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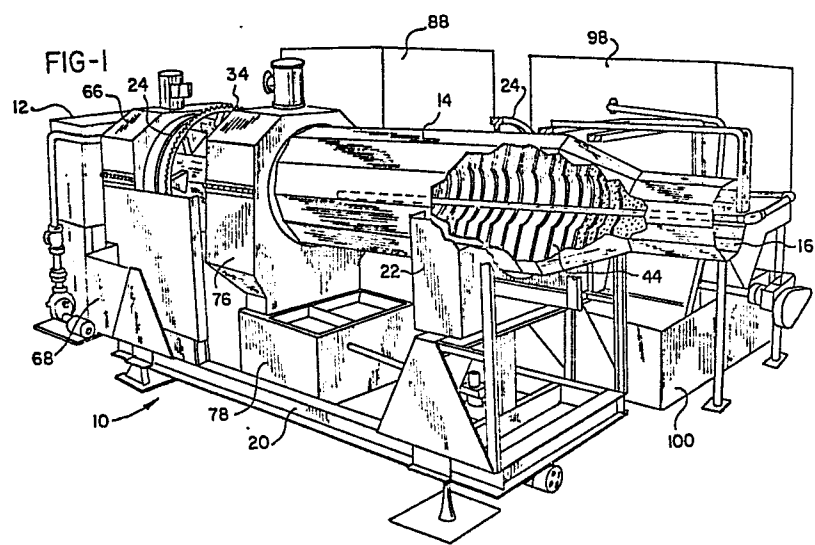
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54 **Method and apparatus for cleaning metallic fines.**

57 A continuous method for cleaning metallic particles such as fines, chips and the like, includes continuously introducing the dirty metallic particles into a flow path in sufficient quantity to form a bed of the particles. The bed is moved along the flow path toward a discharge point while continuously agitating the bed of particles. A gravity flow of a detergent solution is provided along the flow path to flow through the bed of particles contra to their movement. The solution is drained from the path at a point beyond the point at which the particles are introduced so as to carry dirt away from the bed. The apparatus for performing the method includes a rotatable hollow drum (14) having the lowest portion of its second end elevated with respect to the lowest portion of its first end. The particles are continuously introduced to the interior of the drum (14) at a point intermediate the ends thereof. A helical worm (42, 44) mounted to the drum interior extending from the first to second end cooperates with rotation of the drum (14) to transport the particles to the second end of the drum (14). The detergent solution is introduced into the drum interior to flow over and through the particles, and is drained from the drum (14) near the first end thereof. Following draining from the drum (14), the solution is continuously passed through a separating device (88) for separating oil and dirt from the solution.



METHOD AND APPARATUS FOR CLEANING METALLIC FINES

The present invention relates to a method and apparatus for cleaning cutting oil, dirt and the like from metallic fines, as well as from larger metallic particles such as chips, turnings or borings, and even bushelings.

In many industrial operations, metalworking results in the generation of relatively large quantities of metallic fines, chips, turnings, borings and other metallic waste. Often, before being worked, the metal workpiece is coated with a cutting oil, both to reduce wear on the metalworking machinery and to reduce heating of the cutting tool machinery and the workpiece. As a result, the fines and other metallic waste particles of the operation are coated with oil. Additionally, any dirt with which the metal may come in contact will be held by the oil.

In view of the large amount of waste that is often generated, it is desirable to recycle this metallic waste by melting it down for reuse. The oil and dirt typically carried by the waste particles, however, create problems during the remelting process. Although the relatively high temperatures used to melt the particles generally result in some oxydizing of the cutting oils, the oxidization is often incomplete, and oil and components thereof may be released into the atmosphere and must subsequently be collected in baghouses or dust collection systems. Further, any carbon from the oil which is not removed by the high melting temperatures will be retained within the molten metal, resulting in a relatively high level of impurities therein. The dirt will result in a greater quantity of slag that must be removed from the melt.

Clearly, the solution to the above-mentioned

problems is to remove the cutting oil and dirt from the metal particles prior to the remelting process. Besides avoiding the disadvantages discussed above, if such a process is also capable of separating the cutting oil from the dirt, the oil may be reused as well.

Several methods and devices are presently known for cleaning oil and dirt from metallic waste particles. In U.S. patent No. 3,163,929, issued January 5, 1965 to Goodstein, a method for cleaning metal chips is disclosed wherein the chips are fed into the lower end of an inclined rotatable drum. A series of helical flange members are mounted to the interior surface of the drum for conveying the chips upwardly therealong. Each flange member constitutes a single flight, and extends partially above and beyond the next succeeding member. As the drum is rotated, the chips are moved along the drum and agitated by the flange members. The chips are sprayed with detergent-laden steam, which is provided to the drum by a pipe extended into the drum at its upper end. The pipe is positioned parallel to the axis of the drum, and steam leaves the pipe through a series of holes defined along its surface. The steam and condensed steam, carrying the oil and dirt, exit the drum following its contact with the chips through holes in a plate closing off the lower end of the drum. Upon exiting the upper end of the drum, the cleaned chips are collected into a hopper.

U.S. patent No. 3,544,369, issued December 1, 1970 to Keogh, discloses a method for cleaning metallic waste, similar to that shown in the Goodstein patent, wherein the chips are carried along by a screw type conveyor. Rather than a rotating drum, however, an open inclined trough is provided wherein the screw

is mounted to a rotating shaft. The chips to be cleaned are dumped into the lower end of the trough, and are moved upwardly therealong by the screw conveyor. A heated detergent solution is continuously poured into the upper end of the trough, and is allowed to form a pool at the lower end. The pool level is such that the solution overflows the lower end plate of the trough, and the chips are moved upwardly out of the pool, exiting the trough at its upper end.

A third device, having a continuous helical flange, is shown in U.S. patent No. 3,754,559, issued August 28, 1973 to Seiwert. The flange is mounted to the interior of a rotatable drum, which is slightly inclined. The chips to be cleaned are introduced at the lower end and are carried by the flange to the upper end. The drum is formed of alternating sections of solid and perforated wall. The wash solution is introduced to the drum interior in the solid sections, and the chips are drained during their passage through the perforated sections. Baffles are mounted to the drum interior adjacent the perforated sections, so as to deflect the chips away from the perforations while permitting the accumulated liquid to flow out of the drum.

Finally, another known device for cleaning metallic waste, which has been sold by the assignee of the present application, includes a three-section rotatable drum. A continuous helical flange is mounted along the entire length of the drum. The drum is mounted with its axis horizontal, but the first two sections of the drum are tapered such that the drum diameter at the entrance to the first section is larger than the diameter of the third section. The taper effectively provides an inclined path for the

waste particles, which are fed into the device at the entrance to the first section. The wash solution is sprayed into the first section, and the particles are drained during their passage through the second
5 section, with the liquid flowing out the wide ends of the first and second sections to exit the drum. The particles are heated during their passage through the third section for drying.

