

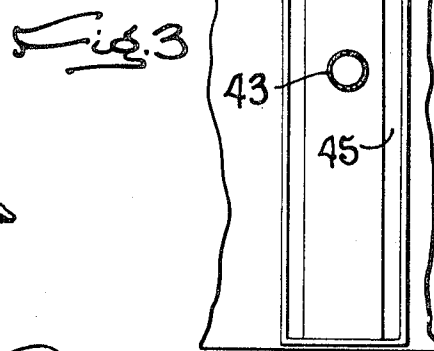
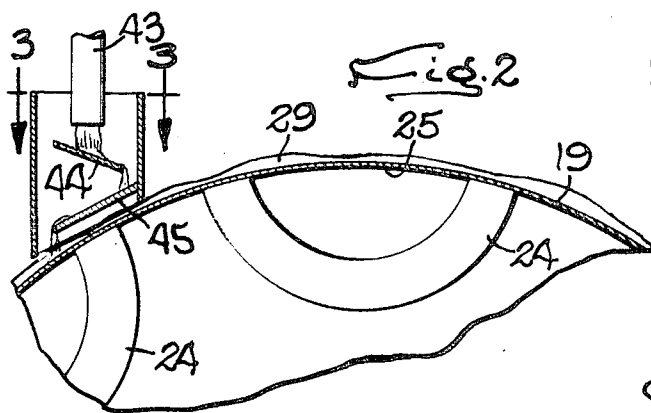
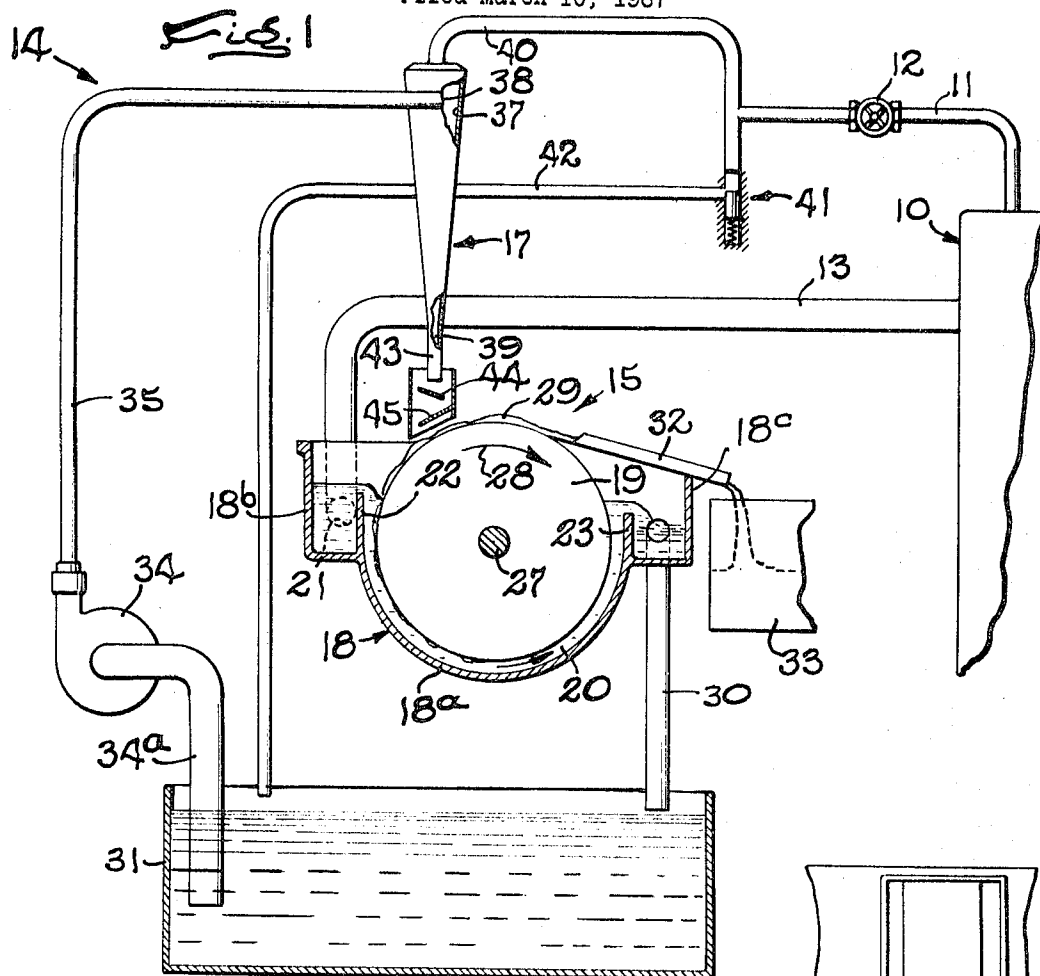
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APPARATUS AND METHOD FOR CLEANING DIRTY LIQUID

