April 12, 1949. H. J. CALDWELL 2,466,839

MAGNETIC SEPARATOR

Filed June 17, 1944 2 Sheets-Sheet 1

Fig. 1

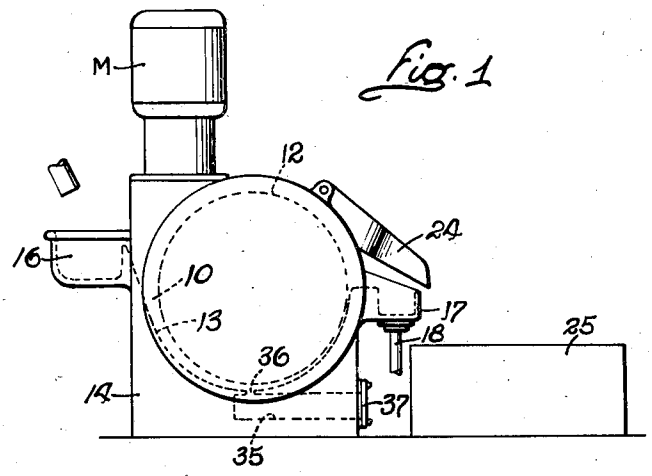
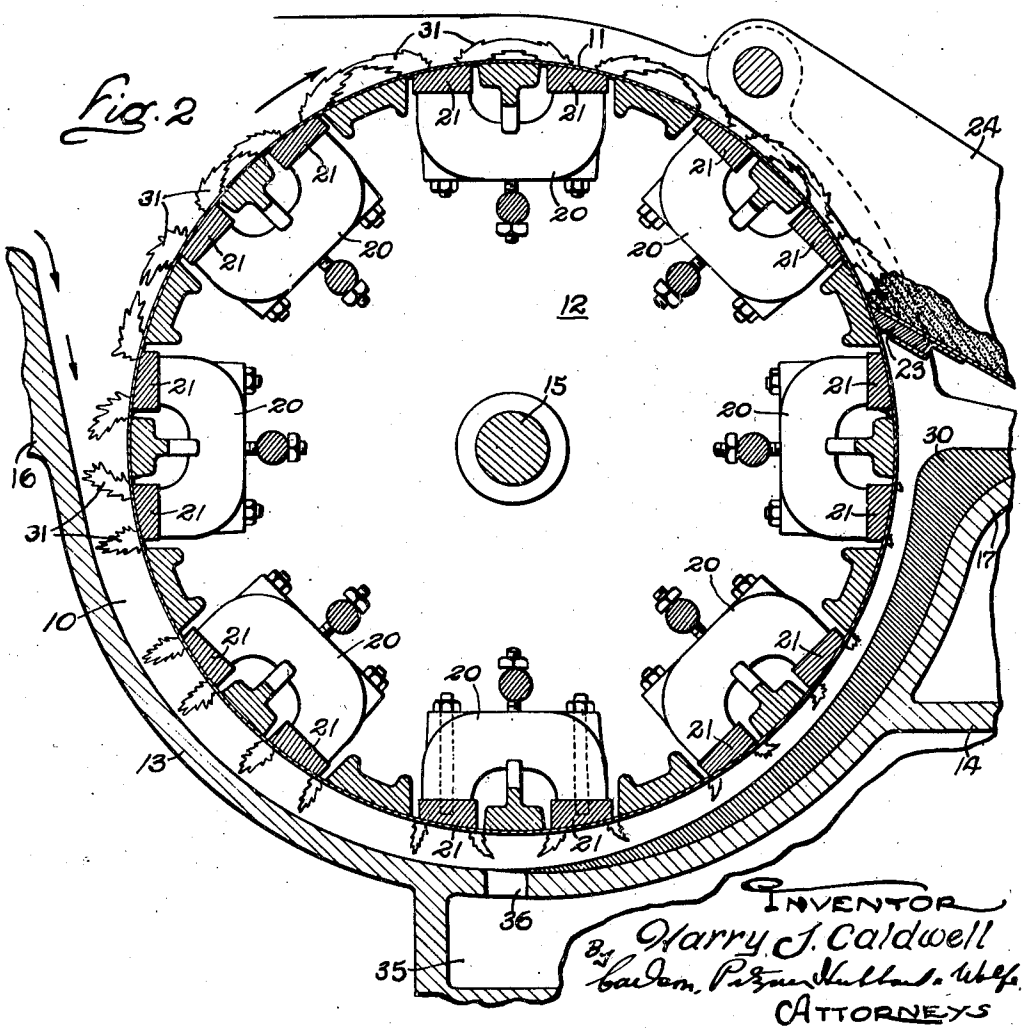


