

Feb. 8, 1966

G. HULTSCH ETAL

3,233,735

CENTRIFUGE

Filed Jan. 24, 1963

3 Sheets-Sheet 1

FIG. 1

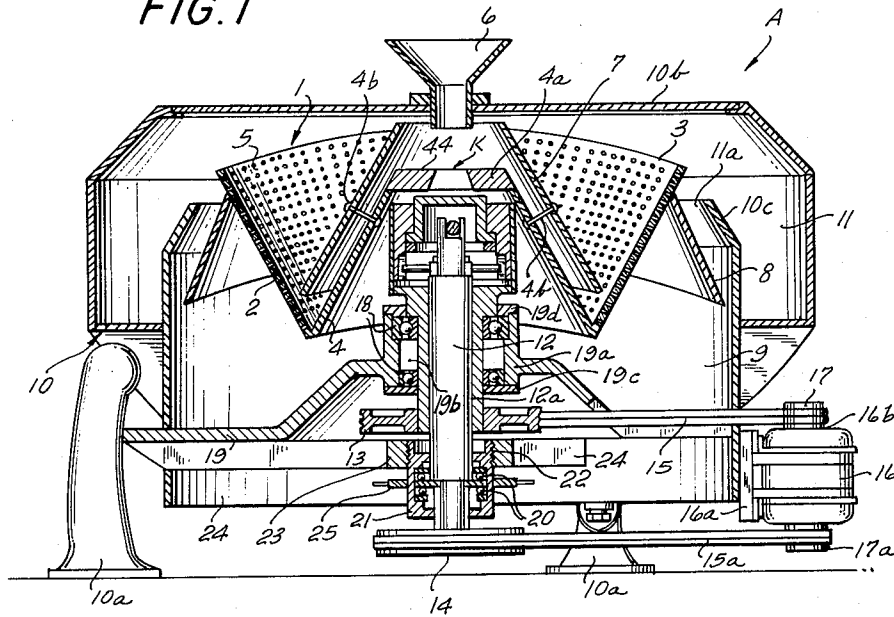
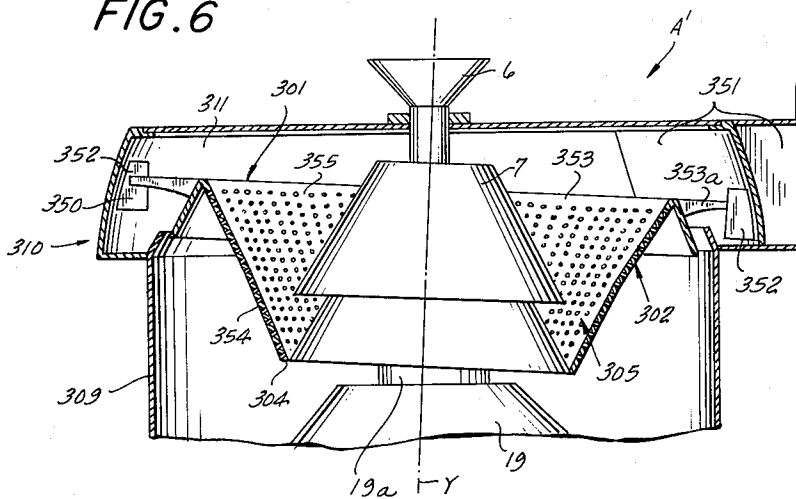


FIG. 6



INVENTORS
GÜNTHER HULTSCH
WALTER KÖCHER

BY

Michael S. Stricker
+ his ATTORNEY

Feb. 8, 1966

G. HULTSCH ET AL

3,233,735

CENTRIFUGE

Filed Jan. 24, 1963

3 Sheets-Sheet 2

FIG. 2

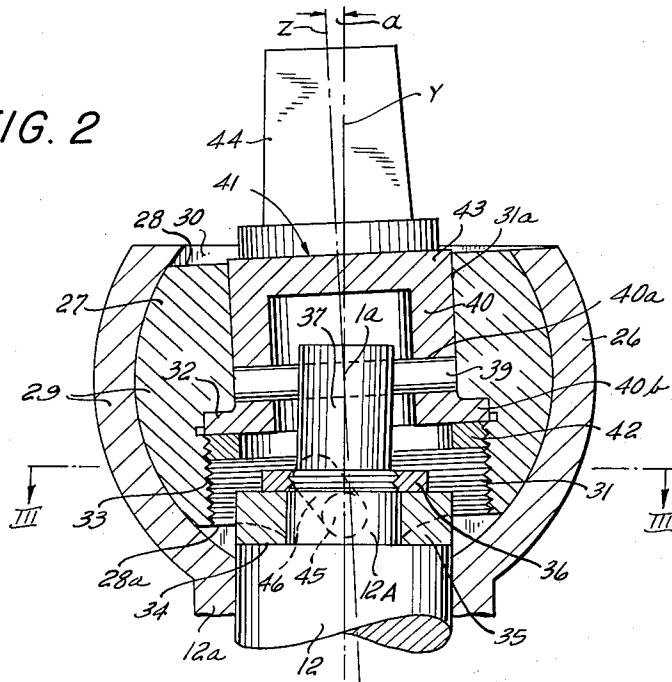
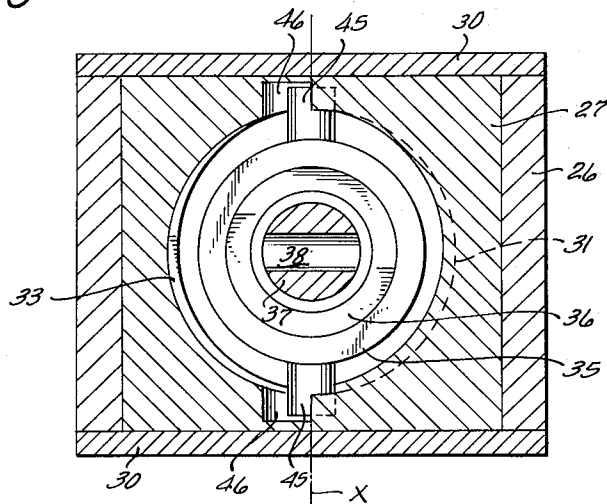


