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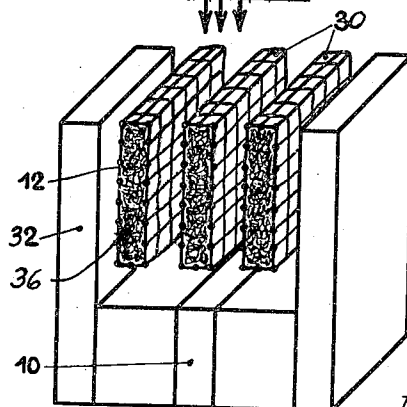
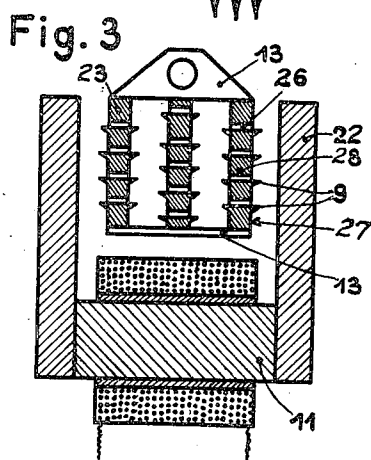
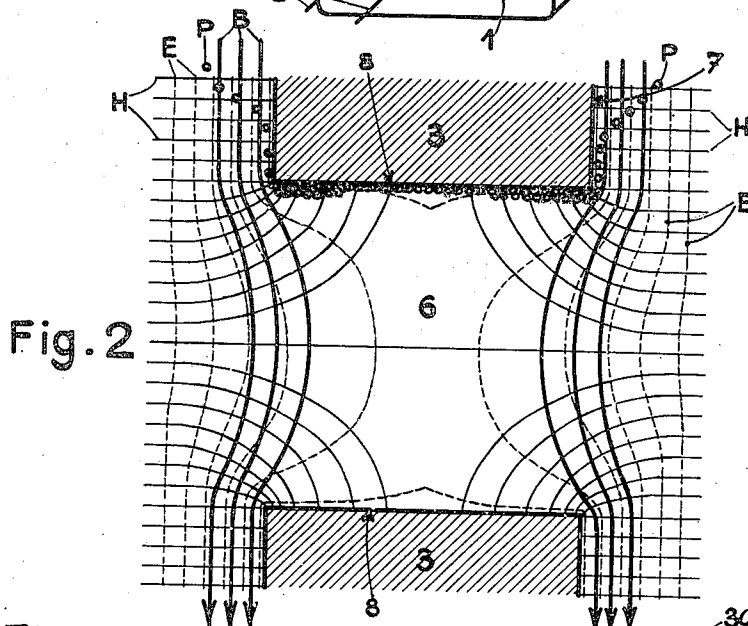
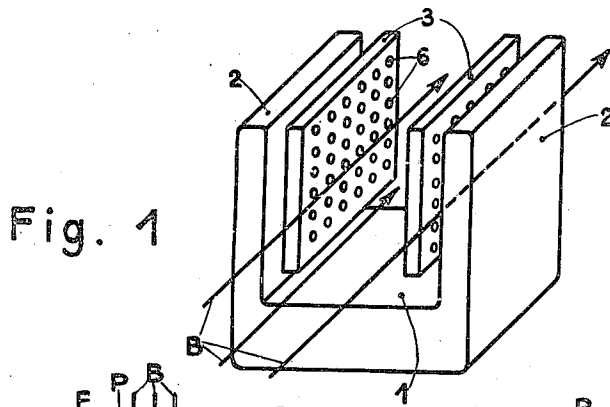
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2,329,893

