Oct. 1, 1968 M. M. WINDSOR ET AL 3,403,848

CENTRIFUGAL SEPARATOR APPARATUS

Filed April 3, 1967 3 Sheets-Sheet 1

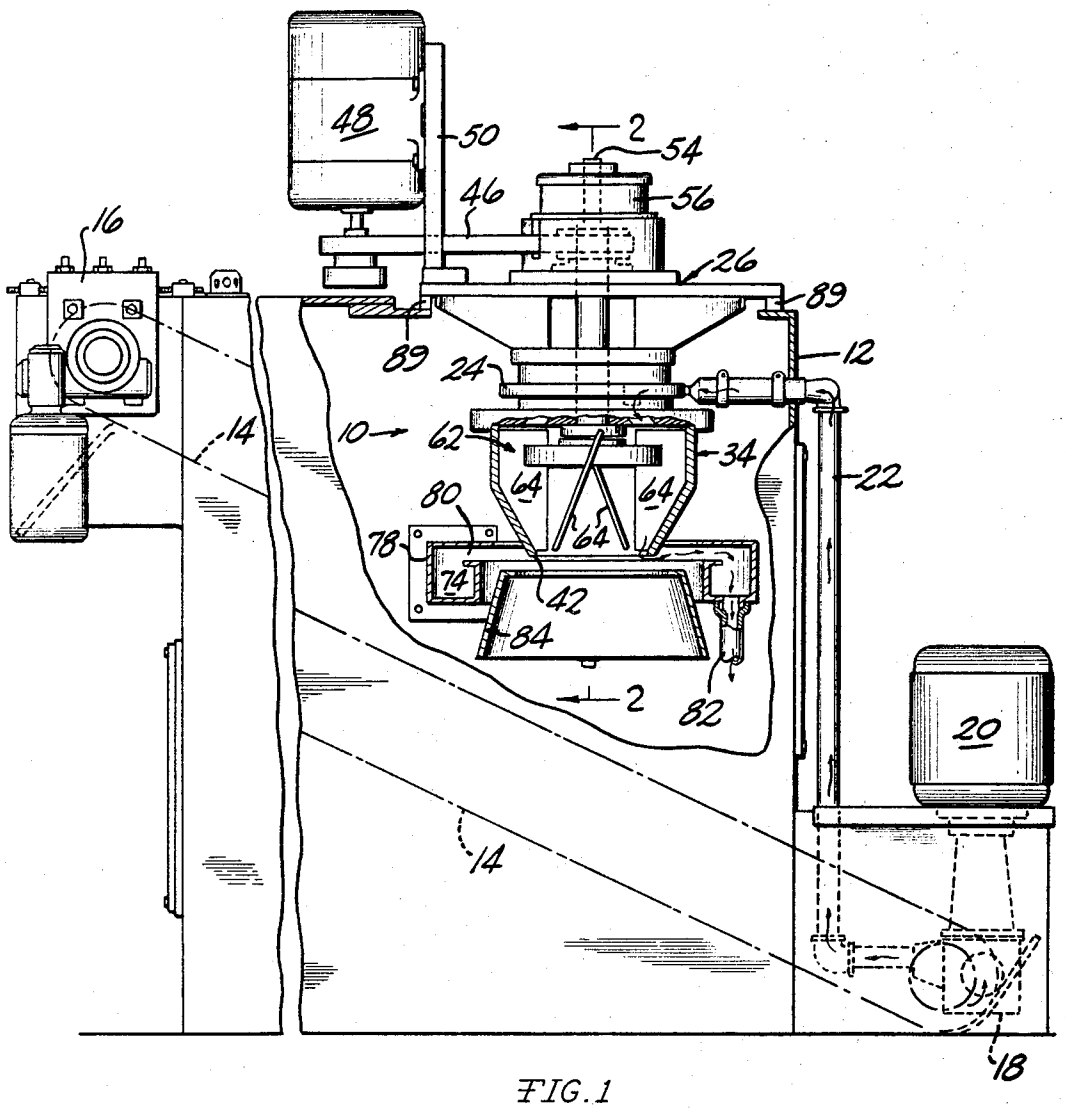

FIG. 1

INVENTORS
MEREDITH M. WINDSOR
HERBERT R. LINCOLN

BY
Olsen and Stephenson
ATTORNEYS

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CENTRIFUGAL SEPARATOR APPARATUS