FIG. 3



INVENTORS
GÜNTHER HULTSCH
WALTER KÖCHER

BY

Michael J. Stricker
their ATTORNEY

Feb. 8, 1966

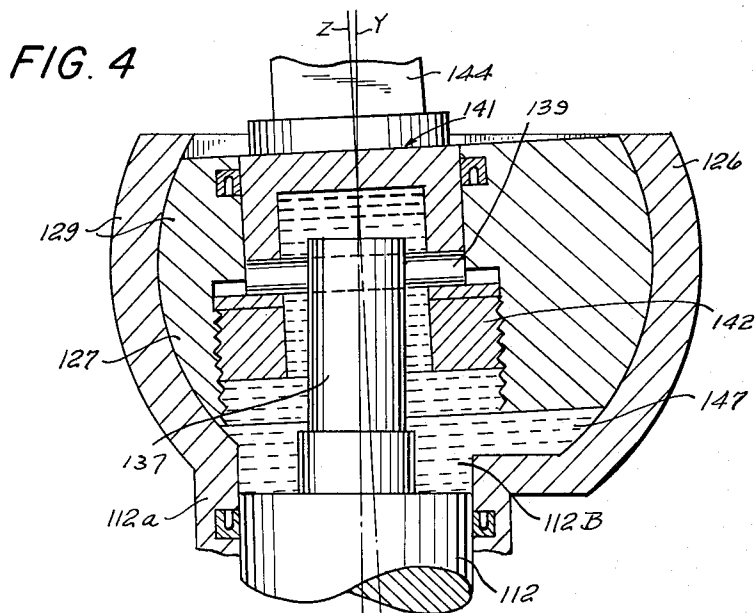
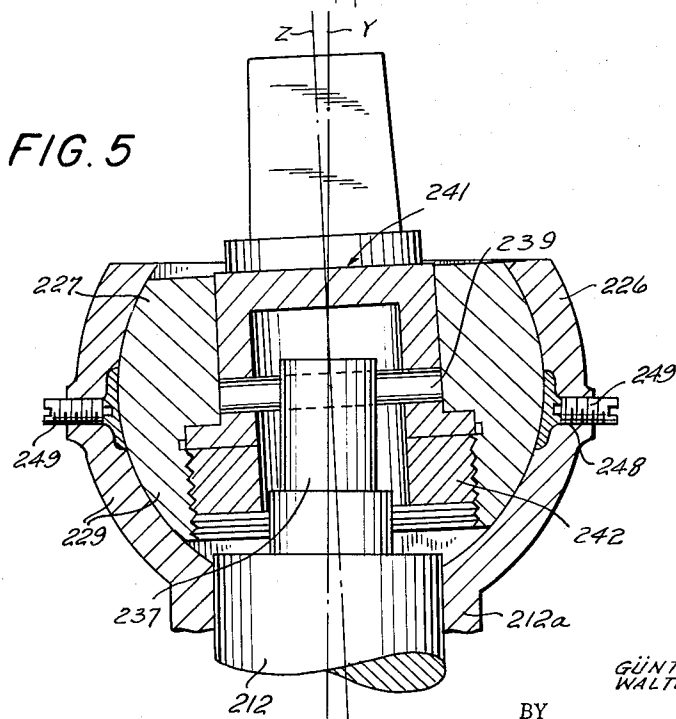
G. HULTSCH ETAL

3,233,735

CENTRIFUGE

Filed Jan. 24, 1963

3 Sheets-Sheet 3



INVENTORS
GÜNTHER HULTSCH
WALTER KÖCHER

BY

Michael J. Stricker
their ATTORNEY

1

3,233,735
CENTRIFUGE

Guenther Hultsch, Munich, and Walter Koecher, Munich-Obermenzing, Germany, assignors to Krauss-Maffei Aktiengesellschaft, Munich-Allach, Germany
Filed Jan. 24, 1963, Ser. No. 253,618
23 Claims. (Cl. 210—367)

The present invention relates to centrifuges, and more particularly to a centrifuge of the type wherein the barrel or drum is rotated about two axes which intersect or cross each other.

It is an important object of this invention to provide a very simple adjusting or regulating device which enables an operator to adjust the angle between such intersecting axes when the drum is at a standstill or when the centrifuge is in actual use.

Another object of the invention is to provide an improved connection or system of joints between the drum and the shafts which form part of the means for driving the drum about two intersecting axes.

