

July 2, 1963

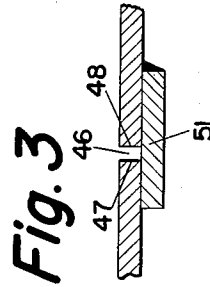
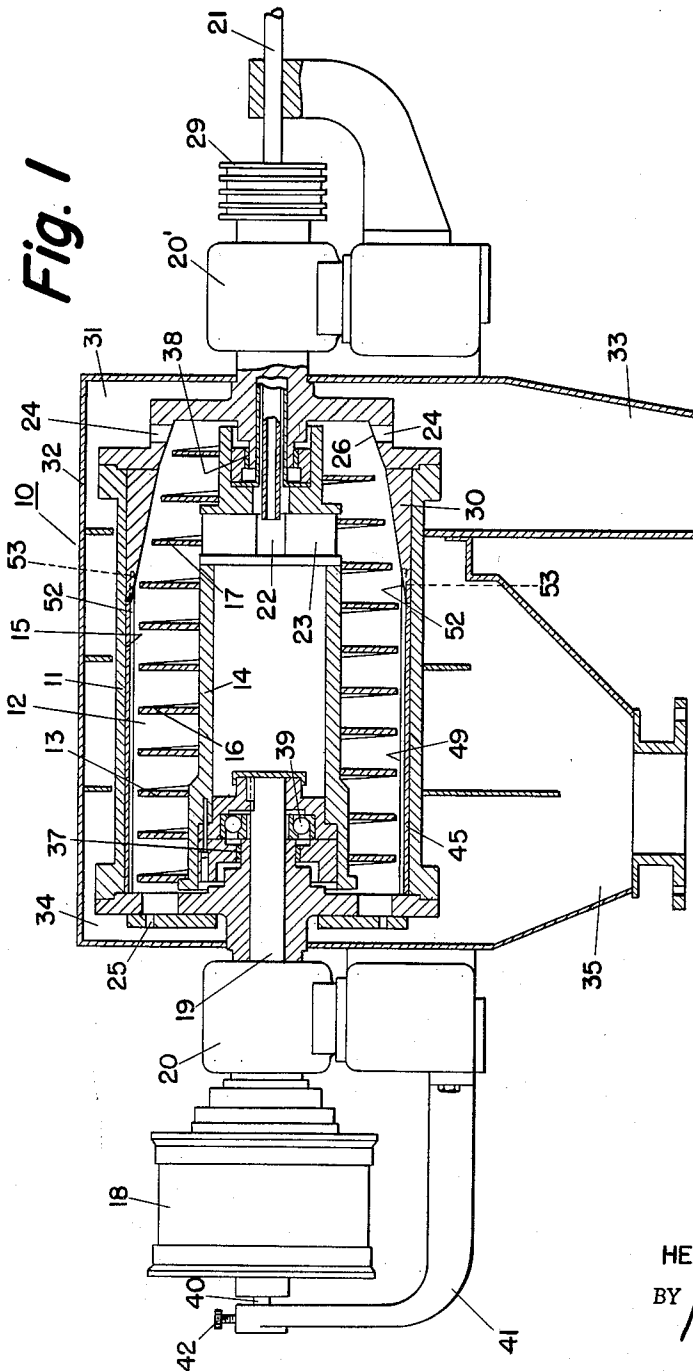
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IMPROVEMENT IN CENTRIFUGES