While presently known devices such as those
10 discussed above are generally effective in cleaning particles of a relatively large size, they are generally not usable with small particles such as metallic fines, i.e., those particles having a size generally less than 60 mesh (60 openings per linear inch, or
15 23.4 openings per linear cm). In the Goodstein and Keogh patents, for example, the flow direction of the detergent solution is opposite the direction of movement of the metal chips. Because of the small size of metallic fines, they tend to become suspended
20 in the cleaning solution. Therefore, upon introduction into the drum or trough, some of the fines will become suspended in the solution, and carried thereby out the lower end of the system. Provision of a filter screen, perforated wall, or the like at the
25 fluid outlet is generally impractical as a means of recovering the fines, since the fines will tend to clog the openings quickly, necessitating virtually continuous cleaning of the openings. In the Siewert patent, by comparison, the fluid flow is in the same
30 direction as movement of the chips. The fluid exits the drum at points along the movement path of the chips, through perforated sections of the drum wall. Nevertheless, notwithstanding the use of baffles mounted to the drum interior for deflecting the waste
35 particles from the perforations, the relatively small

fines suspended in the solution will be carried to the perforations by the fluid flow, where they will tend to block the openings.

5 The method disclosed in the Keogh patent also provides for recovery of the oil from the cleaning solution. This is accomplished by directing solution after exposure to the chips to a settling tank, where the solution is allowed to stand while the oil forms a
10 separate layer on the top of the solution due to the lower specific gravity of the oil. The oil is drawn off, and the solution is returned to the trough. Such a method is disadvantageous, however, since it requires the use of a relatively large settling tank to allow the solution to become relatively quiescent
15 for a period of time to allow proper settling. This in turn requires the use of a relatively large quantity of detergent solution.

A second method for recovering oil from the detergent solution is disclosed in U.S. patent No.
20 3,734,776, issued May 22, 1973 to Keogh. The used detergent solution is subjected to centrifugal force to separate the oil and dirt from the solution. As pointed out in the patent, however, unless a continuous-discharge centrifuge is used, with resulting
25 relatively great expense, the oil and dirt can be separated from the solution only in batches.

What is needed, therefore, is a method and apparatus for the cleaning of metallic fines. Such a method and apparatus should be capable of cleaning
30 fines with a recovery of substantially all fines from the detergent solution. Separation of oil and dirt from the used solution should be provided for, to enable reuse of the solution for further cleaning, as well as for recovery and reuse of the oil. The method
35 should also provide a continuous, rather than batch,

operation.

The present invention discloses a method and apparatus particularly suited for cleaning metallic fines, but also useful in the cleaning of other
5 metallic particles such as chips, turnings, borings, bushelings and the like.

According to one aspect of the present invention, a gravity flow of a detergent solution is provided along an inclined path toward a first point
10 from an elevated second point. The dirty metallic particles are continuously introduced into the detergent flow at a point along the path intermediate the two points. The particles are then caused to flow or progress as a moving agitated bed in counter-current
15 fashion through the detergent flow toward the second path point.

The method may be accomplished by introducing the particles into a rotating drum equipped with a continuous helical baffle or internal worm, such that
20 the drum interior defines an inclined path extending from the first end to the second end of the drum. The particles are introduced intermediate the ends of the drum, and are caused to flow or progress as a moving agitated bed in a rising direction. The detergent
25 solution is introduced along the flowing bed of particles and is drained from the drum at a location downstream of the point of introduction of the particles. The cleansed particles are then recovered at the second or discharge end of the drum.

30 Alternatively, if it is desired to separate metallic fines or other particles from a fluid flow, such as a slurry, the present invention also includes a novel method for performing this task. A rotating drum equipped with a continuous helical baffle or
35 internal worm is provided, defining an inclined path

along the interior of the drum, and the fluid flow containing the metallic particles is introduced into the drum interior at a point along the path remote from the lower end. The separated particles are then
5 recovered at the second or discharge end of the drum, while the fluid is drained away near the first or lower end of the drum.

The oil and dirt carried by particles to be cleaned by the disclosed method may be recovered
10 through additional steps to the method. Following flow past the first or lower end of the drum, the detergent solution is directed to a separation tank adapted for separating oil and dirt from the solution. The solution is continuously flowed through the
15 separation tank, and is then returned to the point at which the fluid is introduced to the drum interior.

An apparatus for cleaning metallic particles includes a rotatable hollow drum having a first end and a second end. The drum defines an inclined flow
20 path along its interior with the second end slightly elevated with respect to the first end. A means for rotating the drum is provided, as well as a means for introducing the metallic particles into the interior of the drum at a point along the flow path intermediate the first and second ends. A continuous helical
25 baffle or internal worm is mounted to the interior of the drum and extends from the first to the second end for transporting the metallic particles along the flow path in the form of an essentially continuously
30 moving, agitated bed of particles progressing toward exit from the drum at its second end. A detergent solution is introduced into the interior of the drum to cause a counterflow of solution through the moving bed of particles. A means for draining the detergent
35 solution is provided near the first end of the drum.

The apparatus may further include a means for continuously separating oil and dirt from the drained detergent solution. The detergent solution is collected at the first end of the drum and directed to the separating means, after which the detergent solution from the separating means is recirculated to the point at which the solution is introduced to the drum interior.

In a preferred embodiment, a funnel member is included having a relatively wide open end and a relatively narrow open end, the wide end being of substantially the same size and shape as the cross-section of the drum. The wide end of the funnel member is mounted to the interior of the drum, and the narrow end is directed toward the second or elevated drum end. The funnel member thus defines first and second sections of the drum, and the means for introducing the metallic particles extends into the first section of the drum to a point along the flow path remote from the first end of the drum. The helical baffle or worm is mounted to the interior of the drum and the funnel member, extending from the first end along the drum interior and along the funnel member to the narrow funnel end. Also, a second helical baffle or worm is mounted to the interior of the drum and extends from the funnel member along the drum interior to the second or discharge end. The first and second worms are each thus operative in response to rotation of the drum for transporting the metallic particles along the drum interior toward the second end. In addition to introducing a first solution into the first drum section, and draining the first solution from the first section, a further means for introducing a second solution into the second drum section, and a means for draining the second solution from the

second drum section, are also provided. A means for draining the solution away from the particles within the funnel member and back into the first drum section is also included.

5 Accordingly, it is an object of the present invention to provide a method and apparatus for cleaning metallic particles wherein the particles to be cleaned are introduced into a path defined by a rota-
10 table hollow drum having a helical baffle or worm mounted to the interior thereof, the point of introduction being remote from the ends of the drum, and wherein a detergent solution is introduced to the drum interior; to provide such a method and apparatus capable of cleaning metallic fines of relatively small
15 size; to provide such a method and apparatus wherein the drum is divided into two sections such that separate solutions may be introduced into each section; to provide such a method and apparatus wherein the detergent solution may be recovered following cleaning of
20 the particles, the oil and dirt separated therefrom, and the cleaned solution reused; and to provide such an apparatus that is additionally suitable for separating from a fluid flow metallic fines carried thereby.