A further object of the instant invention is to provide a centrifuge of the type which embodies a conical drum and wherein the drum is constructed and assembled in such a way that the heavy, e.g., solid fraction may be separated from the light, e.g., liquid fraction in a series of immediately following consecutive steps and wherein the drum comprises specially constructed means for facilitating expulsion of heavy fraction from the collecting compartment into which the heavy fraction is being discharged when the centrifuge is in actual use.

Still another object of the invention is to provide a centrifuge of the above entitled characteristics wherein the joint between the shafts and the drum permits adjustments in the inclination of the axis of the drum not only when the drum is arrested but also when the drum performs a composite angular movement about its own axis and about the axes of the shafts.

An additional object of the invention is to provide a novel system of joints for the drum of a centrifuge of the type which is especially suited for separation of liquor from crystalline substances.

A concomitant object of the invention is to provide a system of joints for a centrifuge of the above outlined characteristics which enables the drum to assume an infinite number of different angular positions with respect to the axes of the driving shafts and which may be readily installed in many types of conventional centrifuges without necessitating substantial changes in the construction of such apparatus.

A further object of our invention is to provide a system of joints for the drum of a centrifuge wherein the inclination of the axis about which the drum is caused to spin may be adjusted by mechanical or by hydraulic means.

An additional object of the invention is to provide a centrifuge which may be rapidly converted for treatment of different materials without necessitating any dismantling or exchange of its parts and without necessitating any or by requiring only short interruptions in the operation of the centrifuge.

With the above objects in view, the invention resides in the provision of a centrifuge which comprises a first shaft, a second shaft which is coaxial with and which surrounds the first shaft, an upwardly and outwardly diverging rotary conical drum which is adapted to receive the material to be centrifuged and which comprises a fluid-permeable outer mantle whose axis is normally inclined with respect to the common axis of the shafts and wherein the separation of light and heavy fractions takes place so that the light fraction passes through the mantle and that the heavy fraction travels upwardly and is discharged by centrifugal force over the upper edge portion of the mantle, a uni-

2

versal joint drivingly connecting the drum with the first shaft so that the drum spins about its axis when the first shaft rotates, and an articulated joint drivingly connecting the second shaft with the drum so that the axis of the drum travels about the common axis of the shafts along a conical surface when the second shaft rotates.

In accordance with our invention, the inclination of the drum with respect to the common axis of the shafts is adjustable, either when the centrifuge is idle or when the centrifuge is in actual use. This may be achieved by mounting the first shaft in such a way that it is axially reciprocable in the second shaft and by providing suitable means which transforms axial movements of the first shaft into angular displacements of the articulated joint to thereby change the inclination of the drum. If the inclination of the drum is to be adjusted when the centrifuge is at a standstill, the construction of the apparatus may be simplified by utilizing means which releasably fixes the component parts of the articulated joint in a selected position corresponding to a desired inclination of the drum.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a central vertical section through a centrifuge which embodies one form of our invention and wherein the drum is driven by two coaxial shafts;

FIG. 2 is an enlarged central vertical section through the system of joints which connects the shafts with the drum;

FIG. 3 is a horizontal section as seen in the direction of arrows from the line III—III of FIG. 2;

FIG. 4 is a central vertical section through a pair of joints one of which is different from the corresponding joint of FIG. 2;

FIG. 5 is a central vertical section through a pair of joints one of which may be fixed manually in any of a series of different positions of adjustment; and

FIG. 6 is a fragmentary central vertical section through a modified centrifuge which comprises a different housing and a differently constructed drum.

Referring now in greater detail to the illustrated embodiments, and first to FIG. 1, there is shown a centrifuge A which comprises a composite housing 10 mounted on spaced ground-contacting legs 10a and accommodating a specially constructed and specially mounted rotary drum or basket 1. This drum comprises an upwardly and outwardly diverging hollow conical fluid-permeable outer mantle 2 and a hollow conical inner mantle 4 which is surrounded by the outer mantle 2, which diverges upwardly and inwardly, and whose central portion or hub 4a is detachably fastened to a system K of joints one of which is a universal joint of the type known as Cardan joint. Material to be centrifuged is fed continuously through a centrally located hopper 6 mounted in the top wall 10b of the housing 10 and discharging such material onto the hub 4a whence the material descends along the inner side of an outwardly and downwardly diverging hollow conical shield or guide 7 which is secured to the inner mantle 4 by stay bolts 4b and which insures that newly admitted material cannot mix with the fractions revolving in the separating or centrifuging chamber 5 of the drum 1. In other words, the shield 7 compels newly admitted material to descend along the outer side of the inner mantle 4 and to enter the lowermost zone of the chamber 5 between the meeting lower edge portions of the mantles 2, 4.

The housing 10 defines a first annular collecting compartment 9 which surrounds the major part of the outer mantle 2 and which receives the light fraction of material which is being centrifuged in the chamber 5, such light fraction passing through the perforations or pores of the outer mantle 2 and impinging against a downwardly and outwardly diverging conical skirt 8 which is secured to the larger-diameter upper edge portion 3 of and which surrounds the mantle 2 so as to deflect the light fraction into the compartment 9. The housing 10 further defines a second or upper annular compartment 11 which collects the heavy fraction of centrifuged material and which is sealed from the lower chamber 9 save for a gap 11a defined by the skirt 8 and by an upwardly and inwardly converging wall portion 10c of the housing 10, such gap 11a being necessary to prevent frictional engagement between the skirt and the housing. The heavy fraction travels upwardly along the inner side of the outer mantle 2 and toward and beyond the upper edge portion 3 of this mantle to be ejected by centrifugal force so that it automatically accumulates in the chamber 11 whence it may be removed at certain intervals or whence it may be evacuated automatically, for example, from the bottom zone of the chamber 11, by means of a screw conveyor or the like, not shown. The centrifuge A of FIGS. 1 to 3 is especially suited for separating liquor from crystalline substances and for avoiding rough treatment of such substances during transfer into the compartment 11, but it is self-evident that the centrifuge may be put to many other uses without in any way departing from the spirit of our invention.

