

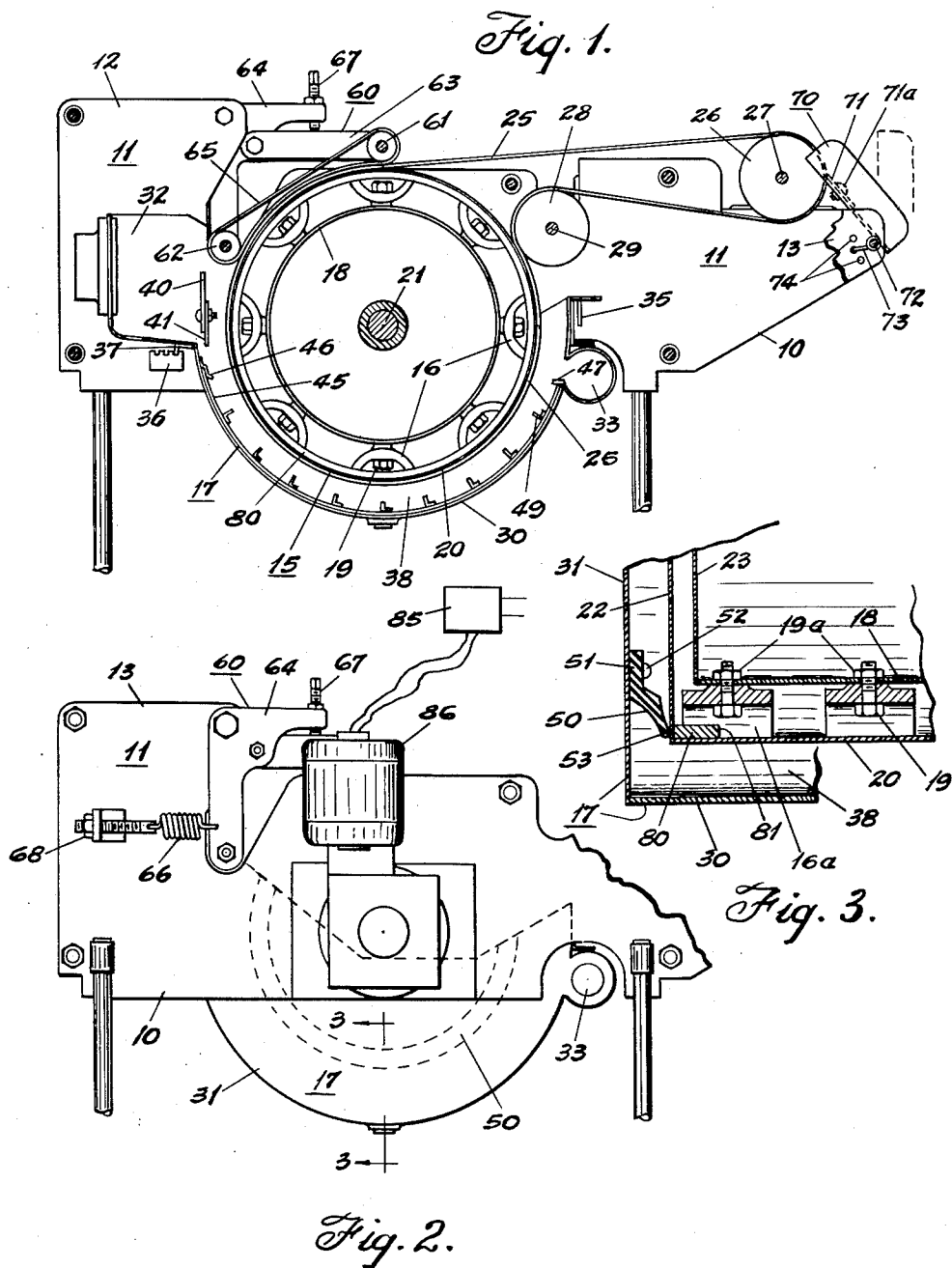
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MAGNETIC SEPARATOR

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## MAGNETIC SEPARATOR

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This invention relates to an improved apparatus for the removal of both magnetic and non-magnetic particles from liquids and is particularly concerned with the removal of such particles, termed "swarf," from coolants and cutting oils used in machining operations. The invention has reference to a magnetic separator of the type in which horseshoe magnets are mounted in longitudinally spaced rows around the inner periphery of a drum and the coolant flows through an arcuate passageway surrounding a portion of the drum, the swarf adhering to the drum in the form of brushes. As used herein, the term "swarf" denotes both magnetic and non-magnetic particles individually and combined.

