March 6, 1951 J. E. THOLL 2,544,367

CENTRIFUGAL SEPARATOR

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Fig. 1.

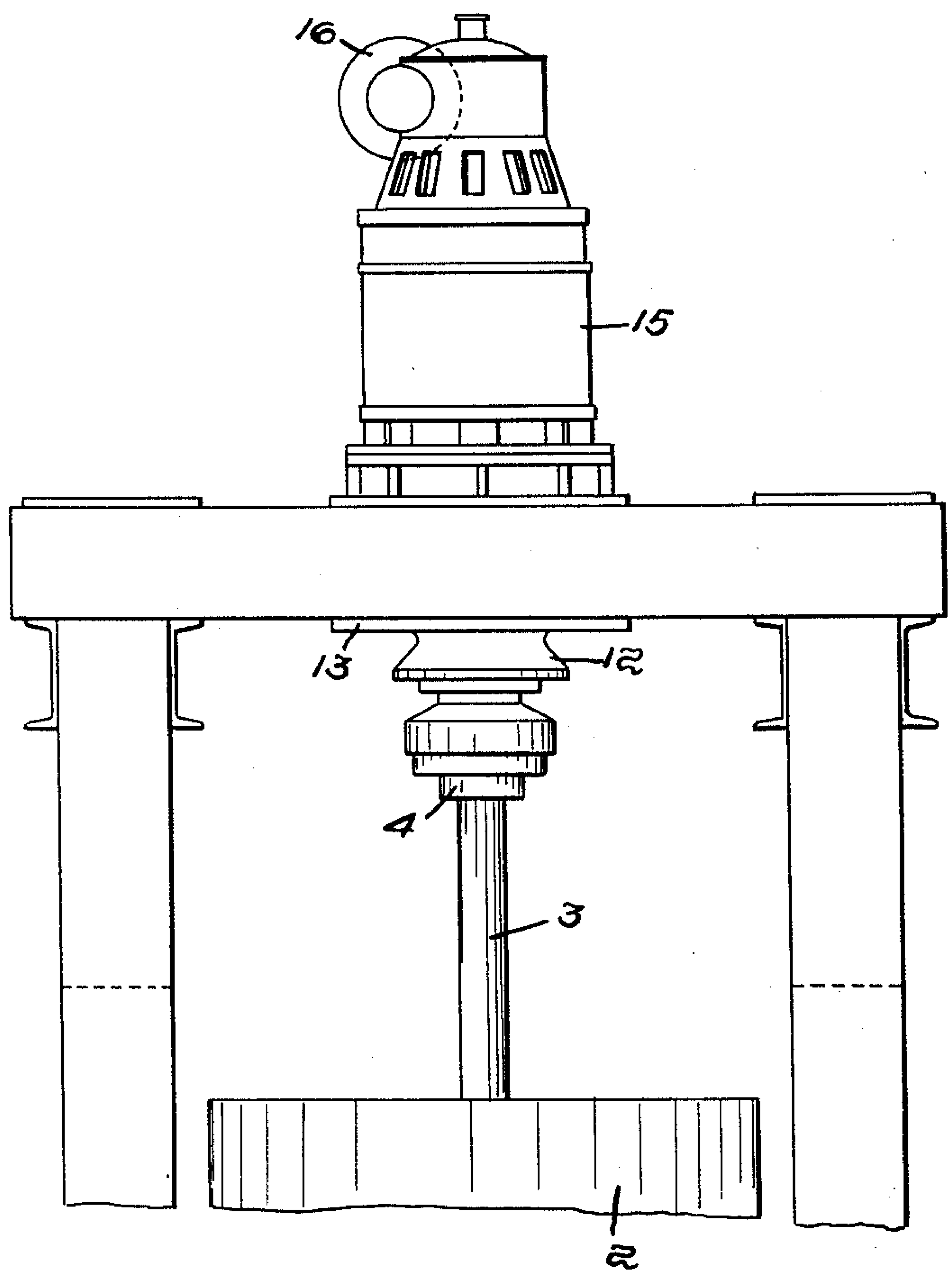

Fig. 4.

