

June 30, 1942.

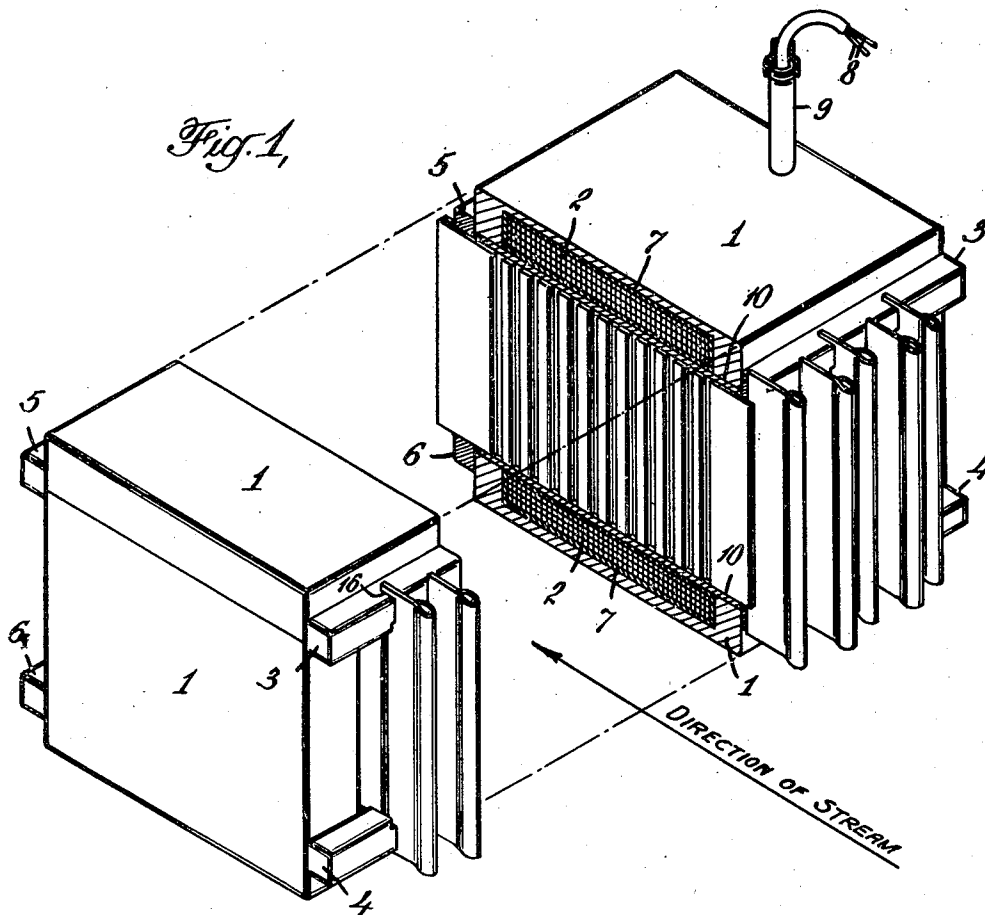
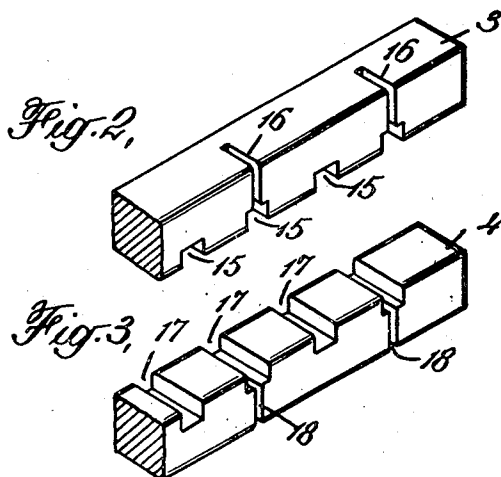
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NONCHOKING MAGNETIC SEPARATOR