It is an object of the invention to provide an improved magnetic separator.

Another object of the invention is to provide a separator of the general type referred to with means for controlling the length of the brush of swarf formed.

A further object of this invention is to provide in a separator of this type an adjustable pan and means for evenly distributing incoming liquid across the drum of the separator.

Another object of this invention is to provide improved sealing means for preventing contaminated liquids from by-passing the magnetic area of a separator.

Another object is to provide a magnetic separator with means which will produce a drier swarf.

A further object is to provide a magnetic separator with means for preventing erosion of the separator drum and objectionable adherence of swarf thereto.

Still another object of the invention is to provide in a magnetic separator means facilitating the trapping and removal of non-magnetic solids from contaminated coolants and cutting oils.

Other objects of the invention will become apparent from the description and claims which follow.

In the removal of swarf from liquid coolants and cutting oils used in machining operations to condition the coolants and cutting oils for reuse, the contaminated liquid ordinarily is directed into an arcuate pan or apron into which a rotatably mounted magnetic drum extends. Although it is not uncommon to provide a continuous magnet around the inner periphery of the drum, the usual practice is to arrange spaced longitudinal rows of horseshoe magnets around the inner periphery thereof. In present-day practice, the drum is caused to rotate continuously through the liquid so that the magnetic contaminants are attracted by magnetic force to the periphery of the drum in the form of rows of swarf, called brushes, which serve also as strainers for non-magnetic solids from the coolant.

As the brushes increase in length, they extend the magnetic field deeper into the liquid being cleaned, the optimum length for these brushes being about  $\frac{1}{4}$  inch, as a brush exceeding this length presents such a long path for the magnetic flux that it becomes dissipated near the end of the brush, reducing its efficient holding capacity necessary to resist velocity created by the flowing liquid.

With a continuously rotating drum, there is no way of controlling the length of the brushes. The more contaminated the coolant, the longer will be the brushes and, vice versa, the less contaminated the coolant, the shorter will be the brushes, for a given speed of rotation.

My invention overcomes this problem by interrupting rotation of the drum at timed intervals which may be set

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so that a  $\frac{1}{4}$  inch brush will result regardless of the contaminant load in the coolant. This close control of the brush length by intermittent operation of the drum is one of the main objects of the invention.

Also, in present-day operation of magnetic separators, the swarf clinging to the drum as it emerges from the arcuate passage is subjected to the weight of a squeeze-roll for dewatering purposes after which the swarf is supposed to be scraped from the drum by a metal blade pressed against the drum. In actual practice, however, the swarf usually is not completely removed by the scraper due to the magnetic force causing some of the swarf to remain on the drum and eventually erode it. I overcome this problem by providing a discharge roller and scraper remote from the drum and placing an endless belt conveyor around both the drum and the discharge roller, so that the swarf is carried by the belt without contacting the drum and is scraped from the belt as it passes over the discharge roller where magnetic force is not present.

Other prior art problems which have been overcome by my improved magnetic separator will manifest themselves as the specification proceeds.

My invention will be fully understood by reference to the following detailed description and the drawings which form a part hereof and wherein like reference characters in the several figures designate similar elements.

FIGURE 1 is an elevational view, partly in section, of the magnetic separator with the front cover and drive mechanism removed;

FIGURE 2 is a partial elevational view of the separator; and

FIGURE 3 is a partial sectional view, on an enlarged scale, taken along line 3-3 of FIGURE 2.

Referring now to the drawings, the magnetic separator or clarifier indicated generally at 10 is mounted in a frame 11 including plates 12 and 13. The separator comprises a rotatable drum 15, in which the permanent magnets 16 are supported, and a pan 17 wherein the drum 15 rotates and through which the coolant flows.

The drum 15 of the separator 10 includes an inner cylindrical portion 18 to which the magnets 16 are secured in longitudinal rows by any suitable means, such as bolts 19 and nuts 19a (see FIGURE 3), and an outer cylindrical portion 20 of non-magnetic material which encircles the rows of magnets 16. The cylindrical portions 18 and 20 are rigidly mounted on a shaft 21 by any suitable means, such as end plates 22 and 23, respectively (FIGURE 3). Shaft 21 is rotatably mounted in bearings, not shown, in frame 11 in such a manner that drum 15 is free to rotate within pan 17.