Filed Dec. 30, 1957

2 Sheets-Sheet 1



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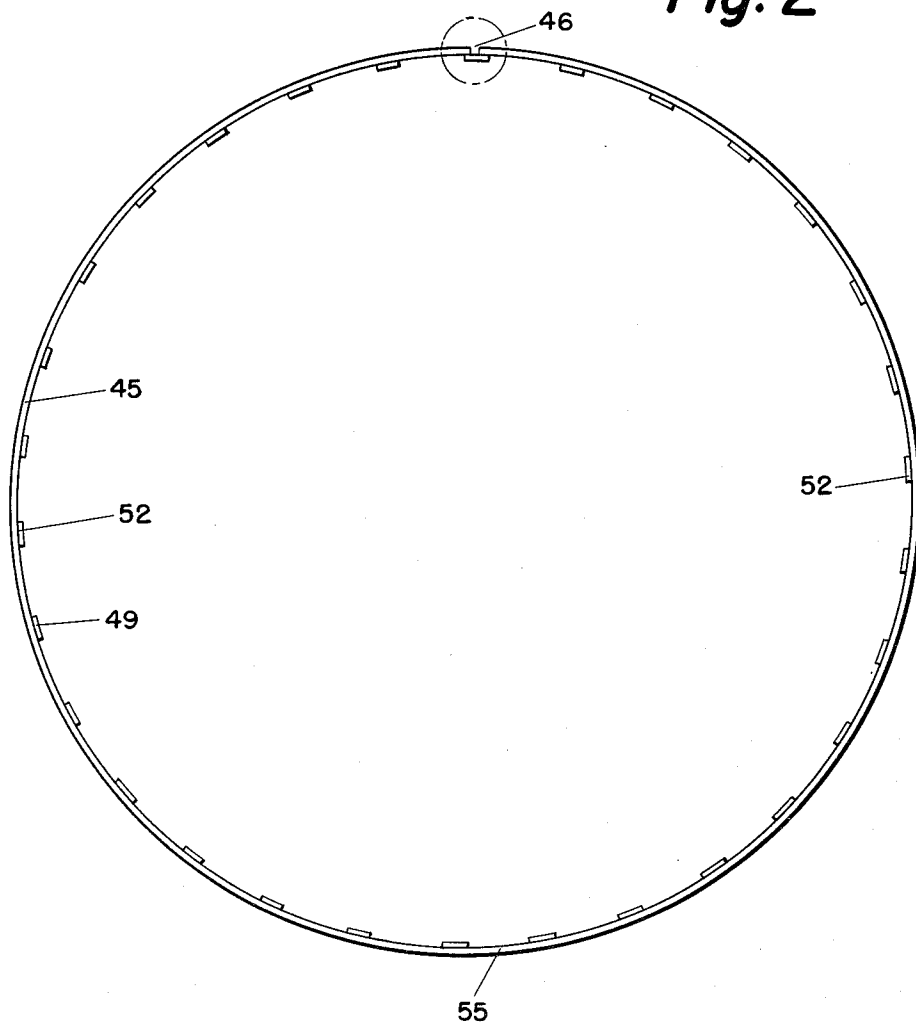
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Fig. 2



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IMPROVEMENT IN CENTRIFUGES

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2 Claims. (Cl. 233-7)

This invention pertains generally to centrifuges of the solids-discharge type, and particularly to centrifuges provided with mechanical means for the movement of solids in effecting their discharge.

Typical of centrifuges of this type are those which are provided with a helical and/or spiral screw or scroll for the movement of separated solids through the zone of centrifugation to a discharge zone thereof. Any such screw, scroll or plow mechanism, whether comprised of a single member, or of a plurality of members, customarily operates by way of sliding the separated solids along the interior wall of the centrifuge rotor, the general direction of movement of the solids relative to the rotor wall being along straight and/or curved lines, e.g. with the movement of solids following a helical and/or spiral pattern. The interior wall of the rotor is thus subjected to wear, the rate of which is increased with increase in abrasiveness of the solids being separated. Such wear of the inner wall of the rotor not only reduces rotor strength by virtue of reduction in wall thickness, but also increases the clearance between the rotor wall and the screw, scroll or plow, referred to herein generally as an impeller, thereby reducing the efficiency of the cooperating elements in the discharge of separated solids from the rotor.

Wear of the impeller does not present a major problem from the standpoint of repair, except for the time and expense involved, for the metal which has been worn away can readily be replaced, such as by welding additional metal thereto in bringing it back to its original shape and dimensions. It is impracticable, however, to employ this expedient for replacing metal removed by wear from the inner surface of the rotor. Nor is it practicable to true up the inner surface of the rotor by machining, for this would further reduce the thickness of the rotor wall with consequent further reduction in rotor strength.