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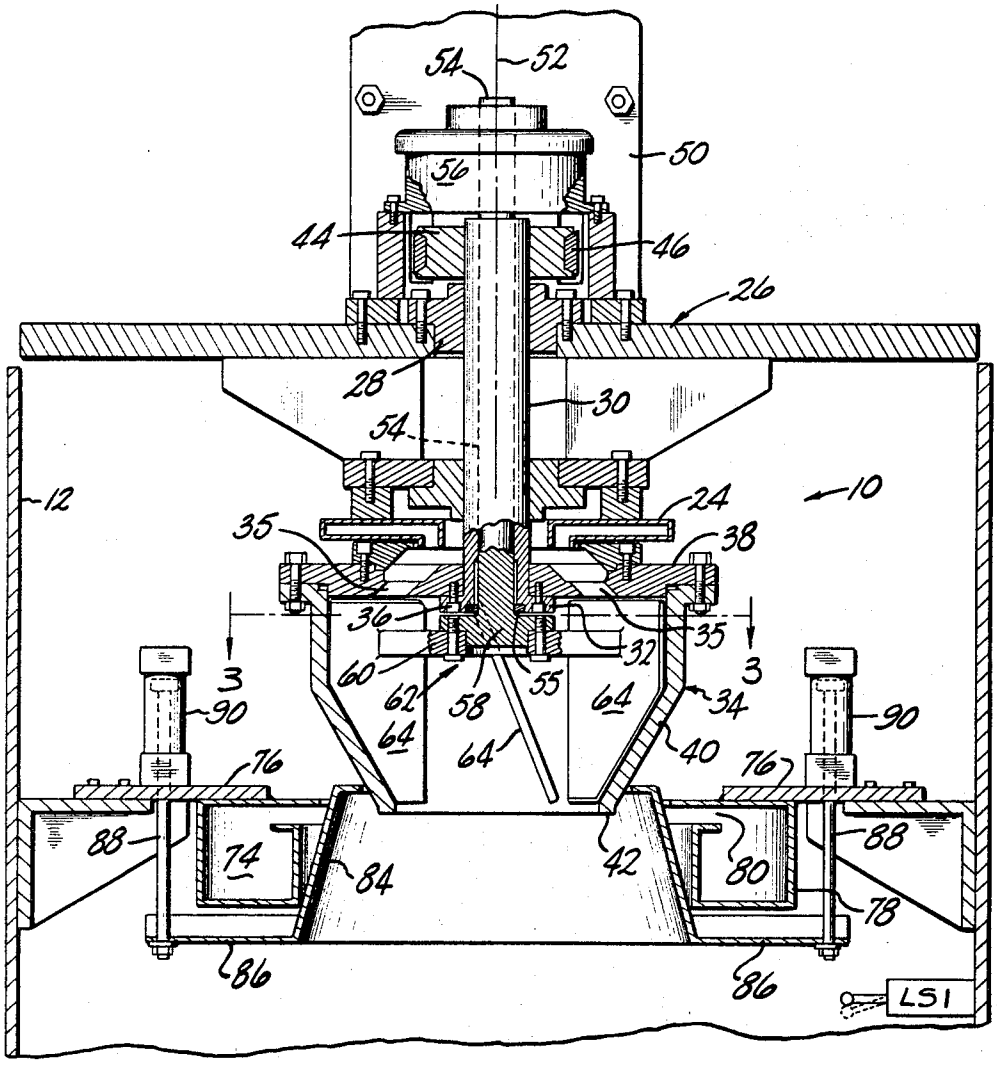

