Jan. 6, 1959 — W. F. HARLOW — 2,867,378

CENTRIFUGING MACHINES

Filed Sept. 16, 1954 — 2 Sheets-Sheet 1

FIG. 1.

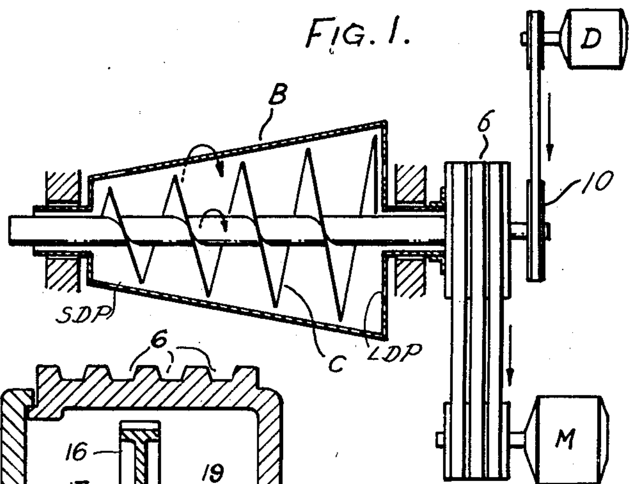

FIG. 3.

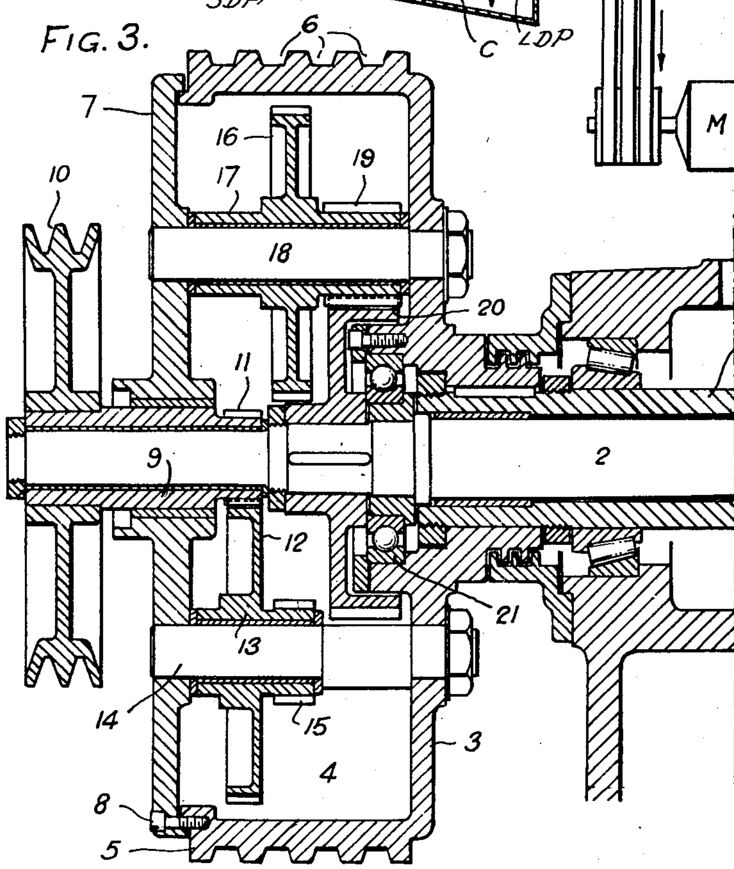

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FIG. 2.

