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## Description

This invention relates to a magnetic separator for minerals.

The invention is particularly concerned with systems in which a strong magnet is used to separate magnetic particles from non-magnetic particles. In the simplest form of such a system the magnet is passed across a layer of ore or vice-versa so that the magnetic particles are attracted towards and become attached to the magnet. Thus the magnetic portion of minerals in an ore may be removed but this method is not a continuous process and several passes are needed to complete the separation.

A continuous process has been developed wherein a stream of mineral is allowed to flow some distance from the high field region of the magnet whereupon the magnetic fraction becomes deflected towards the higher field region whilst the non-magnetic fraction falls relatively unaffected. Such a process is described and claimed in British Patent 2064377.

However continuous processes of this type have the disadvantage that the stream of mineral never experiences the maximum magnetic force and consequently the separation is not completely clean particularly so when it is required to separate out only very weakly magnetic particles. Moreover in order to prevent capture of the magnetic particles on the magnet wall, the mineral has to be dropped from a height so that the vertical momentum is sufficient to carry the strongest magnetic particles through the high field region. This reduces the degree of deflection of the weakly magnetic particles and consequently again prevents a clean separation.

Another problem which has been found in known magnetic separators is to do with the magnet itself. In order to separate the magnetic particles from the non-magnetic particles a powerful magnet with a long reach is required and super-conducting or very strong conventional magnets have therefore been employed. Known linear magnets have had two coils carried side by side and enclosed in a single cryostat. However this design has been found in practice to have several drawbacks. Firstly, because the two coils attract each other with a considerable force any inaccuracies in the manufacture of the support structure will result in non-perfect mating surfaces which can lead to degradation of the magnet. This problem is exacerbated by the expansions and contractions of the components of the magnet which occur when the temperature within the cryostat varies. Secondly, each coil suffers a large repulsive force along its length and requires a very robust support structure. This has been found to be difficult to

achieve in practice. Thirdly, because the coils are positioned relatively close together to give a strong magnetic field on both sides of the magnet there is only a small amount of space available for the cooling system behind each coil and the support structure between the coils. In practice it has been found that because of these associated problems there is a noticeable reduction in the theoretical magnetic force that can be realised from multiple coil magnets.

The general object of the invention is to provide a magnetic separator which will operate efficiently and produce a cleaner separation than was previously possible.

British Patent Application 2102702 describes a magnetic separator with a magnet which, it is said, may include a single coil. However the described and illustrated embodiment of the separator includes a two-coil magnet of the type discussed above.

A magnetic separator, in accordance with the invention, comprises a linear super-conducting magnet having a single magnetic coil with two generally straight parallel sections joined by curved ends, a clamp surrounding both longitudinal straight outer edges of the coil and one face thereof, the clamp supporting the coil in a cryostat vessel so that the major axis of the coil is orientated substantially horizontally therein and so that the other face of the magnetic coil is located adjacent a first outer wall of the cryostat vessel, at least one radiation shield between the clamp and the walls of the cryostat vessel and means for feeding a mixture of magnetic and non-magnetic particulate material to a magnetic separation zone provided by the magnet such that the particulate material mixture is separated into fractions and thereafter falls freely under the action of gravity, characterised in that the or each radiation shield surrounds the clamp and magnetic coil and a reservoir is provided between the clamp and the other outer walls of the cryostat vessel which is filled with helium, whereby a single magnetic separation zone is provided at the said first outer wall of the cryostat vessel.

The advantage of this is by employing a single magnetic separation zone, only one half of the magnet is exposed so that the heat losses are reduced, the coil is held firmly by the clamp which is not subject to the same degree of expansions and contractions as the multiple coil design and the production of the magnet is simplified since there is no need to provide two exactly identical coils.

Preferably a potting medium is provided around the coil windings.

The magnet may be positioned with its sides horizontal and the magnetic separation zone below the magnet, and a belt provided which moves

horizontally through the magnetic separation zone adjacent to the magnet and substantially at right angles to the long axis of the magnet, the particles being fed horizontally such that the non-magnetic particles fall under gravity whereas the magnetic particles are attracted towards and captured by the belt which carries them through the magnetic separation zone until the gravitational force exceeds that of the magnet and the particles fall from the belt.