FIG. 2

INVENTORS
MEREDITH M. WINDSOR
HERBERT R. LINCOLN

BY
Olsen and Stephenson
ATTORNEYS

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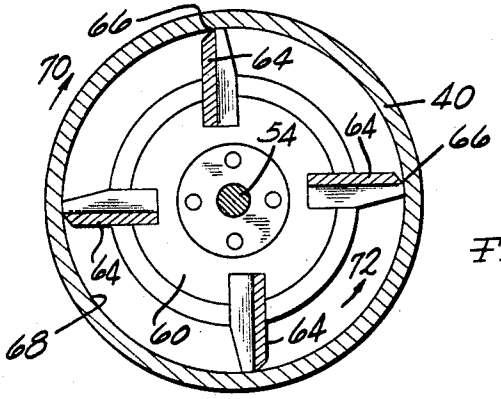


FIG. 3

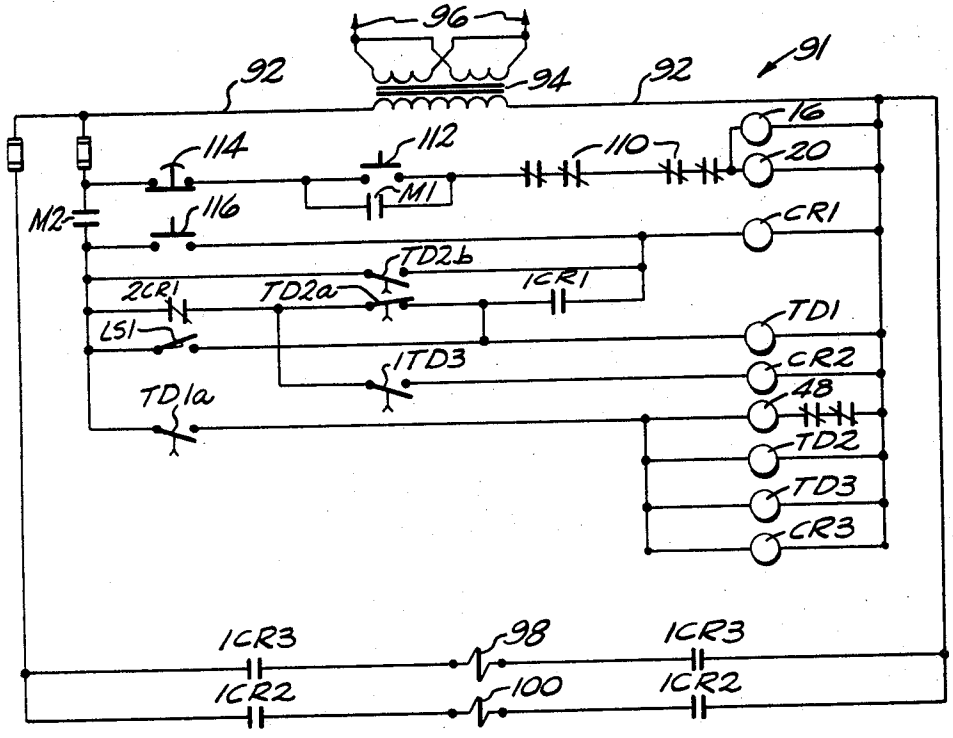
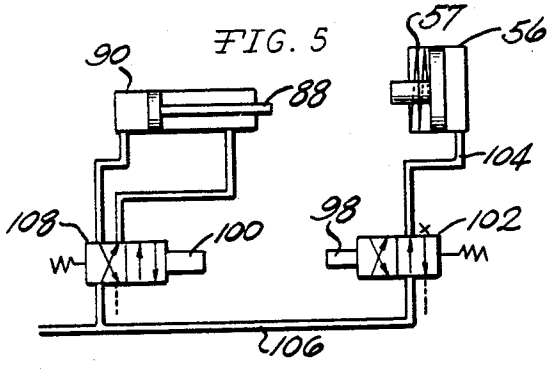


FIG. 4

FIG. 5



INVENTORS
MEREDITH M. WINDSOR
HERBERT R. LINCOLN

BY Olsen and Stephenson
ATTORNEYS

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CENTRIFUGAL SEPARATOR APPARATUS

Meredith M. Windsor and Herbert R. Lincoln, Detroit, Mich., assignors to Star Cutter Company, Farmington, Mich., a corporation of Michigan

