



(11) Publication number : **0 687 504 A1**

(12)

EUROPEAN PATENT APPLICATION

(21) Application number : **95830244.0**

(51) Int. Cl.⁶ : **B03C 1/035, B03C 1/12,
B03C 1/18, B03C 1/22**

(22) Date of filing : **12.06.95**

(30) Priority : **14.06.94 IT MI941234**

(43) Date of publication of application :
20.12.95 Bulletin 95/51

(84) Designated Contracting States :
BE CH DE ES FR GB LI NL

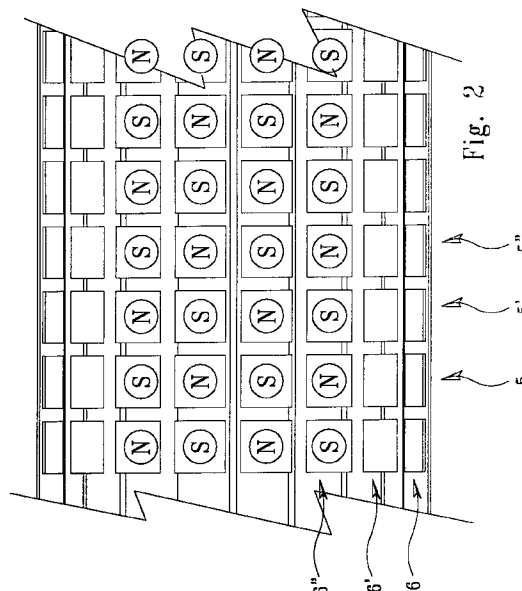
(71) Applicant : **SGM S.p.A.**
Via Leno, 2/D
Manerbio (Brescia) (IT)

(72) Inventor : **Molteni, Danilo**
Via Papa Giovanni XXIII, 49
Manerbio, (Brescia) (IT)

(74) Representative : **Pizzoli, Pasquale Vincenzo et al**
c/o Società Italiana Brevetti
Via G. Carducci 8
I-20123 Milano (IT)

(54) **Process and device for separating stainless steel from mixed material containing it**

(57) A process for separating stainless steel from mixed materials containing it, wherein these materials are conveyed through a magnetic field having a magnetic potential gradient higher than 1500 Oe/cm with consequent attraction and stopping of stainless steel and its separation from the inert materials which are not attracted. Such a process is carried out with a device comprising a magnetic field generator consisting of a plurality of magnets arranged in parallel lines and rows wherein the polarities of the magnets are alternated in each line and in each row, every magnet being magnetically insulated each other.



The present invention relates to a process and a device for separating stainless steel from mixed materials containing it, and in particular a process and a device wherein stainless steel is separated from magnetically inert materials by means of magnetic attraction.

It is known that for recycling an important raw material such as steel, the scraps of many industrial products, for instance automobiles, are crushed and their steel fragments are subsequently separated from the other mixed materials combined with them. Iron and ferromagnetic steels are separated from the other components with known devices wherein the ferromagnetic material is attracted by a magnetic field and reclaimed. However, the mixed material resulting from such first separation still contains fragments of stainless steel in such quantities that an industrial reclamation is economically justified.

Techniques based on the specific weight difference of the materials to be separated, for instance flotation or centrifugation, are used at the present for separating stainless steel from the inert materials. These techniques have many disadvantages and, above all, they do not offer the advantage of simplicity, selectivity and cleanness of the magnetic separation plants.

It is also known that stainless steels, even if their iron content may vary within very broad limits, are commonly considered as paramagnetic or non-magnetic materials so that they are considered until now not suitable to be separated by means of magnetic attraction. As a matter of fact, the attraction force of a material subject to a magnetic field is proportional to the intrinsic magnetization value of such material, to its volume and to the magnetic potential gradient in that point of the field, according to the known formula $F = B_i/4\pi \times V \times dH/dx$. For the stainless steels the intrinsic magnetization value B_i is very low and may vary from 0 to 100 Gs depending on the size, the shape and the magnetic permeability of the item to be attracted. On the contrary, the B_i value of the ferromagnetic materials amounts to some thousands of Gs. Thus, until now the way of separating stainless steel with devices or processes based on the magnetic attraction thereof has been always disregarded.