This arrangement is particularly suitable when a high capacity process is required.

Suitably the belt may move in the same or opposite direction to the direction of particle feed.

Preferably the magnet is supported with the coil minor axis at an acute angle to the vertical, the feed means feeding the particulate material in the region of high magnetic field of the magnetic separation zone so that the non-magnetic particles fall under the action of gravity only whereas the magnetic particles are diverted towards the magnet until the gravitational force exceeds that exerted by the magnet.

This arrangement has the advantage that the feed point is close to the magnet. This means that all the particles can be made to pass through the region or regions of highest magnetic field allowing separation of weaker magnetics than that possible with the previous methods of separation. The ore feed position also results in the particles experiencing the highest magnetic field for a greater distance thereby increasing the efficiency of the separation.

An additional advantage of the arrangement is that the inclination of the magnet to the vertical ensures that the magnetics and non-magnetics are physically well separated.

Conveniently the angle at which the coil minor axis is inclined to the vertical may be adjusted for a particular ore so that the strongest magnetic particles follow a path which is parallel and close to the magnet. This prevents clogging on the magnet face.

Preferably however, a belt is provided which moves past and closely adjacent to the magnet. The belt acts to remove any strongly magnetic particles which become captured on the belt face from the separation zone thus preventing clogging. This is particularly suitable for an ore whose constituents are not known with a great deal of precision.

Preferably a splitter plate is provided in the lower portion of the falling particles paths to separate the stream of magnetic and non-magnetic particles.

Preferably the particles are fed so that they fall past the belt and do not impinge the belt face. This prevents weaker magnetics from bouncing away from the belt with sufficient momentum to fall into the stream of non-magnetic particles. Suitably, the

particles are supplied at a speed which is less than that of the belt thereby reducing the risk of entrapment of non-magnetics in the magnetic layer, since there will only be a thin layer of strongly magnetic particles captured on the belt face.

Conveniently the angle at which the coil minor axis is inclined to the vertical may be adjusted for a particular ore so that the weakest magnetics within the ore follow a path which is parallel and close to the belt. This ensures that the separation between magnetic and non-magnetic particles is completely clean.

Conventionally also a splitter or splitters may be provided in the lower portion of the falling particles paths to separate the particles according to degree of magnetic susceptibility.

Conveniently the mixture of magnetic and non magnetic particulate material is fed from a hopper the outlet wall of which that is adjacent to the magnet being inclined to the vertical at the same angle as the magnet. The particulate material may alternatively be supplied from a hopper onto a plate inclined to the vertical, preferably at the same angle as the magnet, down which the material falls and is thereby fed adjacent the magnet. These feed methods ensure that the particles have a long residence time within the zone of high magnetic field.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a sketch of a magnetic separator

Figure 2 is a second sketch of the magnetic separator of Figure 1 showing the approximate positioning of the components;

Figure 3 is a vector diagram of the forces experienced by a magnetic particle in the magnetic separator of Figure 1;

Figures 4a, 4b, 4c and 4d are fragmentary sketches of the magnetic separator of Figure 1 showing different embodiments of the feed means;

Figure 5 is a sketch of a magnet forming part of a magnetic separator, in accordance with the invention;

Figure 6 is a sketch of the coil of the magnet shown in Figure 5;

Figure 7 is a sketch of a typical force profile of the magnet of Figure 5;

Figure 8 is a sketch of one embodiment of a magnetic separator incorporating the magnet of Figure 5; and

Figure 9 is a sketch of another embodiment of a magnetic separator incorporating the magnet of Figure 5.

Referring to Figures 1 and 2, a magnetic separator comprises a magnet generally designated by 2 and a feed means 4. The magnet 2 is inclined at

an angle 3 to the vertical.

