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(71) Applicant:
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO
2628 VK Delft (NL)

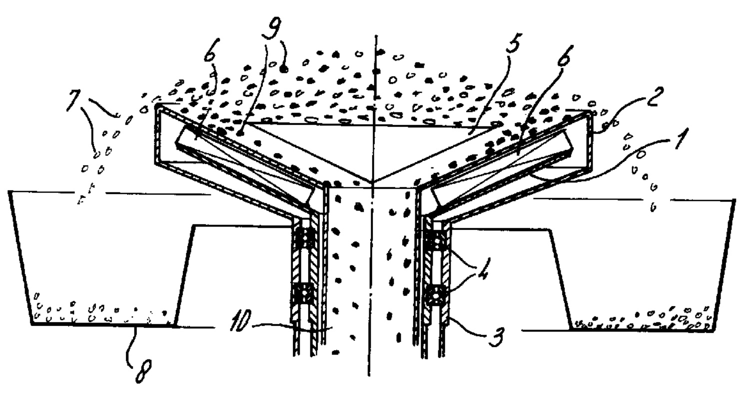
(72) Inventors:
- **Langerak, Edwin**
  7329 CE Apeldoorn (NL)
- **Verschut, Cornelis**
  6952 GC Dieren (NL)
- **Krajenbrink, Gerard Willem**
  7327 DM Apeldoorn (NL)

(74) Representative:
de Bruijn, Leendert C. et al
Nederlandsch Octrooibureau
P.O. Box 29720
2502 LS Den Haag (NL)

(54) Eddy current separator

(57) For separating off non-ferrous metals from a stream of particles or separating non-ferrous metal particles from one another on the basis of composition, size, shape or density, by means of eddy currents, use is made of an installation having a rotor which is rotatable about an essentially vertical axis and has a number of magnets distributed over 360°, the north and south poles of said magnets alternating at the circumference, the jacket surface of which rotor, or a guard plate covering said jacket surface, having the shape of an optionally truncated cone. There are means for rotating the rotor and feed means for feeding the stream of particles to the jacket surface of the rotor or said guard plate. Said last-mentioned feed means are so constructed that the particles to be separated impinge on the cone surface along an essentially closed circular strip. During rotation of the rotor a magnetic field is generated which is sufficiently powerful tangentially to repulse the conductive particles, or some of the particles which are to be separated on the basis of composition, size, shape or density, from the rotor surface or guard plate surface, such that a radial separation between the particles is achieved. An exceptionally good separation efficiency is achieved by this means.

fig-1



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Description

The invention relates to an installation for separating off non-ferrous metals from a stream of particles, or separating non-ferrous metal particles from one another on the basis of composition, size, shape or density, by means of eddy currents, comprising:

a rotor, rotatable about an essentially vertical axis, having a number of magnets distributed over 360°, the north and south poles of which magnets alternate at the circumference, the jacket surface of which rotor, or a guard plate covering said jacket surface, having the shape of an optionally truncated cone,
means for rotating the rotor and
feed means for directing the stream of particles towards the jacket surface of the rotor or said guard plate.

An installation of this type is disclosed in US-A 4 313 543 and JP-A 57-139 740.

The physical principle of separating off non-ferrous metals from a material stream by a dry method by means of eddy currents has already been known for over a century. Electric currents are induced in the metals by an alternating magnetic field, which electric currents, in their turn, generate a magnetic field which is opposed to the original magnetic field. The non-ferrous metals are repelled, whilst although any ferrous metals present are also subjected to a repellent force, the normal magnetic force of attraction is much greater. It is essential that the non-ferrous metal particles to be separated off are exposed to a magnetic field of continually changing magnitude. The forces exerted on the particles are the greater, the more powerful the magnetic field and the change in the magnetic field. Of course, the forces generated will have to be such that the non-ferrous particles are repulsed from the material stream with as little effect as possible on the other particles. The repulsion of the non-ferrous particles is determined by the ratio of the electrical conductivities and the densities of said particles, as well as by the strength of the magnetic field. Assuming particles of the same size, the greater the conductivity the greater is the eddy current and the greater the force of repulsion. Furthermore, the greater the relative density of the non-ferrous particles, the greater the force of repulsion has to be. In the case of aluminium this ratio is very advantageous, with the result that aluminium particles can readily be separated off. The opposite is found to be the case with lead and stainless steel. The latter are more difficult to separate off by the eddy current technique. The size and the shape of the particles also have an influence on whether or not it is easy to separate off the non-ferrous particles. A flat particle is easier to separate off than a spherical particle. A relatively large particle is easier to separate off than a small particle.