The drum 1 receives motion from two coaxial vertical drive shafts 12, 12a the latter of which assumes the form of a hollow tube and surrounds the inner shaft 12. The shafts 12, 12a are driven by a variable-speed electric motor 16 which is secured to the housing 10 by a bracket 16a and whose vertical output shaft 16b carries at its opposite ends a pair of sheaves 17, 17a. The lower end portion of the inner shaft 12 projects downwardly and beyond the lower end portion of the outer shaft 12a and carries a sheave 14 driven by an endless V-belt 15a which is trained around the sheave 17a. A similar endless V-belt 15 is trained around the sheave 17 and drives a fourth sheave 13 which is non-rotatably secured to the lower end portion of the outer shaft 12a. The parts 17a, 15a, 14 and 17, 15, 13 constitute two belt transmissions which respectively transmit motion to the drive shafts 12, 12a. The outer shaft 12a rotates in two radial antifriction bearings 18 which are accommodated in an opening 19b provided in the sleeve-like median portion 19a of a bottom wall 19 forming part of the housing 10. An annular plate 19c closes the lower end of the opening 19b, and a similar annular plate 19d is provided to close the upper end of this opening. It will be noted that the inner race of the upper radial bearing 18 abuts against an external shoulder of the outer shaft 12a so that the latter is held against axial displacement in downward direction. The diameters of the sheaves 13, 14 are different and it is assumed that the r.p.m. of the inner shaft 12 exceeds the r.p.m. of the outer shaft 12a.

The lower portion of the inner shaft 12 rotates in a thrust bearing 20 which is accommodated in a bearing sleeve 21 having an externally threaded upper end portion 22 which mates with an internally threaded housing portion here shown as a retaining ring or nut 23 which is secured to the bottom wall 19 by a series of radial arms or spokes 24. The bearing sleeve 21 carries a sprocket wheel 25 which may be driven by a suitable motor (not shown) through a chain or the like and which serves as a means for axially adjusting the inner shaft 12 with respect to the outer shaft 12a and for thereby adjusting the inclination of the axis of the drum 1 with respect to the common axis of the shafts 12, 12a.

Referring to FIGS. 2 and 3, the upper end portion of the outer shaft 12a is rigid or integral with a hollow cylindrical socket or shell 26 whose axis X is horizontal and which accommodates a roller 27, the latter being free to turn about the axis X. The roller 27 is formed with a flat upper side 28 and with a flat underside 28a, the latter being parallel with the upper side 28 and being provided with an upwardly extending cylindrical bore having a larger-diameter lower section 31 and a smaller-diameter upper section 31a which terminates in the upper side 28. The axis Z of the bore 31, 31a coincides with the axis of the drum 1 and is perpendicular to the common axis X of the parts 26, 27. The axial length of the upper section 31a preferably approximates the axial length of the lower section 31. The socket 26 and the roller 27 together constitute an articulated joint 29 which permits tilting movements of the drum 1 in a vertical plane, i.e., about the axis X. When the joint 29 permits the drum 1 to assume a position in which the common axis Z of the mantles 2, 4 is inclined with respect to the common axis Y of the drive shafts 12, 12a, the drum revolves about the axis Y and simultaneously spins about the axis Z without any wobbling. To reduce the effect of unbalance of the drum 1, the center 1a of gravity of this drum is preferably located in the common axis X of the parts 26, 27, and more particularly in the point of intersection between the axis X and the common axis Y of the shafts 12, 12a. In other words, the axes X, Y, Z intersect each other in the center 1a. The ends of the socket 26 are closed by two detachable vertical end plates 30, see FIG. 3, which hold the roller 27 against axial displacements in the concave internal space of the socket. In other words, the walls 30 serve to hold the roller against movements other than about the horizontal axis X. The internal surface bounding the lower section 31 of the through bore in the roller 27 is formed with threads 33 which mate with external threads of a retaining ring 42, the latter serving as a means for retaining the cylindrical wall portion 40 of an inverted cup shaped member 41 which is accommodated in the upper bore section 31a. The wall portion 40 is formed with a diametral bore 40a for a rotary horizontal coupling pin 39, and the lower portion of this wall portion forms a collar 40b which rests on the ring 42 and which is normally spaced from an internal shoulder 32 of the roller 27, this shoulder dividing the bore sections 31, 31a from each other. The top wall 43 of the cupped member 41 carries an upwardly extending stub shaft 44 of polygonal outline which is received in a complementary aperture of the hub 4a so that the drum 1 is compelled to share angular movements of the cupped member.

The upper end portion 12A of the inner shaft 12 is formed with a shoulder 34 for a rotatable annulus 35, and this end portion 12A is provided with external threads which mate with the threads of a nut 36 serving as a means to hold the annulus 35 against axial movements with respect to the inner shaft. A stub shaft 37 which constitutes the upper terminal of the end portion 12A is formed with a diametral slot 38, see FIG. 3, for the central portion of the pin 39.