However, by keeping in mind that in the above mentioned formula the volume may be considered as a constant, the only variable quantity is the gradient value dH/dx . The present invention is based on the idea of highly increasing the magnetic potential gradient value dH/dx so that force F , in determinate areas of the resulting magnetic field, reaches values sufficient for attracting stainless steels having a low B_i index.

It is therefore an object of the present invention to provide a process for separating stainless steel from magnetically inert materials by means of a magnetic attraction. Such an object is achieved with a

process wherein the mixed material free from ferromagnetic components is conveyed through a magnetic field whose magnetic potential gradient in the working area is higher than 1500 Oe/cm, with consequent attraction and stopping of stainless steel and its separation from the inert materials which keep on moving.

Another object of the present invention is to provide a device for practically performing the above process. This object is achieved with a device wherein the magnetic field generator having a high magnetic potential gradient consists of a plurality of magnets arranged in parallel lines and rows wherein the polarities of the magnets are alternated in each line and in each row, every magnet having the open poles magnetically insulated from the others. With this arrangement of the magnets the generator produces a magnetic flux cross-over which can generate in the working area a very high magnetic potential gradient, anyway higher than 1500 Oe/cm as required from the process according to the present invention.

According to a first embodiment of the device according to the present invention, the plurality of magnets is arranged in parallel lines and rows on a flat surface.

The thus obtained flat generator is placed under a conveyor belt capable to carry the material to be processed. By moving the conveyor belt, when the material to be processed is above the aforesaid generator, the stainless steel is attracted by the generator and therefore kept on a conveyer area, while the inert materials keep on moving. With suitable means the stainless steel fragments are then detached from the conveyor and collected in suitable containers.

According to a preferred embodiment of the device according to the present invention, the magnetic field generator consists of a roller whose cylindrical surface is provided with parallel lines and rows of magnets, which is used for driving the conveyor belt which carries the material to be processed. This particular embodiment offers a high selectivity, as well as all the advantages connected to the magnetic separation technique.

Further advantages and features of the process and the device according to the present invention will result clear to those skilled in the art from the following detailed description of an embodiment thereof with reference to the attached drawings wherein:

Fig. 1 shows a side view of the magnetic field generator according to the present invention;

Fig. 2 shows an enlarged view of a portion of the generator of Fig. 1;

Fig. 3 shows an enlarged cross-sectional view taken along line A-A' of Fig. 1; and

Fig. 4 shows a schematic elevation side view of the complete separation device including the generator according to the present invention.

Referring to Fig. 1, it is seen that the generator ac-

cording to the present invention consists of a plurality of lines of permanent magnets 1 aligned on the cylindrical surface of a roller 2 provided with a shaft 3. One end of shaft 3 is provided with a key 4 for keying a motor. As a matter of fact, roller 2 is preferably used for driving the conveyor belt as it will be afterwards described in detail. However, it is obvious that roller 2 may be also an idle or driven roller.

Magnets 1 are arranged in parallel lines 5, 5' ,5" etc., circumferentially placed side by side on the outer surface of roller 2. Lines 5, 5', etc. are placed side by side so that magnets 1 are perfectly aligned so as to form also parallel rows 6, 6' and 6" of permanent magnets 1 axially placed side by side.

In Fig. 2 there is shown in detail how magnets 1 are arranged along their lines 5, 5' etc. and rows 6, 6', etc. Letters N and S point out the north and the south pole of each magnet 1 so that it is evident that all magnets 1 are arranged in such a way that their polarities are alternated along circumferential lines 5 as well as along axial rows 6, 6', etc.

Each magnet 1 is magnetically insulated from the neighboring ones. This can be easily carried out, for example, by leaving free gaps between the magnets so that each magnet is perimetricaly in contact with air. However, in order to further strengthen the magnets as a whole, it is preferable to fill the gaps with a suitable insulating material, for instance an epoxidic resin. The resin casting, besides strengthening the whole structure, also ensures that each magnet permanently stays in its seat without being moved even under high stresses. As a matter of fact, roller 2, while being used as the driving roller of the conveyor belt, is subjected to high stresses during the working of the device according to the present invention.

The arrangement of the polarities of magnets 1, as shown in Fig. 2, is such that the plurality of magnets 1 causes that particular magnetic flux cross-over capable of generating in the working area a very high magnetic potential gradient, higher than 1500 Oe/cm, needed for carrying out the process of the present invention. However, with the magnets available now on the market it is possible to manufacture according to the present invention a device which is capable of generating in the working area a magnetic potential gradient higher than 4000 Oe/cm and even equal to 5000 Oe/cm.