 Other objects and advantages of the invention
25 will be apparent from the following description, the accompanying drawings, and the appended claims.

 In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:

30 Fig. 1 is a perspective view of the apparatus for cleaning metallic particles of the present invention, showing a portion of the drum exterior broken away;

 Fig. 2 is an elevational view of the drum,
35 with portions of the drum exterior broken away;

Fig. 3 is a sectional view taken generally along line 3--3 of Fig. 2;

Fig. 4 is a sectional view taken generally along 4--4 of Fig. 2;

5 Fig. 5 is a sectional view taken generally along 5--5 of Fig. 2;

Fig. 6 is a sectional view taken generally along line 6--6 of Fig. 2;

10 Fig. 7 is a sectional view taken generally along line 7--7 of Fig. 2;

Fig. 8 is a schematic diagram illustrating the method for cleaning metallic particles of the present invention;

15 Fig. 9 is a perspective view of a portion of the separator of the apparatus; and

Fig. 10 is a view illustrating generally the operation of the separator.

Referring generally to the drawings, an apparatus for the cleaning of oil and dirt from metallic
20 particles, including fines, and recovery of the oil cleaned therefrom, is shown. For purposes of description of the invention, it will be understood that the term "metallic fines" describes metallic particles of a size approximately 200 mesh (200 openings per linear
25 inch, or 78 openings per cm), and larger. It will be further recognized, however, that use of the term metallic fines in describing the method and apparatus of the present invention does not represent an intention to limit use of the present invention to metallic
30 fines. While the present invention is particularly well suited for cleaning fines, it is equally usable with larger metallic waste particles, such as chips, turnings, borings, bushelings and the like.

The apparatus 10 for cleaning metallic fines
35 may be seen generally in Fig. 1. Oil-saturated, dirty

fines are loaded into hopper 12, from which the fines are passed into the lower end of a rotatable, slightly inclined drum 14. Drum 14 functions as a conveyor for the fines during cleaning, carrying the fines along the length of the interior of the drum 14. Cleaning fluids are applied to the fines while within drum 14. The fluid is drained from the interior of drum 14, and the cleaned fines are passed out of the drum 14 at its upper end 16.

10 While in the preferred embodiment, the drum 14 is generally cylindrical in shape, it will be recognized that the requisite characteristic is that the conveyor path formed by drum 14 for transporting the fines be inclined. This will allow drainage of the fluid from the fines to the lower end of the drum 14, thereby providing separation of the fluid from the fines. Accordingly, any shape for drum 14 in addition to an inclined cylinder, for example a conical drum having its axis horizontal to the ground, that provides an inclined path for the fines may be used.

20 Drum 14 is shown in detail in Fig. 2. A frame 20 for supporting drum 14 is provided, to which is mounted a pair of cradle members 22, only one of which is shown. A pair of support rings 24 are mounted about the exterior of drum 14, shown also in Fig. 5, resting within one cradle member 22, freely movable therein and guided thereby during rotation of drum 14. Frame 20 is further constructed so as to maintain drum 14 at a slight angle 26 with respect to the ground 28, preferably on the order of 2 to 7°.

30 A means for rotating drum 14 is provided, including a motor 30 driving a gear 32 through an appropriate gear reduction (not shown), which in turn engages sprocket ring 34 mounted, as shown in Fig. 4,

about the exterior of drum 14. Motor 30 is selectively actuated so as to rotate drum 14 in the direction indicated by arrow 36, preferably at a rotational speed in the approximate range of 1/2 to 5 rpm.

5 The interior of drum 14 is divided generally into a first section 38 and a second section 40. Each section 38 and 40 of drum 14 includes a helical worm 42 and 44, respectively, mounted along the entire length of the section. Drum sections 38 and 40 are
10 substantially similar, and the details shown with respect to drum section 40 in Fig. 2 generally apply to drum section 38 as well.

Drum section 40 extends from a lower end at which a section of perforated wall 46 is provided as a
15 portion of the exterior of drum 14, to an upper end at which a cone-shaped funnel member 48 is provided. The helical worm 44 extends along the length of drum section 40, from a point adjacent the perforated wall section 46, along the interiors of drum 14 and funnel
20 member 48. Worm 44 is generally of a solid structure, but includes a perforated section 50 as that portion of worm 44 contained within funnel member 48, as is also shown in Fig. 6.

Similarly, drum section 38 includes a perforated section 52 of the exterior of drum 14 as its
25 lower end. A cone-shaped funnel member 54 defines the upper end of drum section 38, and, as also shown in Fig. 7, the helical worm extending along drum section 38 includes a perforated section 56 as that portion of
30 worm 42 contained within funnel member 54. Funnel member 54 additionally serves as a divider between the drum sections 38 and 40.

The fines to be cleaned are introduced to the interior of first section 38 of drum 14 by a conveyor
35 58. The fines are deposited within section 38 at a

point beyond the perforated wall section 52 and several flights along worm 42. Rotation of drum 14 causes worm 42 to advance the fines along drum section 38 toward funnel member 54. A detergent solution is
5 supplied to drum section 38 by a conduit 60 extending into the interior of drum 14 from the lower end thereof. Conduit 60 has a plurality of orifices defined therealong, such that the detergent solution is
10 applied to the fines in the form of spray jets, indicated generally as 62.

The detergent solution provided to drum section 38 as spray jets 62 travels along drum section 38 in a direction generally opposite to that of the metallic fines, and exits section 38 through perforated wall section 52 as indicated by arrows 64, seen
15 also in Fig. 3. A drain housing 66 is provided about the perforated wall section 52 of drum 14, so as to channel the used detergent solution into a sump 68.

The rotation of drum 14 causes the fines to
20 be tumbled and agitated as they are moved along the path defined by worm 42. Generally, the opposite flow of detergent solution will cause some of the fines to become suspended within the solution. By providing
25 conveyor 58 such that the fines are introduced to drum section 38 at a point several flights along the worm 42, however, sufficient path length is provided for the suspended fines to settle from the solution prior to the solution's exit from drum section 38 through the perforated wall section 52. Thus, with proper
30 selection of flow velocity from the orifices of conduit 60, very few of the fines are carried out of the drum 14 by the solution, nor do the fines tend to block the openings along perforated wall section 52.

The fines are conveyed along drum section 38
35 by worm 42, and then traverse the interior of funnel

member 54. The fines are carried along funnel member 54 by the perforated section 56 of worm 42, whereby any detergent solution still carried by worm 42 may be drained away from the fines. Any liquid so drained
5 flows from funnel member 54 back into drum section 38.