Filed Dec. 21, 1939

2 Sheets-Sheet 1



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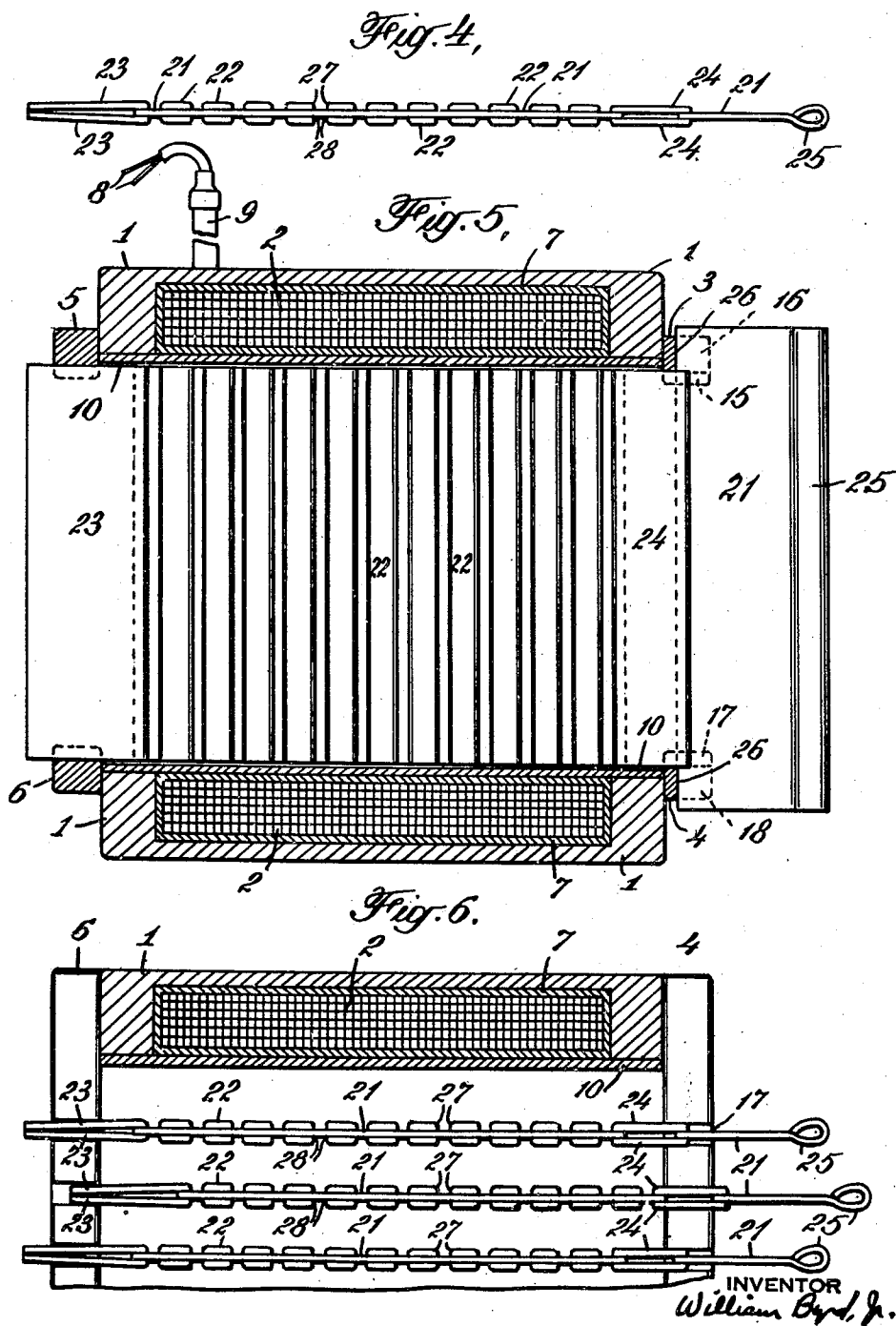
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UNITED STATES PATENT OFFICE

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NONCHOKING MAGNETIC SEPARATOR

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7 Claims. (Cl. 209—223)

This invention relates to magnetic separators and has for its object the provision of a separator which may be used with suspensions of fibrous materials in liquids without becoming choked by the solid or semi-solid fibres.

