

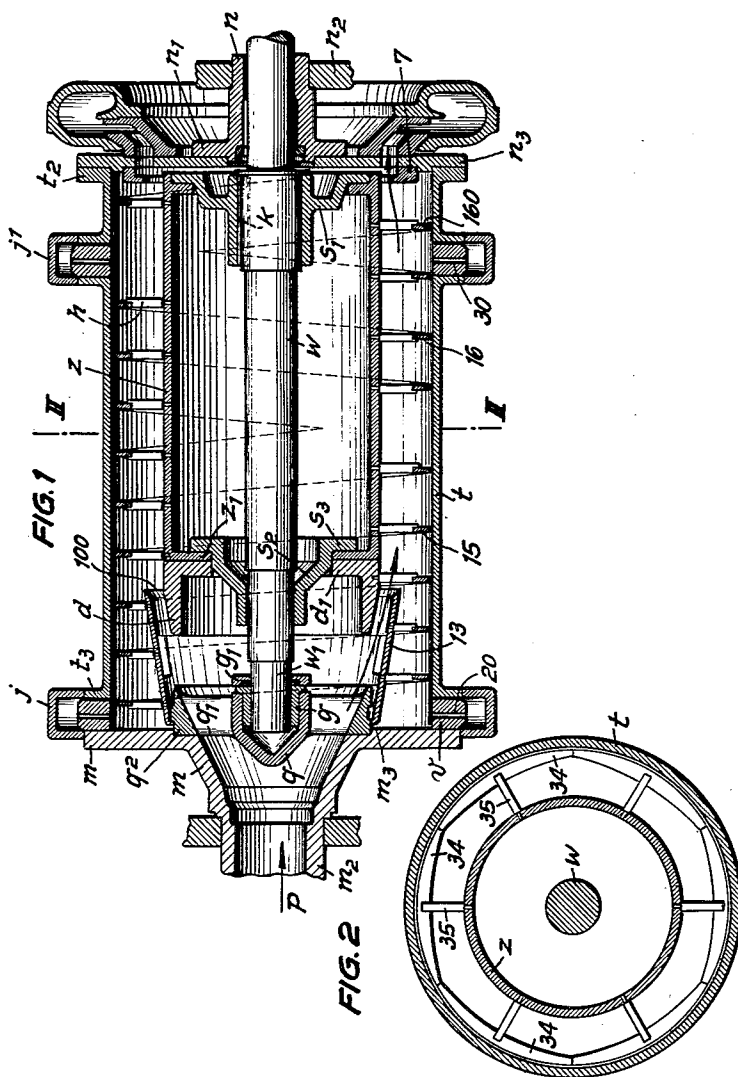
Oct. 16, 1956

L. SCHMIEDEL
CENTRIFUGAL SEPARATOR

2,766,930

Filed Dec. 10, 1952

4 Sheets-Sheet 1