Fig. 2



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Fig. 7

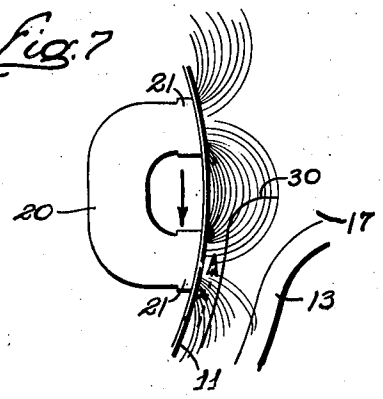


Fig. 6

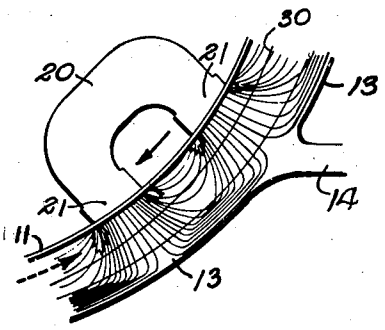
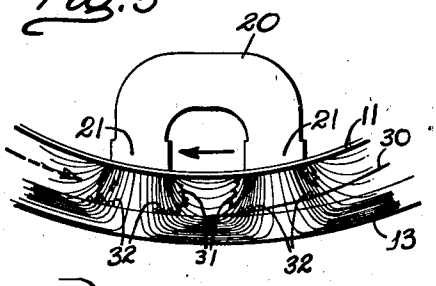


Fig. 5



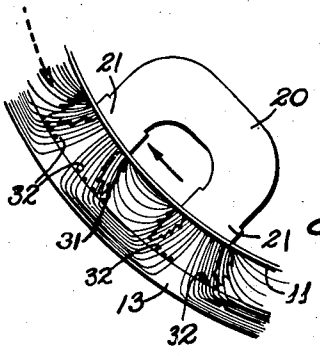


Fig. 4

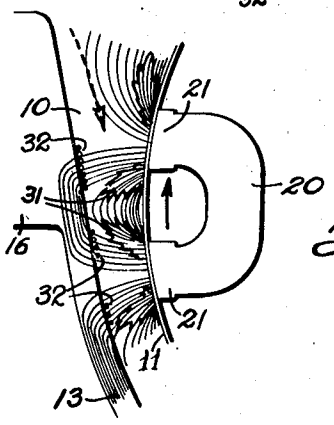


Fig. 3

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Patented Apr. 12, 1949

2,466,839

UNITED STATES PATENT OFFICE

2,466,839

MAGNETIC SEPARATOR

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Application June 17, 1944, Serial No. 540,818

7 Claims. (Cl. 210—1.5)

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The invention relates to improvements in apparatus for removing metal chips and abrasive particles from liquid coolant used in abrading operations and more particularly to magnetically operated apparatus for removing such material from the coolant.

To permit repeated use of liquid coolant in abrading operations, it is desirable to remove the entrained grinding chips and abrasive particles after each passage of the coolant over the tool and work. Removal of such material has been effected heretofore usually by means of settling tanks and filters. When the material operated on is iron or steel, the use of magnetic separators has been proposed and a substantial increase in efficiency has been obtained with apparatus in which the used coolant is passed through a channel having a plurality of magnets disposed along one side and an apron or shunt plate of magnetic material at the other side providing a flux path of a low reluctance for the magnets. In practice, the magnets are usually mounted so that they may be traversed along the channel counter to the flow of liquid therein and subsequently withdrawn to permit convenient removal of the material collected by the magnets.