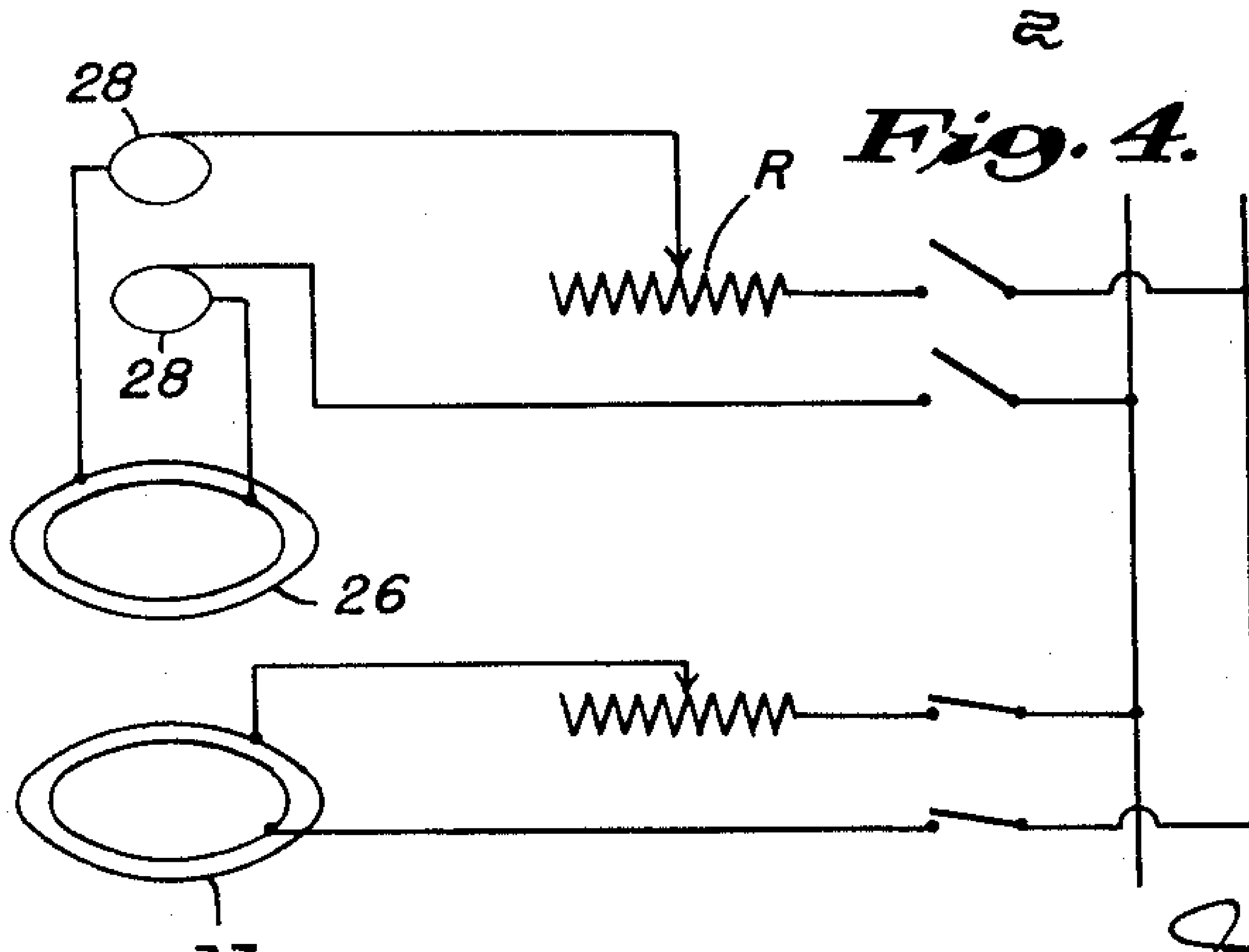

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Fig. 2.