The cupped member 41 and the pin 39 together constitute one component or fork of a universal joint. The other component or fork of this universal joint is formed by the slotted stubbed shaft 37 of the inner shaft 12.

The inclination of the axis Z of the drum 1 with respect to the vertical axis Y of the shafts 12, 12a may be adjusted by radial bolts or studs 45 which project from the periphery of the annulus 35 and which are accommodated in inclined recesses or grooves 46 of the roller 27. The common axis of the bolts 45 is parallel with the axis X. If the shaft 12 is axially displaced with respect to the shaft 12a, i.e., in response to rotation of the bearing sleeve 21 by the sprocket 25, the bolts 45 slide in the respective recesses 46 and change the inclination of the drum 1. If

the shaft 12 is lifted, the bolts 45 cause the drum 1 to turn in an anticlockwise direction, as viewed in FIG. 2, because the recesses are inclined upwardly and to the left so that the angle α between the axes Y and Z becomes smaller. The roller 27 shares such angular displacement of the drum and turns about the horizontal axis X to thereby change the inclination of the upper fork 41.

An important advantage of such construction of the universal joint is that the inclination of the axis Z of the drum 1 may be changed when the centrifuge is in actual use, namely, when the motor 16 drives the shafts 12, 12a.

The articulated joint 29 may be modified in a number of ways without departing from the spirit of my invention. For example, the parts 26, 27 may be replaced by a true ball and socket joint wherein the roller 27 is of spherical shape and is formed with a pair of arcuate ribs arranged in opposed meridian planes and fitting into complementary channels of the socket to insure that the roller shares all angular movements of the socket. Such ribs and channels permit tilting of the roller in a single plane about an axis corresponding to the axis X of FIG. 3. It is also possible to provide the spherical roller of a true ball and socket joint with four equidistant projections which are disposed in a common equatorial plane and to form the socket with two circular channels disposed in two meridian planes and each of which receives two projections so that the roller is tiltable in each of the two meridian planes. Such modifications are so obvious that they can be readily comprehended without additional illustrations.

All that is necessary to provide on the roller 27 and on the socket 26 some means which (as the bolts 45 and recesses 46) is capable of transforming axial movements of the inner shaft 12 into angular movements of the fork 41 and hence of the drum 1.

The centrifuge of FIGS. 1 to 3 operates in the following manner:

When the motor 16 is started, the transmission including the sheave 14 drives the inner shaft 12 which in turn causes the drum 1 to spin about the axis Z. Such spinning movement is transmitted to the drum by the universal joint whose lower fork 37 is rigid with the upper end portion of the shaft 12 and whose upper fork 41 is rigid with the central portion of hub 4a.

At the same time, the belt transmission including the sheave 13 drives the outer shaft 12a which rotates the articulated joint 29 whereby the roller 27 compels the drum 1 to revolve about the axis Y so that the axis Z describes a conical surface whose conicity corresponds to the angle α .

If the operator desires to change the angle α , he drives the sprocket 25 in a direction to lift or to lower the inner shaft 12 whereby the bolts 45 travel in the respective recesses 46 and cause the roller 27 to be tilted about the horizontal axis X. The roller 27 changes the inclination of the upper fork 41 and of the shaft 44 which in turn changes the angular position of the axis Z. Such adjustments may be made when the motor 16 is running.

A very important advantage of the centrifuge A is that the angle α may be adjusted as often as desired, that this angle may be adjusted when the centrifuge is in actual use, and that this angle may be changed to an infinite number of magnitudes so that the centrifuge may be used in connection with a wide variety of materials. Thus, by changing the inclination of the axis Z, one may select the angle α in a way as to insure that a heavy fraction of given specific weight, of given moisture content and of given consistency will be discharged from the chamber 5 at a predetermined rate. By reducing the inclination of the axis Z, one can insure that the heavy fraction remains in the chamber 5 for a longer period of time and that it loses a greater percentage of light fraction prior to being evacuated into the upper compartment 11. In addition, by changing the inclination of the axis Z, the operator may change the angle of repose (slope) of material in

the chamber 5. The heavy fraction is being discharged over that zone of the edge portion 3 which is momentarily located at the lowest level, i.e., which is nearest to the upper edge of the skirt 8. The inclination of the plane of the upper edge portion 3 with respect to a horizontal plane determines the rate at which the heavy fraction is being discharged into the compartment 11, and this inclination equals the angle between the axes Y and Z. Thus, by providing the centrifuge with a device which can change the angle α , we may utilize the centrifuge of our invention in connection with different materials without necessitating any interruptions in the operation of the apparatus and without necessitating dismantling of any parts. In certain conventional centrifuges of which we have knowledge at this time, the joints between the driving shafts and the central portion of the drum must be taken apart or exchanged if it is desired to change the inclination of the drum. Therefore, such conventional centrifuges must be furnished with two or more sets of joints in order to insure that the drum may be used for separation of different materials. Whenever such conventional centrifuges are converted for separation of different materials, it is necessary to arrest the motor, to remove the drum, and to exchange the joints in order to change the inclination of the drum axis with respect to the axes of the shafts.