While actual use has shown that such magnetic separators are capable of removing a substantially higher percentage of the entrained material from the liquid coolant than is removed by filters of the type commonly available for such use, it has been found that some of the extremely fine metal particles somehow escape the attraction of the magnets and thus remain in the treated liquid upon its discharge from the separator. This is apparently due to the trapping of such particles by the magnetic poles induced in the apron structure whereby the particles are restrained from collecting at the magnet poles and are eventually released to be carried away by the current of the flowing liquid.

One object of the invention is to overcome the above difficulty and provide an improved magnetic separator capable of effectually removing all of the extremely fine metal particles as well as coarser particles from the liquid coolant.

Another object is to provide a magnetic separator in which the liquid under treatment is passed through a channel having a series of magnets disposed at one side and a magnetic member or shunt plate at the other side to form a low reluctance flux path for the magnets and embodying novel means for directing the liquid stream progressively farther from the magnetic shunt plate so as to bring all of the particles entrained in the stream into close proximity to the magnet poles thereby insuring the attraction of all such entrained metal particles to the magnets.

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A further object is to provide an improved apron structure for magnetic separators of the above general character by which the attractive force of the induced magnet poles on the metal particles entrained in the liquid stream passing through the separator is progressively reduced toward the discharge end of the apparatus whereby the particles are effectually drawn to and held by the pole faces of the magnets, thus insuring their removal from the liquid coolant.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings in which:

Figure 1 is a side elevational view of a rotary drum type magnetic separator embodying the features of the invention.

Fig. 2 is a sectional view of the magnetic separator taken in a vertical plane substantially perpendicular to the axis of the magnet supporting drum.

Figs. 3, 4, 5, 6 and 7 are diagrammatic views showing the relative positions of the magnets and apron structure in successive sections of the channel through which the liquid to be treated is directed.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

For purposes of illustration, the invention has been shown as applied to magnetic coolant treating apparatus of the type disclosed in my copending application, Serial Number 507,270 filed October 22, 1943, and now abandoned. As shown in Figs. 1 and 2 of the drawings, the liquid coolant to be treated is directed through a relatively shallow passage or channel 10 formed jointly by a cylindrical shell 11 comprising the peripheral wall of a drum 12 and an arcuate apron or magnetic shunt plate 13 spaced from and partially encircling the drum 12. The shunt plate 13, as herein shown, constitutes a part of a housing 14 within which the drum 12 is rotatably supported by a shaft 15.

As will be seen by reference to Fig. 1, the liquid to be treated is introduced into the channel 10 at one side of the drum from an inlet tank 16 carried by the housing 14. After flowing through the channel 10, the treated liquid is discharged through an outlet 17 from which it may be delivered by way of a pipe 18 to the sump or reservoir of the abrading machine with which the apparatus is associated.

Removal of the particles of magnetic material from the liquid flowing through the channel 10 is effected by a series of magnets 20 mounted within the drum 12. The magnets of the exemplary apparatus are permanent magnets of the horse shoe type and are provided with elongated pole pieces 21 adapted to extend entirely across the channel 10. The outer faces of the pole pieces are shaped to fit snugly against the inner surface of the shell 11 and thus provide magnetic fields extending substantially across the channel. The shell 11 is preferably constructed of aluminum or other suitable non-magnetic material to minimize leakage of flux between the magnet poles.

The drum 12 is rotatably driven at relatively low speed through suitable gearing (not shown) by a motor M mounted on the housing 14 thereby carrying the magnets 20 progressively along the channel. Rotation of the drum is preferably counter to the flow of liquid in the channel thus enabling the masses of magnetic particles collecting at the magnet poles to entrap the non-magnetic particles of abrasive material entrained in the liquid. As the drum rotates, the collected masses adhering to the shell 11 at the magnet poles are withdrawn from the liquid. The collected material may be removed from the drum by a scraper blade 23 (Fig. 2) held against the periphery of the drum and arranged to discharge the material through a chute 24 into a receptacle 25 (Fig. 1).

In order to enable the magnets 20 to function efficiently, their magnetic fields are concentrated in the channel by the magnetic shunt plate 13 which, for this purpose, is constructed of material adapted to provide a flux path of low reluctance between the magnet poles. Thus the fields of the magnets exert their maximum force in a zone through which all of the liquid under treatment is directed. Accordingly, a substantial portion of the magnetic particles entrained in the liquid are attracted to the magnet poles adjacent the entrance of the channel 10 thus building up a series of mat-like masses of such particles each extending from the face of the drum approximately to the shunt plate. A large percentage of the particles which pass the magnets nearest the entrance to channel 10 are picked up by the poles of the following magnets.