Separation of particles magnetically from a liquid, sludge or slurry in which they are suspended is usually accomplished by passing the liquid containing the particles, and possibly large quantities of suspended non-magnetic solids as well, through a trough, container or conduit in which are arranged sharp-edged attractors of magnetizable material and subjecting the attractors to the influence of a magnetic field. The magnetic field converges to and diverges from the edges of the attractors, and since magnetic particles tend to travel from regions of less field density to regions of greater field density the particles migrate toward and are held on the edges.

When it is attempted to pass a fibre-bearing liquid, such as pulp from which paper is felted in a paper mill, through a series of such attractors it is found that the attractors rapidly become so choked or clogged by the fibrous material as to be substantially useless. The choking starts when a single fibre which chances to lie across the stream meets a leading edge of an attractor and straddles it, being caught thereby. The choking builds up by reason of the tendency of fibres already caught to entwine others until finally a thick mat of fibres covers each leading edge and the separator is rendered useless until cleaned. This fibre choking constitutes a serious objection to the use of a screen-separator for fibre-bearing liquids.

To prevent this choking from taking place I have devised a novel attractor in the form of a plate which, while it has a multiplicity of magnetically polarized edges, capable of attracting and holding magnetic particles, is yet a continuous non-choking wall from the geometrical or hydraulic standpoint; and I provide the separator with a number of such plate attractors. Having thus eliminated all leading edges but the first, I then give to the leading edges of my plates a stream-lined form which completely prevents the attachment of fibres thereto.

More particularly, the invention consists in the novel construction and combination of parts hereinafter described, illustrated in the accompanying drawings and defined in the claims hereto appended, it being understood that various changes in form, proportion, size and minor details of construction within the scope of the

claims may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention.

For a clearer comprehension of the invention reference is directed to the accompanying drawings which illustrate a preferred embodiment thereof, wherein:

Fig. 1 is a broken view in perspective of a separator according to my invention intended for use in a trough or flow box;

Fig. 2 is an enlarged view in perspective of an upper plate-holder spacing-bar for use in the separator of Fig. 1;

Fig. 3 is an enlarged view in perspective of a lower plate-holder spacing-bar for use in the separator of Fig. 1;

Fig. 4 shows a preferred form of attractor plate according to my invention as seen edge-wise;

Fig. 5 is an elevation of a cross section of the separator of Fig. 1 taken at a point intermediate its ends, and showing an attractor plate of preferred form in place; and

Fig. 6 is a plan of a cross section of the separator of Fig. 1 taken at one end and showing a preferred arrangement of the attractor plates.

Referring now to the figures, a yoke-frame 1 of magnetizable material contains a magnetizing coil 2 and bears an upper plate spacing bar 3 and a lower plate spacing bar 4 at its front, leading, or upstream end and corresponding upper and lower plate spacing bars 5, 6, at its rear or downstream end. The yoke-frame 1 may be constructed of any desired magnetizable material and may be assembled in any desired manner. I have found ordinary iron castings, machined at their faces of contact, to be adequate. The coil 2 should be well insulated, particularly since the separator normally operates in a stream of water or other liquid. It is preferably wound of insulated wire and packed in insulating compound in a water-tight copper case 7 which is laid in place in the yoke-frame in the course of assembly. The coil leads 8 are preferably brought out as shown through a copper tube 9, securely attached to the copper case 7 in water-tight fashion, and extending through a hole in the top of the yoke-frame 1 to a point remote from the liquid. The tube is preferably packed with insulating compound and a water-tight bushing fitted to the open end.

A protective sheet 10 of non-magnetic material is preferably extended all around the passage defined by the yoke-frame, to cover the inner exposed face of the coil case.

The attractor plates, which will be described in full detail hereinafter, are supported in place within the yoke-frame by spacing bars 3, 4, 5, 6 bolted or otherwise fixed to the frame both in front and at the rear and at the top and bottom of the opening. These spacing bars may conveniently be formed as shown in Figs. 2 and 3. The upper front bar 3 is provided on its underside with a series of slots 15 of width slightly greater than the overall thickness of an attractor plate and equally spaced at the intervals desired for plate spacing. The bar also has a series of notches 16 on its front side, each corresponding with a slot 15 and arranged to fit a portion of one of the plates and correctly determine the position of the plate in a direction axially of the coil.