The use of a conventional tubular sleeve between the rotor wall and the impeller to take the wear is impracticable for a variety of reasons. It will be seen that a tubular sleeve must, of necessity, have a sliding fit with respect to the inner wall of the rotor in order to be replaceable. This results in a clearance between the sleeve and the rotor wall wherein materials subjected to separation may collect and harden, with or without corrosion of the metal, so that it becomes virtually impossible from a practicable standpoint to remove the sleeve when the time arrives. Moreover, difficulty is encountered in adequately securing the sleeve to the rotor wall. This is because of the high resistance to relative movement between the impeller and the sleeve during the plowing of the solids. The most feasible method for such attachment that suggests itself is the use of a large number of screws passing through the sleeve and entering threaded holes in the rotor wall, but the drilling of holes in the rotor wall in the case of high speed centrifuges is impracticable in view of the resulting reduction in strength of the rotor.

I have discovered a new combination of means whereby a sleeve or lining employed between the rotor wall and the impeller is made readily removable even after long periods of use and without the need of any securing mechanism for the sleeve. This is accomplished by employing a sleeve or lining of resilient material which conforms to the inner surface of the rotor wall, and which is split or unconnected along a longitudinal line so as to be expandable under the influence of centrifugal force.

It is found that by making the sleeve expandable, the

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centrifugal force thereon when the rotor is in motion is far more than sufficient to secure the sleeve against relative movement with respect to the rotor wall, even when plowing the most difficult of solids from the rotor.

Thus by the use of my invention, wear of the inner rotor wall is avoided, and is instead taken up by a sleeve which can be readily replaced with wear. Moreover, there is no need to mechanically secure the sleeve to the rotor wall.

Further features of the invention will become apparent to persons skilled in the art as the specification proceeds, and upon reference to the drawings in which:

FIGURE 1 is an elevation partly in section of a centrifuge embodying the invention;

FIGURE 2 is an end view of a type of sleeve; and

FIGURE 3 is an enlarged view of the region enclosed by a dot and dash circle in FIGURE 2.

Referring now to FIGURE 1 of the drawings, centrifuge 10 is of the scroll solids-discharge type. As shown, its rotor 11 is cylindrical in shape, and encloses an impeller member 12, which, as shown, comprises a continuous screw 13 attached along its inner helical and spiral edge to a supporting member 14, with its outer edge partly of helical shape as illustrated at 16, and partly of spiral shape, as illustrated at 17.

As illustrated, a pulley 29 is connected to the rotor 11, and both rotor 11 and impeller 12 are caused to rotate, but at a slightly different speed such as at a difference of from 10 to 60 r.p.m., by virtue of being interconnected through a planetary gear box 18, the design, construction, operation and function of which are well known in centrifuges of this type. A typical gear box, for instance, is shown and described in U.S. Patent 2,703,676.

As illustrated, the casing of gear box 18 is connected to rotor 11, and a driving connection between gear box 18 and member 14 is accomplished through shaft 19 which extends from the interior of the gear box 18 and connects with member 14, in a well-known manner. In couplings of this type, it is customary to hold a sun gear (not shown) in gear box 18 stationary. This is accomplished in the usual manner by mounting the sun gear on a shaft 40 held stationary by mounting it in a bracket 41 and securing the shaft 40 by a screw 42. Any other suitable coupling between the rotor 11 and the impeller member 12 to effect relative rotation therebetween may be substituted, as is well understood in the art. Then too, and as is also well known, rotor 11 and member 14 may be separately driven, but at slightly different speeds.

20 and 21' are pillow blocks containing bearings in which extensions on rotor 11 rotate. 37 and 38 are bearings between rotor 11 and member 14. 39 is thrust bearing for member 14.

The mixture of liquid and solids to be separated is fed into the rotor 11 through a conduit 21, and reaches a chamber 22 inside of the member 14. It then passes into the zone of centrifugation, situated between the member 14 and the inner wall 15 of the rotor 11, through a plurality of channels 23 in the member 14. Due to centrifugal force generated by the rapid rotation of the rotor 11 and associated parts, and the relative rotational movement of the screw 13 with respect to the rotor 11, solids are sedimented radially outwardly of rotor 11, onto inner wall 15 when my invention is not employed, and are moved to the right as seen in FIGURE 1.