In the apparatus, as heretofore constructed, a small percentage of the magnetic particles entrained in the liquid, particularly those of extremely small size, are attracted and held by the induced poles in the shunt plate 13. These induced poles are constantly shifted of course, as the magnets 20 are rotated with the drum 12 and the particles attracted to the shunt plate tend to follow the poles by rolling along the shunt plate. Movement of the induced poles, however, is counter to the flow of liquid and consequently, many of the particles become detached from the shunt plate and are carried along with the liquid toward the outlet 17. This action is repeated as each magnet passes along the channel and while most of the particles are effectually attracted to the magnet poles, some escape and are discharged with the treated liquid.

In carrying out the invention, the magnetic shunt plate and its beneficial field concentrating effects are retained, but the shunt plate is constructed and arranged in a novel manner with respect to the magnet structure of the apparatus so that the attractive force of the induced poles on the metal particles entrained in the liquid under treatment in a selected section of the channel is reduced sufficiently to insure that even the finest particles will be attracted to and held by the magnets. More particularly, the shunt plate is so arranged that the liquid stream is directed progressively farther from the shunt plate structure so as to bring all of the entrained particles in the stream into close proximity to the magnet poles as it passes along the channel. In this way, removal of all magnetic particles from the liquid coolant is insured.

While the attractive force of the induced poles on the entrained metal particles may be reduced throughout the entire length of the channel, if desired, it is preferred to effect such reduction adjacent the discharge end of the channel 10 so that the particles released therefrom are subject to attraction by the relatively clean magnet poles just entering the channel. To this end, the shunt plate 13 is provided on its inner surface with a shield 30 of non-magnetic material extending substantially from the center of the channel to the end at which the liquid is discharged. The shunt plate may be shaped so that its spacing from the drum increases progressively toward the discharge end of the channel thus further weakening the magnetic fields at a distance from the magnet pole faces.

The shield 30, which may be made of aluminum, brass or other suitable non-magnetic material, has its outer surface convex shaped to conform accurately to the contour of the shunt plate 13 and provide a tight fit therewith effective to prevent the liquid in the channel from passing between the shunt plate and the shield. In its preferred form, as shown in Fig. 2, the shield 30 is gradually increased in thickness toward the discharge end, thus progressively restricting the channel 10 and correspondingly reducing the depth of the channel through which the liquid under treatment passes.

It will be observed that the location of the shield is such that the liquid stream is directed progressively farther from the shunt plate 13 or toward the magnets thus gradually reducing the attractive force of the magnetic poles induced therein upon the metal particles entrained in the stream. Moreover, by reason of the location of the shield, all metal particles in the liquid are brought into relatively close proximity to the poles of the magnets 20 and are thus subjected to the full intensity of their magnetic fields. In other words, the tapering form of the shield causes the metal particles entrained in the liquid to be carried progressively farther from the induced poles in the shunt plate 13 and closer to the poles of the magnets 20. Accordingly, the action of the shunt plate in restraining fine particles of magnetic material from collecting on the magnet poles is effectually eliminated while its field concentrating effect is retained.

The manner in which the improved shunt plate structure functions will be readily seen by reference to Figs. 3–7 of the drawings. Thus as liquid coolant enters the channel 10 at the inlet end 16, it is subjected to the action of the mag-

net 20 which has substantially completed its traverse of the channel and has collected substantial masses 31 of metallic and abrasive particles as shown in Fig. 3. The heavier particles of magnetic material are attracted to the masses 31 and withdrawn from the liquid in the continued rotation of the magnet carrying drum.

A substantial quantity of magnetic material is also attracted to the induced poles in the shunt plate 13 as indicated at 32. As the induced poles shift in response to the rotational movement of the magnet carrying drum, the attracted particles tend to follow by rolling along the shunt plate but all are eventually released as the pole inducing magnet is withdrawn further from the shunt plate. The released particles mix with the incoming liquid and are carried back into the channel where a portion of them are attracted to the poles of the next magnet in the series.