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APPARATUS AND METHOD FOR CLEANING DIRTY LIQUID

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7 Claims

ABSTRACT OF THE DISCLOSURE

The combination of a magnetic separator having a rotary separating element, with a cyclone separator and a pump for feeding the relatively clean discharge of the magnetic separator to the cyclone, the dirty discharge of the cyclone being deposited on the magnetic element and strained back into the dirty liquid fed to the magnetic separator.

BACKGROUND OF THE INVENTION

This invention relates to the cleaning of liquids, generally, and more specifically to the cleaning of machine tool coolants containing highly abrasive particles that usually are both ferrous and nonferrous in nature so as to be both magnetic and nonmagnetic.

The practice has been to clean such coolants either with a magnetic separator in which particles are removed by magnetic attraction, or with a filter having a sheet through which the liquid is filtered. Magnetic separators are satisfactory only as long as the contaminant is magnetic material and highly effective cleaning is not required. Filters, on the other hand, though capable of more effective cleaning, are limited as a result of flow capacity problems and the expense and bother of filter media. Another type of separator, the so-called cyclone, has found limited use at most in this area because of the problems of pumping coolants with the entrained abrasive particles to high pressures and the disposal of the dirty discharge of the cyclone.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a competitively priced separating apparatus capable of cleaning machine tool coolants more effectively than has been possible with prior apparatus, handling higher volumes with less difficulty than has been possible with filters, and cleaning more completely than has been possible with magnetic separators. For these purposes, a magnetic separator and a cyclone separator are combined in a novel manner such that the magnetic separator pre-cleans the coolant to an extent permitting the pumping of the coolant to the pressure level required for effective cyclone operation, and the dirty discharge of the cyclone is returned to the magnetic separator for recycling through the apparatus.

Other objects and advantages of the invention will be apparent from the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a fragmentary schematic view, partly in cross-section and partly broken away, of a system including a separating apparatus embodying the novel features of the present invention.

FIG. 2 is an enlarged fragmentary cross-sectional view similar to a portion of FIG. 1 and showing the drum of the magnetic separator and the discharge of the cyclone.

FIG. 3 is a fragmentary sectional view taken substantially along the line 3—3 of FIG. 2.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the drawings for purposes of illustration, the invention is embodied in a coolant-cleaning system (FIG. 1) supplying one or more machines (indicated generally at 10) with clean coolant through a pipe 11 and a valve 12 and receiving dirty coolant through a return pipe 13 leading to the cleaning apparatus 14. The liquid in this return line may contain entrained metal chips, worn-away abrasive particles from the tool or tools of the machine, and other contaminants such as particles of a bonding material for holding the abrasive particles of the tool. The exact composition, of course, varies with the type of tool being used and the type of workpiece being machined, and the volume of flow may vary from 20 gallons per minute to 120 gallons or more.

In accordance with the present invention, the cleaning apparatus 14 comprises a magnetic separator 15 and a cyclone separator 17 combined to provide a competitively priced apparatus in which the magnetic separator pre-cleans the dirty coolant sufficiently to permit high-pressure pumping of the coolant to the cyclone for final, more effective, cleaning by the cyclone, and the liquid and solids discharged from the cyclone are returned to the magnetic separator for recycling, thereby facilitating the disposal of the cyclone discharge. Moreover, this discharge is strained through collected solid particles on the magnetic separator to remove at least a portion of the particles, both magnetic and nonmagnetic, from the discharged liquid before recycling it through the magnetic separator. Accordingly, the clean liquid returned to the using machinery from the cyclone has been cleaned to a far greater extent than is possible with a magnetic separator alone, is virtually free of magnetic and nonmagnetic contamination, and many of the so-called "fines" are continuously removed from the system as a result of the straining action.