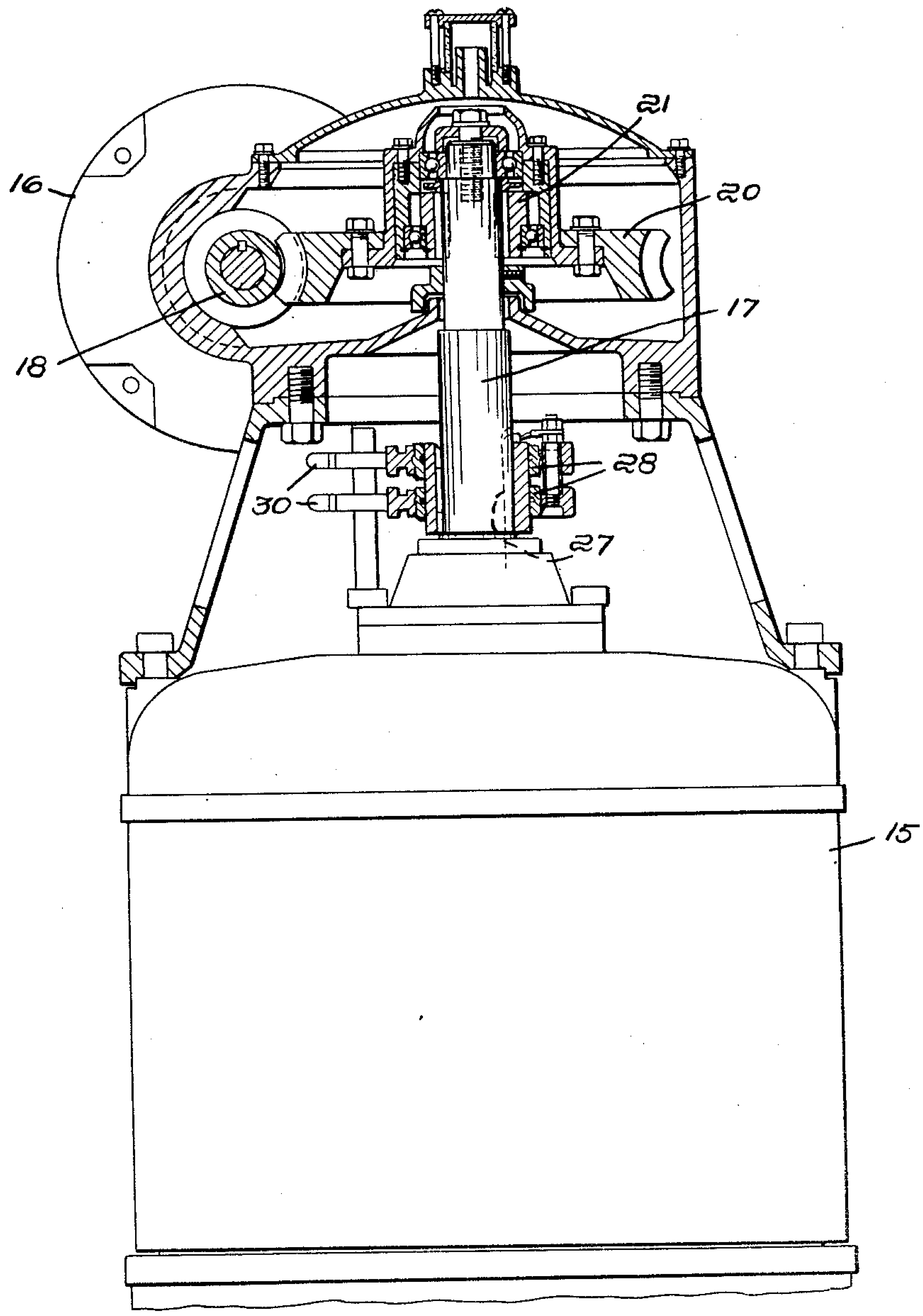

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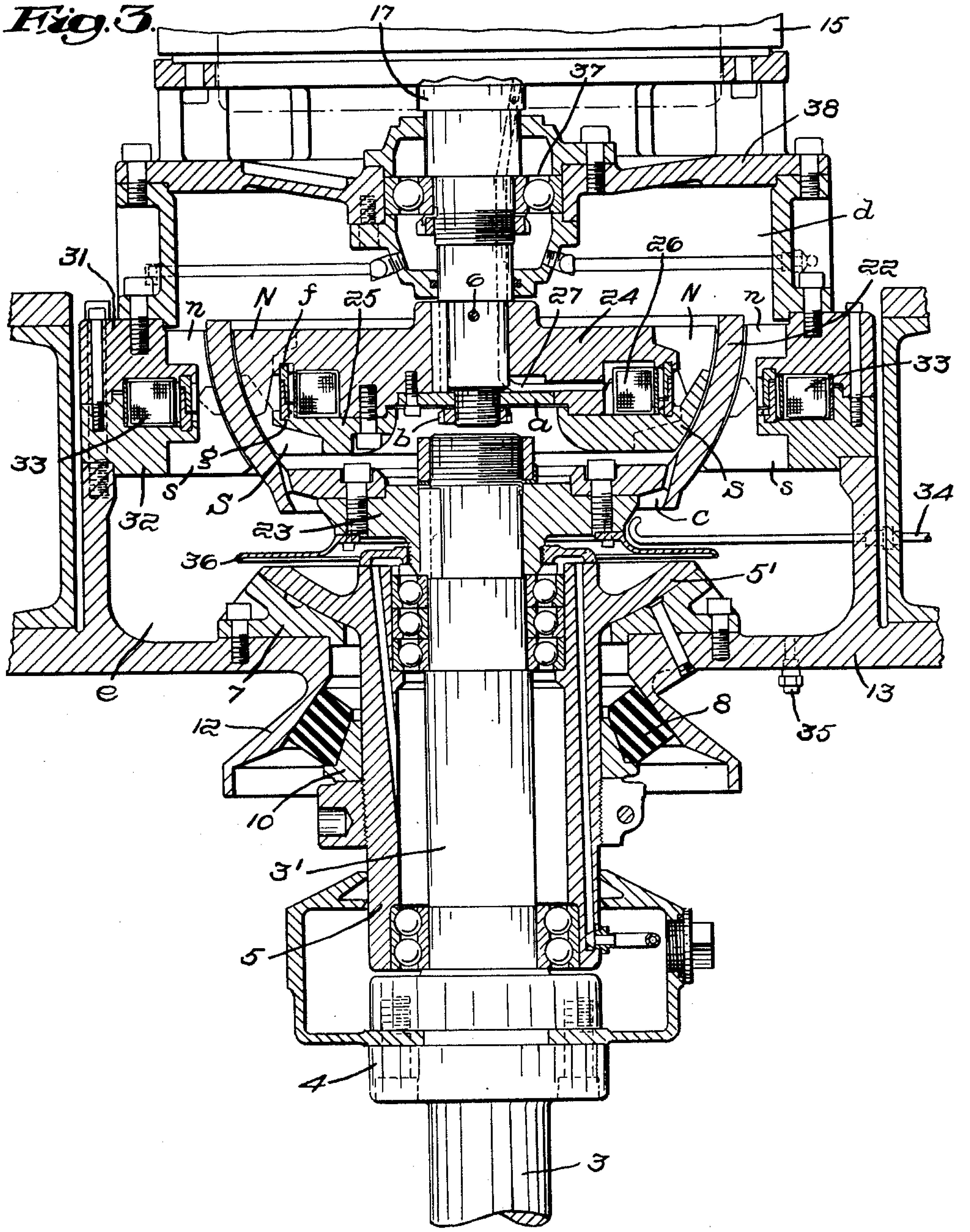
Fig. 3.



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UNITED STATES PATENT OFFICE

2,544,367

CENTRIFUGAL SEPARATOR

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Application December 18, 1945, Serial No. 635,804

13 Claims. (Cl. 210—72)

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In the centrifuging of some materials as, for example, sugar, it is important to the production of the best all-around results to bring the entire load up to normal speed rather gradually, sometimes in steps spaced apart by a definite value, and, in other cases, by a slow continuous increase in speed. A further speed requirement is the fact that when the centrifuging operation has been completed the basket must then be slowed down to a very low speed while the unloading or discharging step is performed.

These speed requirements introduce serious problems in devising a driving mechanism which will satisfy them (particularly if the cycle is to be controlled by some automatic mechanism) and which, at the same time, will not be too expensive in first cost, operation, or upkeep to be practical.

For example, in centrifuging low-grade sugar in machines of the size commonly used for this purpose, the entire weight of the basket and the parts revolving with it, plus the weight of the sugar load, is likely to total between 1800 and 2000 lbs. At top speed the basket will be revolved at, say 1600 to 1800 R. P. M. If, as usual, the accelerating period permitted is short, then the motor required to drive the basket and its load must be selected to deliver initially the very high torque required under these circumstances. This means a specially designed motor having a much higher power rating than is required to drive the basket at high speeds. That is, machines of this type are customarily equipped with a 40 to 60 horse-power motor, although the actual power delivered by them at maximum operating speeds may not be more than 15 to 20 horsepower. At the same time a smaller motor, particularly one of a standard design, cannot be substituted in the ordinary drives for the special motor because it could not deliver the necessary high torque required during the early stages of the centrifuging cycle.

The present invention is especially concerned with the foregoing considerations, and it aims to devise a driving mechanism for centrifugal separators in which the high torque required at slow speeds can be obtained with standard motors while, at the same time, providing a much finer gradient of speed and torque control than can be obtained with the prior art drives. A further object of the invention is to simplify the driving, braking and supporting mechanism for a centrifugal separator of the suspended type.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings, and the novel features will be particularly pointed out in the appended claims.