Upon reaching the narrow end of funnel member 54, the fines are dumped into the second drum section 40. As in the first drum section 38, the fines are deposited into drum section 40 along worm 44, both
10 beyond perforated wall section 46 and several flights along worm 44. The fines are advanced by worm 44 toward funnel member 48, and a second cleansing liquid, which may be used as a rinse solution, is applied to the fines, supplied through a conduit 70
15 extending into drum section 40 from the upper end 16 of the drum 14. Conduit 70 has a plurality of orifices defined therealong, such that the liquid is applied to the fines in the form of spray jets, indicated generally as 72. The liquid flows along the
20 interior of drum section 40 toward the lower end thereof, and is drained from the drum section 40 through the openings of perforated wall section 46, as indicated by arrows 74. A drain housing 76 encloses perforated wall section 46, so as to channel used
25 solution into a second sump 78.

It will be recognized that the use of the funnel member 54 as the divider between drum sections 38 and 40 enables two separate solutions to be applied to the fines and maintained as separate solutions
30 within a single drum.

Again, since the fines are deposited into drum section 40 at a point several flights along worm 44, the fines may be transported without being carried out of drum section 40 by the flow of liquid. The

fines are moved into funnel member 48, where the perforated section 50 of worm 44 along the interior of funnel member 48 allows the liquid to be drained from the fines. The fines are then delivered to the upper end 16 of the drum 14.

Appropriate apparatus may be provided such that upon emergence from upper end 16 of drum 14, the cleaned fines may be deposited within a hopper (not shown). Alternatively, the chips may be supplied to a conveyor (also not shown), and may be delivered to a means for drying the fines.

The operation of the entire apparatus 10 may be seen by reference to Fig. 8. Preferably, the supply of cleansing liquids to drum sections 38 and 40 is arranged such that first drum section 38 functions as a wash section for the metallic fines, while section 40 serves as a rinse section. Both the wash fluid and the rinse fluid are a heated alkaline water-base solution, with the alkaline detergent preferably being in an approximate concentration of 22g per liter (3 oz. per gallon).

The fines to be cleaned are supplied to drum section 38 of drum 14 from hopper 12 by conveyor 58. The wash solution is applied to the fines, supplied to drum section 38 as indicated schematically at 80. The fines are transported through drum section 38 and deposited into drum section 40, where the rinse solution is applied to the fines, supplied to drum section 40 through a supply line indicated schematically at 82. The fines are then delivered from the drum 14 at the upper end 16.

Following exposure to the fines within drum section 38, the used wash solution is drained from drum 14 through perforated wall section 52 into sump 68. The liquid is then removed from sump 68 by pump

84, and passed through a heat exchange 86. Heat exchange 86 lowers the temperature of the wash solution, so that the subsequent separation of oil and dirt from the wash solution will be facilitated.

5 Following cooling in heat exchange 86, the wash solution is directed to separation tank 88. The wash solution is continuously passed through separation tank 88, wherein the oil is removed from the solution, collecting at the top of the separation tank 88, while
10 the dirt accumulates at the bottom. The cleaned solution is then passed to a heat tank 90, where the solution is heated to the cleaning temperature. The wash solution is then returned to the first section 38 of drum 14 by pump 92.

15 Similarly, following exposure to the fines within drum section 40, the used rinse solution is drained through perforated wall section 46 into sumps 78. The used solution is transported by pump 94 through a heat exchange 96 and passed through separation
20 tank 98. Following separation of the oil and dirt from the rinse solution in separator 98, the fluid is directed to heat tank 100 whereafter it is delivered by pump 102 back to drum section 40.

The separator 104 contained within each of
25 separation tanks 88 and 98 may be partially seen in Fig. 9. Separator 104 includes a frame 106 to which is mounted a plurality of corrugated plates 108. The plates 108 are mounted within frame 106 so as to be mutually parallel, and are further mounted in an
30 inclined orientation with the corrugations extending from the upper to the lower edge of each plate 108. The fluid to be separated is directed into separator 104 as generally indicated by arrows 110, such that the fluid flows between the plates 108 in a direction
35 perpendicular to the corrugations of plates 108.

Referring now to Fig. 10, as the fluid passes between a pair of corrugated plates 108, the oil 112 contained within the solution moves toward the upper of the two plates 108, indicated by arrows 14, due to its lower density relative to the water-based solution. Similarly, the dirt 116 carried within the solution precipitates downward toward the lower of the plates 108, as shown by arrows. Because both the oil 112 and the dirt 116 tend to collect into the corrugations of the plates 108, they are relatively shielded from the flow of solution continuously passing between plates 108. Thus, the oil 112 is able to move upwardly along each corrugation of plates 108, as shown by arrows 120, until arriving the top of separation tank 88 or 98, where it forms an upper layer on the solution contained therein. The dirt 116 travels in a downward direction along the corrugations of plates 108, as shown by arrows 122, until reaching the bottom of separation tank 88 or 98.

Referring again to Fig. 8, the oil collected at the top of separation tank 88 is drawn off as indicated at 124. Similarly, the oil from the top of separation tank 98 is drawn off as indicated at 126. The dirt collected at the bottom of separation tank 88 is removed therefrom by an auger (not shown) as indicated at 128, while the dirt collected at the bottom of separation tank 98 is similarly removed as indicated at 130. The dirt collected from both tanks 88 and 98 is supplied to a filter unit 132, where any remaining liquid is removed from the dirt. The dirt is then collected from filter unit 132 at 134, while the liquid is directed by pump 136 back into separation tank 88.

Because the concept embodied by the present

invention of introducing metallic fines into a rotatable drum at a point remote from the lower end of the drum enables the apparatus 10 to be used with relatively small particles such as metallic fines, it will
5 be recognized that the apparatus 10 may also be modified for use in separating small particles such as fines from a slurry. Referring generally to Fig. 2, in such an application, a drum similar to drum 14 having only a single section is used. The slurry is
10 provided as a stream into the uppermost end of the drum, so as to provide the maximum drum interior length for separation of the fines from the fluid in which they are suspended. As in the case of the apparatus for cleaning metallic fines, the fines
15 separated from the fluid are recovered as they exit the upper end of the drum, while the fluid is drained away through a perforated wall section at the lower end of the drum.

While the methods herein described, and the
20 form of apparatus for carrying these methods into effect, constitute preferred embodiments of this invention, it is to be understood that the invention is not limited to these precise methods and form of apparatus, and that changes may be made in either
25 without departing from the scope of the invention, which is defined in the appended claims.

1. A continuous method for cleaning metallic particles such as fines, chips and the like, characterized by the steps of:

continuously introducing the dirty metallic
5 particles into a flow path in sufficient quantity to form a bed of the particles;

moving the bed of metallic particles along said flow path toward a discharge point while continuously agitating the bed of particles;

10 providing a gravity flow of a detergent solution along said flow path to flow through the bed of particles contra to their movement and draining the solution from the path at a point beyond the particle introduction point so as to carry dirt away from the
15 bed.