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9 Claims. (Cl. 233—7)

ABSTRACT OF THE DISCLOSURE

Apparatus for removing the solid particles from a liquid in which an inverted cup shape bowl is rotated about a vertical axis concurrently with the supply of a liquid containing solid particles to the upper end of the bowl, so that as the fluid runs down the inner surface of the bowl, the solid particles are centrifugally forced against the inner surface of the bowl and retained thereon. Blades, positioned within the bowl so that they have scraping edges located adjacent the bowl inner surface, are mounted independently of the bowl for rotation about the same vertical axis on which the bowl is rotated and normally rotate with the bowl. When the blade movement is braked, relative movement between the blade edges and the inner surface of the bowl is obtained so that the blades scrape the solid particles off the inner surface of the bowl so that the solid particles can fall out of the bowl through the open lower end.

Background of the invention

The apparatus of this invention is usable in practically any situation in which solid particles can be centrifuged out of a liquid in which they are contained. The apparatus is particularly useful for removing solid particles from the liquid coolant used in machine tools. A large volume of this coolant is used by each machine tool, and before the coolant can be reused, the metal chips and pieces which are flushed away by the coolant must be removed. Most of the coolant cleaning devices employed in the past have used filters to separate the metal chips and pieces out of the coolant. However, this filter apparatus has been found to be objectionable both from the standpoint of cost and reliability.

The apparatus of this invention employs a rotary centrifuge bowl which is effective to remove the metal chips and pieces from the used coolant so that the coolant is readily cleaned for re-use. Internal blades which normally rotate with the bowl while used coolant is running therethrough are braked so that they move relative to the inner surface of the bowl so as to scrape the accumulated chips and pieces therefrom. It has heretofore been known to separate solid particles from a fluid by rotating a centrifuge member and moving an internal member relative to the centrifuge member so as to remove the solid particles from the inner surface of the centrifuge member. The apparatus shown in U.S. Patent No. 605,087 dated June 7, 1898, is an example of apparatus of this type. However, this apparatus employs an internal screw for removing the solid material and the centrifuge rotates about a horizontal axis. It is believed that this apparatus would be unacceptable for coolant cleaning purposes because the removed solid material would be constantly dropping back into the clean coolant. Furthermore, the metal chips and pieces which are removed by centrifugal force from a coolant compact themselves into a very hard mass of relatively high density on the inner surface of a centrifuge. Sharp dynamic action is required to effectively remove this hard dense material. Consequently, it is believed that an auger-type apparatus as shown in the aforementioned patent would be ineffective in removing this material.

Accordingly, it is an object of the invention to provide improved centrifugal separating apparatus which is readily self-cleaning since the blades can be periodically braked to remove material from the centrifuge bowl.

Summary of the invention

In the apparatus of the invention a bowl of generally inverted cup shape having an open lower end is rotated about a vertical axis. A plurality of blades, mounted on a common support, are positioned within the bowl so that they are rotatable independently of the bowl about an axis coincident with the axis of rotation of the bowl. Coolant to be cleaned is introduced into the upper end of the bowl between the blades, and this fluid, during its flow down the inner surface of the bowl under the action of gravity, has the solid particles therein removed by centrifugal action so that these solid particles build up on the inner surface of the bowl between the blades. At suitable intervals, the rotation of the blades is braked, without braking the bowl, so as to move the blades quickly across the inner surface of the bowl and dislodge the accumulated particles on the inner surface. These particles fall through the open lower end of the centrifuge into a suitable tank. The cleaned coolant that flows off the open lower end of the centrifuge bowl in between bowl cleaning operations is collected in a trap and conveyed to the desired point of use. During the dislodging action of the blades, the inlet for the trap is blocked so that the previously cleaned fluid will not be contaminated by the material dislodged from the centrifuge bowl and dropping downwardly into the tank.