The magnet 2 is arranged to create a strong magnetic field in such a way that any magnetic particles will experience a force at right angles to and towards the magnet i.e. in the direction of arrow 6.

Dry particulate material to be separated is fed by supply means 4 at a point closely adjacent to the magnet but separated by a gap 8 therefrom. The feed means 4 which is described below is preferably adjustable towards and away from the magnet 2. Preferably the material is fed at a low speed and non-magnetic particles fall under the action of gravity in a vertical path straight down from the feed means 4.

The magnetic particles are attracted towards the magnet 2 and are diverted away from the non-magnetics. They therefore fall in a parabolic path away from the ore feed point. The magnetics pass through the magnetic field until the gravitational force exceeds the magnetic attraction, at which point they fall under the action of gravity. The inclination of the magnet 2 to the vertical causes the path of the magnetics to be physically well separated from the path of the non-magnetics.

The ore feed point may be arranged so that the material is supplied within the highest field of the magnet. If the constituents of the mineral ore are well defined the inclination of the magnet can be set so that the strongest magnetic particles fall parallel and close to the face of the magnet to prevent clogging.

Alternatively if the mineral ore constituents are not well known a belt 10 is provided which moves past and closely adjacent to the face of the magnet 2 as shown in Figures 1 and 2. The belt is supported on rollers 12. Any strongly magnetic particles will be captured on the belt and carried away from the magnet thereby preventing clogging of the magnetic separation zone. The belt preferably moves at a relatively fast speed so that there is only a thin layer of strongly magnetic particles captured on the belt thus reducing the risk on a non-magnetic particle being trapped within the magnetic particles. Even when the feed point is close to the magnet, the inclination of the magnet ensures a clean separation. In previous methods of magnetic separation the ore had to be supplied at a distance away from the highest field region and the resultant force on weakly magnetic particles was insufficient to divert them away from the non-magnetics.

The angle 3 at which the magnet is inclined to the vertical is preferably set for a particular ore so that the particles within the ore with the lowest magnetic susceptibility are forced to move in a path parallel and closely adjacent to the magnet and/or belt. In this way it can be ensured that all

the magnetic particles are removed from the particulate material.

A further advantage of inclining the magnet at an angle to the vertical is that any non-magnetic particle scattered into the magnetic stream still has the opportunity of escaping. Obviously the greater the angle of inclination the greater the chance that non-magnetics will be separated out. Although this might suggest that the best arrangement is one in which the magnetic and gravitational forces are arranged in direct opposition i.e. a lifting operation as previously described, this is not the case since in such an operation the material and the magnet must be physically well separated in order to achieve separation of particles. Therefore weakly magnetic particles will not be cleanly separated out from the ore. Inclination of the magnet to the vertical provides for a compromise between exposing the material to a large region of high magnetic field, allowing any trapped non-magnetics to escape and ensuring that the particulate material is well separated.

The angle 3 may be calculated from a simple vector diagram such as that shown in Figure 3. The magnetic force, represented by  $F_m$ , on a particle with the lowest magnetic susceptibility in a particular ore is the product of the magnetic susceptibility of the particle, the magnetic field strength, the field gradient, and the particle mass.  $F_g$  represents the gravitational force which acts vertically downwards and is the product of the acceleration due to gravity and the mass of the particle. The resultant force is represented by  $F_r$  and is arranged to be at right-angles to the magnetic force. By simple geometry or by equating the forces on the particle in a direction perpendicular to the magnet or belt it can be shown that the sine of the angle 3 is directly proportional to the magnetic susceptibility of the particle. Therefore the angle 3 may be readily calculated and the inclination of the magnet and therefore the magnetic field direction can be arranged so that the weakest magnetic material is constrained to move along the face of the magnet or belt thereby ensuring that all the magnetic particles are removed from the ore.

The calculation outlined above is an oversimplification in that no consideration is given to the drop in magnetic force away from the magnet face or to other effects such as collisions. The assumption is made that the magnetic force is uniform and acts at right angles to the face of the magnet. A further assumption is that 'optimum' separation is achieved when the magnetic particles fall along the face of the inclined magnet or belt. The latter assumption is based on the fact that separation in this way will firstly increase the likelihood that any non-magnetics trapped in the magnetic particle stream will fall out and secondly produce a large

physical separation between the magnetics and non-magnetics.