2. A method for cleaning metallic particles such as fines, chips and the like, characterized by the steps of:

continuously introducing dirty particles into
5 a rotating hollow drum (14) having a helical worm (42, 44) mounted to the interior thereof and extending from a first end of said drum (14) to a second end elevated with respect to said first end, the metallic particles being introduced into said drum at a point remote from
10 said first end;

rotating the drum (14) such that the direction of advance of said worm (42, 44) is toward said second end;

introducing a detergent solution into said
15 drum interior to flow over and through the particles;

draining said detergent solution from said drum interior near said first end of said drum; and

discharging the metallic particles from said second end of said drum.

3. A method for cleaning metallic particles such as fines, chips and the like, characterized by the steps of:

rotating a hollow drum (14) having mounted to
5 the interior thereof a means (54) dividing said drum
interior into a first section adjacent (38) a first
end of said drum and a second section (40) adjacent a
second end elevated with respect to said first end,
said drum (14) further having mounted to the interior
10 thereof a first helical worm (42) extending from said
first end to said dividing means (54), and a second
helical worm (44) extending from said dividing means
to said second end, said drum (14) being rotated such
that the direction of advance of said first and second
15 worms (42, 44) is toward said second end;

continuously introducing the dirty metallic
particles into said first section (38) of said drum
interior at a point remote from said first end;

introducing a first solution into said first
20 section (38) of said drum interior to flow over and
through the particles therein;

draining said first solution near said first
end of said drum (14);

discharging the metallic particles from said
25 first section (38) at a point adjacent said dividing
means (54), and introducing the particles into said
second section (40) at a point remote from said first
section (38);

introducing a second solution into said
30 second section (40) to flow over and through the
particles therein;

draining said second solution from said
second section (40) near said dividing means (50); and

discharging the metallic particles from said
35 second end of said drum (14).

4. . . . A method as claimed in claims 1 or 2, including the further steps of:

directing said detergent solution following flow past said first point to a separation tank (88) adapted for separating oil and dirt carried by said detergent solution therefrom;

continuously flowing said detergent solution through said separation tank (88); and

returning said detergent solution to said drum interior.

5. . . . An apparatus for cleaning metallic particles such as fines, chips and the like, including a rotatable hollow drum (14) having a first end and a second end, said drum being disposed with the lowest portion of said second end elevated with respect to the lowest portion of said first end; a helical worm (42, 44) mounted to the interior of said drum and extending from said first to said second end for transporting the metallic particles along said drum interior; and means (30) for rotating said drum (14) in a direction such that said worm (42, 44) advances the particles toward said second end characterized by:

means (58) for continuously introducing the metallic particles into the interior of said drum (14) at a point intermediate said first and said second ends;

means (60) for introducing a detergent solution into the interior of said drum (14) to flow over and through the particles; and

means (52) for draining said detergent solution near said first end of said drum.

6. An apparatus as claimed in claim 5, wherein said means (60) for introducing a detergent solution into the interior of said drum includes a conduit disposed within said drum interior along at least a portion of the length thereof and having at least one orifice therein located to discharge solution onto the particles.

7. An apparatus as claimed in claims 5 or 6, wherein said means (52) for draining said detergent solution from said drum (14) includes a portion of said drum (14) adjacent said first end thereof having a plurality of perforations defined therethrough.

8. An apparatus as claimed in claim 5, wherein said drum (14) is disposed such that the rotational axis of said drum (14) defines an angle (26) of less than 11° above horizontal.

9. An apparatus as claimed in claim 5, further comprising:

means (88) for continuously separating oil and dirt from said detergent solution;

means (68, 84) for collecting said detergent solution from said solution draining means (52) and directing said solution to said separating means (88); and

means (92) for directing said detergent solution from said separating means (88) to said solution introduction means (60).

10. An apparatus as claimed in claims 5 or 9 including means (90) for heating said detergent solution prior to introduction thereof into said drum (14).

11. An apparatus for cleaning metallic particles such as fines, chips and the like, including a rotatable hollow drum (14) having a first end and a second end, said drum (14) being disposed with the lowest portion of said second end slightly elevated with respect to the lowest portion of said first end characterized by:

a funnel member (54) having a relatively wide open end and a relatively narrow open end, said wide end being of substantially the same size and shape as the cross-section of said drum (14), said funnel member (54) being mounted to the interior of said drum (14) at said wide end of said funnel member (54) with said narrow end directed towards said second drum end, said funnel member defining a first section (38) of said drum (14) adjacent said first end and a second section (40) adjacent said second end;

a first helical worm (42) mounted to the interior of said drum (14) and said funnel member (54) and extending from said first end along said drum interior and said funnel member (54) to said narrow end;

a second helical worm (44) mounted to the interior of said drum (14) and extending from said funnel member (54) along said drum interior to said second end;

means (58) for continuously introducing the metallic particles into said first section (38) of said drum (14) at a point along said drum path remote from said first end;

means (30) for rotating said drum (14) in a direction such that said worm (42, 44) advances the particles toward said second end;

means (60) for introducing a first solution into said first drum section (38) to flow over and

through the particles therein;

means (52) for draining said first solution
from said first drum section (38);

40 means (70) for introducing a second solution
into said second drum section (40) to flow over and
through the particles therein; and

means (46) for draining said second solution
from said second drum section (40).

12. An apparatus as claimed in claim 11, including means (56) for draining said first solution away from the metallic particles along said funnel member (54).