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FIG. 3

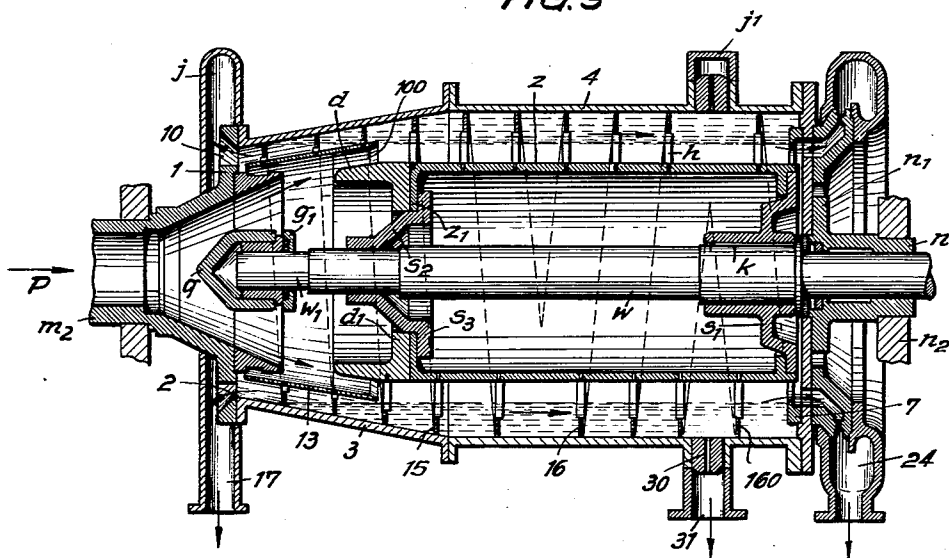
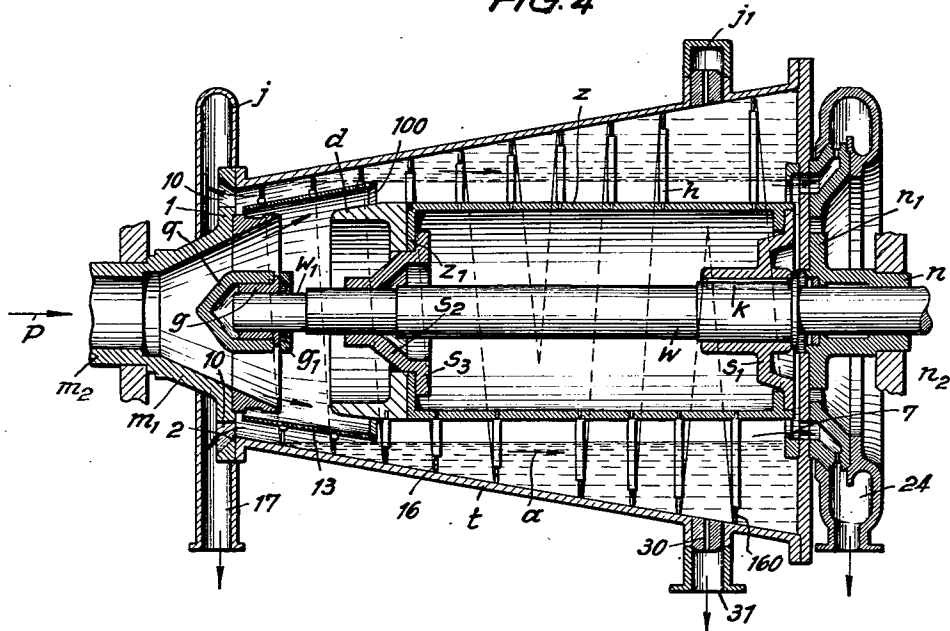