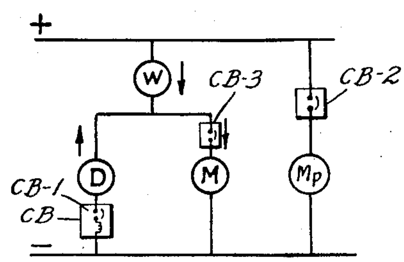
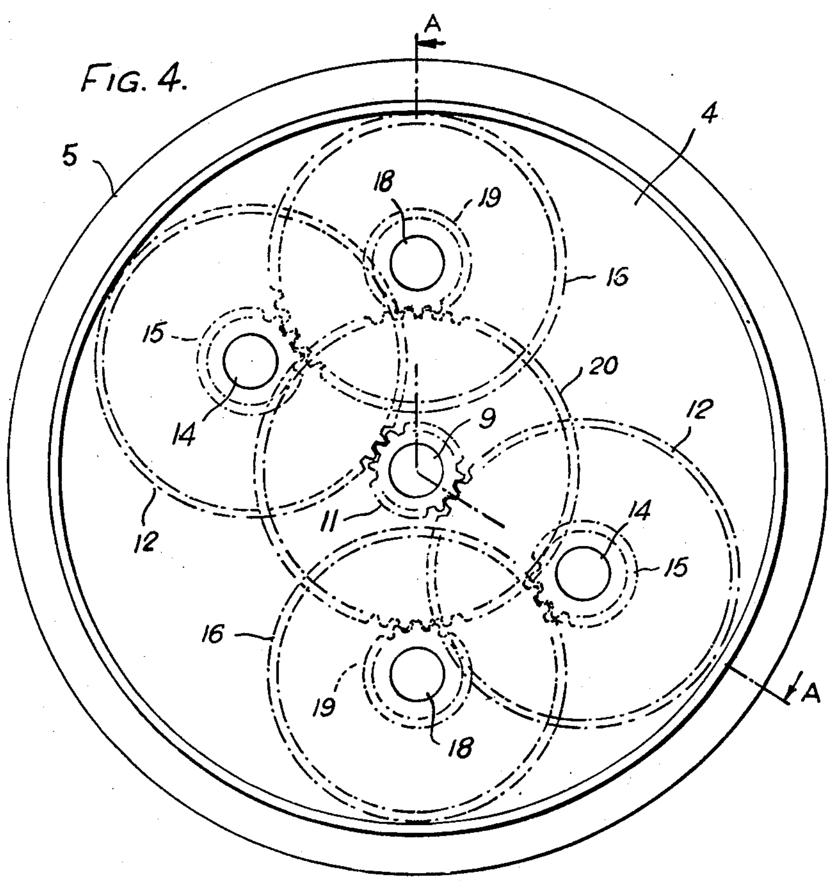


FIG. 4.



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CENTRIFUGING MACHINES

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2 Claims. (Cl. 233—7)

This invention relates to centrifuging machines in which two members of the centrifuge, a shell member and a conveyor member are rotated in the same direction but at slightly different speeds. The invention relates particularly to centrifuging machines in which the shell is rotated at a high speed and a screw conveyor arranged co-axially within the shell is rotated at a slightly different speed so that material contained in a liquid fed to the centrifuge is removed continuously from the shell after separation from the liquid by centrifugal force.

It has been proposed that the shell member and the conveyor member be driven from separate sources of power via main and auxiliary drives through an epicyclic gearing which couples the members together. With this arrangement the differential speed of the two members of the centrifuge depends upon the difference in speed between the main and auxiliary drives. It is found, however, that only a certain proportion of power applied via the auxiliary drive is utilized in overcoming resistance between conveyor and shell and the balance is unavoidably imparted to the rotating shell thereby relieving the load on the main motor.

It can be shown that the proportion of the power from the auxiliary source which is actually utilized in turning the screw conveyor relatively to the shell is expressed by the fraction

$$\frac{dR}{M+dR}$$

where d is the difference in speed between the conveyor and shell in revolutions per minute, R is the gear box ratio and M is the machine speed i. e. the speed of rotation of the shell member in revolutions per minute. Thus, to utilize any considerable proportion of the power of the auxiliary source the auxiliary driving member must rotate at a speed very much greater than that of the machine which is itself rotating at a high speed. This raises considerably the capital cost of the machine and renders its design difficult since it is undesirable for the auxiliary drive to take up the main drive as power is usually applied at a point remote from the main bearings of the centrifuge.

It is an object of the present invention to provide a centrifuging machine in which the disadvantages referred to above are substantially overcome.