MAGNETIC DEVICE FOR THE PURIFICATION OF FLUIDS

Filed July 2, 1941

2 Sheets-Sheet 1



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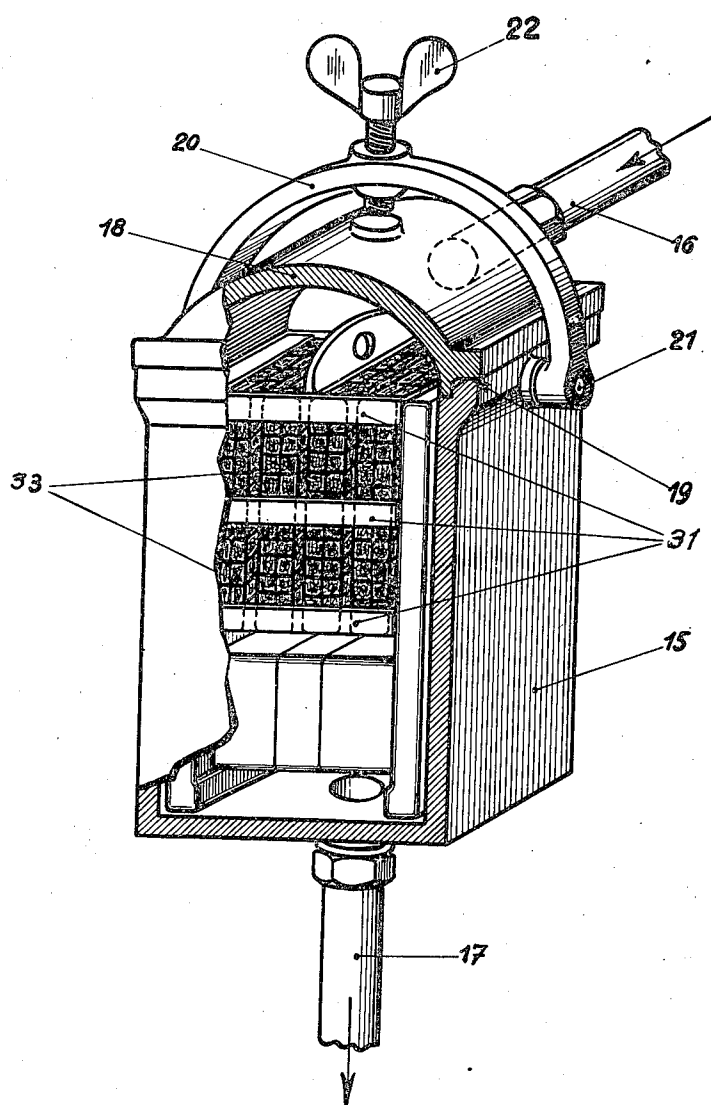
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Fig. 5



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MAGNETIC DEVICE FOR THE PURIFICATION OF FLUIDS

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There are already known processes and magnetic devices for the purification of fluids, for example fluids such as engine oil. While the magnetic separation and extraction of ferromagnetic particles in suspension in a fluid at rest is easy, it is, on the contrary, very difficult, when the fluid is in circulation, to retain and accumulate these particles and to prevent them from being detached from the attraction surfaces by the action of the moving fluid.

Various processes and devices have been proposed for separating and accumulating these particles, for example by forming impressions or grooves in the attraction surfaces in such a manner as to retain them against the action of the fluid.

Other devices have been provided with magnets of which the pole pieces are provided with perforations through which the fluid to be purified passes. In these devices the stream of the fluid is therefore parallel to the lines of magnetic force, and the extraction of the particles is effected in a satisfactory manner, but the surfaces on which the particles accumulate are washed by the fluid which detaches the particles so that they are again picked up by the fluid.

On the other hand efforts have been made to retain the particles by points of attraction, but without good results, as the particles are always detached by the stream. Efforts have also been made to divide the air gap into a number of small air gaps in which the particles are allowed to accumulate, the fluid circulating outside these air gaps. These latter have given better results; however, their efficiency is low and the purification slow by reason of the fact that the particles contained in suspension in the fluid are only subjected to a stray field. Further as the particles accumulate in the air gaps, they short-circuit these magnetically so that the stray field, by which the particles are attracted, becomes practically non-existent.

The subject of the present invention is a device for the magnetic purification of a fluid and separation of impurities therefrom which obviates the disadvantages above referred to by the fact that the fluid to be purified is caused to circulate in the air gap of a magnet and that the ferromagnetic particles in suspension in the fluid are attracted by means of attraction surfaces subjected to the action of the fluid in movement, and that the particles extracted from the fluid are accumulated mechanically and magnetically on accumulating surfaces which bound open spaces in which the intensity of the magnetic

field and the intensity of the streams of fluid are weak.

The device for the magnetic purification of a fluid is provided with a magnet of which the air gap is traversed by the fluid to be purified, this air gap being provided with ferromagnetic elements having surfaces of attraction subjected to the action of the fluid in movement, and with a plurality of surfaces for accumulating the particles extracted magnetically from the fluid, which bound open spaces in which the intensity of the magnetic field and the intensity of the flow of fluid are weak.