Referring to Fig. 3, which shows a cross-sectional view of roller 2, there can be seen that the latter essentially consists of a hollow cylinder 7 made of ferromagnetic material, having each base closed by a flange 8 and provided with a shaft 3. Cylinder 7 is made of ferromagnetic material, preferably mild steel which notoriously is the cheapest material having a high magnetic permeability. The outer surface of cylinder 7 is shaped so as to form a plurality of rectangular seats 9 each of them is destined to hold a magnet 1.

In Fig. 3 there can be clearly seen gaps 10, 10', 10" etc. which separate each other the magnets of rows 6, 6', 6" etc. Such gaps avoid short-circuits between magnets 1. As mentioned above, each gap is preferably filled with an epoxidic resin.

In order to secure the necessary wear resistance to roller 2, this is coated with a thin outer jacket 11 made of a suitable material. Stainless steel is a material suitable to this purpose, even if it negatively influences the magnetic field in the operative area. If necessary, jacket 11 may be made of glass reinforced resin.

Magnets 1 used in the embodiment here described and illustrated in the attached drawings are permanent magnets. It is obvious that they can be replaced by electromagnets, but this naturally involves manufacturing complications.

Referring now to Fig. 4, there will be described in its simplest form an apparatus for practically carrying out the stainless steel separation process according to the present invention. The apparatus comprises a vibrating table 12 where the mixed material 13 to be submitted to the stainless steel separation process is introduced. Material 13, essentially made of stainless steel and inert materials, is transferred on conveyor belt 14 driven by roller 2 constructed as above described and illustrated in Figs. 1 to 3. The motion is given by motor 15 on which the end of roller 2 is keyed.

By operating such an apparatus, material 13, pushed by the vibrating table 12, is carried by belt 14 up to the working area wherein the magnetic field generated by the magnets arranged on the surface of roller 2 prevails. In the said area the stainless steel fragments are attracted by the magnetic force and remain adherent to the outer surface of belt 14. Stainless steel remains firmly adherent to the surface of conveyor belt 14, even if the latter begins the downwards run while the roller is still rotating. On the contrary, the inert materials, since they are not attracted by the magnetic field force generated by roller 2, come off belt 14 for gravity and inertia as soon as belt 14 begins its downwards run, as indicated by arrow 16. The inert material is collected into hopper 17.

Stainless steel fragments remain adherent to conveyor belt 14 even when they are below roller 2. The detachment occurs only when the particles move away from roller 2 and the gravity force acting on such particles prevails on the magnetic attraction force generated by roller 2. The detachment of such particles is indicated by arrow 18 in Fig. 4 which also shows how such particles are collected into hopper 19.

It should be noticed that the stainless steel fragments, from the point where they are stopped on the conveyor belt 14 up to the point where they leave such belt, do not move with respect to magnets 1 arranged on roller 2. Thanks to this arrangement the preferred embodiment of the separating device according to the present invention allows the best separation possible

at the present time for stainless steels. The treatment of mixed materials is thus highly selective so that the reclaimed stainless steels are substantially free from inert materials.

The embodiment above described and illustrated in the attached drawings is only an example of the invention. Many modifications are possible and one of them could be the replacement of the permanent magnets 1 with equivalent electromagnets. In such a case more complex constructive arrangements should be provided.

The present invention has been described referring to its applications to the treatment of mixed material for separating stainless steels. It is obvious that it can be also applied with success to the separation of other materials characterized by low Bi values of intrinsic magnetization, i.e. materials commonly considered paramagnetic or non-magnetic.