Further objects, features and advantages of this invention will become apparent from a consideration of the following description, the appended claims, and the accompanying drawing in which:

FIGURE 1 is a foreshortened elevational view of the centrifugal separator apparatus of this invention, with some parts broken away and other parts shown in section for the purpose of clarity, and showing the parts of the apparatus in the positions that they are in during the separation of solid particles from a liquid;

FIGURE 2 is an enlarged sectional view of a portion of the apparatus shown in FIG. 1, showing the parts of the apparatus in their positions during cleaning of particles from the inner surface of the centrifuge bowl;

FIGURE 3 is a transverse sectional view of the separator bowl and scraping blade assembly in the apparatus of this invention as seen from substantially the line 3—3 in FIG. 2;

FIGURE 4 is a wiring diagram of the controls for the apparatus of this invention; and

FIGURE 5 is a schematic diagram illustrating the fluid controls for portions of the apparatus of this invention.

With reference to the drawing, the centrifugal separator apparatus of this invention, indicated generally at **10**, is illustrated in FIG. 1 mounted on a tank **12** which receives liquid containing solid particles, such as machine tool coolant containing metal chips, particles, and pieces. The tank **12** is provided with a conventional conveyor **14** that is driven by a motor **16** and is operable to remove solid material which has settled into the tank **12** and deposit this material externally of the tank. A sump pump **18**, driven by a motor **20**, is operable to pump coolant to be cleaned from the tank **12** through a pipe **22** to a manifold **24** which forms a part of the apparatus **10** of this invention.

As shown in FIG. 2, the apparatus **10** consists of a main frame **26** on which the manifold **24** is supported and on which a pair of axially spaced shaft supports **28** are also mounted. A tubular shaft **30** extends through the shaft supports **28** and is provided at its lower end

with a transversely extending flange 32. A generally inverted cup shape bowl 34 is secured by bolts 36 to the flange 32. The bowl 34 has a top cover 38 which is formed with a series of liquid inlet openings 35 that communicate with the manifold 24. The bowl 34 also has a depending annular rim 40 which is of a decreasing diameter in a downward direction so that the lower open end 42 of the bowl 34 is of a reduced diameter relative to the upper end thereof which is attached to the cover 38.

The upper end of the shaft 30 carries a pulley 44 driven by a belt 46 which is in turn driven by a motor 48 (FIG. 1) mounted on a bracket 50 secured to the main frame 26. Thus, on operation of the motor 48, the shaft 30 is rotated by the pulley 44 about a vertical axis 52.

A shaft 54 is rotatably supported in the shaft 30, by means such as the thrust bearing 55, so that it is rotatable about an axis coincident with the axis 52. The shaft 54 has its upper end extended through a conventional air brake 56 which is operable to apply a braking force to the rotating shaft 54. The lower end 58 of the shaft 54 is secured to the hub 60 of a hub and blade unit 62 (FIGS. 2 and 3). The unit 62 includes a plurality of blades 64, illustrated as being four in number, which are secured at their inner ends to the hub 60 and provided at their outer edges with relatively sharp scraping edges 66 disposed adjacent the inner surface 68 of the bowl rim 40. Each blade 64 is of a flat plate construction inclined relative to the axis 52 for a purpose to more clearly appear hereinafter. As shown in FIG. 3, the bowl 34 normally rotates in the direction of the arrow 70 and the hub and blade unit 62 is carried along with the bowl 34 by the frictional forces applied to shaft 54 by shaft 30 and the force of the material in bowl 34 on blades 64. The brake 56 is operable to brake the shaft 54 to prevent it from rotating in the same direction to thereby provide for movement of the blades 64 relative to the bowl 34 in the direction of the arrow 72. The purpose of this relative rotation will become more apparent from the following description.

A trap 74 for clean liquid is illustrated as being mounted on brackets 76 (FIG. 2) carried by the tank 12. The trap 74 consists of a hollow annular ring 78 having an annular inlet opening 80 on its inner side and provided with an outlet 82 which conveys the cleaned liquid to the desired point of use, such as a machine tool in the case of coolant. The inlet 80, as shown in FIG. 2, is located in horizontal alignment with the lower edge 42 of the bowl 34.