FIG. 4



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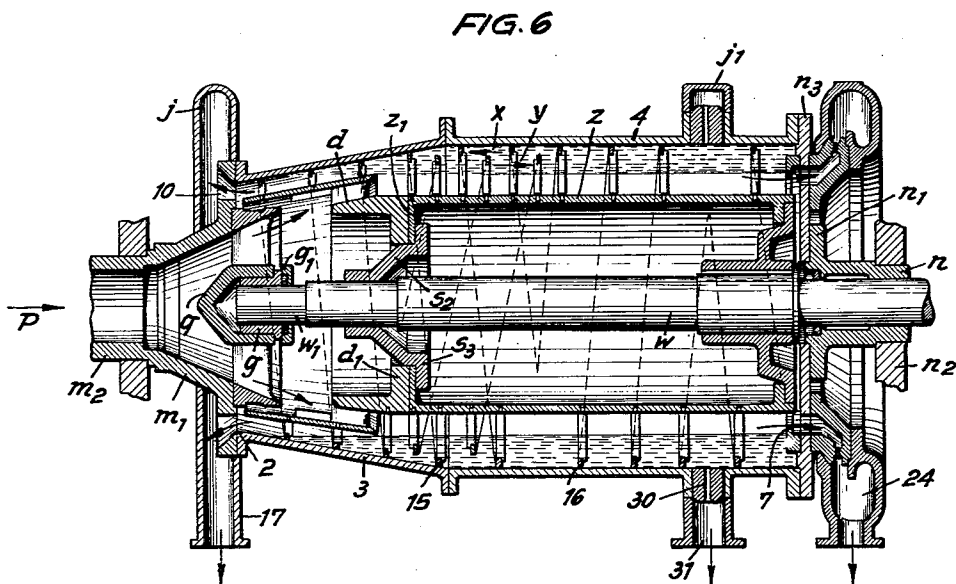
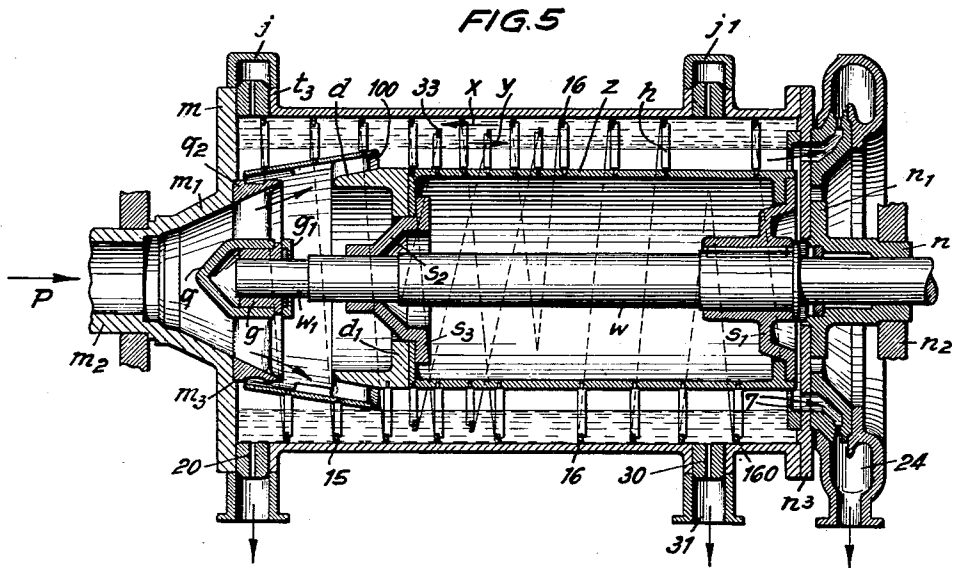
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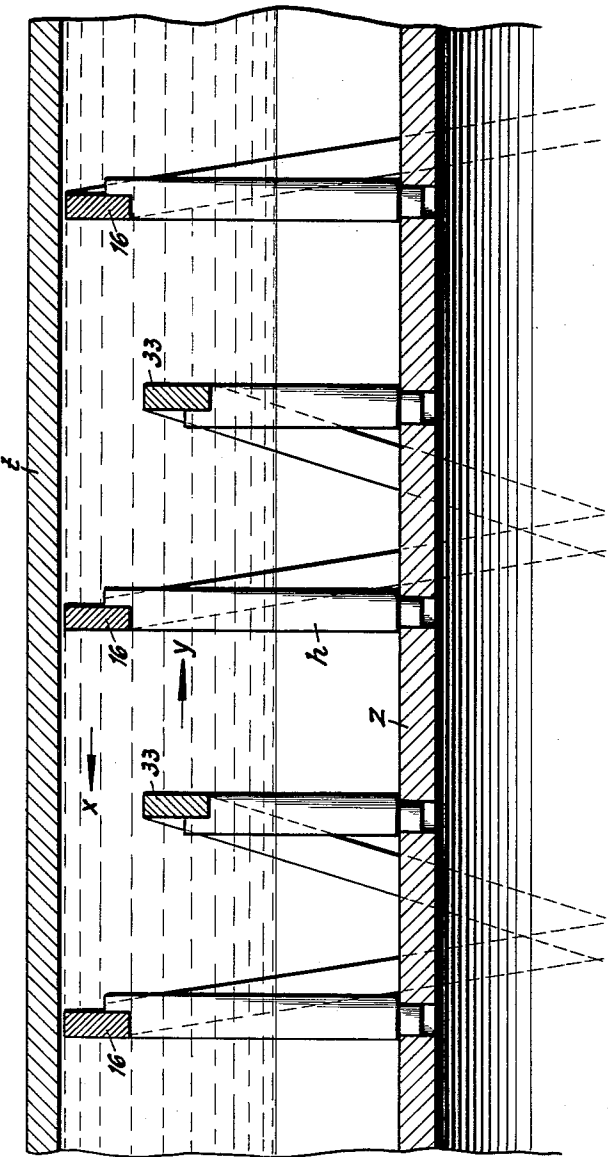
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FIG. 7



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10 Claims. (Cl. 233-7)

This invention relates to an improvement in centrifugal separators of the type having a horizontal shaft and a non-perforated centrifugal drum for discharge of the heavy solids or media at one end of the drum and discharge of the carrier liquid more or less freed from solids at the opposite end of the drum.