According to the present invention a centrifuging machine comprises in combination a shell member, a conveyor member contained within the shell member, a driving shaft for said shell member and a driving shaft for said conveyor member coaxial with said shell member driving shaft, a housing containing epicyclic gearing, said shell member driving shaft being splined in said housing and said conveyor shaft projecting into said housing and being splined to a pinion therein, an output shaft projecting from said housing, a train of epicyclic gears inside the housing coupling said pinion with said output shaft, an electric motor for rotating said housing, an electric current generator coupled to said output shaft and pro-

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viding an output indicative of the power necessary to produce differential movement of the shell member and the conveyor member, said output being utilized by said electric motor and a current overload device in the output of the generator for cutting out the latter on overload.

In a centrifuge according to the invention the proportion of power imparted to produce differential speed of the conveyor member is expressed by the fraction

$$\frac{dR}{M-dR}$$

The balance of power adds to the load on the main drive. It is apparent that a much greater proportion of power may be imparted to the conveyor member thus allowing the speed of the epicyclic gearing to be reduced. In addition the function of driving the centrifuge is restored to the main power source for which the latter is designed.

As an example of the invention a centrifuging machine in accordance therewith will now be described in greater detail with reference to the accompanying drawings of which:

Fig. 1 shows in diagrammatic form the arrangement of the machine and its power source,

Fig. 2 shows the electric connections of electric driving motors,

Fig. 3 is a cross section along the line A—A of Fig. 4 of an epicyclic driving gear, and

Fig. 4 is an end view of the driving gear with a cover plate removed.

Referring to Fig. 1 the centrifuging machine consists of two coaxial elements, separately rotating in the same direction, a shell member B and a conveyor C.

Solid bearing liquid to be centrifuged is admitted to the inside of the shell member B and the liquid and solid constituents receive an angular momentum which imposes a high centrifugal force on solids suspended in the liquid. That force causes the suspended solids to settle on the inside surface of the shell member at a greatly accelerated rate depending upon the rotational speed of the shell member. The liquid assumes a solid of revolution whose surface is cylindrical. When the liquid level reaches a predetermined position the liquid overflows through liquid discharge ports LDP in one end wall of the shell member. In the meanwhile, the solids on the interior surface of the shell member are "screwed" or conveyed by the conveyor C out of the liquid towards the other end of the shell member and are ultimately discharged through the solid discharge sorts SDP. During their passage towards the discharge ports SDP, solids are progressively dewatered.

The shell member B is driven by a main motor M through a pulley **6** which is directly coupled to it, whereas the conveyor is carried on the output shaft of a reversing reduction gear housed in the main driving pulley. The input shaft of the gear box carries the conveyor pulley **10** which is belt connected to a conveyor control dynamo-electric machine D which of course is a generator capable of serving as a motor according to whether it is supplied with mechanical or electrical energy and whether it is therefore giving out electrical or mechanical energy respectively, as is well known to those skilled in the art. See for example New Standard Encyclopedia, Funk and Wagnalls Co., New York and London, 1931, vol. X, page 66. To avoid confusion with the main motor M the dynamo-electric machine D will herein be termed the controller or generator D. The pulley **10** constitutes the auxiliary control driving member which in the form shown is coupled to the controller D by a belt drive. The arrangement provides a speed difference between the main and conveyor pulleys equal to dR. In practice d is required to vary between 4 and 20 R. P. M. and the gear box ratio R may be 20 or 30 according to design. The conveyor C is made to revolve faster than the shell member B thereby conveying the settled material separated from a fluid fed into the machine towards the small end of the cone and, since the gear box is of the reversing type, the conveyor pulley rotates slower than the main drive. Therefore the revolutions per minute of the pulley 6 fixed to the shell B, minus the revolutions per minute of the pulley **10** which drives the conveyor C through the epicyclic gearing shown in Fig. 4 and hereinafter described, equals dR in the above equation.

Any resistance to the differential rotation of conveyor and shell member tends to reduce their speed difference and to produce a corresponding but greater reduction in speed difference between the main and conveyor pulleys. This tends to increase the actual speed of the conveyor pulley.

The effect of the resistance between conveyor and shell member B is to drive the conveyor pulley and consequently when the conveyor control generator D is placed in circuit, this unit delivers current. This is shown in Fig. 2 by the arrows which indicate current direction, W is a watt-meter which indicates net power. As the machine is loaded with material, this current increases. The power output of the conveyor control generator is proportional but not equal to the power transmitted by the gears giving the relative movement between conveyor and shell.