An annular baffle 84, of a size to cover the inlet 80 for the trap 74 is mounted below the bowl 34 for movement between the lower and upper positions illustrated in FIGS. 1 and 2, respectively. Horizontal extensions 86 on the lower end of the baffle 84 are secured to the piston rods 88 for fluid actuated cylinder assemblies 90 which are mounted on the brackets 76. When the assemblies 90 are operated to extend the piston rods 88, the baffle 84 is moved to its lower position illustrated in FIG. 1 in which it does not interfere with flow of liquid off the lower end 42 of the bowl 34 and through the inlet 80 for the trap 74 under the action of the centrifugal force imparted to the liquid by the rotating bowl 34. When the cylinder assemblies 90 are actuated to retract the piston rods 88, the baffle 84 is moved to its upper position illustrated in FIG. 2 in which it positively prevents liquid from the bowl 34 from flowing into the trap 74 and directs this liquid back into tank 12.

It can thus be seen that liquid from the tank 12 can be supplied to the upper end of the rotating bowl 34 through manifold 24. This liquid flows downwardly, under the action of gravity, along the inner surface 68 of bowl 34 and during such flow all of the solid particles in the liquid are moved by centrifugal force onto the bowl surface 68 where these particles accumulate. The resulting liquid with solid particles removed flows off the lower end 42 of rotating bowl 34 and is thrown into the trap 74. Periodically, the blade shaft 54 is braked and at such time the baffle 84 is raised to its FIG. 2 position. The blades 64 are then moved sharply and dynamically across the inner surface 68 of the bowl 34, which is rotating, so as to scrape the accumulated solid particles therefrom. These particles then drop from the bowl into the tank 12 and the liquid traveling downwardly in the bowl at the same time acts to flush these particles off the bowl inner surface 68. The blade shaft 54 is then released and the baffle 84 is returned to its lower position so that the liquid cleaning action of the apparatus 10 is resumed. The frequency of braking of shaft 54 is determined by the rapidity of particle build-up on bowl surface 68 in each installation of apparatus 10. The main frame 26, which supports the rotating bowl 34, is supported on resilient mounting units 89 on the tank 12 so that the bowl 34 and the mass rotating therewith can seek its own center during operation of the apparatus 10 thereby reducing undesirable vibration of the apparatus 10 and the tank 12.

The control circuit, illustrated generally at 91 in FIG. 4, for the apparatus 10 includes leads 92 connected to a transformer 94 which is connected to a source of current indicated generally at 96. A control solenoid 98 for the brake 56 and a control solenoid 100 for the cylinder assemblies 90 are connected in parallel across the leads 92. The brake 56 (FIG. 5) is of a type which includes a spring means 57 that, in the absence of a counteracting air pressure force, releases the brake from the shaft 54. Thus, when a valve 102 (FIG. 5) controlled by the solenoid 98, is in the position illustrated in FIG. 5 in which the air inlet line 104 for the brake 56 is connected to an air pressure inlet line the brake is applied. When the solenoid 98 is energized to shift the valve to the right in FIG. 5, air from the inlet line 106 is blocked at the valve 102, the brake line 104 is connected to atmosphere, and the spring means 57 releases the brake. Thus, when the solenoid 98 is energized the brake 56 is released, and when the solenoid 98 is de-energized, the brake is applied, thus preventing the blades 64 from rotating to a stop after the apparatus 10 is shut off, which might cause undesirable vibration.

The solenoid 100 for the cylinders 90 controls a two-position valve 108 (FIG. 5). In the position of the valve 108 shown in FIG. 5, the solenoid 100 is de-energized and the piston rods 88 for the cylinder assemblies 90 are retracted so that the baffle 84 is in its "up" position shown in FIG. 2. When the solenoid 100 is energized, the valve 108 is shifted to the left as viewed in FIG. 5 so that air from the inlet line 106 is effective to extend the piston rods 88 to move the baffle 84 to its "down" position shown in FIG. 1. Thus, when the solenoid 100 is de-energized, the baffle 84 is up, and when the solenoid 100 is energized, the baffle 84 is down.