In the drawings,

Fig. 1 is a side elevation showing, on a small

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scale, a driving mechanism embodying this invention and applied to a centrifugal of the suspended basket type;

Fig. 2 is a vertical, sectional view, with some parts in elevation, showing the mechanism at the upper end of the assembly illustrated in Fig. 1;

Fig. 3 is a similar view showing the lower part of the driving mechanism shown in Fig. 1; and

Fig. 4 is a diagrammatic view of certain of the electrical connections.

Referring first to Figs. 1 and 3, the basket 2 is supported on the lower end of a shaft 3, the latter including an upper section indicated at 3', Fig. 3, which is connected to the lower section by the coupling 4 and is supported in a suspension head assembly which may be of a known construction. As shown in Figs. 3, this assembly comprises a non-rotating sleeve 5 provided with an integral head 5', the outer surface of which consists of a section of a sphere centered in the axis of the shaft at 6. At certain periods in the operation of one of these suspended basket centrifugals, the basket shaft has a strong tendency to gyrate, and the suspension head shown in Fig. 3 includes a concave socket member 7 supporting the head 5' of the sleeve to permit such gyratory motion. In order to limit and cushion this action an annular tapered elastic buffer 8 is interposed between a tapered collar 10, encircling the sleeve 5, and a flaring skirt portion 12 extending downwardly from the supporting frame piece 13. Upper and lower sets of ball bearings mounted inside the sleeve 5 support the section 3' of the basket shaft, the upper bearings taking the greater part of the thrust exerted by the load and also cooperating with the lower bearings to support the shaft radially. The mechanism so far described is much like that used heretofore.

Preferably the primary drive for the basket is organized in accordance with my earlier Patent No. 2,112,430, and includes a main driving motor 15 and a smaller supplemental motor 16 which is connected with the shaft 17 of the main motor through a worm 18, a worm wheel 20 driven by it, and an overrunning clutch 21 interposed between the worm wheel and the shaft 17. As explained more fully in the patent just mentioned, the motor 16 is used only in driving the shaft 17 during the discharging operation. At this time the drive is effected through the over-running clutch, but when the unloading operation has been completed and the main motor 15 resumes its driving function, the clutch 21 then ceases to function and the shaft is driven solely by the larger motor.

An important feature of this invention resides in a novel mechanism through which the motors 15 and 16 are connected with and drive the basket shaft **3**, and this mechanism, in the specific form shown, functions as a clutch; as a variable speed transmission mechanism; as a flexible coupling and also, when desired, as a brake.

It comprises an armature so associated with two magnetic fields as to produce the results just described. As shown in Fig. 3, it includes a bowl-shaped armature **22** bolted to a collar **23** which, in turn, is keyed to the shaft **3'**. Both the inner and outer surfaces of the armature are sections of a sphere, the center of which is located at the point **6** in the common axis of the two shaft members **3'** and **17**. This armature is the driven member of the connecting mechanism. The driving magnet cooperating with the armature comprises a core composed of upper and lower sections **24** and **25**, both secured to the lower end of the shaft **17**. They terminate in pole tip fingers indicated, respectively, at N and S which form the north and south poles of the magnet. Preferably these tips are staggered and intermeshed, one with the other, although out of contact with each other. Between these pole pieces an annular cavity is formed to receive the energizing coil **26**. It should be noted that the turns of this coil extend around the axis of the shaft **17** so that they lie approximately in horizontal planes positioned at right angles to said axis. Consequently, when this magnet is energized by a direct current, a magnetic field is set up in it, the lines of force encircling the winding, and being positioned mainly in radial vertical planes intersecting said coil.

With this arrangement, when the shaft **17** revolves the magnet and its field, the latter creates heavy eddy currents in the metal armature **22**, and the local field set up by them reacts with that produced by the magnet to create a strong force tending to make the armature **22** revolve in unison with the rotating magnetic field. Some slip between these rotating parts necessarily occurs, and such slip during periods of acceleration is large, but with good design the slip at high operating speeds can be reduced to very low limits. By suitably controlling the supply of exciting voltage applied to the winding **26**, as by a rheostat R, Fig. 4, or by a governor or electronic device, the degree of torque transmitted to the basket, and the speed at which it rotates, can be very easily controlled and varied, as desired.