In this instance, the return line 13 empties into a receptacle in the form of the usual trough 18 of the magnetic separator 15 which may be of conventional construction. A rotary magnetic member, herein a drum 19, is supported in the trough in spaced relation with the curved bottom wall 18^a thereof to define a flow path at 20 extending underneath the drum. The dirty liquid from the return line enters the trough, preferably by gravity flow, through an inlet 21 opening into a channel 18^b on the left side of the drum, spills over a baffle plate 22, flows under the drum and up on the right side, and spills over a lip 23 on the right side which thus determines the liquid level in the trough.

To create a magnetic field in the trough 18 for attracting particles to and collecting them on the drum 19, permanent magnets 24 (FIG. 2) are disposed inside the drum and supported with their opposite poles facing outwardly closely adjacent the inner surface 25 of the drum. Stub shafts or the protruding ends of a single through-shaft 27 (FIG. 1) coaxial with the drum are suitably journaled on the sidewalls of the trough at both ends to support the drum for rotation about its longitudinal axis.

The details of construction and operation of such separators are well known to those skilled in the art and thus need not be specified herein. For present purposes, it should be sufficient to note that the drum 19 is partially submerged in the liquid and typically is rotated clockwise as indicated by the arrow 28 in FIG. 1, either intermittently or continuously. The liquid flowing under the drum carries entrained particles through the magnetic fields of the magnets 24 so that most of the magnetic particles are collected as at 29 on the periphery of the drum before the liquid reaches and spills over the lip 23. This pre-

cleaned liquid then flows a discharge channel 18° on the right end of the trough through a discharge pipe 30 into a collecting tank 31 where it is held for further treatment.

As the collected mass 29 of particles, called "swarf," is raised out of the liquid and carried over the drum 19, liquid is permitted to drain back to the entry end of the flow path or passage before the swarf is removed from the drum for disposal. As shown in FIG. 1, removal is accomplished by a chute 32 that is inclined downwardly and to the right over the discharge channel 18° and as an upper edge for scraping the swarf off the drum. The lower end of the chute is disposed over a waste receptacle 33 to dump the swarf for eventual disposal.

To raise the pressure of the precleaned liquid to a level high enough for effective operation of the cyclone 17, a pump 34 draws liquid from the tank 31 through an intake pipe 34^a communicating with the body of precleaned liquid and discharges the liquid into an output pipe 35 leading to the cyclone. While the pump may be of various types, the one shown herein is a centrifugal pump capable of delivering liquid to the cyclone at pressures on the order of 50 p.s.i. Because most of the contamination, and all of the coarse particles, have been removed from the liquid by the magnetic separator 15, excessive wear on the pump is not a problem.

The cyclone 17 also may be of conventional construction with a conical inner wall 37 defining the separating chamber and an inlet at 38 admitting liquid into the chamber generally tangent to the conical wall whereby the liquid spirals around the wall while traveling progressively downwardly within the chamber. The resulting centrifugal separating action causes the denser contamination to follow the conical wall to the bottom outlet 39 of the chamber while clean liquid flows out along the axis of the cone through an outlet formed by the open end of an upwardly extending pipe 40. The treated liquid leaving the chamber through this pipe is fed to the supply pipe 11 under the control of a flow regulator 41 that bypasses any excess flow back to the tank 31 through a pipe 42.

The specifications of cyclones are variable and are well known in the art. An example of a suitable basic cyclone is one that has a cone angle of 10 degrees, a length of 7 inches, and a discharge outlet on the order of ¼ of an inch in diameter. It will be seen that the outlet 39 feeds the separated solids, together with a quantity of liquid, into a discharge spout 43 that is disposed above the level of the exposed portion of the drum. The strain this liquid-solid underflow through the swarf 29 on the drum, the mixture is deposited on the drum and the swarf thereon so that the liquid drains back through the swarf to the entry side of the separator while the solids, both magnetic and nonmagnetic, are trapped by the swarf and thus carried with the swarf to the chute 32. In this way, many of the fines are removed from the system instead of being allowed to accumulate at the normal rate.

If a substantial flow of the discharged mixture from the cyclone were allowed to fall unobstructed onto the drum 19, this could result in the washing of swarf 29 off the drum and back into the trough. To avoid this, one or more baffles are provided to break the fall of the mixture, spread and distribute it across the drum, and deposit it gently into the swarf. Herein, a first baffle plate 44 is disposed immediately beneath the discharge spout 43 and inclined downwardly to the right toward the drum to break and spread the underflow from the spout. Beneath the first plate is a second baffle plate 45 that is inclined downwardly to the left and further spreads the flow before releasing it close to the swarf on the drum, for example, about one inch from the drum. It will be evident that many different baffling and spreading arrangements may be used to distribute the mixture across the drum.