With the installation according to US-A 4 313 543, the stream of particles is fed in four separate streams at the top of the cone, the conductive particles sliding downward along a path over the cone surface, which path deviates from the path along which the non-conductive particles slide over the cone surface. A separation in the circumferential direction takes place in four segments.

In the case of the installation according to JP-A 53-139 740, the stream of particles is fed to the outside of a funnel-shaped rotor at a specific point, the conductive particles slide along a path over the cone surface to a first central discharge, whilst the non-conductive particles are carried along a different path over the cone surface to a second central discharge which is separated from the first central discharge by a partition. In this case also separation takes place in the circumferential direction.

The separating efficiency of these known separators leaves something to be desired. It is for this reason that they are not available commercially.

The aim of the invention is to overcome this drawback and to provide an installation of the type mentioned in the preamble which gives an appreciably improved separation result.

According to the invention, the installation mentioned in the preamble is, to this end, characterised in that the said feed means are constructed such that the particles to be separated impinge on the cone surface along an essentially closed circular strip, and in that the magnetic field generated during rotation of the rotor is sufficiently powerful to repulse the conductive particles, or some of the particles to be separated on the basis of composition, size, shape or density, tangentially away from the rotor surface or guard plate surface, the various features being such that a radial separation between the particles is achieved.

It is pointed out that EP-A 0 083 445 discloses an installation for sorting non-ferrous metal particles on the basis of conductivity, use being made of a cylindrical rotor which has a conical surface at the top for feeding the particulate material over the circumference of the rotor. The more conductive particles of the material stream falling over the rotor are carried further outwards than the less conductive particles. Because the actual separation takes place during the free fall of the material stream the separation efficiency is relatively poor with this installation as well.

In a first embodiment, the jacket surface of the rotor is funnel-shaped, the various features being such that when the rotor is rotating the conductive particles are moved essentially tangentially outwards and the non-conductive particles slide towards a central discharge tube. The cone angle of the funnel must be at most a value at which the non-conductive particles slide into the central discharge tube and at least a value at which conductive particles are able to escape outwards.

Metered feeding of a thin annular layer of particulate material with very little or negligible vertical movement to the rotor can take place if the feed means consist of a disc which can be made to vibrate in the axial and circumferential directions by means of a vibratory motor.

In a second embodiment, the rotor will widen from top to bottom, the cone angle being between 20 and 150° and preferably about 90°, in which context the lower limit of the cone angle must still lead to an adequate effect on the conductive particles and the upper limit is determined by the fact of whether the distance which the two types of particles travel in the radial direction can be differentiated. Furthermore, means are present for feeding the particles with a negligible vertical movement component to a jacket surface of the rotor or a guard plate.

In connection with the optimum effect of the magnetic field, the height of the rotor will be at most 1/5 times the smallest diameter of the rotor. The height of the rotor is, for example, about 5 cm and the average diameter about 30 cm.

The feed means can consist of an annular vibratory disc having drive means to bring the disc into vibration both in the circumferential direction and in the axial direction, such that material fed to the outside of the vibratory disc falls off said disc in a metered manner at the inside of the vibratory disc.

Another embodiment of the feed means consists of a vibratory disc which is arranged above the truncated cone-shaped rotor and which has drive means for vibrating the disc both in the circumferential direction and in the axial direction, such that particles fed centrally onto the disc are slowly carried towards the outside and fall from the circumferential edge.

The use of permanent magnets in the rotor leads to a very strong alternating magnetic field and is therefore highly preferable.

The invention will now be explained in more detail with reference to the figures.

Figure 1 shows a first embodiment in cross-section.

Figure 2 shows a top view of the embodiment according to Figure 1.

Figure 3 shows, highly diagrammatically, a view of a second embodiment.

Figure 4 shows, highly diagrammatically, a third embodiment which is a variant of the embodiment according to Figure 3.