The conveyor motor 16 and the sump pump motor 20 are parallel connected across the leads 92 in series with the usual overload relays 110, a start switch 112 and a normally closed stop switch 114. Normally open relay contacts M1, in parallel with the start switch 112, are closed when the motors 16 and 20 are energized so that the start switch 112 can then be released. Normally open relay contacts M2 are also closed when the motors 16 and 20 are started so that timer TD1 is energized through normally closed contacts 2CR1 and timer switch contacts TD2*a* which are closed at this time. After the expiration of a predetermined adjustable time interval corresponding to the time necessary to clean the bowl 34, the normally open switch TD1*a* closes.

When switch TD1*a* closes, the drive motor 48 for the bowl 34 is energized and timers TD2, TD3 and control relay CR3, which are in parallel with the motor 48 are also energized. The timer TD2 is set for a time period corresponding to the frequency at which the bowl 34 is to be cleaned by the blades 64. When the timer TD2 times out, the normally open timer switch TD2*b* is closed and the timer switch TD2*a* which is normally

closed is opened. When CR3 was energized the normally open contacts 1CR3 were closed to energize solenoid **98** causing the valve **102** to shift to the right in FIG. 5 and resulting in release of the brake **56**. After TD3 was energized, and had timed out, switch 1TD3 was closed to energize CR2 to in turn close contacts 1CR2 so as to energize solenoid **100**, shift the valve **108** to the left in FIG. 5 and cause the cylinder assemblies **90** to move the baffle **84** to its "down" position shown in FIG. 1. TD3 is set to time out before TD2. Consequently, during most of the time that the timer TD2 is timing, the brake **56** is released, the baffle **84** is in its "down" position, and the bowl **34** is rotating so as to centrifuge solid particles out of the liquid supplied thereto from manifold **24**. Cleaned liquid is thus flowing off the lower end **42** of bowl **34** into the trap **74**.

When TD2 has timed out so as to close the switch TD2*b*, control relay CR1 is energized to close the normally open relay contacts 1CR1. A limit switch LS1, in series with the contacts 1CR1 is positioned relative to the baffle **84** so that it is closed when the baffle is down. Consequently, while the baffle **84** is down, the relay CR1 is held energized by a circuit through LS1 and 1CR1. This prevents the bowl **34** from being cleaned while the baffle **84** is down. When CR1 is energized, normally closed contacts 2CR1 are opened to de-energize CR2 thereby opening the contacts 1CR2, de-energizing the solenoid **100**, and causing the cylinder assemblies **90** to raise the baffle **84** thereby opening LS1. When LS1 opens, CR1 is de-energized, and TD1 is also de-energized. When TD1 is de-energized, switch TD1*a* opens to de-energize the centrifuge drive motor **48**, de-energize the timers TD2 and TD3 and de-energize control relay CR3 so that the brake **56** is applied to the shaft **54**. At this time, therefore, the blades **64** scrape the accumulated solid particles off the bowl **34**.

When TD2 is de-energized, the switch contacts TD2*a* close so that the timer TD1 is again energized through 2CR1 and TD2*a*. TD1*a* times closed to start the drive motor **48** for the bowl **34**, release the brake **56** and repeat the above sequence. In the event it is desired to clean the bowl **34** at a time other than that provided automatically by the circuit **91**, the operator can energize CR1 by closing manual switch **116**. The result is the same as timing out of TD2 to energize CR1.

It can thus be seen that the circuit **91** provides for automatic cycling of the apparatus **10** so that the bowl **34** is periodically cleared of accumulated solid particles. The timer TD1 is set so that it provides for braking of the shaft **54** for a time period necessary for the blades **64** to thoroughly scrape the inner bowl surface **68**. The timer TD2 is set to control the time between bowl cleaning operations and experience in each instance determines the frequency with which the bowl must be cleared. The timer TD3 is set to provide for lowering of the baffle **84** only after the cleaning operation has been completed and the bowl surface **68** has been flushed clean so as to avoid any loosened particles being thrown into the trap **74**.