The accompanying drawings show diagrammatically and by way of example, a few forms of construction of the subject of the present invention.

Fig. 1 is a perspective view of a first form of construction, some of the elements being omitted for the sake of clearness.

Fig. 2 is a partial section to a larger scale of a ferromagnetic element and an accumulating aperture therein, showing the distribution of the magnetic field and illustrating the process of accumulation of the particles.

Fig. 3 is a section of a second form of construction.

Fig. 4 is a sectional view of a third form of construction.

Fig. 5 shows the device mounted in a casing, a portion of the latter being broken away.

The device for the magnetic purification of a fluid is formed by a permanent magnet 1 of horse-shoe form, provided with two pole pieces 2 opposite one another, and field concentrating elements 3 of ferromagnetic material placed between the pole pieces approximately normal to the lines of force of the magnetic field and lying in the direction of the circulation of the fluid (indicated by the arrows B). The elements 3 are provided with accumulating faces 8 (Fig. 2) which bound open spaces formed by apertures or holes 6 adapted to receive and retain the particles extracted magnetically from the fluid.

The very simple operation of the fluid purifier is shown diagrammatically in Fig. 2.

In Fig. 2, the lines H represent approximately the magnetic lines of force while the lines E indicate approximately the points of equal magnetic potential. The operation of the device may be understood from this figure.

The filamentary paths of the circulation of fluid are represented by the lines B.

A particle P in suspension in the fluid is carried along by the latter between the pole faces 2 and

therefore between the field concentrating ferromagnetic elements 3 (Fig. 1, 3, 4). This particle P reaching the field prevailing in the air gap, is attracted by one external attraction face 7 of the elements 3. This particle P is then held magnetically against this face and cannot detach itself therefrom, but no force opposes the sliding of this particle P along the face 7. It is therefore picked up mechanically by the action of the fluid passing over the external attraction face 7 and slides along the latter. When it reaches the edge of an aperture 6, bounded by the accumulation surface 8, it is attracted magnetically just into the plane of the attraction surface 7 where this place passes over aperture 6 and then slides on to the accumulation surface 8. This magnetic action acting on the particle is increased by a mechanical action exerted by the fluid. In fact, the fluid having the tendency to enter the open space 6, causes the particle to slide on the accumulation surface 8 on the periphery of apertures 6 towards the interior of the latter. This particle, held magnetically to the accumulating surface 8, is then pushed along the latter towards the interior of the element 3 by the succeeding particles sliding along the attraction surface 7.

The particles are thus more or less accumulated in successive layers, and gradually all the free space in the interior of the hole is filled with particles. The magnetic field present in this free space bounded by the accumulation surface 8 is weak, as will appear from Fig. 2, as is also the intensity of the circulation of the fluid therein. The particles accumulated on the surface 8 are thus enclosed in apertures 6 and cannot leave these as on the one hand the weak circulation passing through these free spaces only applies a feeble force tending to carry along the particles and, on the other hand, in order to leave these spaces, the particles must pass to outside of a zone of a strong magnetic field located at the edge of the spaces or apertures 6 (see Fig. 2). In order that the particles shall pass through this zone or region they must be picked up by a powerful current or eddies of fluid. But the velocity of circulation of the fluid therein is necessarily relatively slow so that the ferromagnetic particles have time to be attracted and to reach the attraction surfaces 7. The stream is therefore always laminated and practically no eddy can occur.

The particles entering the air gap, subjected to a very intense field, reach the attraction surfaces of the field concentrating elements 3 very rapidly. At the commencement of the operation, practically only the portions of the accumulating surfaces 8, which are located near the inlet for the fluid, receive the particles. Then, as the portions of these apertures or spaces, bounded by these surfaces, near the inlet, are filled in the course of time, other portions of the accumulating surfaces 8 in turn receive particles.

According to the modification shown in Fig. 3, the permanent magnet is replaced by an electromagnet 11, and elements 3, similar to the elements, of Fig. 1, have attraction surfaces 27 provided with projecting attraction points 9 located on the lower edge of the holes 6. These attraction points 9 have the advantage of attracting very violently the particles in suspension in the fluid by reason of the fact of their high degree of magnetic saturation. These points of attraction being subjected to the action of the fluid, the particles, which are held on their points, slide

on the surfaces 27, then on the accumulation surfaces 28, as described above.