The leads or terminals for carrying current to the field coil **26** are located in grooves in the shaft **17**, one of these leads being shown at **27**, Figs. 2 and 3, and the other being similarly positioned. These leads run, respectively, to two slip rings **28—28**, Fig. 2, to which current is conducted by brushes **30—30**, as in the conventional arrangements of this type. A diagram of these electrical connections is shown in Fig. 4. In order to facilitate assembly and disassembly of the parts, the core member **24** is held in its operative position on the shaft **17** by a collar *a* and a nut *b*, Fig. 3.

For the purpose of braking the rotation of the basket, another annular field assembly is provided to cooperate with the armature **22**. This mechanism comprises upper and lower field pieces **31** and **32**, Fig. 3, of annular form, each having a series of pole pieces integral with it, as indicated at *n* and *s*, respectively, and they may be of essentially the same form as the pole tips N and S of the field pieces **24—25**. An energizing coil **33** is associated with these members **31** and **32** to form a powerful electromagnet when the winding is energized. This coil **33** is wound in the same manner as is the coil **26**, and it is energized by direct current so that when it is desired to stop the rotation of the basket and its load, current is cut off the field coil **26** and is turned on to the brake coil **33** by means of a suitable switch or switches. This entire brake field assembly is stationary and, consequently, eddy currents created in the armature **22** by its rotation in said field react on the latter to reduce the rotative speed of the armature and ultimately to stop it.

It should be observed that the clearance between the inner concave surface of the armature **22** and the adjacent pole tip surfaces of the field members inside the armature preferably should be very small, say in the neighborhood of thirty-thousandths of an inch. A similar clearance should be maintained between the outer convex surface of the armature and the complemental surface of the surrounding field parts. With such clearances and a design made in accordance with the well known principles of electromagnetic engineering, a highly efficient, reliable, and thoroughly satisfactory drive can be made by any competent engineer embodying the invention above described.

Because the eddy currents created in the armature **22** produce much heat, artificial cooling means for this member are provided. As shown in Fig. 3, cooling water, brine, or other coolant, is led into the frame **13** through a pipe **34** and the inner end of this pipe is curved to direct a jet of water upwardly into the annular tapered space *c* formed in the bottom of the armature **22** where it can pass upwardly through a series of holes along the concave inner surface of said armature. The tapered construction of these parts creates a centrifugal force which urges the cooling water up through the clearance space above mentioned. This water is thrown off the upper edge of the armature centrifugally into the space *d* and then flows by gravity down between the fingers of the outer magnet **31—32** into the chamber *e* in the frame member **13**, and thence out through the drain pipe **35**. A splash disk **36** secured to the lower surface of the collar **23** prevents the entrance of this water into the bearings in the sleeve **5**. In some cases, however, it will be found more convenient to cool the armature and magnets with air or some other gaseous fluid.

Also, for the purpose of protecting the coil **26**, two thin rings *f* and *g* are welded, respectively, to the core members **24** and **25**, in such a relationship that when these core members are pressed together, the rings will telescope snugly, one within the other, and tightly close the perimeter of the chamber in which the field coil **26** is located. A similar construction is provided to protect the coil **33**.

Preferably a ball bearing **37** is provided for the shaft **17** immediately above the electromagnetic transmission mechanism, and it is supported in a frame piece **38** which forms part of the spacing frame work separating the magnet assembly and its frame from the motor **15**. A free circulation of air is provided through the upper of these spacing members, just above the part **38**, to assist in cooling the adjacent parts.

In using a centrifugal equipped with a basket supporting and driving mechanism, as above described, a typical procedure is as follows:

The main driving motor **15** is started up, the transmission mechanism at this time being deenergized. While the motor is revolving at its full normal speed, the rheostat, or other controlling means provided, is adjusted to produce a weak flow of current through the coil **26**, thus creating a relatively weak magnetic field in the magnet **24—25**. This results in initiating the rotation of the basket. When the basket speed has been adjusted to suit the requirements of the loading operation, that step is performed, and then the exciting current is further increased by operation of the rheostat to bring the basket up to the desired operating speed. This may be done either by a continuous gradual acceleration, or in steps separated by suitable time periods. When the machine has been held at its maximum speed for the desired length of time to complete the centrifuging operation, the excitation current is cut off, thus de-energizing the magnet **24—25**. If it is desired to bring the basket to a stop quickly, then current is turned on to the field of the braking magnet **31—32**, whereupon the basket is stopped in the manner above described. Or, prior to being actually brought to a full stop, the current may be cut off the coil **33** of the braking magnet and turned on to the other magnet coil **26**, and the small motor **16** may be started up at this time to drive the basket at a slow steady speed while the load is discharged.