A conveyor belt 25 comprising an endless belt of resilient material is trained around both the drum 15 and a discharge roller 26. The discharge roller 26 is rigidly mounted on a shaft 27 which is rotatable in bearings, not shown, in frame 11 a suitable distance from drum 15. After passing around the discharge roller 26 the belt is re-trained on the drum 15 by passing it over a guide roller 28 mounted close to the drum 15. The guide roller 28 is rigidly mounted on a shaft 29 which is rotatable in suitable bearings, not shown, in frame 11. Thus, as shown in FIGURE 1, the belt 25 is held in contact with the drum 15 over a major portion of its periphery.

The pan 17 has an arcuate bottom 30 and side walls 31 of non-magnetic material. It includes an influent channel 32 at one end and an effluent conduit 33 at the other end. The pan 17 is slidably supported by a bracket 35 affixed to the plate 12 and a similar bracket, not shown, affixed to the plate 13 near the effluent end of the pan. Near its influent end the pan is supported by a notched plate 36 affixed to plate 12 and a similar plate affixed to plate 13, not shown. The pan 17 is adjustable relative to the drum 15 and undesired horizontal movement of the pan 17 is

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prevented by a bar 37 which is longitudinally disposed on the underside of influent channel 32, and is inserted in suitable corresponding notches of plates 36. In the position of the bar 37 shown in FIGURE 1, an arcuate channel or passageway 38 of uniform width from its influent to its effluent end is formed between the pan 17 and the drum 15. By using the other notches the influent end of passageway 38 becomes wider and the effluent end narrower.

A stationary weir 40 across the influent channel 32 regulates the flow of liquid to the arcuate passageway 38 and uniformly distributes the entering liquid in the form of a sheet longitudinally across the periphery of the drum 15. A depending plate 41 is adjustably mounted on weir 40 by any suitable means, such as bolts engaging slots in weir 40, and is positionable to restrict the opening between the lower end of the weir 40 and the influent channel 32.

A flexible sheet 45 of non-magnetic material, such as for example aluminum, is inserted in pan 17 and secured in position by clips 46 and 47, as shown in FIGURE 1. The sheet 45 is provided with longitudinal rows of cleats or projections 49 which may be integral with or rigidly affixed to the sheet and are preferably L-shaped. The projections 49 not only direct the liquid flowing along the arcuate bottom 30 of the pan 17 against the drum 15, but also provide pockets wherein non-magnetic solids, not strained out by the magnetic brushes, are retained. These solids may be readily removed from the magnetic separator 10 by withdrawing the sheet or insert 45 and flexing it a few times.

Contaminated liquid is prevented from passing around the ends of the drum 15 by semicircular sealing strips 50, one of which is shown in detail in FIGURE 3. The root portions 51 of strips 50 are affixed to the sidewalls 31 of pan 17 by screws 52. The lip portions 53 of the sealing strips 50 are adapted to contact end plates 22 of drum 15, as shown in FIGURE 3 for one of the end plates. The sealing strips 50 are resilient and are made of rubber-like material, such as neoprene, or of a plastic material, such as a plasticized polyvinyl chloride.

A squeeze-roller assembly 60 is provided and may comprise rollers 61 and 62, rotatably mounted between pairs of arms 63 and arms 64, respectively. Arms 63 are pivotally mounted on arms 64 which, in turn, are pivotally mounted on plates 12 and 13 of frame 11. An endless belt 65 is trained about rollers 61 and 62, as shown. The squeeze-roller assembly 60 is urged into contact with conveyor belt 25 and drum 15 by springs 66, attached to the arms 64 with one end and to frame 11 with the other end, as shown in FIGURE 2 for one arm 64. The pressure exerted by the squeeze-roller assembly 60 on the drum 15 can be regulated by screws 67. The tension of the springs 66 can be adjusted by setting of the nuts 68.

A discharge chute 70, provided with a scraper blade 71, is swingably mounted on a shaft 72, as shown in FIGURE 1. The chute 70 is held in position to maintain the scraper blade 71 in scraping engagement with a portion of the conveyor belt 25 on discharge roller 26 by means of tension springs 73 which engage holes 74 in the plates 12 and 13 of frame 11. The scraper 71 is adjustably mounted on the chute 70 with screws, one of which is shown at 71a, which engage slots, not shown, in scraper 71. The chute 70 may be swung to the position shown in broken lines in FIGURE 1 to facilitate inserting and removing the removable insert 45.