The separating installation shown in Figures 1 and 2 comprises a funnel-shaped rotor 1 which is accommodated in a stationary funnel-shaped box 2, which is connected to a stationary vertical tube 3. Bearings 4 are mounted between the rotor 1 and the tube 3. The rotor 1 can be brought into rotation by a motor, which is not shown.

A conical material divider 5 is located above the funnel-shaped box 2, which material divider 5 can be brought into vibration in the circumferential direction and in the axial direction by means of a vibratory motor, which is not shown, as a result of which particulate material poured onto the divider 5 is carried towards the circumferential edge of the divider 5 and impinges on the funnel-shaped box 2 as an annular stream. The gap between the box 2 and the divider is very small at this point, so that the vertical movement component of the particles is negligible.

A number of permanent magnets 6 are arranged inside the rotor 1 in such a way that the north and south poles alternate at the circumference of the rotor. By allowing the rotor to rotate, an alternating magnetic field is generated, the frequency of which depends on the rotary speed and the number of magnets. The alternating magnetic field in the metal particles generates induction currents which are associated with a magnetic field which is always opposed to the alternating magnetic field of the permanent magnet. The conductive non-ferrous particles are repulsed in the tangential direction and move, as is indicated by arrows in Figure 2, over the funnel-shaped top surface of the box 2 towards the outside and fall over the edge of box 2 into a collection tray 8. The non-conductive particles 9, which, for example, consist of plastic, slide over the top surface of the box 2 towards the central discharge channel 10. Excellent separation is achieved as a consequence of the negligible speed at which particulate material impinges on the top surface of the box 2 and as a consequence of the funnel shape of the rotor 1 and the box 2.

In the embodiments according to Figures 3 and 4, the rotor 11, or a stationary guard plate which is not shown individually, has the shape of a truncated cone which widens from the rotor downwards and has a cone angle of between 20 and 150°, preferably about 90°. The particulate material to be separated is supplied horizontally, by means which will be described in more detail, close to the jacket surface of the rotor, so that the vertical movement component on reaching the rotor is virtually zero. With these embodiments also, the rotor 11 can be brought into rotation by a motor and the rotor has a number of permanent magnets, the north and south poles of which alternate at the circumference.

In the embodiment according to Figure 3, a disc-shaped material divider 15, onto which material is fed, is located above the rotor 11. The divider can be subjected by means of a vibratory motor to a vibratory movement such that the material moves from the inside to the outside and impinges in the form of an annular stream from the divider 15 on the conical jacket of the rotor or the conical guard plate. The non-conductive particles slide over the rotor jacket or the guard plate into a tray 20 and the conductive particles (non-ferrous metals) come under the influence of the magnetic field, a magnetic field which is opposed to the alternating magnetic field of the permanent magnets being generated in the particles by induction. The conductive particles are thus repulsed and end up in the tray 18.

The difference between the embodiment according to Figure 4 and that according to Figure 3 is that, instead of the circular disc 15, a slightly inclined ring 15a is used, onto which the particulate material to be separated is fed. By bringing the ring 15a into vibration, an annular material stream from the inner circumferential edge of the ring will impinge on the rotor 11 or a conical guard plate. The result is the same as that according to Figure 3; the conductive non-ferrous particles are repulsed and end up in the tray 18 and the non-conductive (plastic) particles slide evenly into the tray 20. Of course, the embodiments described can also be used to separate conductive particles from one another on the basis of differences in composition (for example aluminium and copper), size and shape and density. The repulsion of one type of particle is greater than that of the other type of particle.

It is of essential importance for the invention that the particles to be separated impinge on the cone surface in an essentially closed circular stream, certain particles being tangentially repulsed and other particles not being tangentially repulsed when the rotor rotates, such that a radial separation between the particles is achieved.

Claims

1. Installation for separating off non-ferrous metals from a stream of particles, or separating non- ferrous metal particles from one another on the basis of composition, size, shape or density, by means of eddy currents, comprising:

    a rotor (1, 11), rotatable about an essentially vertical axis, having a number of magnets distributed over 360°, the north and south poles of which magnets alternate at the circumference, the jacket surface of which rotor, or a guard plate covering said jacket surface, having the shape of an optionally truncated cone,
    means for rotating the rotor and
    feed means for directing the stream of particles towards the jacket surface of the rotor or said guard plate

    characterised in that the said feed means are constructed such that the particles to be separated impinge on the cone surface along an essentially closed circular strip, and in that the magnetic field generated during rotation of the rotor is sufficiently powerful to repulse the conductive particles, or some of the particles to be separated on the basis of composition, size, shape or density, tangentially away from the rotor surface or guard plate surface, the various features being such that a radial separation between the particles is achieved.