It should be observed, however, that with this arrangement the motor **15** may consist of a standard alternating current motor such, for example, as the squirrel-cage type of induction motor, which can be of much lower horse-power than that required in the present drives, while still being ample to operate the basket at the maximum speed desired. For example, the 40 to 60 horse-power special motor customarily used may be replaced by, say, a 25 horse-power standard design motor or, for some purposes, even by one of somewhat smaller rating. This is possible, for two reasons: first, because a very wide ratio of speed transmission from the motor to the basket can be obtained merely by varying the exciting current while the motor continues to run at its normal maximum speed, and second, because the heat generated at this time is dissipated in the transmission mechanism instead of in the rotor of a motor designed especially to handle these conditions, so far as possible, in a prime mover of this type. Important in this connection is the fact that the torque created in the eddy current transmitting mechanism is proportional, for any degree of slip, to the intensity of the field excitation and, consequently, it may be made to have a high value, even at low operating speeds. Thus for very low unloading speeds, say 40 R. P. M., the high torque required in this operation can be obtained by proper adjustment of the excitation while the power necessary is derived from the small motor **16**.

Different materials require different loading and unloading speeds, and in operating on some materials it may be possible to use the large motor exclusively, obtaining the entire speed and torque variations required solely by adjusting the exciting current for the driving magnet **24—25**.

As above pointed out, the mechanism provided by this invention can be made to perform several functions, in addition to its inherent function as a flexible coupling. That is, it serves as a clutch because, first, it transmits power only when the coil **26** is energized; second, by varying the intensity of the exciting current flowing through the coil **26** it will function as a variable speed transmission mechanism; and third, it can be made to operate as a brake merely by energizing the brake coil **33**.

Further advantages of this driving mechanism are:

(1) It eliminates the "shock" load involved in frequent starting and which is practically unavoidable in using the ordinary drives.

(2) It avoids the use of mechanical clutches with their difficulties.

(3) It reduces substantially the maintenance expense as compared to that involved in operating a centrifugal separator by the usual driving mechanisms.

While I have herein shown and described a preferred embodiment of my invention, it will be evident that the invention may be embodied in other forms without departing from the spirit or scope thereof.

Having thus described my invention, what I desire to claim as new is:

1. The combination with a centrifugal separator including a basket and a vertical shaft supporting said basket in a suspended position for rotation about the axis of the shaft and for oscillation about a center point in said axis, of a bowl-shaped armature fast on said shaft and having a surface which is a section of a sphere centered at said point, a magnet having pole faces which are in the form of a section of a sphere coinciding with the spherical shape of the armature and which are positioned closely adjacent to, but out of contact with, said surface so that the field of said magnet passes through portions of said armature, means for relatively revolving said magnet and said armature around an axis passing through said center, and energizing means for said magnet.

2. A combination according to preceding claim 1, in which said energizing means is adjustable to vary the intensity of the magnetic field created by it.

3. A combination according to preceding claim 1, in which said energizing means includes a coil encircling said axis with the turns of said coil extending circumferentially thereof.

4. The combination with a centrifugal separator including a basket and a vertical shaft supporting said basket in a suspended position for rotation about the axis of the shaft and for oscillation about a center point in said axis, of a bowl-shaped armature fast on said shaft and having inner and outer surfaces, both of which are sections of a sphere centered at said point, two magnets having pole faces which are in the form of a section of a sphere coinciding with the spherical shape of the armature and which are positioned close to, but out of contact with, said inner and outer surfaces, respectively, of said armature so that the fields of said magnets pass through portions of said armature, means for revolving one of said magnets around the axis of said shaft, means supporting the other magnet in a stationary position, means for selectively energizing said magnets, whereby, when said revolving magnet is energized, the mechanism serves to transmit motion to said armature, and when said stationary magnet is energized it acts as a brake to reduce the speed of said armature.

5. The combination with a centrifugal separator including a basket and a vertical shaft supporting said basket in a suspended position for rotation about the axis of the shaft and for oscillation about a center point in said axis, of a bowl-shaped armature fast on said shaft and having a surface which is a section of a sphere cen-

tered at said point, a magnet having pole faces positioned closely adjacent to, but spaced from said surface of the magnet by a gap which also has substantially the form of a section of a sphere centered at said point so that the field of said magnet passes through portions of said armature, energizing means for said magnet adjustable to vary the intensity of the magnetic field created by it, and means for revolving said magnet about said center.