The lower front spacing bar 4 is provided on its upper side with slots 17 to correspond with the slots 15 on the lower side of the upper bar 3 and with notches 18 on its front side to correspond with the notches 16 on the front of the upper bar.

As shown, notches 16, 18 on both upper and lower spacing bars correspond to alternate slots 15, 17. This provides adequate support for the plates and correct staggered arrangement with a minimum of complication in manufacture.

The rear spacing bars 5, 6 are horizontally slotted similarly to the front ones. However, they are not notched because it is contemplated that the axial position of the attractor plates shall be determined entirely by the notches on the front spacing bars.

Fig. 4 shows the attractor plate of my invention as seen edgewise. It consists of a base sheet 21 of non-magnetic material to which are attached a series of strips 22 of magnetizable material. These strips 22 extend across the full width of the base sheet 21 in a direction perpendicular to the direction of the magnetic field and may be attached to only one side, though I prefer to arrange them in two series on opposite sides, because this increases the magnetic efficiency without greatly decreasing the hydraulic resistance to flow.

When two series of strips are employed, they may be symmetrically arranged as shown in Fig. 4, or they may be staggered, in which case the spacing of each series must be somewhat greater than the width of each strip, so as to leave gaps in the ferromagnetic circuit, at which magnetic material can be caught.

The strips should be held in close contact with the plate 21 so that liquid cannot pass between the plate and the strips. Although not necessary to the invention to attach the strips directly to the non-magnetic base sheet (they are not subjected to severe mechanical strains, and the base-sheet plate takes no part in determining the configuration of the magnetic field) I prefer to attach them to the base by welding, merely as the simplest way to hold them in close contact.

A satisfactory material for the base sheet is the non-magnetic stainless steel alloy known as "eighteen-eight." A satisfactory material for the strips is ordinary magnetizable stainless steel.

The front and rear strips 23, 24 are somewhat wider than the intermediate strips, and are placed adjacent the front and rear portions of the yoke frame 1. This provides better support for the plates in the slots, and also serves to re-

duce somewhat the reluctance of the magnetic circuit as a whole. Additionally, the rear strips 23 may be squeezed together as shown to provide the attractor plates with tapered rear ends. This serves to hold them securely in position.

A piece of sheet material extends well forward from the leading magnetic strips in the upstream direction. At its forward end it is turned over into a loop 25 which, as shown, gives the leading edge of the plate an enlarged, rounded streamlined form. As shown by Fig. 5, this leading sheet material is of greater width than the main strip-supporting body of the attractor plate so that the plate as a whole has upper and lower shoulders 26 which, in the case of alternate plates, fit into the vertical notches 16, 18 of the upper and lower front spacing bars 3, 4 while the shoulders of the remaining plates merely fit against the faces of the bars. Thus the plates, when forced home into the notches and against the bars, stand in a staggered arrangement as shown in Fig. 6, alternate plates standing forward of their neighbors by an amount roughly equal to the length of the stream-lined loop 25. This arrangement decreases the reduction in cross-sectional area presented to the liquid stream by the looped ends of the plates.

If reduction of hydraulic channel area is especially serious, the plates may be staggered in groups of three or four. Generally, it is desirable to keep the area at the leading rounded ends 25 equal to or greater than the area of the main channels between plates so that the stream velocity may be at least as low at the leading ends as elsewhere.

I prefer to make these forward sheets of magnetic material, so that magnetic attraction, pulling against the shoulders, may hold the plates snugly in place. If they extend as far forward of the yoke and coil as shown, the field at their leading ends will not be strong and this, together with the small curvatures of the looped ends, reduces attraction of particles to these looped ends to negligible values. But if desired, the whole forward plate, including the loop, or the loop alone, may be made of non-magnetic material. In such case it may, if desired, be integral with the main non-magnetic sheet. When of magnetic material it may be integral with one of the leading magnetic strips 24 or a separate piece, as desired.

I prefer to make the length of the forward loop 25 substantially equal to the distance between centers of adjacent magnetic strips 22 so that when the plates themselves are staggered as shown in Fig. 6 there is little or no staggering between the strips 22 of adjacent plates.

Each plate may thus be identical with every other plate, which simplifies manufacture; and each plate is individually removable to clean off the collected magnetic material.