Claims

1. Process for separating stainless steel or other paramagnetic materials from mixed materials containing it, characterized in that the mixed material free from ferromagnetic components is conveyed through a magnetic field whose magnetic potential gradient in the working area is higher than 1500 Oe/cm, with consequent attraction and stopping of stainless steel and its separation from the inert materials which keep on moving.
2. Process according to claim 1, characterized in that the magnetic field is generated by a plurality of magnets magnetically insulated each other and arranged so as to form parallel lines and rows wherein the polarities of the magnets are alternated, every magnet having the open poles magnetically insulated each other.
3. Device for separating stainless steel or other paramagnetic materials from mixed materials containing them, characterized in that it comprises a magnetic field generator consisting of a plurality of magnets arranged in parallel lines and rows, wherein the polarities of the magnets are alternated in each line and in each row, every magnet being magnetically insulated each other.
4. Device according to claim 3, characterized in that the magnetic field generator is flat and is arranged under a conveyor belt on which the mixed material to be processed is placed.
5. Device according to claim 3, characterized in that the magnetic field generator is roller-shaped (2).
6. Device according to claim 5, characterized in that the roller-shaped generator (2) acts as the driver roller of a conveyor belt (14) for carrying the mixed material to be processed.
7. Device according to claim 3, characterized in that it also comprises a vibrating table (12) arranged upstream conveyor belt (14).
8. Device according to one or more of the previous claims, characterized in that it also comprises two collecting hoppers (17, 19) for collecting the separated materials, placed under conveyor belt (14), one hopper (19) for collecting stainless steel being placed upstream roller (2) and the other hopper (17) for collecting inert materials being placed downstream roller (2).