For example, when the characteristics of the material which is being admitted through the hopper 6 are known, the angle α may be adjusted in advance and thereupon remains unchanged during the entire centrifuging operation. On the other hand, if the characteristics of the material which is to be centrifuged are unknown, the operator experiments by adjusting the axial position of the inner shaft 12 until the heavy fraction begins to enter the upper compartment 11 at a desired rate per unit of time and contains a desired percentage of light fraction or is free of any traces of light fraction. The speed at which the fractions are separated may be varied by changing the r.p.m. of the shaft 12 and/or 12a in response to adjustments in the r.p.m. of the output shaft 16b.

Another important advantage of the centrifuge A is that the inclination of the axis Z may be adjusted from a readily accessible point of the housing, i.e., beneath the raised bottom wall 19. It is immaterial whether the inclination is adjusted manually (e.g., by means of a tool which engages the bearing sleeve 21) or by means of a motor and through a transmission (such as the chain transmission of which the sprocket 25 constitutes a component part). If the sleeve 21 is rotated manually, its periphery may be of hexagonal or other non-circular contour so that it may be engaged by a conventional wrench or the like.

The composite movement of the drum 1 may be compared with the movement of a top which spins about its own axis and whose axis simultaneously revolves about a vertical axis to describe a hollow conical surface. In other words, the drum need not wobble in a manner as is known from the art of swash plates for pumps and similar hydrodynamic machines. Consequently, the wear on the bearings is minimal and such bearings remain usable for very long periods of time.

Referring to FIG. 4, there is shown a portion of a different centrifuge wherein the inclination of the stub shaft 144 (and hence of the axis Z) may be adjusted by a hydraulic device. The cupped member 141, the ring 142, the horizontal coupling pin 139 and the stub shaft 137 all cooperate in the same manner as members 41, 42, 39 and 37, respectively, previously described with reference to FIGS. 2 and 3. The hollow socket 126 is asymmetric with respect to the hollow outer shaft 112a and the space 147 between the roller 127 and the lower portion of the socket 126 is filled with a non-compressible fluid, this fluid also filling the internal space 112B of the shaft 112a. When the inner shaft 112 is moved upwardly, it expels some fluid from the internal space 112B whereby the fluid

compels the roller 127 to pivot about the horizontal axis of the joint 129, such pivotal movement taking place in an anticlockwise direction, as viewed in FIG. 4. When the shaft 112 moves downwardly, the fluid entrapped in the space 147 causes the roller 127 and the drum to pivot in a clockwise direction.

In other words, the specially configured (assymetric) roller 127 and the fluid filling the space 147 perform the function of the bolts 45 and recesses 46 in that they transform axial movements of the inner shaft into angular displacements of the stub shaft 144 about the horizontal axis of the socket 126.

The connection between a drum and the driver shafts may be simplified if the centrifuge is constructed in such a way that the inclination of the drum is adjustable only when the apparatus is at a standstill. In such instances (see FIG. 5), the inner shaft 212 need not be mounted for axial movements so that the bearing sleeve (corresponding to the sleeve 21 of FIG. 1) may be permanently fixed to the housing. In addition, the ring 35, the bolts 45 and the recesses 46 may be dispensed with. The socket 226 is formed with two tapped bores 248 for holding means here shown as screw bolts 249 which engage and normally hold the roller 227 against angular displacements with respect to the socket 226. When the shafts 212, 212a are at a standstill, the operator loosens the screw bolts 249 and adjusts the inclination of the roller 227 whereupon the bolts 249 are tightened again to retain the roller in the newly selected position of adjustment with respect to the socket 226. The construction of the universal joint may be the same as in FIGS. 2 and 3. In this embodiment, the screw bolts 249 which are fixed to the socket 226 serve as a means for maintaining the drum in a selected angular position with respect to the socket. The cupped member 241, the ring 242, the horizontal coupling pin 239 and the stub shaft 237 all cooperate in the same manner as previously described with reference to FIGS. 2 and 3, relative to members 41, 42, 39 and 37, respectively.

FIG. 6 illustrates a portion of a centrifuge A' wherein the upper compartment 311 is bounded by a hollow spherical wall portion 350 forming part of a modified housing 310. The curvature of this wall portion 350 has its center in the point of intersection between the common vertical axis Y of the drive shafts 12, 12a and the horizontal axis of the roller-and-socket joint which is not shown in FIG. 6 because it is assumed to be identical with the joint 29 of FIGS. 2 and 3. The drum 301 comprises an outer mantle 302 which includes a hollow conical upper section 355 and a hollow conical lower section 354. The upper edge portion 353 of the upper section 355 includes a horizontal collar 353a which is provided with outwardly extending vanes or blades 352 serving as a means for expelling the heavy fraction into a tangential outlet 351 which communicates with the compartment 311. The angle of divergence of the upper section 355 exceeds the angle of divergence of the lower section 354. Thus, the tendency of the heavy fraction to move upwardly and toward the edge portion or lip 353 is less pronounced while the heavy fraction is still contained in the lower zone of the centrifuging chamber 305, i.e., in that zone which is immediately adjacent to the bottom 304 and which is surrounded by the lower section 354 wherein the major part of the separating action takes place. In other words, at the time the heavy fraction reaches the upper section 355, the major part of the light fraction has already passed through the perforations of the lower section 354 to accumulate in the lower compartment 309.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are

intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion; means for driving said shafts; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a universal joint comprising a first component rigid with the end portion of said first shaft and a second component driven by said first component and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint comprising a socket rigid with the end portion of said second shaft and a roller received in and sharing rotary movements of said socket in response to rotation of said second shaft, said roller rotatably receiving said second component and being turnable in said socket about a horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second component changes the inclination of the axis of the drum with respect to said common axis; adjusting means for turning the roller about said horizontal axis to any one of a plurality of predetermined positions; and means for maintaining the axis of said drum in such predetermined position.

2. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion; means for driving said shafts; bearing means axially reciprocally supporting said first shaft in said second shaft; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a universal joint comprising a first component rigid with the end portion of said first shaft and a second component driven by said first component and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint comprising a socket rigid with the end portion of said second shaft and a roller received in and sharing rotay movements of said socket in response to rotation of said second shaft, said roller rotatably receiving said second component and being turnable in said socket about a horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second component changes the inclination of the axis of the drum with respect to said common axis; and adjusting means for turning the roller about said horizontal axis, said adjusting means comprising means for axially moving said first shaft with respect to said second shaft, and means for transforming axial movements of said first shaft into angular movements of said roller about said horizontal axis.

3. A combination as set forth in claim 2, wherein the means for axially moving said first shaft comprises a motor-driven member drivingly connected with said bearing means and wherein said bearing means is axially movable with said first shaft in response to rotation thereof.

4. A combination as set forth in claim 3, further comprising a housing for said drum, said housing having a threaded portion mating with threads provided on said bearing means.

5. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion; a rotary centrifuging drum having an axis which is normally inclined with respect to the common axis of said shafts,

and comprising a central portion located above the upper end portions and a fluid-permeable conical outer mantle which diverges upwardly and outwardly; a universal joint drivingly connecting said central portion with the upper end portion of said first shaft whereby the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint drivingly connecting said central portion with the upper end portion of said second shaft so that the axis of said drum travels about the common axis of said shafts in response to rotation of said second shaft; and adjusting means for adjusting the inclination of the axis of said drum with respect to said common axis, said adjusting means comprising means for axially moving one of said shafts with respect to the other, and means for transforming axial movements of said one shaft into angular movements changing the inclination of said axis of said drum with respect to said common axis.

6. A combination as set forth in claim 5, wherein said outer mantle comprises an upper section and a lower section and wherein the angle of divergence of said upper section exceeds the angle of divergence of said lower section.

7. In a centrifuge, in combination, a first shaft; a second shaft coaxial with and surrounding said first shaft; means for driving the shafts; a centrifuging drum having an axis of rotation which is normally inclined with respect to the common axis of said shafts; a first angularly adjustable articulated joint drivingly connecting said first shaft with said drum so that the drum spins about its axis in response to rotation of said first shaft; a second angularly adjustable articulated joint drivingly connecting said drum with said second shaft so that the axis of said drum travels about said common axis in response to rotation of said second shaft; and adjusting means for adjusting the inclination of the axis of said drum with respect to said common axis during rotation of said shafts, said adjusting means comprising means for axially moving said first shaft with respect to said second shaft, and means for transforming axial movements of said first shaft into angular movements changing the inclination of said axis of said drum with respect to said common axis.

8. In a centrifuge, in combination, a first shaft; a second shaft coaxial with and surrounding said first shaft; means for driving the shafts; a centrifuging drum having an axis of rotation which is normally inclined with respect to the common axis of said shafts; a first angularly adjustable articulated joint drivingly connecting one of said shafts with said drum so that the drum spins about its axis in response to rotation of said first shaft; a second angularly adjustable articulated joint drivingly connecting said drum with the other of said shafts so that the axis of said drum travels about said common axis in response to rotation of said other shaft, said second joint constructed and arranged so as to be adjustable to change the inclination of the axis of said drum to any one of a plurality of predetermined positions; and means for maintaining the axis of said drum in such predetermined position.

9. A combination as set forth in claim 8, wherein said first joint is a universal joint comprising a first component rigid with said first shaft and a second component driven by said first component and rigid with said drum, said second joint comprising a socket rigid with said second shaft and a roller received in said socket and rotatably receiving said second component, said roller being turnable in said socket about an axis which is perpendicular to said common axis to thereby change the inclination of said second component and of said drum.

10. A combination as set forth in claim 9, further comprising holding means secured to said socket and adapted to engage said roller for maintaining the roller in a selected angular position with respect to said socket.

11. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end por-

tion; means for driving said shafts; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a universal joint comprising a first component rigid with the end portion of said first shaft and a second component driven by said first component and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint comprising a socket rigid with the end portion of said second shaft and a roller received in and sharing rotary movements of said socket in response to rotation of said second shaft, said roller rotatably receiving said second component and being turnable in said socket about a single horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second component changes the inclination of the axis of the drum with respect to said common axis to any one of a plurality of predetermined positions, said socket comprising means for holding the roller against movements other than about said horizontal axis; and adjusting means for turning the roller about said horizontal axis to move said axis of said drum to one of said predetermined positions and for maintaining the roller in such adjusted position.

12. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of said shafts having an upper end portion; means for driving said shafts; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a Cardan joint comprising a first fork rigid with the end portion of said first shaft and a second fork driven by said first fork and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint comprising a socket rigid with the end portion of said second shaft and a roller received in and sharing rotary movements of said socket in response to rotation of said second shaft, said roller rotatably receiving said second fork and being turnable in said socket about a horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second fork changes the inclination of the axis of the drum with respect to said common axis to any one of a plurality of predetermined positions; and adjusting means for turning the roller about said horizontal axis to move said axis of said drum to one of said predetermined positions and for maintaining the roller in such adjusted position.