In the above-described operation of the apparatus **10**, operation of the bowl motor **48** is discontinued during the time that the blades **64** are clearing the bowl inner surface **68**. The purpose in discontinuing the drive for the bowl **34** while the bowl is being cleared is to allow the rotating bowl to slow down during clearing so as to reduce the centrifugal forces on the material in the bowl. This enables the material in the bowl to more readily drop, under the action of gravity, out of the lower end **42** of the bowl into the tank **12**. The blades **64** are inclined such that the upper ends of the blades **64** are ahead of the lower ends, in the direction of arrow **72**, so that the blades **64** also act to move the particles scraped off the bowl toward the bowl lower end **42** during rotation of the blades **64** relatively to the bowl **34**.

From the above description, it is seen that this invention provides apparatus **10** in which an inverted cup-shaped bowl **34** is utilized for effectively removing solid particles from a liquid to thereby effectively clean the liquid. The construction of the bowl **34** so that the lower end **42** thereof is of a smaller diameter than the upper end slows down the gravity flow of liquid in the bowl so that all of the solid particles will be removed before the liquid reaches the bowl lower end **42**. The circuit **91** provided for automatic operation of the apparatus **10** and the blades **64** cooperate with the bowl **34** to thoroughly clean the bowl inner surface **68**. The baffle **84** cooperates with the trap **74** so as to prevent solid particles from entering previously cleaned liquid.

It will be understood that the self-cleaning centrifugal separator apparatus which is herein disclosed and described is presented for purposes of explanation and illustration and is not intended to indicate limits of the invention, the scope of which is defined by the following claims.

What is claimed is:

1. Centrifugal separator apparatus for separating solid particles from a fluid, said apparatus comprising a bowl of generally inverted cup shape having an inner surface and an open lower end, means for rotating said bowl about a generally vertical axis, a plurality of blades positioned within said bowl and having scraping edges disposed in close proximity to said inner surface of said bowl, means mounting said blades for rotation about an axis substantially coincident with said vertical axis, means for introducing a fluid containing solid particles onto said bowl inner surface at a position above said bowl lower end for gravity flow down said inner surface and out of said bowl through said open lower end thereof so that upon rotation of said bowl about said vertical axis solid particles in said fluid are thrown by centrifugal force onto said bowl inner surface, and means for causing relative rotational movement of said bowl and blades about said axis so as to move said blades along said bowl inner surface to dislodge accumulated particles thereon so that said dislodged particles can drop through the lower open end of said bowl.

2. Centrifugal separator apparatus according to claim **1** wherein said mounting means for said blades is a shaft, and said means for causing relative rotational movement of said bowl and blades consists of brake means for braking said shaft.

3. Centrifugal separator apparatus according to claim **2** wherein said means for rotating said bowl includes a tubular shaft disposed in a coaxial relation with and positioned about said shaft on which said blades are mounted.

4. Centrifugal separator apparatus according to claim **3** further including motor means for driving said bowl shaft, and means for discontinuing the operation of said motor during relative rotational movement of said bowl and said blades.

5. Centrifugal separator apparatus according to claim **3** further including circuit means operatively connecting said motor and said brake and providing for operation of said brake at predetermined time intervals to cause said relative rotational movement of said bowl and said blades, and means discontinuing the operation of said motor while said brake is applied.

6. Centrifugal separator apparatus according to claim **1** wherein said inverted cup-shaped bowl has a downwardly extending annular rim, the lower end of which is of a reduced diameter relative to the upper end thereof.

7. Centrifugal separator apparatus according to claim **1** further including a hollow body for receiving centrifuged fluid from said bowl, said body having an annular inlet opening disposed radially outwardly of and in substantially horizontal alignment with the lower end of said bowl.

8. Centrifugal separator apparatus according to claim **7** further including vertically movable baffle means posi-

tioned below the lower end of said bowl, and means for moving said baffle means between an upper position in which said baffle means is disposed between the lower end of said bowl and the inlet opening for said body, and a lower position in which said baffle means is below said body inlet opening.

9. Centrifugal separator apparatus according to claim 1 wherein said blades are disposed so that they are inclined relative to said vertical axis in a direction such that during said relatively rotational movement of said bowl and said blades, the upper ends of said blades are positioned ahead of the lower ends thereof so that said blades act to move solid material in said bowl toward the lower end thereof.

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ROBERT W. JENKINS, *Primary Examiner.*