2. Installation according to Claim 1, characterised in that the jacket surface of the rotor (1) is funnel-shaped, the various features being such that when the rotor is rotating the conductive particles are carried essentially tangentially outwards and the non-conductive particles slide towards a central discharge tube.

3. Installation according to Claim 2, characterised in that the rotor is accommodated in a stationary funnel-shaped box.

4. Installation according to Claim 2 or 3, characterised in that the feed means consist of a disc (5) which can be made to vibrate in the axial and circumferential directions by means of a vibratory motor.

5. Installation according to Claim 1, characterised in that the rotor (11) widens from top to bottom and the cone angle is between 30 and 150° and preferably about 90° and in that means are present for feeding the particles with a negligible vertical movement component to the jacket surface of the rotor or a guard plate.

6. Installation according to Claim 5, characterised in that the height of the rotor is at most 1/5 times the smallest diameter.

7. Installation according to Claim 5 or 6, characterised in that the feed means consist of an annular vibratory disc (15a) having drive means to bring the disc into vibration both in the circumferential direction and in the axial direction, such that material fed to the outside of the vibratory disc falls off said disc in a metered manner at the inside of the vibratory disc.

8. Installation according to Claim 5 or 6, characterised in that the feed means consist of a circular vibratory disc (15) arranged above the truncated cone-shaped rotor (11) and in that drive means are present to vibrate the disc both in the circumferential direction and in the axial direction, such that particles fed centrally onto the disc are slowly carried towards the outside and fall from the circumferential edge.

9. Installation according to one of the preceding claims, characterised in that the rotor is provided with permanent magnets.