It is an object of the present invention to keep the liquid leaving the separator as much as possible free from solid matter.

Another object of the invention is to provide means for the separation of solids with high settling rate.

Still another object of the invention is to provide means permitting separation not only basing on the settling rate of the solids, but also to consider their "settling power" as will be hereinafter described in greater detail.

With these and further objects in view, the invention consists in the constructional and operational features, combination of elements and other details as hereinafter described and defined in the accompanying claims.

In order that those skilled in the art may understand how to use the invention and to achieve its various objects, some embodiments and exemplifications of the invention have been illustrated in the accompanying drawings, in which:

Fig. 1 is a horizontal axial section through a centrifugal separator at the inlet end of the drum and nozzle discharge for the less heavy solids in the vicinity of the liquid outlet,

Fig. 2 is a cross section of Fig. 1,

Figs. 3 and 4 are axial sections showing two different modifications of a centrifugal separator having the invention applied thereto, with discharge of the heavier solids over a forward annular edge,

Figs. 5 and 6 are axial sections of two different modifications according to the invention each with a second screw conveyor unit arranged within the outer discharge screw, and

Fig. 7 is an enlarged fragmentary sectional view of the screw conveyor means as per Figs. 5 and 6.

Similar reference numerals denote similar parts in the different views.

In order that the invention and its various aspects may be fully understood by those skilled in the art, I will at first describe the same in a general way.

To achieve the above mentioned object of keeping the liquid discharging from the centrifugal separator as much as possible free from any solids, there is provided a second discharging device in the vicinity of the liquid outlet. In operational connection therewith the discharge screw consists of two parts with oppositely directed angle of pitch, in such a way that the forward part acts to convey the heavier media, settling earlier than the lighter media, towards the front side outlets in an opposite direction of the liquid flow, while the rearward part of the screw with opposite angle of pitch acts to convey the lighter solids depositing in the rearward part of the drum to the outlets situated in the vicinity of the liquid outlet.

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The boundary or separating line between the two settling zones with different settling power of the solids depends upon the size of the particles and the specific gravity of these solids. From this boundary onwards the heavier particles have to be conveyed to the forward outlets by the forward screw or the forward part of the screw conveyor, and behind this boundary the lighter solids have to be conveyed to the outlets in front of the liquid outlets by the rearward screw or the rearward part of the screw conveyor with opposite angle of pitch. In this case it is oftentimes useful to construct the outlet for the said lighter solids in the form of nozzles; the outlets for the heavier solids may also be nozzles.

Since the boundary for the division of the discharge screw into two oppositely operating portions is not fixed once and for all, it is contemplated according to a further feature of the present invention to adapt the separator to the varying requirements of the material to be handled by providing means permitting axial displacement of the boundary between one conveying direction and the opposite conveying direction of the discharge screw in relation to the centrifugal separator. This can be achieved by constructing the discharge screw conveyor of a plurality of single segments which are pivoted on their carrier body. The boundary line can thus be axially displaced by suitable turning of the segments. After the turning of the segments they have to be fixed. To this end, auxiliary pins may be provided.

In order to achieve the above mentioned object of centrifuging solids with a high settling rate, means are provided for discharging the heavier solids in the forward end of the drum over an annular edge which is higher than the liquid level in the drum which is defined by the discharge weir, rather than through nozzles. In this case the discharge by the screw is independent of the density of the liquid which is fed, or independent of the solid content of the liquid, and the screw will discharge always only the solids fed for discharge, regardless of their quantity. In this case, always only a predetermined quantity of liquid contained in the medium is discharged. At any rate, however, this amount of liquid will be smaller than in case of discharge of the solids through a nozzle. The use of nozzles for discharging the heavier solids is advantageous if said solids are of a slimy or muddy condition and thus unsuitable for being seized and lifted by a screw conveyor.