The choice of strip width, thickness, and spacing and the plate spacing depends on many factors, including the thickness of the pulp, the speed of its flow and the amount and particle size of the magnetic material to be caught. In a plant employing wood pulp of the thickness customarily used for the manufacture of high quality heavy paper, and flowing at the rate of 1 foot per second, I recommend plates 14 inches long, spaced apart $\frac{3}{4}$ inch, the magnetic strips being $\frac{1}{8}$ inch thick and $\frac{3}{8}$ inch wide and spaced on $\frac{1}{2}$ inch centers, to leave $\frac{1}{8}$ inch gaps between. Any variation of size and spacing of strips and plates

which appears suitable to a particular pulp or flow may be employed without departing from the spirit of my invention.

Each exposed edge 27 (see Fig. 6) of each strip 22 of each attractor plate is slightly rounded and carefully smoothed either before or after attachment to the non-magnetic base so as to remove all rough edges and points which might catch fibres as they pass by with the stream. Naturally, smoothing and rounding the edges of the strips reduces the convergence of the magnetic field in the immediate vicinity of these edges. But smoothing and rounding in an amount sufficient to prevent catching fibres still leaves the corner 27 of each strip with a radius of curvature which is small in comparison with the distance between adjacent strips; and this means that the strips are still "sharp edges" in the magnetic sense of this expression while not so in the mechanical sense. Additionally, the field is relatively greater at the inner angles 28, so that collection of the magnetic material occurs in these angles first. This reduces the building up of magnetic material at the edges 27 where it might entangle pulp fibres.

It is contemplated that the separator as a whole with my attractor plates in position shall be placed in a trough carrying the fibre-bearing liquid and the liquid guided between the enlarged rounded leading ends 25 and between the passages between adjacent plates 21, whereupon, the coil 2 being energized, magnetic particles suspended in the liquid are attracted to and held on the edges of the magnetizable strips 22. Collection is greatest where the magnetic field is strongest; i. e., in the angles 28 between the magnetic strips 22 and the non-magnetic base sheet 21. Here the particles accumulate until the spaces between strips are substantially filled.

It is in order to permit the collection of particles to take place in this manner that I leave the spaces between adjacent magnetizable strips open, at some slight sacrifice of smoothness of the side of the attractor plate. I contemplate that under some circumstances it may be preferable to alternate the magnetizable strips 22 with strips of non-magnetizable material, placed between them and flush with them so that the side of the plate is entirely smooth. I also contemplate that the magnetic strips may abut one against the other, leaving a mere fissure between. In either case the magnetic particles are then collected at the joints between magnetic and non-magnetic strips, or between adjacent magnetic strips, and lie squarely in the liquid stream which if its velocity is high, may drag them off. Nevertheless, should such a construction appear desirable, I do not intend to be limited to the construction shown, since such other construction is within the spirit of my invention.

I have found that fibers do not collect on the leading ends of my plates when I employ the enlarged, rounded stream-lined shapes 25. Additionally, I have found that fibres do not catch on the edges 27 of the magnetic strips 22 formed as above described and I conclude this is on account of the fact that these strips do not present any "leading edges" directly toward the stream, since the "leading edge," consisting of the upstream sides of the two oppositely placed strips 22, is divided in half by the non-magnetic plate 21 so that fibres cannot possibly straddle it.

The strips 22 of magnetic material are shown and described as extending in a direction perpendicular to the direction of the magnetic field.

Though I consider this to be the normal construction I do not wish to be limited thereto since the invention is equally applicable to a construction in which the strips extend in directions oblique to the direction of the magnetic field, it being necessary only that the angles to the field be such that a substantial amount of the magnetic flux crosses the spaces between strips.

The invention is, of course, applicable to a separator energized in any desired manner and to an attractor plate or plates of any desired form or arrangement, it being necessary only that the strips or pieces of magnetizable material be so placed with respect to the non-magnetic base that liquid cannot pass between the strips and the non-magnetic base, which prevents fibres from clinging to the strips; and that, for purposes of leading edge-choking, that this leading edge be stream-lined and, if of magnetic material, that it have a fairly small curvature and be placed in a region where the magnetic field is relatively weak.