Shunt bands 80 are placed around the outermost magnets 16a of the longitudinal rows in notches 81 (see FIGURE 3) provided therefor. The shunt bands 80 are preferably made of soft iron and divert the flux, which would ordinarily flow over the edges of the drum 15, back toward the center of the drum. This prevents magnetic material from being attracted under the edges of the conveyor belt 25.

To afford intermittent rotation of the drum 15, a timer 85, which may be of any well known type, is electrically

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connected to a motor 86 and is adjusted to periodically interrupt rotation of drum 15. I have found that a  $\frac{1}{4}$  inch brush can be established regardless of the solids content of the contaminated coolant by setting the timer 85 to impart to the drum 15 an optimum cycle of operation wherein periods of rotation alternate with rest periods; the length of said periods depending on the specific solids content of the liquid under treatment.

The operation of the device will be readily understood.

The pan 17 is adjusted relative to drum 15 by inserting bar 37 into suitable notches in plates 36 to regulate the width of the inlet portion of passageway 38. The more viscous the liquid to be cleaned, the wider should be passageway 38 at the influent end of the separator 10. This adjustment controls the depth of the liquid in the passageway 38. The optimum depth of the liquid is one where liquid friction on the magnetically attracted solids is at a minimum. The depending portion 41 of weir 40 is then adjusted so that the incoming liquid passes over weir 40 in a thin sheet for uniform distribution and initial contact with the drum 15.

The seals 50 confine the liquid to the passageway 38 by preventing flow of liquid around the ends of the drum 15. As will be seen in FIGURE 3, if the seals 50 were not used, contaminated liquid could escape the magnetic fields set up on the periphery of the drum 15 by flowing through a channel defined by the end plates 22 of the drum 15 and the sidewalls 31 of the pan 17.

Contaminated liquid is caused to flow through passageway 38 in one direction while the motor 86 rotates the drum 15 in the opposite direction. The timer 85 is set to interrupt power to the motor 86 at intervals which will maintain each row of magnets 16 in the liquid in pan 17 for periods of time just sufficient to permit a brush of swarf of desired length, usually  $\frac{1}{4}$  inch, to build up across each row of the magnets 16. These intervals of power interruption will be inversely proportional to the amount of magnetic contaminants in the liquid being cleaned.

After the swarf emerges from the liquid in pan 17, it passes under squeeze-roller assembly 60 where it is dewatered. By employing two rollers 61 and 62 and an endless belt 65, the squeeze-roller assembly 60 produces a drier swarf than can be obtained with the single rollers usually employed. The swarf is prevented from being attracted under the edges of the belt 25 and adhering to the drum by shunt bands 80.

The dewatered swarf is conveyed on belt 25 to scraper 71 which scrapes it from the belt into chute 70, from which it may slide down into a receptacle, not shown.

The filtering effected by the swarf removes a large percentage of the non-magnetic solids. The remaining solids settle in the pockets formed by the projections 49. These solids are readily removed by swinging chute 70 to the position shown in broken lines in FIGURE 1, withdrawing insert 45, and flexing it a few times.

It will be seen that my invention overcomes many deficiencies of prior art magnetic separators and provides a new method of operating such separators.

Many modifications and variations of the invention may be made by persons skilled in the art without departing from the spirit and scope thereof. For example, while the belt 25 is a very desirable feature, inasmuch as it protects the drum from erosion due to direct contact with the magnetic particles and permits more complete removal of the swarf, it is to be understood that the magnetic separator can be operated without the belt, in which case the shunt bands 80 also would be eliminated. Therefore, while best results will probably be attained with the construction and arrangement and combination of elements shown and described, these are to be taken as constituting a preferred embodiment of the invention rather than limitations thereof.

I claim:

1. A magnetic clarifier including a horizontally-disposed drum mounted to rotate about its longitudinal

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axis, a plurality of permanent magnets mounted within said drum, an arcuate pan concentrically mounted about the lower portion of said drum and spaced radially outwardly from the drum periphery to define an arcuate passageway between the pan and the drum for the flow of liquid containing magnetic and non-magnetic particles, said pan having a bottom and two sidewalls, an influent channel and an effluent conduit in hydraulic communication with said passageway, resilient sealing members affixed to said pan and contacting said drum, and means for rotating said drum, said magnetic clarifier being characterized by an insert removably mounted in, and covering a major portion of, the bottom of said pan, said insert comprising a flexible sheet having projections disposed in spaced continuous rows extending longitudinally of said insert, each projection having on its upstream side a straight face normal to the bottom of the pan so as to retain particles not attracted to said drum in the spaces between said projections.