As mentioned above, it is also intended according to the present invention to consider the "settling power" of the solids. The following example will explain this term:

If a suspension consisting of water and starch with a predetermined solid content, is introduced into a show vessel of about 300 mms. height and 40 mms. inner width, and the starch is allowed to settle, the starch will settle on the bottom of the show vessel after a predetermined time in a predetermined height, while the liquid above the starch is clear. Experience has shown that the starch settles in the show vessel with a moisture of about 50 to 55%. If maize gluten is stirred into a suspension with the same quantity by weight of water and allowed to settle, the maize gluten will settle almost within the same time; however, the height of the layer is a multiple of that of the starch. For instance, if the starch layer has a height of 10 mms., the settled layer of maize gluten will have a height of about 60 mms. This is due to the fact that the maize gluten is not granular like the starch, but flaky and that it will never condense to the same extent as starch. Settled maize gluten has a moisture content of about 90% water. Accordingly the "settling power" of maize gluten is much worse, in fact, 6 times worse than that of starch.

Where it is intended to cause settling and separation of two solids of a greatly different settling power and nearly equal settling rate, by means of a centrifugal separator, there will invariably be deposited on the wall of the drum at first the solid of a higher settling power, i. e., in the above example, the starch layer, and above the same in a muddy form, the medium of inferior settling power, i. e., in the above example, the gluten.

Since there is a flow or current from the inlet towards the outlet of the centrifugal separator, this muddy layer of course is slowly carried towards the outlet end; however, the muddy layer prevents separation of the succeeding mixture of starch and gluten; for the separation of two substances is greatly hampered in such a mud layer. The rate of flow of the liquid passing through the machine depends on the charge per hour in cubic meters.

This rate of flow cannot be increased at will, for in case of a high rate of flow the solids with a low settling rate would be discharged with the waste water. On the other hand it must be avoided that a layer of mud is formed above the deposited starch.

To overcome this difficulty, a second conveyor screw is arranged within the discharge worm serving for the removal of the solids depositing on the wall of the drum, for seizing the settling mud layer and conveying it towards the discharge end. Since this inner screw conveyor is also formed of a narrow strip, there is left a free space between the same and the axis of rotation, for unhampered passage of the liquid flow. The annular internal screw acts upon the lighter solid substances and prevents the same from settling together with the heavier solids. Said inner annular screw need not extend over the entire length of the drum, but is required only where mixing of heavier and lighter settling media might occur without its operation. Therefore, the inner annular screw may comprise only a few screw threads or segment threads, which advantageously are swivel-mounted and flexible on their carrier.

Some embodiments of centrifugal separators based on these general principles will now be described in greater detail with reference to the drawings.

The general construction of the centrifugal separators shown in the drawing is known per se, the discharge screw conveyor being carried by a tubular body *z* within a non-perforated centrifugal drum *t*. The drum *t* and the cylinder *z* are driven at different rates of speed, so that a differential speed exists between them. The constructional means for such drives are generally known and described, for instance, in my copending patent application 222,595, now Patent 2,734,681 of February 14, 1956, and in the German Patent 653,056, and therefore are not shown in detail. It is merely shown in Fig. 1 that a tubular cylinder *z* is concentrically held on shaft *w* by means of a hub *s*₁ keyed to the shaft *w* and disc or hub *s*₂ at the opposite end of the cylinder, for rotation with shaft *w* which passes through the hub *n* of a flanged sleeve *m*₁. Mounted on the hub *n*, by a key (not shown) or by shrinking-on, is a driving wheel *n*₂ which is only partly indicated and operated in the manner as shown in greater detail in the German Patent 653,056. By means of arms *h* the cylinder *z* bears an annular discharging screw consisting of two portions 15 and 16 which, as indicated by the dotted lines, have an oppositely directed angle of pitch, so that, in case of a suitable direction of rotation of the cylinder *z*, the left hand part 15 of the discharging screw exerts a conveying action in a left-hand direction while the part 16 disposed on the right hand side of the plane II—II exerts a conveying action in a right-hand direction.