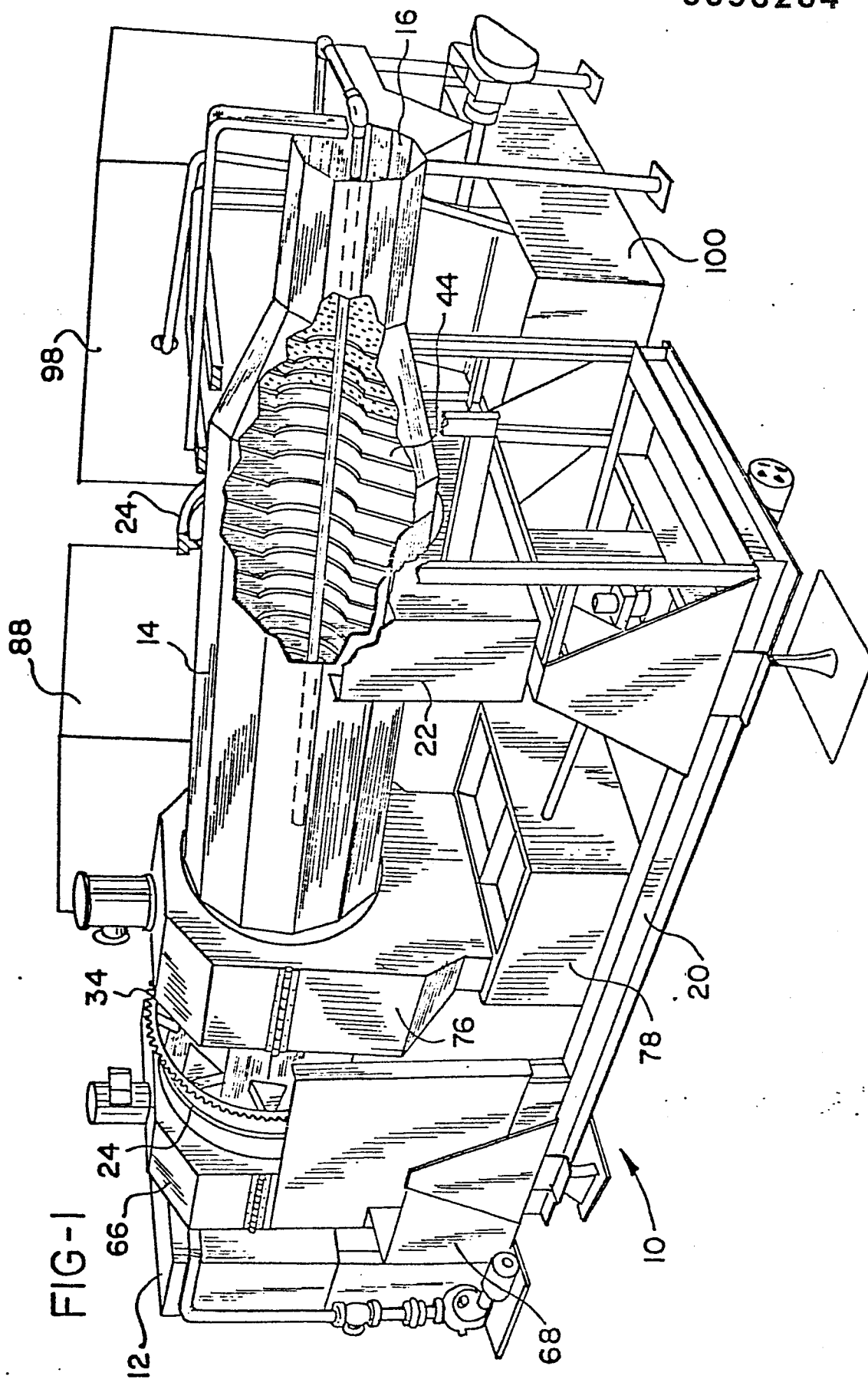


FIG-2

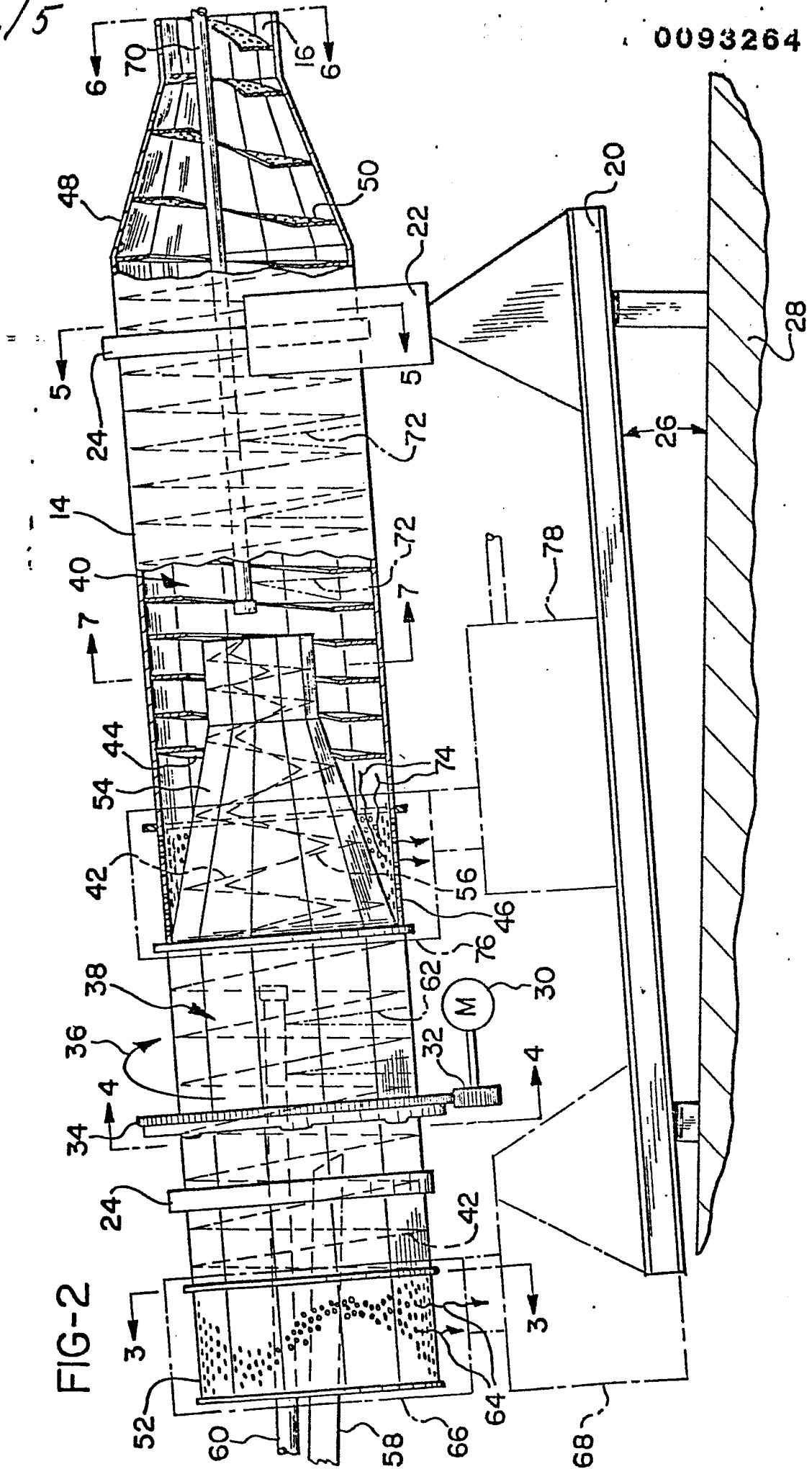


FIG-3

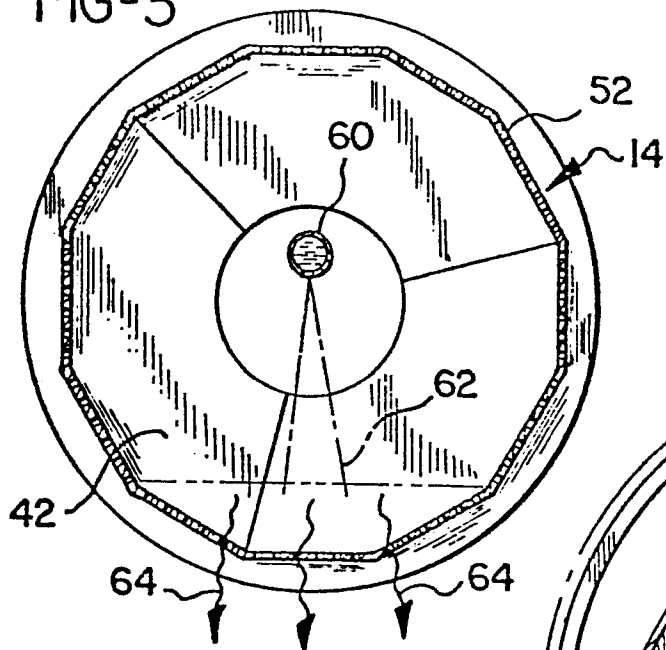