In the particular centrifuge shown in FIGURE 1, and when my invention is not employed, portion 16 of screw 13 coacts with the inner wall 15 of rotor 11 in causing movement of solids to the right, and the portion 17 of screw 13 coacts with annular filler ring 30 in causing continued movement of such solids. Filler ring 30 is secured to rotor 11 and its inner surface is conveniently provided with grooves extending from left to right as

seen in FIGURE 1, which grooves serve to reduce or prevent any tendency of the solids flowing toward solids-discharge ports 24, to roll, grate or turn due to the relative rotation of screw 13 with respect to rotor 11. If desired, filler ring 30 may be omitted, in which case its place is taken up by separated solids over which further separated solids slide in moving to the right as seen in FIGURE 1.

The separated solids in completing their movement to the right as seen in FIGURE 1, are conveyed radially inwardly out of the level of the liquid in the zone of centrifugation, while continuing to be subjected to centrifugal force to separate liquid therefrom, the liquid thus separated flowing back to the main zone of centrifugation, and the solids are then discharged from the rotor 11 through ports 24, each at the time radial distance from the axis of rotation, and of which there may be any desired number.

It will be noted that the inlets 26 of ports 24 are closer to the axis of rotation than the ports 25, which causes the separated liquid to be discharged through ports 25 instead of through ports 24.

In the usual commercial embodiments of centrifuges of this type, discharge ports 25, of their equivalent, are made radially adjustable to increase or decrease their distance from the axis of rotation, as desired. This decreases and increases, respectively, the depth of the liquid layer in the rotor 11, but in no event is the depth of the liquid layer increased to the point where liquid would be discharged from the rotor through the ports 24.

Solids discharged from the rotor 11 are collected in section 31 of rotor housing 32, and are removed through hopper 33 at the bottom of section 31.

Liquid discharged from the rotor 11 through the ports 25 is collected in the section 34 of the housing 32, and is removed through the hopper 35 at the bottom of section 34.

As is well known, screw 13 may be either right-hand or left-hand in shape, that is, it may advance along member 14 either clockwise or counterclockwise, and/or it may, through its coupling to rotor 11, rotate either faster or slower than the rotor 11. Furthermore, screw 13 and rotor 11 may rotate together in either direction, that is, either clockwise or counterclockwise, as seen from the gear box 18. However, the shape of screw 13 and its relative rotation with respect to rotor 11, by virtue of the characteristics of the coupling employed between screw 13 and rotor 11, are coordinated so as to impel the separated solids in the zone of centrifugation to the right as seen in FIGURE 1, that is toward the discharge port 24.

Another typical and well known commercial centrifuge, otherwise constructed similarly to the one above particularly described, employs a conical rotor and a spiral screw conforming to the shape of the inner wall of the conical rotor with which it coacts throughout substantially its entire length to impel separated solids, similar to the coaction of section 16 of screw 13 with the inner wall 15 of rotor 11, as previously described. A centrifuge having a conical rotor and spiral screw is shown and particularly described in the above-mentioned U.S. patent.

Still another typical and well known commercial centrifuge, otherwise constructed similarly to the one above particularly described, is provided with a rotor having a plurality of perforations or holes through the rotor wall, whereby the rotor wall acts as a screen through which the separated liquid escapes, in which case there is no need for ports 25 for the escape of separated liquid. Such centrifuges may have a conical and/or cylindrical rotor, but in view of the use of a perforated or screen-like wall instead of a solid wall, rotor strength is very substantially reduced, accompanied by a substantial reduction in the maximum permissible speed of rotation when in use.

The foregoing description of typical centrifuges is to be considered as if sleeve 45 shown in FIGURE 1 is not present, that is, as if sleeve 45 were removed from FIG-

URE 1, in which case portion 16 of screw 13 is conveniently of somewhat larger diameter than illustrated, so as to bring its outer edge somewhat closer to wall 15 of the rotor 11, as will be obvious.