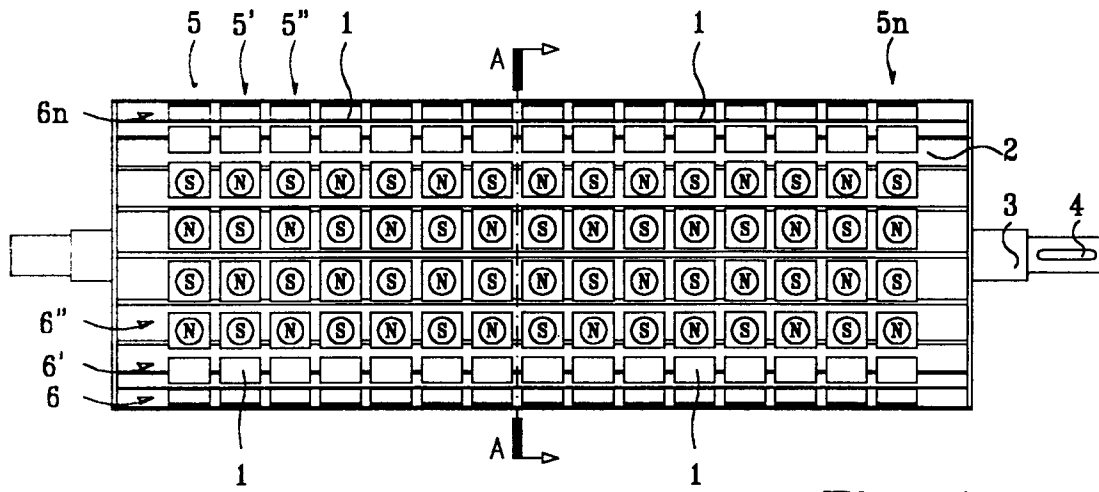


Fig. 1

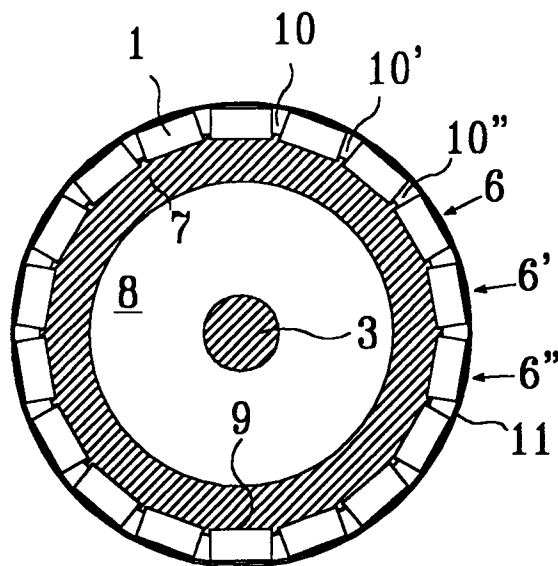
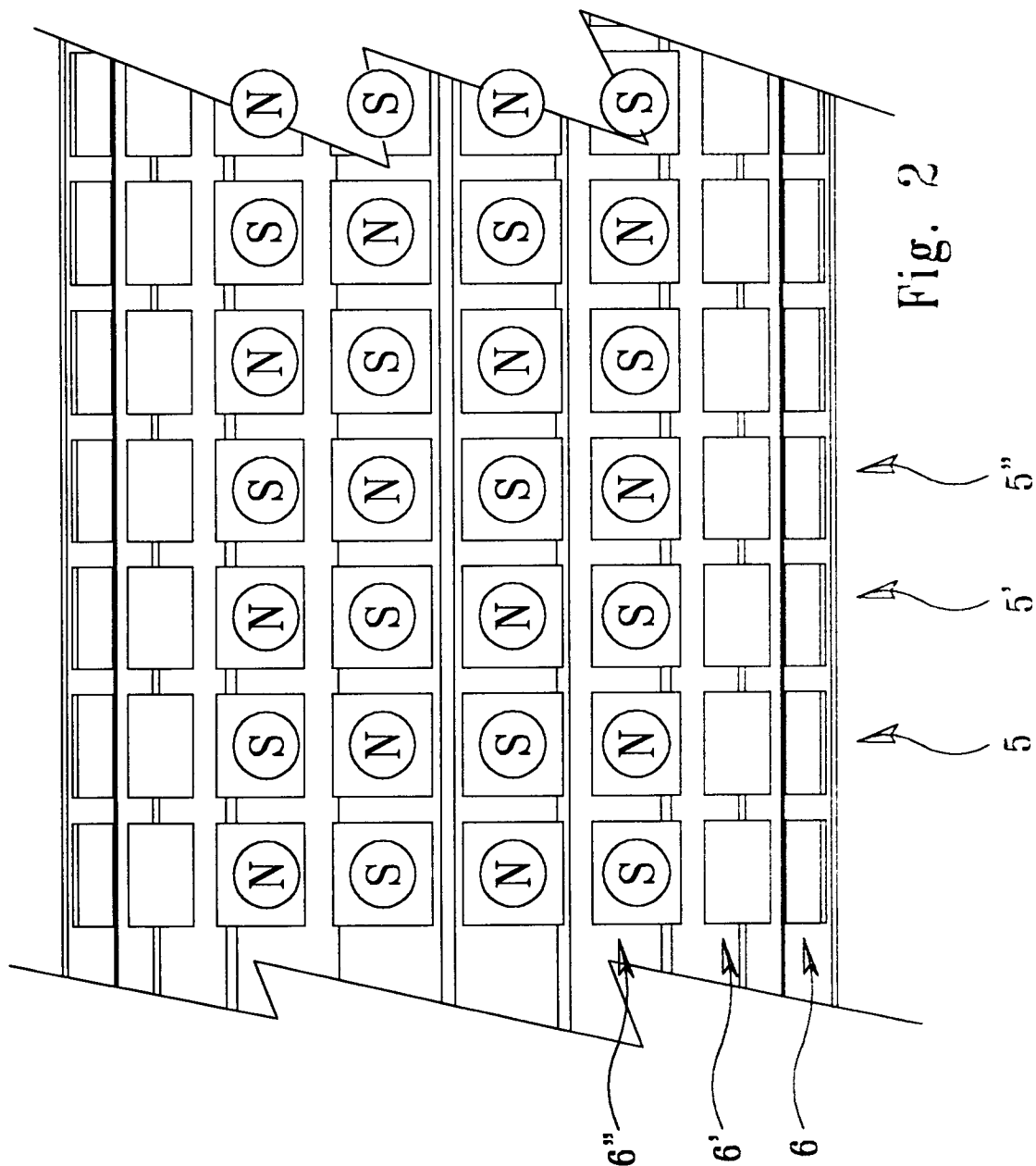