fig-1

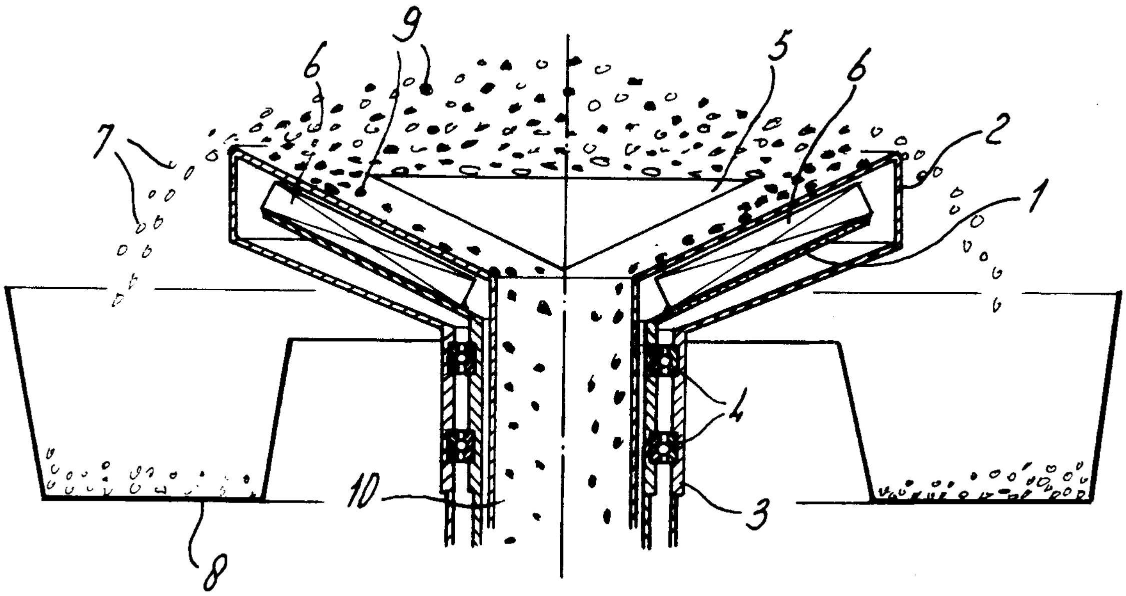


fig-2

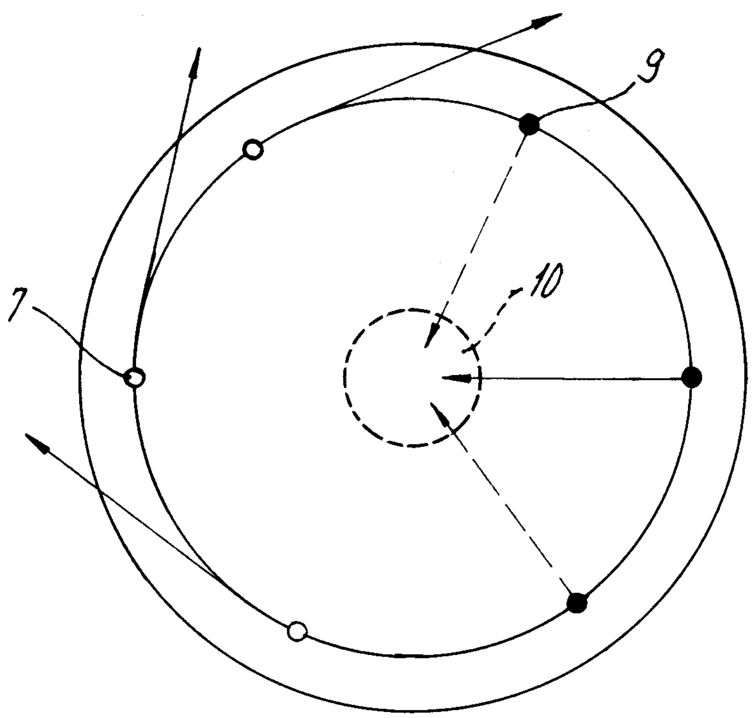


Fig-3

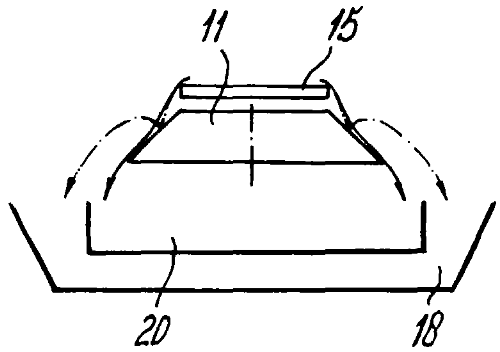
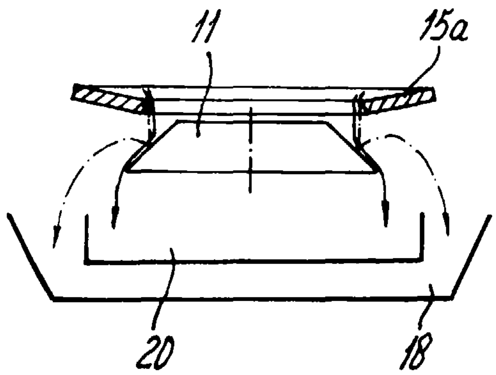


Fig-4



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EUROPEAN SEARCH REPORT

Application Number
EP 97 20 1670

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	PATENT ABSTRACTS OF JAPAN vol. 008, no. 118 (C-226), 31 May 1984 & JP 59 032958 A (MITSUBISHI SEIKOU JIZAI KK), 22 February 1984, * abstract *	1-3,9	B03C1/247
A	EP 0 484 309 A (SCANDINAVIAN RECYCLING AB) 6 May 1992 * column 2, line 46 - column 3, line 48 * * column 4, line 43 - column 5, line 20; claims 1,4; figures 1,2 *	1-4,7-9	
D,A	EP 0 083 445 A (STEINERT ELECTROMAGNETBAU GMBH) 13 July 1983 * claims 1-6,14; figure 1 *	1,2,9	
A	GB 2 153 707 A (BARWELL FREDERICK THOMAS) 29 August 1985 * claim 1; figure 1 *	1,2	
D,A	US 4 313 543 A (PATERSON MALCOLM M) 2 February 1982		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 August 1997	Decanniere, L

CATEGORY OF CITED DOCUMENTS

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