 5 and 6 the container **1'** is shown as generally cylindrical in shape and as having opposite closed ends, and with such cylindrical container, the mercury or other sealing liquid can, as shown, cover substantially the whole inner cylindrical wall portion of the container, this body of sealing liquid constituting the left or inner liquid column **35a'**.

The right end of the container **1'** is provided with openings **40** for the discharge of the heavier separated component, these openings being spaced inwardly from the inner cylindrical wall of the container a sufficient distance to confine within the rotating container the right-hand or outer liquid column **35b'** of the sealing liquid.

The compartments **9'** and **10'** for the heavier and lighter separated components respectively, are shown as located at the opposite ends of the cylindrical container, to receive these respective components from the openings **40** in the right-hand end of the container and from one or more openings **11'** in the left-hand end of the container.

The shaft **23'** for the disk **22'** which constitutes the right-hand barrier element is extended throughout the length of the container and beyond the both of its ends, and is provided with a passage **45** for entrance into the container of the material to be separated and also the body of mercury or other sealing liquid that cooperates with the barrier element **22'**.

Shaft **23'** of the device of Figs. 5 and 6 has its ball bearings **24'** and **25'** mounted, respectively, in slide blocks **54** and **55** at the left and right ends of the frame.

A non-rotating collar **62**, screw-threaded into the slide block **55**, surrounds the right end of shaft **23'** and holds a non-rotating tube **65** adapted to be connected to a supply of material to be separated, a spring **66** yieldingly holding the tube **65** against the hollow shaft **23'**. The vertical tube **15'**, formed at its top as a funnel **16'**, and provided with a removable stopper **17'**, communicates with tube **65** and hence with passage **45** of shaft **23'** to supply mercury to the interior of the container.

A further barrier element, shown as a further disk **47** is preferably provided near the left end of the container, fastened to the same shaft **23'** that holds the barrier element **22'**. One or more holes **48**, close to the axis of rotation are provided in order to allow the lighter separated component to pass the disk **47** on its way to the exit hole or holes **11'**. As shown in Fig. 5 the container is provided with an enlarged annular pocket **49** into which the periphery of the left barrier disk **47** extends, and a further body of mercury or other sealing liquid **50** is provided in the pocket **49** and cooperates with the disk **47** as a seal. This body of sealing liquid **50** is sufficiently large and the penetration thereof of the disk **47** is sufficiently deep so that during operation of the centrifuge no material escapes around the periphery of the disk **47**, regardless of the adjustment of the apparatus. An annular shoulder **49a** (Fig. 5) separates the body of sealing liquid **50** from the inner column **35a'** in all adjustments of the apparatus.

A non-rotating collar **72**, screw-threaded into the slide block **54**, surrounds the left end of shaft **23** and holds a non-rotating tube **75** which is pressed by a spring **76** against the left end of shaft **23**. The left end of shaft **23** is provided with a passage **145** communicating with the interior of the container in the region of the pocket **49**, and a passage **77** in the slide block **72**, communicating with tube **75** and passage **145**, permits mercury to be supplied to the pocket **49** preparatory to operating the centrifuge. The opening to passage **77** may be closed by a removable stopper **78** after the mercury has been supplied.

As in the device of Figs. 1 to 4, the barrier element **22** of Figs. 5 and 6 is preferably allowed to rotate by its frictional engagement with the sealing liquid, and in this case the second disk **47** rotates, in a similar manner.

A bell crank **60**, pivotally mounted at **61** on the frame of the machine, has one of its arms forked to engage the collar **62** and the other arm of bell crank **60** is shaped to provide a handle **63** by which the bell crank can be turned by the operator and the slide block **55**, shaft **23'**, the two barrier elements **22'** and **47** and slide block **54** shifted lengthwise of the container.

In the normal running of the container the parts may for example have the position shown in Fig. 5, in which the right-hand column of

liquid 35b' is relatively narrow in axial extent, and the height of the sealing liquid constituting the inner column 35a' is high enough with respect to the periphery of disk 22' to prevent discharge of the heavier separated component, for example the separated dirt.

Shifting the shaft 23' and the barrier element 22' to the left in the device of Fig. 5 tends to lower the level of the inner sealing liquid column with relation to the periphery of the barrier disk 22', and upon sufficiently shifting the disk 22' to the left, for instance as to the position shown in Fig. 6, the level of the inner column 35a' is lowered sufficiently with relation to the periphery of the disk 22' to permit discharge of the dirt D past the disk.

It will be understood that because the radially inner face of the inner column of sealing liquid is subject to the pressure of the contents of the container and the radially inner face of the outer column 35b' is not subject to the pressure of the contents of the container, the outer column 35b' will extend to a greater height than the inner column in all adjustments of the disk 22'. Consequently when the disk 22' is shifted over toward the left, the space for the right-hand or outer column 35b' is enlarged in an axial direction, and sealing liquid will flow from the left of the disk 22' over to the right of the disk 22'. The column 34b' may tend to fall somewhat because the space at the right of the disk is increased, but the height of column 35b' will not fall below the height of column 35a' because the pressure upon column 35a' is larger than the pressure upon column 35b'.

During the shifting of the disk 22' either to the left or right, the other disk 47 shifts accordingly, but does not affect the sealing liquid 35a', the disk merely shifting back and forth in its own body of sealing liquid 50 which, as indicated above, is sufficiently deep to prevent exit of material in any adjustment of the disks.

Preferably the hole or holes 48 for the passage of the lighter separated component through the disk 47 are relatively small, and offer substantially more resistance to passage of this material than do the hole or holes 11' at the left end of the centrifuge container. With this construction a material amount of the thrust of the container contents against the right-hand disk 22' is counterbalanced by the thrust of the container contents against the left-hand disk 47, thus materially reducing the axial thrust of the container against the lengthwise shiftable barrier elements and shaft 23'.