Fig.3



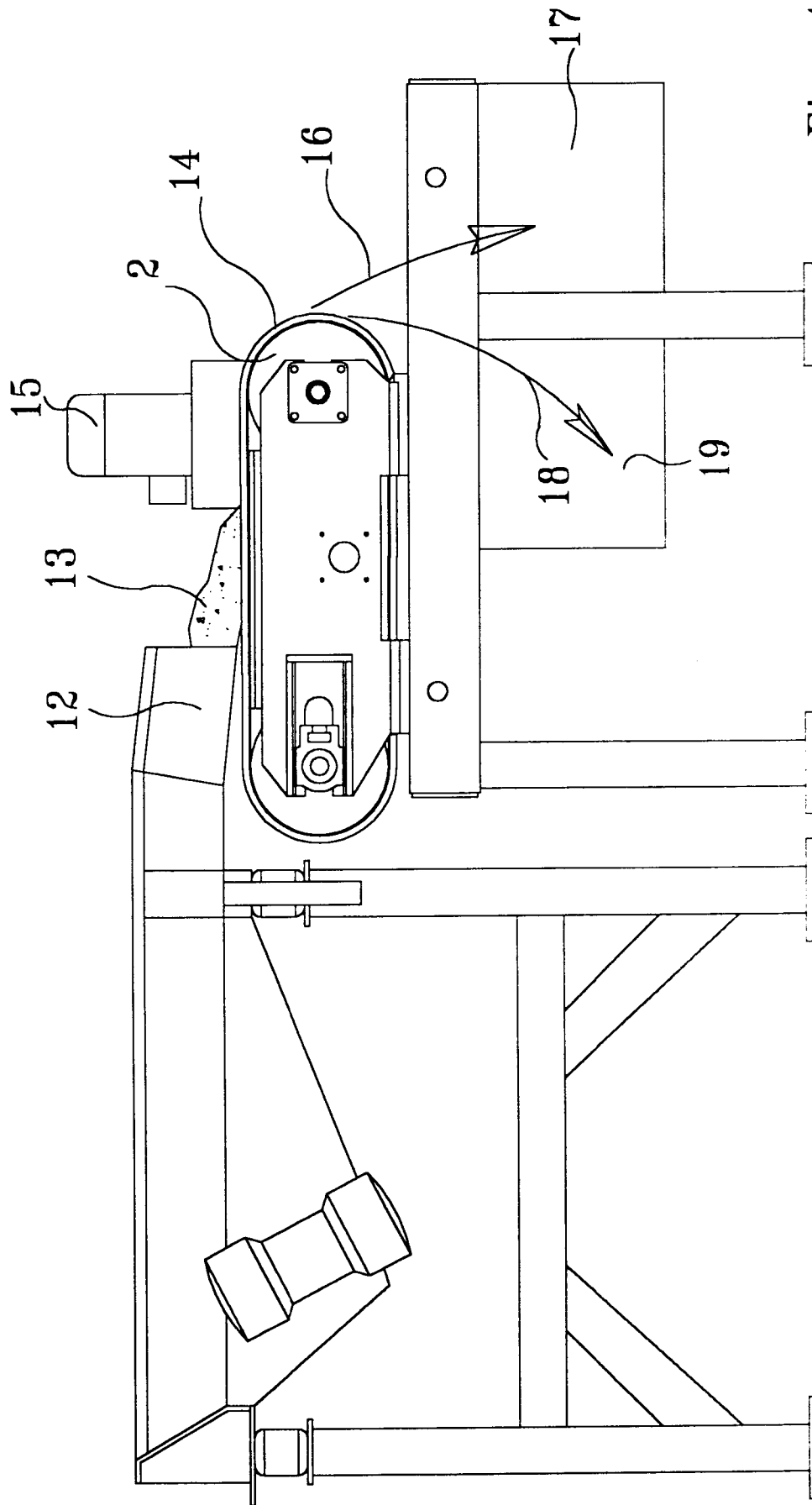


Fig. 4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 83 0244

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	IEEE TRANSACTIONS ON MAGNETICS, vol. 20, no. 5, September 1984 NEW YORK US, pages 1204-1206, J.KOPP * page 1204, column 1, line 1 - column 2, paragraph 2 *	1	B03C1/035 B03C1/12 B03C1/18 B03C1/22
A	R.M.BOZORTH 'Ferromagnetism' 1951, VAN NOSTRAND COMP., NEW YORK US * page 147 - page 149 *	1	
A	FR-A-2 326 979 (KLOCKNER-HUMBOLDT-DEUTZ AG) * page 6, line 9 - line 19 * * page 7, line 32 - page 8, line 8; claims 1,2,6,10; figures 3,5 *	1-4,8	
A	US-A-2 959 288 (L.L.FOWLER) * column 2, line 2 - line 58; claim 1; figures 1-3 *	1-3,5	
A	US-A-4 225 047 (A.A.GRUBMAN)		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 5 September 1995	Examiner Decanniere, L
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.92 (P4/C01)