The construction of a typical sleeve 45 can be more clearly seen upon reference to FIGURE 2, in which it will be noted that sleeve 45 is discontinuous circumferentially, that is, it is provided with a longitudinal slit 46, more clearly seen in FIGURE 3. Otherwise stated, sleeve 45 is provided with longitudinal ends 47 and 48 which are joined together, and which preferably are slightly spaced from each other for reasons to be hereinafter more particularly described.

The outer surface of sleeve 45 is made to conform in shape to the inner surface of the rotor, such as rotor 11 particularly described, and its radial dimensions are preferably such that the clearance between the outer surface of sleeve 45 and the inner wall of the rotor provides a sliding fit, although such precision is by no means necessary in view of the flexible character of the material from which sleeve 45 is made.

By providing a small space between edges 47 and 48 at slit 46, e.g. from $\frac{1}{64}$ " to $\frac{3}{8}$ " in width, and particularly between $\frac{1}{64}$ " and $\frac{1}{16}$ ", sleeve 45 may be collapsed, by bringing edges 47 and 48 together with use of a suitable tool, to facilitate the insertion of sleeve 45 into and its removal from the interior of the rotor.

Sleeve 45 is preferably, though not necessarily, provided with circumferentially spaced ribs or ridges 49, which may be secured thereto by any suitable means, such as by welding. As illustrated, ribs 49 extend along the inner surface of sleeve 45 in straight lines in an axial direction, although ribs 49 may take any other desired shape. For instance, in some cases it may be preferred to have ribs 49 proceed along the inner surface of sleeve 45 generally in an opposite helical and/or spiral direction from that of the screw impeller, but usually with a substantially greater pitch, for it can be shown that, under normal conditions of separation, the separated solids tend to progress in this manner along the inner wall of the centrifuge rotor.

Ribs 49 are particularly helpful in making separations when in their absence the separated solids might tend to become wedged between the screw and the rotor wall, or otherwise tend to cause plugging.

When ribs 49 are employed, one rib 49 illustrated at 51 is preferably secured, such as by welding, to one longitudinal edge of the sleeve, such as edge 48 in FIGURE 3, with rib 51 slidably overlapping the other edge, such as edge 47. The result is that the slit 46 remains covered during operation.

As illustrated in dotted lines in FIGURE 1, one set of oppositely positioned ribs 49 illustrated at 52 (see FIGURE 2) are made somewhat longer to extend beyond the edge of sleeve 45 so as to enter somewhat larger slots 53 in annular ring 30, such arrangement serving merely as a guide for orienting sleeve 45 in rotor 11. Provision for orienting sleeve 45 is particularly helpful when the sleeve is perforated to match the perforations in a perforated rotor when employed.

While slit 46 has been illustrated as straight, i.e. in the form of a missing element in a surface of revolution, it is to be understood that it may take any other suitable shape, such as curved or jagged, without departing from the spirit of the invention.

An outstanding feature of my invention is that sleeve 45 may have any desired thickness, for the centrifugal force applied thereto, when the rotor is in operation, is directly proportional to the mass of the sleeve. For practicable purposes, however, it is preferred that the thickness of sleeve 45 should not exceed $\frac{1}{4}$ ", and particularly $\frac{1}{8}$ ". While theoretically sleeve 45 has no minimum thickness, it is preferred that it be sufficiently thick to maintain its shape and to withstand a considerable degree of wear prior to the necessity for replacement.

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Thus it is preferred that it be at least $\frac{1}{64}$ " thick and particularly at least $\frac{1}{32}$ ".

Sleeve 45 may be constructed of any desired substance of which metals, and particularly abrasion-resistant metals, are preferred. It is to be noted that metals generally possess the properties of flexibility and resiliency, albeit to varying degrees. Flexibility is the property of yielding at least to a degree without breaking. Resiliency is the property of springing back to a former shape, which is a preferred characteristic facilitating the removal of sleeve 45 for replacement purposes. It is to be understood, however, that sleeve 45 may take a permanent set while in use.