13. A combination as set forth in claim 12, wherein said roller is provided with a cylindrical bore for said second fork and wherein said second fork comprises a cylindrical wall portion which is rotatable in said bore.

14. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion; means for driving said shafts; bearing means axially reciprocable supporting said first shaft in said second shaft; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a universal joint comprising a first component rigid with the end portion of said first shaft and a second component driven by said first component and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint comprising a socket rigid with the end portion of said second shaft and a roller received in and sharing rotary movements of said sockets

in response to rotation of said second shaft, said roller rotatably receiving said second component and being turnable in said socket about a horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second component changes the inclination of the axis of the drum with respect to said common axis to any one of a plurality of predetermined positions; and adjusting means for turning the roller about said horizontal axis, said adjusting means comprising means for axially moving said first shaft with respect to said second shaft, an annular member rotatably supported by the upper end portion of said first shaft, and a pair of diametrically arranged bolts extending radially outwardly from said annular member and received in inclined recesses provided in said roller so that axial movements of said first shaft compel the roller to pivot about said horizontal axis to move said axis of said drum to one of said predetermined positions.

15. A combination as set forth in claim 14, wherein said bolts have a common axis which is parallel with said horizontal axis.

16. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion and said first shaft being movable axially with respect to said second shaft; means for driving said shafts; a rotary centrifuging drum having an axis normally inclined with respect to and intersecting the common axis of said shafts, said drum comprising a central portion located above the upper end portions; a universal joint comprising a first component rigid with the end portion of said first shaft and a second component driven by said first component and rigid with said central portion so that the drum spins about its axis in response to rotation of said first shaft; an articulated joint comprising a socket rigid with the end portion of said second shaft, a roller received in and sharing rotary movements of said socket in response to rotation of said second shaft, said roller rotatably receiving said second component and being turnable in said socket about a horizontal axis which intersects the axis of the drum in the point wherein the axis of the drum intersects said common axis whereby, in response to turning of said roller, the second component changes the inclination of the axis of the drum with respect to said common axis, said roller having an underside and being asymmetric with respect to said common axis, and a supply of fluid in said socket beneath the underside of said roller; and adjusting means for turning the roller about said horizontal axis, said adjusting means comprising means for axially displacing said first shaft in said second shaft whereby the upper end portion of said first shaft compels the fluid to change the angular position of said roller and to thereby change the inclination of the axis of said drum.

17. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion and said first shaft being axially movable in said second shaft; a rotary centrifuging drum having an axis which is normally inclined with respect to the common axis of said shafts and comprising a central portion located above the upper end portions; a universal joint drivingly connecting said central portion with the upper end portion of said first shaft whereby the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint drivingly connecting said central portion with the upper end portion of said second shaft so that the axis of said drum travels

about the common axis of said shafts in response to rotation of said second shaft; and hydraulic means for adjusting the inclination of the axis of said drum with respect to said common axis in response to axial movements of said first shaft.

18. In a centrifuge, in combination, a first vertical shaft; a second shaft coaxial with and surrounding said first shaft, each of the shafts having an upper end portion; a rotary centrifuging drum having an axis which is normally inclined with respect to the common axis of said shafts, said drum comprising a central portion located above the upper end portions and a fluid-permeable conical outer mantle which diverges upwardly and comprises an upper edge portion; a universal joint drivingly connecting said central portion with the upper end portion of said first shaft whereby the drum spins about its axis in response to rotation of said first shaft; an angularly adjustable articulated joint drivingly connecting said central portion with the upper end portion of said second shaft so that the axis of said drum travels about the common axis of said shafts in response to rotation of said second shaft; means for adjusting said articulated joint so as to adjust the inclination of the axis of said drum with respect to said common axis to any one of a plurality of predetermined positions; and means for maintaining the axis of said drum in such predetermined position; and a housing having a fixed wall portion surrounding said upper edge portion in each position of inclination of said drum.

19. A combination as set forth in claim 18, wherein said wall portion is of hollow spherical shape.

20. A combination as set forth in claim 18, wherein said wall portion defines a collecting compartment for the heavy fraction of material which is being centrifuged in said drum, and further comprising an outlet extending substantially tangentially of said wall portion and communicating with said compartment.

21. A combination as set forth in claim 8, wherein said axis of rotation of said drum intercepts the common axis of said shafts, said drum having a center of gravity which is located in the point of intersection of the axes.

22. A combination as set forth in claim 8, wherein said means for driving said first and second shafts are arranged to drive said shafts at different speeds.

23. A combination as set forth in claim 22, wherein the means for driving said shaft comprises a motor having an output shaft, a first belt transmission driven by said output shaft and drivingly connected with said first shaft, and a second belt transmission driven by said output shaft and drivingly connected with said second shaft.

References Cited by the Examiner

UNITED STATES PATENTS

211,971	2/1897	Chrystal et al.	287—12 X
1,603,757	10/1926	Farrell	210—367
1,727,354	9/1929	Newhall	210—78 X
2,806,603	9/1957	Van der Molen	210—380
2,886,179	5/1959	Heckman	210—370

FOREIGN PATENTS

421,336	5/1947	Italy.
---------	--------	--------

OTHER REFERENCES

German printed application, 1,072,199, 12/1959.
German printed application, 1,140,147, 11/1962.

REUBEN FRIEDMAN, *Primary Examiner*.