2. A clarifier according to claim 1 wherein said influent channel and said effluent conduit are integral with said pan and means are provided for moving said pan in a horizontal plane relative to said drum whereby said arcuate passageway becomes wider at one end than at the other, and said sealing members are adapted to contact said drum in any position of said pan, said means for moving said pan comprising a pair of brackets slidably supporting one end of said pan, a pair of notched plates subjacent its other end portion, and a bar affixed to said pan and adapted to engage corresponding notches in said plates.

3. In a magnetic clarifier for removing magnetic and non-magnetic solids from liquids and including a drum having a horizontally disposed cylindrical portion mounted to rotate about its longitudinal axis and carrying magnets arranged in longitudinal rows parallel to said axis, a liquid holding pan into which said drum extends, and an endless conveyor belt trained about said drum, the combination with said belt of means preventing solids from collecting subjacent the edges of said belt, said means comprising bands of magnetic material encircling the outermost magnets in said longitudinal rows at opposed ends of said cylindrical portion and diverting magnetic flux from said ends toward the center of said cylindrical portion.

4. In a magnetic clarifier for removing magnetic and non-magnetic solids from contaminated liquid and including a horizontally-disposed drum mounted to rotate about its longitudinal axis, a plurality of magnets mounted within said drum, an end plate on each end of said drum, an arcuate pan concentrically mounted about the lower portion of said drum and spaced radially outwardly from the drum periphery to define an arcuate passageway between the pan and the drum for the flow of contaminated liquid, said pan having a bottom and two sidewalls, an influent channel and an effluent conduit in hydraulic communication with said passageway, an endless conveyor belt trained about said drum, and means including a motor and a power circuit through said motor for rotating said drum, means for moving said pan in a hori-

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zontal plane relative to said drum whereby said arcuate passageway becomes wider at one end than at the other, said means for moving said pan including a pair of brackets slidably supporting one end of said pan, a pair of notched plates subjacent its other end portion, and a bar affixed to said pan and adapted to engage corresponding notches in said plates, sealing means affixed to said sidewalls and contacting said end plates in any position of said pan, means removably mounted in the bottom of said pan for collecting contaminants from said liquid, said removably mounted means extending over a major portion of said bottom and including a flexible sheet having projections disposed in spaced continuous rows extending longitudinally of said insert, means preventing magnetic solids from collecting subjacent the edges of said belt including bands of magnetic material encircling the end portions of said drum and diverting magnetic flux from said end portions, and a timer alternately opening said power circuit to interrupt rotation of said drum for periods of time sufficient to permit magnetic solids in said liquid to be attracted to said drum while it is at rest and form thereon brushes of predetermined length, and closing said power circuit for periods of time sufficient to move said brushes out of the liquid and immerse another portion of said drum.

5. A magnetic clarifier including a horizontally-disposed drum mounted to rotate about its longitudinal axis, a plurality of permanent magnets mounted within said drum, an arcuate pan concentrically mounted about the lower portion of said drum and spaced radially outwardly from the drum periphery to define an arcuate passageway between the pan and the drum for the flow of liquid containing magnetic and non-magnetic particles, said pan having a bottom and two sidewalls, an influent channel and an effluent conduit integral with said pan and in hydraulic communication with said passageway, means for moving said pan in a horizontal plane relative to said drum whereby said arcuate passageway becomes wider at one end than at the other, said means for moving said pan comprising a pair of brackets slidably supporting one end of said pan, a pair of notched plates subjacent its other end portion, and a bar affixed to said pan and adapted to engage corresponding notches in said plates, and resilient sealing members affixed to said pan and adapted to contact said drum in any position of said pan.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |          |               |
|-----------|----------|---------------|
| 468,540   | Cane     | Feb. 9, 1892  |
| 1,775,155 | Boykin   | Sept. 9, 1930 |
| 2,410,601 | Crockett | Nov. 5, 1946  |
| 2,466,839 | Caldwell | Apr. 12, 1949 |
| 2,597,561 | Blind    | May 20, 1952  |
| 2,604,207 | Scott    | July 22, 1952 |
| 2,736,432 | Gardes   | Feb. 28, 1956 |
| 2,758,715 | Fowler   | Aug. 14, 1956 |

##### FOREIGN PATENTS

|         |         |               |
|---------|---------|---------------|
| 523,812 | Belgium | Nov. 14, 1953 |
|---------|---------|---------------|