By this means the relatively high torque required for screwing out the material against the influence of centrifugal force is indicated, and when this approaches a value dangerous to the gearing, the generator is tripped as at CB–**1**, Fig. 2, by the usual current overload device CB. After this occurs the conveyor and pulley revolve together and no gear damage can result.

By electrically interlocking the pump motor Mp feeding the machine with the conveyor control generator, say, by a second circuit breaker contact CB–**2**, the supply of material fed to the machine can automatically be cut off before overload occurs. If necessary the machine can be shut down by the same means as indicated at CB–3, Fig. 2.

The current delivered by the conveyor control generator partly offsets the consumption of the main motor and the net power is only that necessary to accelerate the feed, screw out the material and overcome the frictional and electrical losses. In effect, the conveyor control generator acts as an electrical brake and gives a control that cannot be obtained with fixed gearing.

With the arrangement described above the differential between conveyor and shell can be readily adjusted by changing the pulley on the conveyor motor drive.

Referring now to Figs. 3 and 4 of the drawings the shell B and the conveyor C have been omitted but it will be understood that these members are driven by shafts **1** and **2** respectively. The shaft **1** is keyed in a wall **3** of a gear housing **4**, whose peripheral edge **5** is formed with driving belt engaging members **6**. The gear housing **4** is closed by an end cover plate **7**, which is secured in position by bolts **8**.

Passing centrally through the cover plate **7** and free to rotate with respect thereto is a stub shaft **9** carrying a pulley wheel **10** outside the housing **4**.

That end of shaft **9** inside the housing **4** has fixed to it a pinion **11** which meshes with two larger pinions **12**. The pinions **12** are each fixed to a hollow shaft **13** rotatably mounted on an axle **14** fixed between the cover plate **7** and the wall **3** of the housing **4**. The relative positions of the axles **14** are shown in Fig. 4. The shafts **13** also have fixed to them pinions **15** which mesh with pinions **16** on hollow shafts **17** rotatably mounted on axles **18** fixed between the end cover plate **7** and the

wall **3** of the housing **4**. The position of the axles **18** is shown in Fig. 4.

The shafts **17** also have fixed to them pinions **19** which mesh with a pinion **20** keyed on the end of the shaft **2** which as can be seen in Fig. 3 projects into the gear housing **4**. That end of the shaft **2** inside the housing **4** is supported on ball bearings **21**.

In use the gear housing **4** is rotated from a main driving motor by means of a driving belt engaging the members **6** while the pulley wheel **10** is connected with an auxiliary generator. Rotation of the housing **4** is transferred directly to the shaft **1** while rotation of the shaft **2** results from the gearing within the housing **4**. The differential speed of the shafts **1** and **2** can be varied by varying the speed of rotation of the pulley wheel **10**. The speed of rotation of the pulley **10** is always less than that of the gear housing **4**.

Discussion of operation

(I) As viewed from pulley **10** in Fig. 1, the main motor M is driving the pulley **5—6** and shell B counterclockwise and the conveyor C is also rotating counterclockwise at a greater speed than shell B. Controller D and pulley **10** are also rotating counterclockwise, in the illustrative embodiment.

(II) Correspondingly, as viewed in Fig. 4, pulley **5** (fixed to B) is moving counterclockwise at the angular velocity imparted by motor M. If pulley **5** (fixed to shell B) and gear **20** (fixed to conveyor C) were rotating counterclockwise at the same angular velocity, then planet pinion pivots **14** and **18** would also be travelling counterclockwise about axis **9** at the same angular velocity, planet pinions **16—19** and **12—15** would not be rotating on their pivots, and sun gear **11** would have to be rotating counterclockwise at the same angular velocity. Thus if the system were frictionless controller D would be rotating counterclockwise at the corresponding angular velocity. Since the system is not frictionless, if controller D were not to act as a brake on the sun gear **11**, it would have to be driven with some torque to drive sun gear **11** counterclockwise at said angular velocity.