For facilitating the manipulation and the cleaning of the ferromagnetic elements, these are assembled together by non-magnetic members 13 into a unit in such a manner as to enable all the elements of a single block to be withdrawn from the magnetic field.

According to the modification shown in Fig. 4, the permanent magnet 10 is formed of small parallelepipeds, of a material of high permeability. The field concentrating elements are formed as perforated or honeycombed parallelepipeds, for example of basket or trellis work, filled with ferromagnetic chips, for example, iron or steel wool or iron or steel filings. In this form of construction of the field concentrating elements 30 there is obtained a plurality of accumulation surfaces which define a plurality of free spaces 36 located in the interior of the elements and in which the magnetic field and the velocity of the stream of fluid are low. By reason of this form of construction of the elements, there is also obtained a plurality of points and attraction surfaces having a very high degree of magnetic saturation. It thus follows that the purification of the fluid by means of elements of this type is effected very rapidly and that the absorption capacity thereof is very great.

According to the modification shown in Fig. 5 the device is placed into a casing 15 of rectangular section provided with a supply intake pipe 16 for the fluid and an outflow pipe 17 for the fluid. This casing is provided with a cover 18, which can be removed easily, and provided with a joint 19. In order to facilitate its removal this cover 18 is secured by means of a strap 20, pivotally mounted on pivots 21, provided on the casing 15, and provided with a tightening screw 22.

It will be understood that the conduit 16 may be secured easily in a wall of the casing 15. For this purpose it is sufficient to make the latter slightly higher. This latter construction enables the cover to be removed without it being necessary to remove the pipe 16.

When the cover 18 has been removed, the ferromagnetic elements 33 may be withdrawn as a block, as they are connected together by means of non-magnetic members 31.

For washing the elements 33 it is sufficient to dip them, for example in gasoline for removing ferromagnetic particles retained in the free spaces thereof.

Ferromagnetic elements according to Fig. 4 have the great advantage of retaining practically all the ferromagnetic particles contained in their free spaces, even when those elements are no longer in a magnetic field, which enables the elements to be removed for cleaning them without the liability of some of these particles falling back into the interior of the casing.

When the apparatus is used for purifying oil, for example, it is of advantage to select a form of construction of the ferromagnetic elements which enables them by film action to retain the major portion of oil contained between them and in their spaces. In this manner oil charged with ferromagnetic particles is not likely to fall back into the casing when the elements are removed from the latter. Elements according to Fig. 4 have given excellent results in this respect.

It will be understood that modifications may be made in the details of the subject of the present invention described as heretofore by way of example with reference to the accompanying dia-

grammatic drawings. For example the magnet need not be of horseshoe shape and may be shaped according to requirements.

In particular it is possible to employ various modifications of the forms of construction of the field concentrating elements 3. These may for example be formed by simple trellis work of fine mesh, staggered trellis work, split plates, or by assemblies of split or apertured plates which may be or may not be provided with attraction points. It is also possible to provide elements in the form of honeycombs. In this case the attraction surfaces 7 are formed by the ends of the honeycombs.

The attraction points may also be located in a different manner and, for example, the attraction surfaces 7 may be placed on end.

For avoiding too large magnetic leakages, the corners of the pole faces and of the magnet may be rounded as is current practice.

The direction of the fluid in the air gap is naturally of no importance from the point of view of the satisfactory operation of the device so long as the direction is substantially perpendicular to the lines of force H, that is, in Fig. 2 the direction of the current can be from top to bottom, or bottom to top, or perpendicular to the plane of Fig. 2, but not from one side to the other of Fig. 2. However in order that the circulation of fluid in the free spaces may be as weak as possible, there is preferably selected a general direction of the fluid which intersects the magnetic lines of force at a right angle.

It will be understood that it is possible to use in combination with any type of ferromagnetic element, either a permanent magnet or an electromagnet.