It will now be apparent that while I have shown in Figs. 1 to 4 a means for effecting a relative lowering of the inner column of sealing liquid by relative adjustment of the barrier element and container in a direction transverse to the axis of rotation, and I have shown in Figs. 5 and 6 means for effecting a relative lowering of the inner column by drawing off liquid from this column into the outer column by relative adjustment of the barrier element, the relative lowering could, if desired, be secured by a combination of these several means.

In either of the illustrated devices the centrifuge may be kept running with its container and barrier element appropriately adjusted to afford a continuous discharge of the heavier separated component, or the parts may be restored to an adjustment such that the heavier separated component is not discharged, and then only adjusted to a discharging relation at intervals as desired.

If the amount of sealing liquid and height of the inner column thereof is sufficient to permit some continuous discharge of the heavier separated component in the normal concentric adjustment of Figs. 1 to 4, or in the normal right-hand position of Figs. 5 and 6, intermittent adjustment of the parts to permit a greater discharge of the heavier separated component will have the effect of flushing out any larger-particle portions of the heavier separated component which may have been held back by the liquid seal in the adjustment permitting some continuous discharge.

For a given set of operating conditions the container and barrier element may be fixed in their desired adjusted positions relative to each other.

Also, while for convenience of construction of the apparatus, the barrier element is preferably truly circular, as shown in the drawings, this is not essential to the broader aspects of the invention.

I claim:

1. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including a sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a barrier element, marginal portions of which dip into the sealing liquid defining connected inner and outer columns of the sealing liquid in the container, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a central shaft for the barrier element, a mounting permitting said shaft and barrier element to be shifted bodily relative to a wall of the container during rotation of the container to cause a relative lowering of the level of the inner column with relation to at least a portion of the peripheral path of the barrier element, and operating mechanism having a portion outside of the container and not partaking of the rotation of the container, said operating mechanism being connected to said shaft to effect such shift of the barrier element during rotation of the container.

2. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a rotatable barrier element, marginal portions of which dip into the sealing liquid defining connected inner and outer columns of the sealing liquid in the container, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a mounting for the container and a mounting for the barrier element, one of said mountings being shiftable relative to the other transversely of the axis of the rotating container, thus permitting a relative displacement of the axes of rotation of the container and the barrier element to cause a relative lower-

ing of the level of the inner column with relation to a portion of the peripheral path of the barrier element.

3. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a barrier element in contact with the sealing liquid, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a mounting for the container and a mounting for the barrier element, one of said mountings being shiftable relative to the other transversely of the axis of the rotating container, thus permitting a non-concentric relation between the rotatable container and the barrier element whereby the extent of contact of the barrier element with the sealing liquid is reduced in an arc of the path of the sealing liquid.

4. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the opening including sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a rotatable barrier element in contact with the sealing liquid, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a mounting for the container and a mounting for the barrier element, one of said mountings being shiftable relative to the other transversely of the axis of the rotating container, thus permitting a non-concentric relation between the rotatable container and the rotatable barrier element whereby the extent of contact of the barrier element with the sealing liquid is reduced in an arc of the path of the sealing liquid.

5. A centrifuge comprising a rotatable container for receiving material to be separated into constituents of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including sealing liquid having a specific gravity greater than that of the heaviest component to be separated, a generally annular pocket for the sealing liquid, and a generally circular barrier element substantially penetrating the sealing liquid in said pocket, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a mounting for the container and a mounting for the barrier element, and mechanism for shifting one of said mountings relative to the other transversely of the axis of the container during rotation of the container to adjust the relation between the axis of the container and the center of the barrier element.

6. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a rotatable barrier element, marginal portions of which dip into the sealing liquid defining connected inner and outer columns of the sealing liquid in the container, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, a mounting for the container and a mounting for the barrier element, the mounting for the barrier element being shiftable transversely of the axis of the rotating container, thus permitting a relative displacement of the axes of rotation of the container and the barrier element to cause a relative lowering of the level of the inner column with relation to a portion of the peripheral path of the barrier element.

7. A centrifuge comprising a rotatable container for receiving material to be separated into components of different specific gravity, said container having an opening through which may be discharged a separated component, a seal to obstruct exit of a separated component through the discharge opening including a sealing liquid having a specific gravity greater than that of the heaviest component to be separated, and a barrier element, marginal portions of which dip into the sealing liquid defining connected inner and outer columns of the sealing liquid in the container, the centrifuge including a conduit permitting entrance into the container, on the inner side of the barrier element, of the material to be separated, mountings for the container and for the barrier element permitting a bodily shift of the barrier element relative to a wall of the container during rotation of the container to cause a relative lowering of the level of the inner column with relation to at least a portion of the peripheral path of the barrier element, and operating mechanism having a portion outside of the container and not partaking of the rotation of the container, said operating mechanism being connected to the barrier element to effect such shift during rotation of the container.

8. The centrifuge of claim 7 in which the bodily shift of the barrier element relative to the container is in the direction of the axes of rotation of the container.

9. The centrifuge of claim 7 in which displacement of the barrier element inwardly of the container increases the axial extent of the outer column and so permits a lowering of the height of the inner column.

10. The centrifuge of claim 9 in which the sealing liquid forms a lining for the container, such lining constituting the inner column.

11. The centrifuge of claim 7 including a second barrier element axially spaced from the first-named barrier element and penetrating a second, separate, body of sealing liquid, the two barrier elements being subject to the outward pressure of the contents of the container in opposite directions and being connected together so as to tend to balance the axial thrusts upon the barrier elements.

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