The foregoing action is repeated along the channel as each successive magnet acts to remove some of the particles passing the preceding magnet or magnets. Some of the finer particles continue to adhere to the shunt plate due to the attraction of the induced magnetic poles and those that are released are carried by the flowing liquid further along the channel. As the particles reach the area of the shunt plate covered by the shield 30, the attractive force of the induced poles is reduced so that fewer particles are attracted thereto. When the liquid reaches the discharge end of the channel, substantially all particles heretofore held by the induced poles are released therefrom and attracted to the poles of the magnets 20. As these particles are carried along by the magnets in their rotation, a layer of heavier particles is gradually built up thereon until the attracted masses substantially extend across the channel as shown in Fig. 3.

As a result of the reduction of the attractive force of the induced poles of the shunt plate 13 and due to the restriction of the channel 10, all of the magnetic particles in the liquid including the smallest are attracted to and effectually held at the surface of the magnet carrying drum. Thus the liquid is completely freed of entrained metal particles and through the filtering action of the collected masses, substantially all of the non-magnetic particles are entrapped and removed from the liquid.

In order to insure removal of relatively large particles of non-magnetic material which cannot be retained by the collected masses of magnetic material, the housing 14 is provided at its lower end with a chamber 35 communicating through an opening 36 in the apron 13 with the channel 10 substantially at its lowest point. As the heavy particles tend to sink to the bottom of the channel, such paricles are collected in the chamber 35 and thus effectually removed from the liquid. As shown in Fig. 1, the chamber 35 may be closed by a removable cover plate 37 through which the collected material may be removed from time to time.

It will be apparent from the foregoing that the invention provides a magnetic separator of novel and improved construction particularly well adapted for removing entrained particles such as grinding chips and abrasive particles from liquid coolant used in abrading operations. Efficient magnetic action is secured through the provision of a magnetic shunt plate arranged to concentrate the fields of the magnets in the channel through which the liquid under treatment is directed. By reason of the novel construction of the shunt plate, retention of fine particles by the induced magnetic poles is effectually avoided and the collection of all such particles as well as coarser particles on the magnetic drum is insured. The improved separator is thus enabled to completely free the liquid of entrained particles and thus condition it for reuse in the machine with which the apparatus is associated.

I claim as my invention:

1. Apparatus for removing entrained metal particles from liquid coolant comprising, in combination, a rotatably supported drum of non-magnetic material, an arcuate shunt plate disposed in spaced relation to and partially encircling said drum to form therewith the opposite walls of a channel for the liquid to be treated, a plurality of magnets mounted in said drum with their poles facing said channel, means for maintaining a flow of liquid through said channel, said shunt plate being of magnetic material and providing low reluctance flux paths operative to concentrate the fields of said magnets in said channel and thereby assist the magnets in attracting the metal particles from said liquid to the surface of said drum, means for rotating said drum to carry the magnets along said channel and successively withdraw the same for the removal of collected particles, a member of non-magnetic material mounted on the inner face of said shunt plate and extending substantially from the center of said shunt plate to the end adjacent the discharge end of said channel, said member increasing gradually in thickness whereby to progressively increase the spacing of the liquid stream from said shunt plate as the liquid approaches the discharge end of said channel, the non-magnetic character of said member acting to reduce the attractive force of the magnetic poles induced in said shunt plate and thereby insure the attraction of all metal particles from the liquid to said drum, and means for removing the collected particles from said drum.

2. Apparatus for removing entrained metal particles from liquid coolant comprising, in combination, a rotatably supported drum of non-magnetic material, an arcuate shunt plate disposed in spaced relation to said drum and partially encircling the same to form therewith the opposite walls of a channel for the liquid to be treated, a plurality of magnets mounted in said drum with their poles facing said channel, means for maintaining a flow of liquid through said channel, said shunt plate being of magnetic material and providing low reluctance flux paths operative to concentrate the fields of said magnets in said channel and thereby assist the magnets in attracting the metal particles from said liquid to the surface of said drum, means for rotating said drum to carry the magnets along said channel and successively withdraw the same therefrom for the removal of collected particles, a shield of non-magnetic material mounted on the inner surface of said shunt plate adjacent the discharge end of said channel, the surface of said shield being spaced from the face of said shunt plate so as to gradually restrict the depth of said channel between the plate and said drum and thereby direct the entire liquid stream into close proximity to the surface of said drum, the non-magnetic character of said shield serving to reduce the attractive force of the magnetic poles induced in said shunt plate and thereby insure release of fine metal particles for attraction to said drum by said magnets, and means for removing the collected particles from said drum.