From the foregoing it will be seen that the apparatus forming the subject of my invention has a high efficiency of magnetic purification, of which the velocity of purification is within wide limits independent of the concentration of ferromagnetic particles in the fluid to be purified, and of the velocity of circulation of the latter. Also the efficiency of the device is only slightly influenced by the quantity of particles already accumulated on the accumulation surfaces. In fact, if after a certain time of operation, a small number of free spaces or apertures are still available for receiving ferromagnetic particles, these particles are in turn attracted more energetically towards attraction surfaces and into the spaces still free, by reason of the fact that the particles accumulated in the elements decrease the reluctance of the magnetic circuit, consequently the greater the quantity of ferromagnetic particles accumulated, the greater will also be the induction in the air gap.

It will be obvious that the fluid may equally well be a gas or a liquid, and that the invention is not limited to one of these latter.

I claim:

1. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid therethrough, a magnet having two pole pieces constituting the respective lateral sides of said channel member, and auxiliary elongated ferromagnetic field concentrating slab-shaped members positioned in said channel member with their length lying in the direction of flow of liquid therethrough, said concentrating members being provided with restricted transverse passages extending therethrough substantially transversely of said channel member transversely between said lateral pole pieces, said members being so arranged that the magnetic field in the interior of

said passages toward their respective axes extending through said members is of low intensity as compared with the field strength at the circumferential periphery of said passages, and the velocity of stream flow in said passages is slow.

2. In a magnetic liquid clarifier, a ferromagnetic channel member adapted for the passage of liquid therethrough, and being constituted of an inverted horseshoe magnet whose pole pieces constitute the respective lateral sides of said channel member, and auxiliary elongated ferromagnetic field concentrating slab-shaped members positioned in said channel member with their length lying in the direction of flow of liquid therethrough, said concentrating members being provided with restricted transverse passages extending therethrough substantially transversely of said channel member transversely between said lateral pole pieces, said members being so arranged that the magnetic field in the interior of said passages toward their respective axes extending through said members is of low intensity as compared with the field strength at the circumferential periphery of said passages, and the velocity of stream flow in said passages is slow.

3. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid therethrough, a magnet having two pole pieces constituting the respective lateral sides of said channel member, and auxiliary elongated ferromagnetic field concentrating slab members positioned in said channel member with their length lying in the direction of flow of liquid therethrough, said concentrating members being provided with restricted transverse apertures extending therethrough substantially transversely of said channel member transversely between said lateral pole pieces, said members being so constructed and arranged that the magnetic flux path of high reluctance through said transverse apertures therethrough has magnetically in parallel therewith a low reluctance ferro-magnetic path of substantially the same physical length.

4. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid therethrough, a magnet having two pole pieces constituting the respective lateral sides of said channel member, and auxiliary elongated ferromagnetic field concentrating slab members positioned in said channel member with their length lying in the direction of flow of liquid therethrough, said concentrating members being provided with restricted transverse apertures extending therethrough substantially transversely of said channel member transversely between said lateral pole pieces, said concentrating members being further provided with projecting ferromagnetic points formed on their surface adjacent to and immediately below said apertures respectively, said members being so constructed and arranged that the magnetic flux path of high reluctance through said transverse apertures therethrough has magnetically in parallel therewith a low reluctance ferro-magnetic path of substantially the same physical length.

5. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid therethrough, a magnet having two pole pieces constituting the respective lateral sides of said channel member, and auxiliary elongated ferromagnetic field concentrating members formed as slab shaped baskets filled with steel wool and positioned in said channel member with their length lying in the direction of flow of liquid there-

through, and being mutually spaced apart forming paths for the flow of liquid therebetween.

6. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid there-through, a magnet having two pole pieces constituting the respective lateral sides of said channel member, auxiliary elongated ferromagnetic field concentrating members formed as slab shaped baskets filled with steel wool and positioned in said channel member with their length lying in the direction of flow of liquid there-through and being mutually spaced apart forming paths for the flow of liquid therebetween and a carrier frame formed of non-magnetic material and containing said concentrating members for insertion into and removal from said channel member as a unit.

7. In a magnetic liquid clarifier, a channel member adapted for the passage of liquid there-through, a magnet having two pole pieces constituting the respective lateral sides of said channel member, and auxiliary elongated ferro-magnetic field concentrating members formed as slab shaped baskets filled with an interstitially spaced assembly of discrete small ferro-magnetic elementary pieces and said baskets being positioned in said channel member with their length lying in the direction of flow of liquid therethrough, and being mutually spaced apart forming paths for the flow of liquid therebetween.

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