(III) If under the above assumed conditions the power supplied to controller D were reduced so that it could act as a brake on the sun gear **11** and slow down its counterclockwise angular velocity, gear **12—15** would be rotated counterclockwise on its pivot **14**, gear **16—19** would be rotated clockwise on its pivot **18**, and gear **20** (and conveyor C) would be rotated counterclockwise about axis **9** by this action, in addition to its counterclockwise rotation at the angular velocity imparted by M (as discussed under II above). Hence the conveyor C would now rotate at a greater rate of speed than the shell B, and gear **11** would rotate at less than the angular velocity of the shell B.

(IV) But the drag of the contents of the shell B on the conveyor C tends to urge the conveyor to return to the same angular velocity as the shell B, i. e. acts as a brake on the conveyor, tending to slow it down, and therefore tending to speed up the angular velocity of the sun gear **11**, which thus tends to drive the controller D rather than be driven by it.

(V) When the drag of the contents of shell B is sufficiently great a state is reached at which the power input to the controller D is zero, and when the drag is still greater a state is reached at which the controller D is absorbing power from the sun gear and putting electrical energy into the electrical system as shown in Fig. 2.

(VI) When the power put back into the electrical system reaches a value corresponding to the limit of permissible drag of the contents of the shell B, then the circuit breaker CB–4 will open the circuit of the controller D, and its braking action will be insufficient to overcome the counterclockwise rotation of the sun gear **11** at the angular velocity approaching that of the shell B see part II above, and the conveyor will therefore slow down to substantially the same rate of angular rotation as the shell B.

(VII) It will be seen that as long as the centrifugal machine is operating with a sufficient drag of the contents on the conveyor, the device D will be driven as a generator and the generated output will flow through the main motor M, reducing the current drawn from the mains.

(VIII) Thus considering the rate of drive of the machine, i. e., the shell, as a base (and supposing the conveyor to be rotating at this same rate, and the device D to be merely idling, neglecting friction) then one could consider the entire power supplied by the motor M to be rotating the system.

Now to rotate the conveyor relative to the shell, power is removed from the system via the device D, slowing down gear **11** and speeding up the conveyor C. This power may be considered equivalent to *d*R. As this much power must be supplied by the motor M, the remainder of the power supplied by the motor M, which is effective to rotate the system as a whole, is $(M-dR)$. Now it will be seen that the ratio, of the power (*d*R) drawn from M to produce differential speed of the conveyor relative to the shell, to the power $(M-dR)$ supplied by M to rotate the system as a whole, is

$$\frac{dR}{M-dR}$$

as above noted. Also since the power applied to produce differential speed of the conveyor (less friction losses) is in part recovered by the dynamo-electric device D, the overall efficiency of the machine is correspondingly increased.

I claim:

1. A centrifuging machine comprising in combination a shell member, a conveyor member contained within the shell member, a driving shaft for said shell member and a driving shaft for said conveyor member coaxial with said shell member driving shaft, a housing containing epicyclic gearing, said shell member driving shaft being splined in said housing and said conveyor driving shaft projecting into said housing and being splined to a pinion therein, an output shaft projecting from said housing, a train of epicyclic gears inside the housing coupling said pinion with said output shaft, an electric motor for rotating said housing, an electric current generator coupled to said output shaft and providing an output indicative of the power necessary to produce differential movement of the shell member and the conveyor member, said output being utilized by said electric motor, and a current overload device in the output of the generator for cutting out the latter on overload.

2. A centrifuging machine comprising in combination a shell member, a conveyor member contained within the shell member, a driving shaft for said shell member and a driving shaft for said conveyor member coaxial with said shell member driving shaft, a housing to which said shell member driving shaft is splined, said conveyor driving shaft projecting into said housing and being splined to a sun pinion therein, planet pinions meshing with said sun pinion, axles secured in said housing on which said planet pinions are rotatably mounted, gear wheels rotatable on said axles with said planet pinions, further pinions meshing with said gear wheels, shafts secured in said housing on which said further pinions are rotatably mounted, additional pinions rotatable on said shafts with said further pinions, a further sun pinion meshing with said last mentioned additional pinions, an output shaft on which said further sun pinion is mounted, an electric motor for rotating said housing, an electric current generator coupled to said output shaft and providing an output indicative of the power necessary to produce differential movement of the shell member and the conveyor member, said output being utilized by said electric motor and a current overload device in the output of the generator for cutting out the latter on overload.

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