3. Apparatus for removing entrained metal particles from liquid coolant comprising, in combination, a rotatably supported drum of non-magnetic material, an arcuate shunt plate disposed in spaced relation to said drum and partially encircling the same to form therewith the opposed walls of a channel for the liquid to be treated, a plurality of magnets mounted in said drum with their poles facing said channel, means for maintaining a flow of liquid through said channel, said shunt plate being of magnetic material and providing low reluctance flux paths operative to concentrate the fields of said magnets in said channel and thereby assist the magnets in attracting the metal particles from the liquid to the surface of said drum, means for rotating said drum to carry the magnets along said channel and successively withdraw the same therefrom for the removal of collected particles, a non-magnetic shield arranged on the inner surface of said shunt plate extending from a point adjacent the center of the channel to a point adjacent the outlet end of said channel for reducing the attractive force of the magnetic poles induced in the shunt plate whereby attraction of the magnetic particles to the drum is promoted, and means operative in the rotation of said drum for removing the collected particles therefrom after their withdrawal from said channel.

4. Apparatus for removing entrained metal particles from liquid coolant comprising, in combination, a pair of members spaced apart to form opposite walls of an elongated channel, one of said members being of non-magnetic and the other of magnetic material, means for maintaining a flow of the liquid coolant to be treated through said channel, a plurality of magnets supported with their pole faces adjacent said one member and facing said channel, said magnets acting to attract the entrained metal particles from said liquid to said one member in the vicinity of the magnet pole faces, said other member providing low reluctance flux paths for said magnets effective to concentrate their fields in said channel for efficient action, a shield of non-magnetic material applied to the face of said other member extending from a point adjacent the center of the channel to a point adjacent the outlet end of said channel for reducing the attractive force of the magnetic poles induced in said second member thereby insuring attraction of the magnetic particles from the liquid to said one member, said one wall member and said magnets being movable as a unit longitudinally of said channel, and means located exteriorly of said channel for removing the collected particles from said one member.

5. Apparatus for removing entrained metal particles from liquid coolant comprising, in combination, a first member of non-magnetic material forming one wall of an elongated channel, a second member spaced from said first member and forming the opposite wall of said channel, means for maintaining a flow of liquid through said channel, a plurality of magnets supported with their pole faces adjacent said first member and facing said channel, said second member being constructed of magnetic material and adapted to provide low reluctance flux paths for said magnets whereby the fields of the magnets are concentrated in said channel for effectually attracting magnetic particles in the liquid to the surface of said first member adjacent the magnet poles, a shield of non-magnetic material extending over a part of the inner surface of said second member operative to prevent the adherence of magnetic particles to the magnetic poles induced in that part of said second member by said magnets, and means coacting with said first member to remove the collected particles therefrom.

6. In a magnetic separator, in combination, a member of non-magnetic material defining one wall of a channel, a plurality of magnets supported adjacent said member with their poles facing said channel, a member of magnetic material spaced from said non-magnetic member defining the opposite wall of said channel and providing a flux path of low reluctance for said magnets, means for maintaining a flow of liquid to be treated through said channel, and means operative to direct the liquid stream progressively away from said magnetic member and toward said non-magnetic member in its passage toward the discharge end of said channel.

7. In a magnetic separator, in combination, a member of non-magnetic material defining one wall of a channel, a plurality of magnets supported adjacent said member with their poles facing said channel, a member of magnetic material spaced from said non-magnetic member defining the opposite wall of said channel and providing a flux path of low reluctance for said magnets, means for maintaining a flow of liquid to be treated through said channel, and a shield of non-magnetic material extending over a portion of said magnetic member adjacent one end of said channel, said shield being shaped to direct the liquid stream progressively away from said magnetic member and toward said non-magnetic member in its passage toward the discharge end of the channel.

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