From the foregoing, it should be apparent that the magnetic separator 15 and cyclone 17 have been combined and arranged in a novel manner to clean machine tool coolant at the high flow rates previously obtainable with

magnetic separators, and with the greater cleaning effectiveness of cyclone separators. The problem of pumping coolant with highly abrasive particles therein is solved by precleaning the liquid, and the problems of disposing of cyclone discharge have been solved by returning it to the magnetic separator, and also by straining it through the amassed swarf on the drum. In addition, these advantages are obtained with a relatively simple apparatus that may be competitively priced.

I claim as my invention:

1. Apparatus for cleaning dirty liquid contaminating magnetic particles, said apparatus having, in combination, a magnetic separator including a trough, a rotary magnetic drum disposed in said trough and cooperating therewith to define a flow path for liquid to pass around said drum and through the magnetic field around the drum for removal of magnetic particles from the liquid, said drum and said trough cooperating to form an entry end for said path on one side of the drum and a discharge end on the other side, said drum being rotatable in one direction to raise collected particles out of the liquid at said entry end; a cyclone separator having a separating chamber, an inlet for liquid to be treated, a first outlet for treated liquid, and a second outlet for particles and liquid separated from said treated liquid; a high-pressure pump receiving partially cleaned liquid from said magnetic separator and delivering the liquid under pressure through said inlet to said chamber whereby said cyclone separator completes the cleaning of the liquid; and means returning the solid particles and liquid discharged through said second outlet to said magnetic separator at said entry end of said path for recycling of the liquid through the apparatus.

2. Apparatus as defined in claim 1 in which said returning means are arranged to deposit the discharge from said cyclone separator upon said drum above the liquid in said trough for straining of returned liquid through collected particles on the drum and removal of returned solid particles with the collected particles.

3. Apparatus as defined in claim 2 further including means distributing the returned particles and liquid across at least part of the length of said drum and depositing the same on the drum in a manner to avoid washing collected particles off the drum.

4. Apparatus as defined in claim 3 in which said distributing means includes a baffle receiving the discharge from said cyclone separator and spreading the same along the drum, said baffle being inclined downwardly toward the drum and having a discharge edge adjacent thereto.

5. Apparatus for cleaning dirty liquid containing magnetic particles, said apparatus having, in combination a magnetic separator including a receptacle, a member disposed in said receptacle and cooperating therewith to define a flow path for liquid to pass around said member, means on said member creating a magnetic field for attracting magnetic particles to the member from liquid flowing along said path and thereby removing a major portion of the particles from said liquid; a cyclone separator having a separating chamber, an inlet for liquid to be treated, a first outlet for treated liquid, and a second outlet for particles and liquid separated from said treated liquid; a pump receiving partially cleaned liquid from said magnetic separator and delivering the liquid under pressure through said inlet to said chamber whereby said cyclone separator completes the cleaning of the liquid; and means returning the solid particles and liquid discharged through said second outlet to said magnetic separator for recycling of the liquid through the apparatus, said member being rotatably supported in said receptacle for rotation with part thereof in liquid in the receptacle to carry collected particles upwardly out of the liquid, said returning means being positioned to release the returned liquid and particles onto amassed particles collected by said member and disposed above the

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liquid whereby the returned liquid is strained through the collected particles.

6. Apparatus as defined in claim 5 in which said second outlet is disposed above the level of said amassed particles, and said returning means distributes the returned particles and liquid over the amassed particles to avoid washing the same off said member.

7. The method of cleaning dirty machine tool coolant containing magnetic and nonmagnetic particles, said method comprising the steps of, passing the dirty coolant through a magnetic separator having a magnetic member for collecting most of the magnetic particles and cleaning the coolant sufficiently to permit pumping thereof through a high-pressure pump without excessive wear, pumping the coolant from said magnetic separator at relatively high pressure into a cyclone separator to remove remaining magnetic particles as well as nonmagnetic particles according to the greater effectiveness of the cyclone separator, returning the dirty discharge of the cyclone separator to said magnetic separator for re-

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cycling through the latter, and straining the dirty discharge of the cyclone separator through particles collected by said magnetic separator to collect discharged particles on the magnetic particles while returning most of the liquid to the magnetic separator for recycling.

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