6. The combination with a centrifugal separator including a basket and a vertical shaft supporting said basket in a suspended position for rotation about the axis of the shaft and for oscillation about a center point in said axis, of a bowl-shaped armature fast on said shaft and having a surface which is a section of a sphere centered at said point, a second shaft, means supporting the latter shaft above the basket shaft for rotation about a fixed axis passing through said center point and aligned with the first shaft when the basket is in its central position, means for revolving said second shaft, a magnet mounted on said second shaft and having pole faces which are in the form of a section of a sphere coinciding with the spherical shape of the armature and which are positioned closely adjacent to, but out of contact with, the inner surfaces of said armature so that the field of said magnet passes through portions of said armature, and direct current energizing means for said magnet.

7. A combination according to preceding claim 6, in combination with a second magnet having pole faces positioned closely adjacent to, but out of contact with, the outer surface of said armature, whereby the field of said second magnet passes through portions of said armature, means for supporting said second magnet in a stationary position, and energizing means for said second magnet.

8. A combination according to preceding claim 1, in which said magnet comprises a core including upper and lower sections having parts constructed to telescope, one within the other, and said energizing means comprises a coil positioned in a chamber formed between said sections, the telescoping portions of said sections being formed to close the side of said chamber adjacent to said armature.

9. The combination with a centrifugal separator including a basket and a vertical shaft supporting said basket in a suspended position for rotation about the axis of the shaft and for oscillation about a center point in said axis, of a bowl-shaped armature fast on said shaft and having a surface which is a section of a sphere centered at said point, a magnet having pole faces of complementary spherical form and which are positioned closely adjacent to, but out of contact with, said surface so that the field of said magnet passes through portions of said armature, means for revolving said magnet around said axis, whereby its revolving field will create eddy currents in said armature that will react with said field to revolve the armature and the parts secured to it, and means for conducting cooling water to the surface of said armature.

10. A combination according to preceding claim 9, in which the means for conducting the cooling water to the armature is arranged to direct the water on to the lower portion of the surface of said armature where it will be distributed by the rotation of the armature.

11. A combination according to preceding claim 9, in which the bottom of said armature is provided with apertures leading therethrough and said means for conducting water to the armature is arranged to conduct the water into said apertures where it will be urged upwardly along the inner surface of the armature by the rotation of the latter.

12. A combination according to preceding claim 4, including means for conducting cooling water to the inner surface of said armature at the lower part thereof where it will be forced by the rotation of the armature to the upper edge thereof and discharged into a position from which it will run down over the pole surfaces of said stationary magnet, and means below said armature for collecting said water and conducting it away from the machine.

13. The combination with a centrifugal separator including a basket and a vertical shaft supporting it, a suspension head including a stationary concave socket member, a sleeve encircling a portion of said shaft and having a convex bearing resting in the socket of said member, and bearings spaced apart vertically in said sleeve and supporting said shaft for rotation around its own axis, said sleeve and bearing also supporting said shaft for oscillating movement about a center point positioned above the upper end of said shaft; of a bowl-shaped armature fast on said shaft and having a surface forming a section of a sphere centered at said point, a second shaft, means supporting the latter shaft above said basket shaft with its axis passing through said center point, a magnet mounted on said second shaft and having pole surfaces which are in the form of a section of a sphere coinciding with the spherical shape of the armature and which are positioned closely adjacent to, but out of contact with, the inner surface of said armature, means for revolving said second shaft and its magnet, whereby the rotating field of the magnet will create eddy currents in said armature that will react on the magnet field to revolve the armature and the parts secured to it, a stationary magnet mounted in said suspension head and having pole faces positioned closely adjacent to, but spaced from, the outer surface of said armature, and means for energizing said magnets.

JOHN E. THOLL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 15,115	Mackintosh	May 31, 1921
726,536	Holz	Apr. 28, 1903
1,334,759	Huebner	Mar. 23, 1920
1,345,596	Hovland	July 6, 1920
1,536,915	Olcott	May 5, 1925
1,687,039	Romp	Oct. 9, 1928
2,060,826	Roberts	Nov. 17, 1936
2,176,440	Tholl	Oct. 17, 1939
2,197,990	Winther	Apr. 23, 1940
2,317,528	Hertrich	Apr. 27, 1943
2,386,701	Martin	Oct. 9, 1945
2,411,122	Winther	Nov. 12, 1946

FOREIGN PATENTS

Number	Country	Date
645,181	France	June 26, 1928