Any of the features of my invention may be employed separately, if desired, without departing from the spirit of my invention, though I prefer to embody them all in a single attractor plate and provide a number of such plates in a single separator as described above.

I claim:

1. An attractor plate for use with a magnetic separator having means for producing a magnetic flux, which comprises a main portion and a leading portion, the main portion being composed of a base of non-magnetic sheet material and a series of strips of magnetic material placed in contact with each surface of the base, each of said strips being in contact with the base throughout at least a major part of the length of said strip, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said main portion being adapted to be placed in a region traversed by the flux and parallel to the direction thereof with the strips extending in a direction perpendicular to the flux, said leading portion having an enlarged, curved leading edge.

2. A magnetic separator which comprises a source of a magnetic field and a plurality of attractor plates disposed in the magnetic field of said source and in parallel juxtaposed relation so as to form narrow channels for the flow of liquid between the adjacent parallel faces of the plates, each of said plates comprising a main portion and a leading portion, the main portion being composed of a base of non-magnetic sheet material and strips of magnetic material placed in contact with the base, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said main portion being disposed parallel to the direction of the magnetic field with the strips extending in a direction perpendicular to the field, said leading portion having an enlarged, curved leading edge, said plates being equally spaced in a direction perpendicular to their faces and staggered in a direction parallel to their faces.

3. A magnetic separator which comprises a source of a magnetic field and a plurality of like attractor plates disposed in the magnetic field of said source and in parallel juxtaposed relation so as to form narrow channels for the flow of liquid between the adjacent parallel faces of the plates, each of said plates comprising a base of non-magnetic sheet material and a series of smooth-edged strips of magnetic material placed

in contact with a surface of the base throughout their lengths, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said plates being disposed parallel to the direction of the magnetic field with the strips extending in a direction perpendicular to the field.

4. A magnetic separator which comprises a source of a magnetic field and a plurality of attractor plates disposed in the magnetic field of said source and in parallel juxtaposed relation so as to form narrow channels for the flow of liquid between the adjacent parallel faces of the plates, each of said plates comprising a main portion and a leading portion, the main portion being composed of a base of non-magnetic sheet material and a series of smooth-edged strips of magnetic material placed in contact with each surface of the base, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said main portion being disposed parallel to the direction of the magnetic field with the strips extending in a direction perpendicular to the field, said leading portion having an enlarged, curved leading edge.

5. A magnetic separator which comprises a source of a magnetic field and a plurality of like attractor plates disposed in the magnetic field of said source, each of said plates comprising a base of non-magnetic sheet material and a series of smooth-edged strips of magnetic material placed in contact with each surface of the base, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said plates being disposed in parallel juxtaposed relation, parallel to the direction of the magnetic field with the strips extending in a direction perpendicular to the field so as to form narrow channels for the flow of fluid between adjacent parallel faces of the plates.

6. A magnetic separator which comprises a source of a magnetic field and an attractor element disposed in the magnetic field of said source, said element comprising a base of non-magnetic sheet material and strips of magnetic material placed in contact with an outer surface of said base substantially throughout the length of each strip, said strips being so placed that their lengths are substantially parallel with each other and with the surface of the base, said element being disposed parallel to the direction of a component of the magnetic field with the strips extending in a direction perpendicular to a component of the field, said element having an enlarged, curved leading edge in position to minimize the resistance of said element to the flow of fluid entering said separator.

7. In a magnetic separator, a conduit adapted to carry a fluid bearing magnetic particles to be removed therefrom, a plurality of solid, imperforate attractor plates disposed in parallel arrangement in said conduit so as to form narrow channels for the flow of said fluid between adjacent parallel faces of the plates, each of said plates comprising a relatively wide sheet of non-magnetizable material extending throughout substantially the whole area of said plate, and an array of relatively narrow strips of magnetizable material fixed to a surface of said sheet and extending in parallel arranged across said surface from one edge of said sheet to an opposite edge thereof, an edge of each plate so formed, parallel to the lengths of said strips, being provided with a curved member of thickness large as compared with that of the body of the plate, to present a non-fibre-collecting leading edge to fluid entering said conduit, and means for passing a magnetic flux through a fluid in said conduit in a direction perpendicular to the lengths of said strips.

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