The non-perforated centrifugal drum *t* is detachably connected to the disc *n*₁ through an intermediate disc *n*₃ by means of a flange *t*₂, for instance by screw means (not shown). The flange *t*₃ at the opposite end of drum *t* is disposed within a U-shaped rim *j*, having a downwardly directed outlet which cannot be seen in the horizontal

section of Fig. 1. An annular body provided with nozzles 20 is arranged adjacent to a disc *m* passing, through a truncated cone-shaped member *m*₁, into a hub *m*₂. The part *m* and the annular body *v* comprising the nozzles 20 and the flange *t*₃ of drum *t* are connected by screw connection, so that the drum *t* takes part in the rotation transmitted to the hub *n* of disc *n*₁ through the wheel *n*₂.

The hollow hub *m*₂ serves to feed the liquid which is to be centrifuged and contains solid media, as indicated by the arrow *p*. The liquid now passes through the inside of the truncated cone *m*₁ into the centrifugal separator and over the bearing hub *q* which is carried by a ring *q*₂ through ribs *q*₁. The ring *q*₂ is inserted in a shoulder *m*₃ of the disc *m*, thus rotating therewith, and bears in a stuffing box *g*, which is shut off by a disc *g*₁ with insertion of a packing ring, the reduced left hand end *w*₁ of the shaft *w*. The hub member *s*₂ bears a sleeve-shaped member *d* by means of an inner flange *d*₁ thereof, a flange *z*₁ of a cylinder *z* being sandwiched between the flange *d*₁ and the flange *s*₃, by screw means (not shown) extending through the three flanges *d*₁, *z*₁, and *s*₃. The free space between the mouth end of the ring *q*₂ and the disc *d* is bridged by a cone 13 opening out at 100 into the space between the drum *t* and the cylinder *z*. Thus the carrier liquid entered into the hub *m*₂ in the direction of the arrow *p* passes from the truncated cone *m*₁ and the conical inner opening of ring *q*₂ into the cone 13, leaving the same at 100. As indicated by the longitudinal sections, this entrance into the centrifugal drum *t* takes place at some distance from the left hand end thereof, where the outlets 20 are located.

During operation of the centrifugal drum the heavier solid substances depositing in the zone of the left hand part 15 of the discharge screw are conveyed in a left-hand direction by said screw part, towards the nozzles 20, while the lighter solid material depositing in the zone of the right hand part 16 of the conveyor screw having an opposite angle of pitch are conveyed in a right-hand direction by said part 16, towards a set of nozzles 30 disposed within a U-shaped ring *j*₁ having an outlet 31 shown for instance in Fig. 3 but not shown in Fig. 1. The lighter material conveyed by the right hand part 16 of the worm passes into this ring *j*₁ through the nozzles 30. As will be seen from the drawings, a short length 160 of the discharge worm is provided for conveying the lighter solid material depositing in the space between the weir 7 and the set of nozzles 30 so as to bridge this space. To this end, said length 160 of the screw has an angle of pitch opposed to that of part 16, as indicated by the dotted projection lines.

As pointed out above, the boundary between the portions 15 and 16 of the discharge conveyor, which boundary is indicated by the line II—II, is advantageously axially shiftable. To this end, as indicated by the cross sectional view, Fig. 2, the helical surface of the screw may be composed of single segments 34 each of which is fulcrumed on a pin 35 and adapted to be locked in various angular positions.

The axial displacement of the boundary line rendered possible by turning the segments, in dependence upon the settling rate of the solids, can be confined to a relatively restricted range. Thus, for instance, the part of the worm 15 disposed more towards the set of nozzles 20 may be constructed as a continuous strip while only the portion of the worm coming into question for the displacement is provided with pivoted segments.

The centrifugal separator shown in Figs. 1 and 2 has nozzles both for the discharge of the heavier and of the lighter solids. This is useful in case of a muddy or spongy condition of the solids. On the other hand, where the solids of high settling rate are of such a nature that they can be discharged by a screw conveyor, it is preferred to use the construction shown in Figs. 3 and 4, with annular edge.