FIG-4

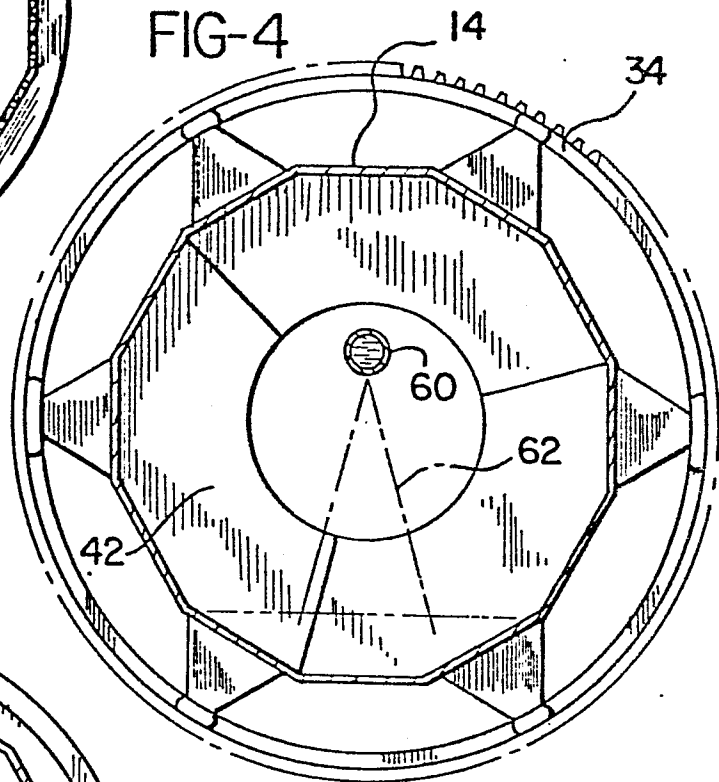


FIG-5

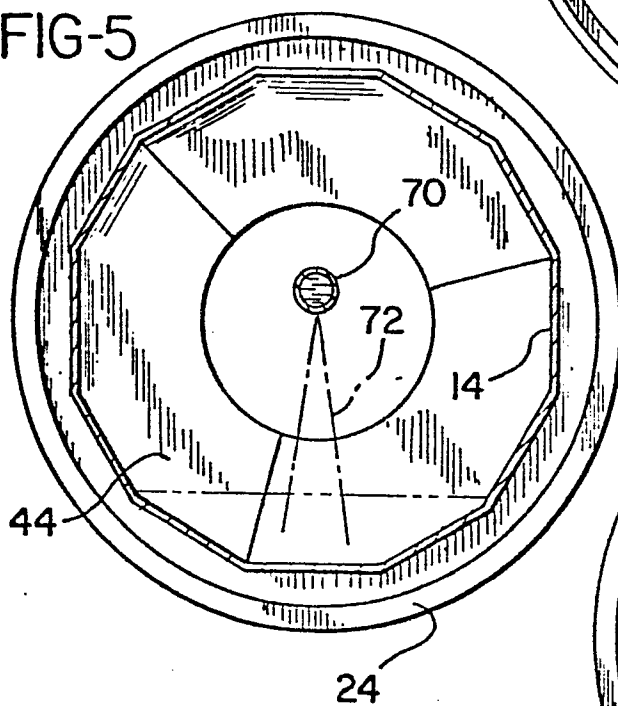
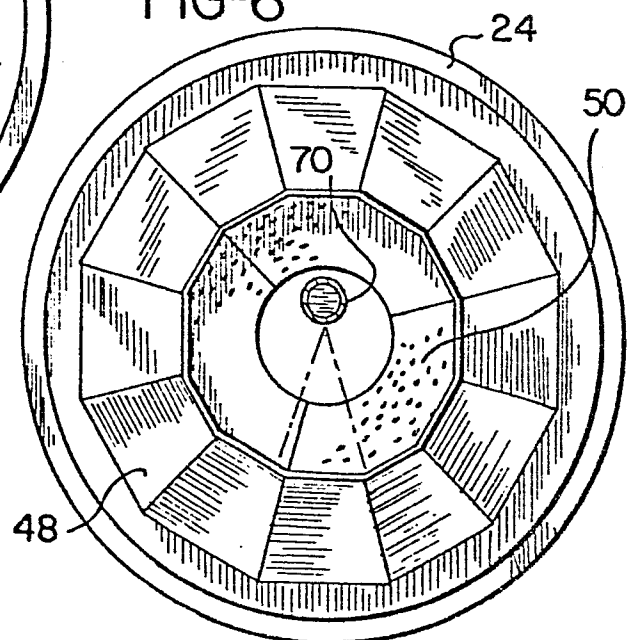