Typical metals from which sleeve 45 may be made are the various American Iron and Steel Institute carbon and alloy steels; ductile iron; stainless steel, such as the austenitic, martensitic, ferritic, and precipitation hardening grades thereof; high nickel alloys, such as those sold under the trade marks Monel, Inconel, and Hastelloy; titanium and its alloys; copper alloys, such as aluminum bronze and silicon bronze; etc.

While extreme brittleness is generally avoided, it is to be understood that breaking of sleeve 45, such as along a longitudinal line opposite slit 46, e.g. at 55, (see FIGURE 2), would not destroy the function of sleeve 45, for it would still adhere to the inner wall of the rotor, being still expandable under centrifugal force, to fulfill its intended purpose. In fact sleeve 45 might be made in sections, such as halves, e.g. by duplicating the structure shown in FIGURE 3 at one or more points around the periphery of sleeve 45, in the case of halves, suitably at 55.

A typical centrifuge of the type particularly described in connection with the drawings has a rotor with an inner diameter of 14", and an inner axial length of 22". The axial length of sleeve 45 is approximately 10", for in this particular case the annular filler ring 30 has a greater axial length than illustrated in FIGURE 1. Another typical centrifuge also has a rotor with an inner diameter of 14". The inner axial length of the rotor is 30", and the axial length of sleeve 45 is approximately 19". In each instance sleeve 45 is made of 316 stainless steel, including ribs 49. Both centrifuges, in view of their unperforated rotor walls, normally operate at between 3000 and 4000 r.p.m.

Uses for centrifuges of the kind herein described are so widely known throughout industry as to require no particular description.

Having particularly described my invention, it is to be understood that this is by way of illustration, and that changes, omissions, additions, substitutions and/or other modifications may be made without departing from the spirit thereof. Accordingly it is intended that the patent shall cover, by suitable expression in the claims, the various features of patentable novelty that reside in the invention.

I claim:

1. The combination with a centrifuge having a rotor for the separation of solids from liquid, said rotor having zones for the discharge of solids and liquid, means for impelling separated solids to the zone of discharge of

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solids, said last-mentioned means comprising an impeller for moving said solids relative to said rotor, and means for rotating said rotor and for actuating said impeller, of a flexible sleeve of thin, non-stretchable, wear-resistant material, the sleeve being received into said rotor in sliding fit and being circular in cross-section in contact with a corresponding area circular in cross-section on the inner periphery of said rotor, the inner surface of said sleeve being close to said impeller, said sleeve having a slit therein extending from one end thereof to the other so as to expand under centrifugal force upon rotation of said rotor to grip the inner periphery of said rotor, thereby preventing relative movement between said sleeve and said rotor upon relative movement of said impeller with respect to said sleeve in moving solids deposited by centrifugal force on the inner surface of said sleeve toward the zone of discharge of solids, and a plurality of circumferentially spaced ribs secured to the inner surface of said sleeve, one of said ribs being attached to one edge of said slit, said rib overlapping said slit in said sleeve.

2. The combination with a centrifuge having a rotor for the separation of solids from liquid with separate zones in said rotor for the discharge of solids and liquid, said zones being axially spaced and positioned on opposite ends of a separating zone in said rotor, means for impelling solids separated in said separating zone to the zone of discharge of solids, said last-mentioned means comprising an axially arranged screw for moving said solids longitudinally of said rotor, and means for rotating said rotor and for rotating said screw relative to said rotor, of a flexible and resilient sleeve of thin, wear-resistant metal received into said rotor in sliding fit and having a smooth outer surface circular at any cross-section thereof in contact with a correspondingly smooth area circular at any cross-section on the inner periphery of said rotor, the inner surface of said sleeve being close to the edge of said screw, said sleeve having a longitudinal slit therein extending from one end thereof to the other so as to expand under centrifugal force upon rotation of said rotor to grip the inner periphery of said rotor, thereby preventing relative movement between said sleeve and said rotor upon relative movement of said screw with respect to said sleeve in moving solids deposited by centrifugal force on the inner surface of said sleeve toward the zone of discharge of solids, and a plurality of circumferentially spaced longitudinally extending ribs on the inner surface of said sleeve, one of said ribs being attached to one edge of said slit and overlapping said slit in said sleeve.

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