Since the general construction of a centrifugal sepa-

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rator according to the invention has been described in detail with reference to Fig. 1, it will be sufficient to discuss only the modified features with reference to Figs. 3 and 4.

The flange 1 of the truncated cone body m_1 is formed with outlets 10 leading into a surrounding casing j with outlet 17. The openings 10 are the direct continuation of the left hand opening of the forward conical part 3 of the centrifugal drum, in such a way that an annular edge 2 is formed which as shown in Figs. 3 and 4, is located at a higher level than the level of the liquid defined by the weir 7 during the centrifuging. The liquid moves within the drum in the direction of the arrow a , Fig. 4.

While the drum according to Fig. 3 consists of two parts 3 and 4, which are interconnected by flanges and screw means (not shown) the drum t of the centrifugal separator as per Fig. 4 is of truncated conical section, the heavier solids being discharged through the narrow part of the truncated cone and the openings 10 disposed in this part while the weir 7 is located at the wide end of the drum t . In both cases the right hand part 16 of the screw conveys settled material to the nozzles 30 located at some distance before the weir 7 and leading to the discharge 31. The continuous conical enlargement of the drum t as per Fig. 4 as distinguished from the construction of the drum part 4 as per Fig. 4 serves the following purpose.

Where the lighter solid constituents have a very small settling rate, the rate of flow of the suspension has to be kept as low as possible in order that the solid constituents have sufficient time to settle. This requirement is met by the construction as per Fig. 4. Owing to the growing cross section of the flow bed in the direction of arrow "a" the rate of flow is gradually decreasing so that the light solids are allowed to settle. Preferably, provision for axial shifting of the boundary between the two parts of the discharging screw is made in the modifications as per Figs. 3 and 4 in the same way as described with reference to Figs. 1 and 2.

The centrifugal separator as per Fig. 5 is constructed on principle in the same way as that shown in Fig. 1, while the centrifugal separator as per Fig. 6 corresponds to that of Fig. 3. In both embodiments as per Figs. 5 and 6 it has been taken into account that a mud layer may form above the solid material of a higher settling power. In both cases, Figs. 5 and 6, a second screw is arranged within the screw serving to discharge the material deposited on the wall of the drum; again, said second screw may consist of a few threads only. It is displaced relatively to the real discharge screw means towards the interior. In the embodiment as per Fig. 5 the solids of higher specific gravity are conveyed by the screw portion 15 to the forward set of nozzles 20 and the solids of lower specific gravity are conveyed to the set of nozzles 30 through the screw portion 16, while in the embodiment of Fig. 6 the forward set of nozzles is substituted by an annular edge 2.

In both cases a second screw 33 is provided within the screw 15, 16. It need not extend over the entire length of the drum and in the exemplifications as per Figs. 5 and 6 is provided substantially in the forward part of the drum, i. e., more towards the inlet side. The fillets of the screw 33 are located so as to dip into the mud layer. The outer edges of the inner screw 33 are disposed within the inner edges of the strips making up the outer worm and have an oppositely directed pitch. Therefore, the forward part 15 of the outer screw Fig. 5 conveys the material to the set of nozzles 20 and in Fig. 6 to the annular edge 2, i. e., in the direction of arrow X, while the inner screw conveys the material in the direction of arrow Y to the opposite side. This will be seen more clearly from Figure 7. Since the inner screw 33 consists of a strip, a free space is left in its interior for unhampered flow of liquid.

It is not always necessary to construct the inner screw

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33 in the form of a complete screw from the start to the end. In many instances it will be sufficient to provide single strip-shaped screw segments. Owing to the oblique arrangement of these segments the liquid is forcibly moved, as by a paddle, i. e. in the direction of arrow Y. The deposited mud is thus conveyed to the outlet end and discharged through the nozzles 30 in Figs. 4 and 5, while the liquid flows off over the weir 7.

While the invention has been described in detail with respect to certain now preferred examples and embodiments of the invention it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended, therefore, to cover all such changes and modifications in the appended claims.

I claim:

1. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for lighter solids in the vicinity of the liquid outlet means, and a rotatable conveyor screw including two parts lying one after the other and constituting oppositely directed helices, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means.

2. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, nozzles for discharging the lighter solids in the vicinity of the liquid outlet means, and a rotary screw conveyor including two parts of opposite pitch angle lying one after the other, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means.

3. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, nozzles for the discharge of the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, nozzles for discharging the lighter solids in the vicinity of the liquid outlet means, and a rotary screw conveyor including two parts of opposite pitch angle lying one after the other, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means.

4. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, a weir disposed at one end of the drum for the flow thereover of the carrier liquid at least partly freed from solids, an annular edge member located nearer to the axis of rotation of the drum than the overflow weir, for discharging the heavier solids at the opposite end of the drum, outlet means for the lighter solids in the vicinity of the liquid outlet means, and a rotary screw conveyor including two parts of opposite pitch angle lying one after the other, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means.

5. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of

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the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, a weir disposed at one end of the drum for the flow thereover of the carrier liquid at least partly freed from solids, and a rotary screw conveyor including two parts of opposite pitch angle, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means, said screw conveyor including means for axially displacing the boundary line between the two parts with opposite direction of conveying.

6. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for the lighter solids in the vicinity of the liquid outlet means, and a rotary screw conveyor including two parts of opposite pitch angle, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means, said screw conveyor including segments which can be adjusted to opposite pitch angles for axially displacing the boundary line between the two parts with opposite direction of conveying.

7. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for the lighter solids in the vicinity of the liquid outlet means, and a rotary screw conveyor including two parts of opposite pitch angle, in such a way that the forward part of the screw is adapted to convey the heavier solids against direction of the liquid flow to the forward outlet means while the rearward part of the screw is adapted to convey the lighter solids to the rearward outlet means, said screw conveyor including a carrier drum and a screw mounted on said carrier drum and comprising segments which are pivotally mounted on the carrier drum and can be fixed at opposite pitch angles for axially displacing the boundary line between the two parts with opposite direction of conveying.

8. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for lighter solids in the vicinity of the liquid outlet means, a first screw conveyor comprising two parts with oppositely directed pitch angle lying one after the other, whereby the forward part of the screw is adapted to convey the heavier solids deposited on the inner wall of the centrifugal drum, against direction of the liquid

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flow, to the forward outlet means, while the rearward part of the screw is adapted to convey the lighter solids deposited on the inner wall of the centrifugal drum to the rearward outlet means, and a second screw conveyor coaxially disposed in the annular space within the first screw conveyor and including a conveyor screw in the form of a helical strip leaving a free space for passage of liquid between the inner edges of the helical strip and the shaft.

9. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for lighter solids in the vicinity of the liquid outlet means, a first screw conveyor comprising two parts with oppositely directed pitch angle lying one after the other, whereby the forward part of the screw is adapted to convey the heavier solids deposited on the inner wall of the centrifugal drum, against direction of the liquid flow, to the forward outlet means, while the rearward part of the screw is adapted to convey the lighter solids deposited on the inner wall of the centrifugal drum to the rearward outlet means, and a second screw conveyor coaxially disposed in the annular space within the first screw conveyor and including a conveyor screw in the form of a helical strip leaving a free space for passage of liquid between the inner edges of the helical strip and the shaft, said helical strip comprising only a few screw threads.

10. A centrifugal separator comprising a horizontal shaft, a non-perforated centrifugal drum mounted thereon, forward outlet means for the heavier solids at one end of the drum, rearward outlet means at the opposite end of the drum for the carrier liquid at least partly freed from solids, outlet means for lighter solids in the vicinity of the liquid outlet means, a first screw conveyor comprising two parts with oppositely directed pitch angle lying one after the other, whereby the forward part of the screw is adapted to convey the heavier solids deposited on the inner wall of the centrifugal drum, against direction of the liquid flow, to the forward outlet means, while the rearward part of the screw is adapted to convey the lighter solids deposited on the inner wall of the centrifugal drum to the rearward outlet means, and a second screw conveyor coaxially disposed in the annular space within the first screw conveyor and including a conveyor screw in the form of a helical strip leaving a free space for passage of liquid between the inner edges of the helical strip and the shaft, said helical strip comprising a few segment-shaped screw threads.

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