FIG-6



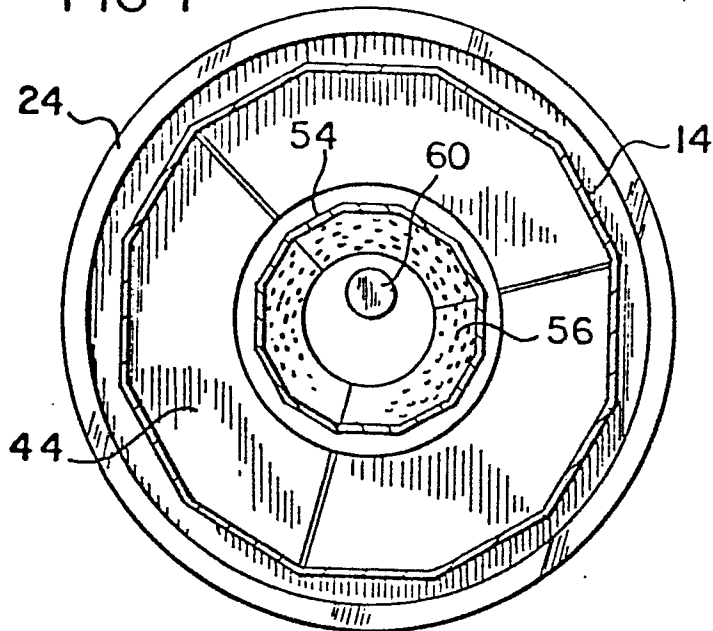
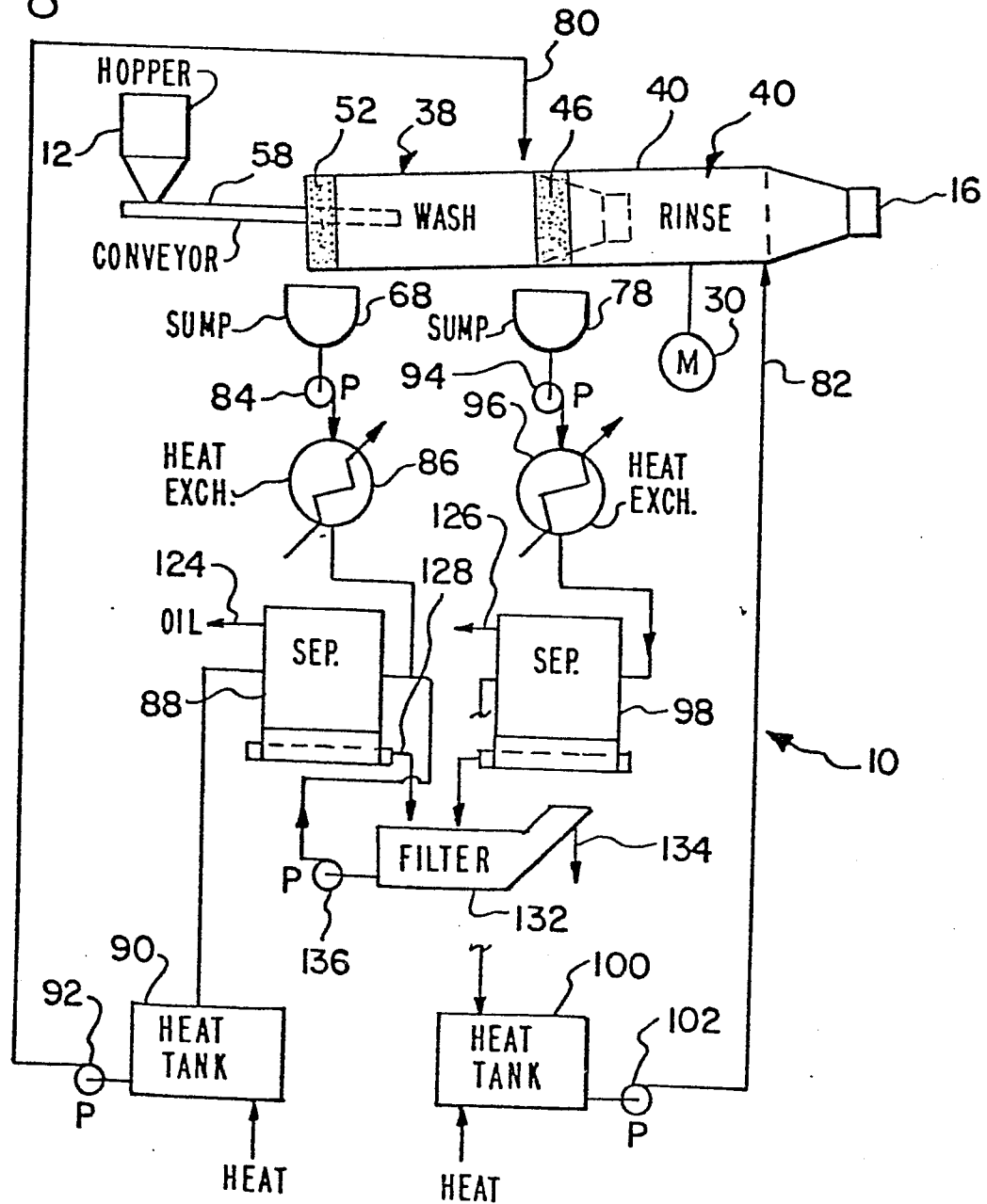


FIG-8



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FIG-9

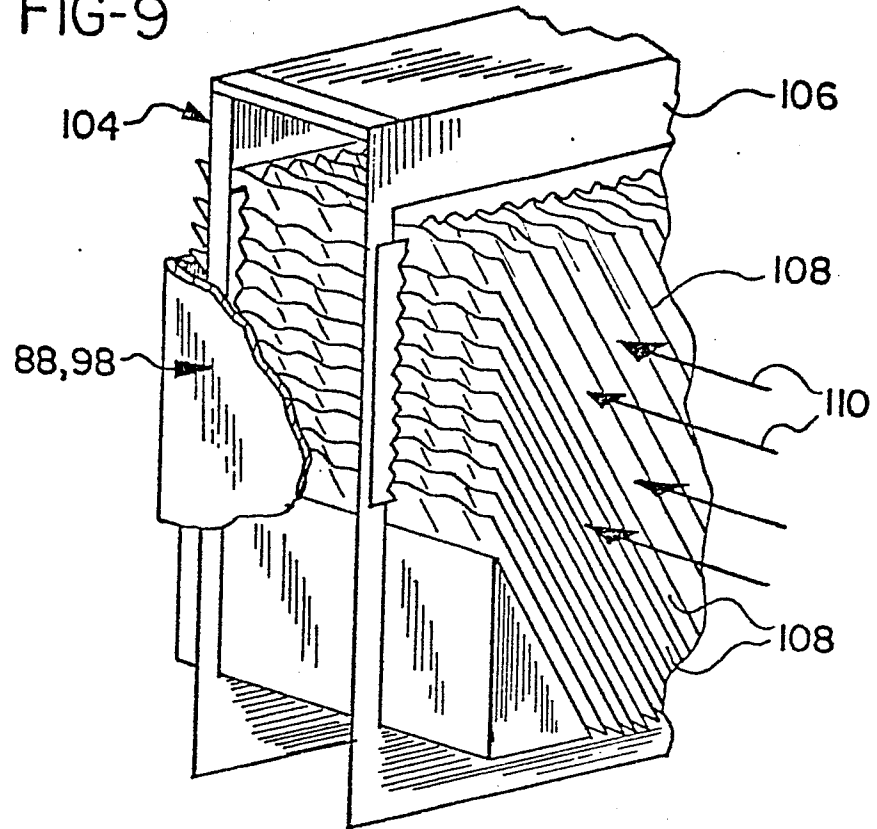


FIG-10