Therefore the calculation gives a minimum limitation on the value of the angle  $\theta$  which will ensure 'optimum' separation. The separator may for example be arranged so that an excess resultant force is produced, in which case the resultant force would no longer be at right angles to the magnetic force. Alternatively, and as previously mentioned, the separator may be arranged so that the strongest magnetic particles follow a path parallel to the face of the magnet. Therefore it can be seen that for normal operation the inclination to the vertical can be easily calculated and arranged for a particular ore to ensure successful results.

All the magnetic particles will therefore be removed from the ore either by being carried by the belt or by being forced to follow a path parallel to the belt. However, the point at which the gravitational force will exceed the magnetic attraction for a particular particle will depend on its magnetic susceptibility. Since the belt is inclined at an angle to the vertical, particles of different magnetic susceptibility will follow different vertical paths under the influence of gravity. Splitters 11 may be positioned to separate the ore not only into magnetic and non-magnetic fractions but also according to degree of susceptibility. This is shown schematically in Figure 1 where section A represents the strong magnetics, section B the weakly magnetics or middlings and section C the non-magnetics or tails. This separation by degree of susceptibility would be extremely difficult to achieve using previous methods of separation.

The following examples of separations performed with the magnetic separator illustrated in Figures 1 and 2 are included to illustrate the efficiency of separation and the improvement over known magnetic separators. In each case the mixture was allowed to fall past a suitably inclined magnet.

#### Example 1

Potassium Permanganate (magnetic susceptibility  $1.75 \times 10^{-7}$  emu/g) was separated from non-magnetic quartz yielding an 80% grade magnetic product with over 90% recovery in a single pass.

#### Example 2

A mixture of nickel sulphate (magnetic susceptibility  $1.6 \times 10^{-5}$  emu/g) copper sulphate ( $6 \times 10^{-6}$  emu/g) and glass sand (non-magnetic) were separated into nearly perfect individual fractions in a single pass.

#### Example 3 (Comparative)

A mixture of bauxite ore and iron-bearing impurities was separated using a magnetic separator with a vertical double coil magnet and a ramp arranged to feed the particles at some distance from the magnetic face, the particles being dropped from a height onto the ramp. After two passes the non-magnetic product contained 2%  $\text{Fe}_2\text{O}_3$ . With the inclined magnet the non-magnetic product in a single pass was 1.7%  $\text{Fe}_2\text{O}_3$ , an improvement of 15%. Moreover the inclined magnet was found to give consistently better results over a range of particle sizes.

Referring now to Figures 4a, b, c and d various embodiments of feed means 4 are shown. In Figure 4a a hopper 13 is used which has one outlet wall 14 inclined to the vertical at the same angle as the magnet. This feed means ensures that the particles are fed closely adjacent the magnet face and is suitable for an arrangement where the inclination of the magnet to the vertical is small. When the inclination to the vertical is large a hopper of the type shown in Figure 4a cannot be used since the particulate material will not flow out of the outlet. The arrangements shown in Figures 4b and 4c are therefore preferably employed. In both of these the feed means 4 comprises a hopper 13 which supplies the particulate material to a flat plate 16 inclined to the vertical down which the material falls and is thereby introduced adjacent the magnet. The arrangement shown in Figure 4b is particularly successful since the plate is inclined at the same angle as the magnet and is positioned such that the magnetic material falls through at least part of the magnetic field region on the plate before being released. This ensures that the particulate material falls close to the magnet over a long distance and therefore has a long residence time in the high magnetic field region which results in a cleaner separation.

Figure 4d shows a further embodiment of the feed means 4 where a hopper 13 deposits the particulate material on a slowly moving belt 18. The belt then feeds the material at a point closely adjacent the magnet. A vibrating table may be used as an alternative to the belt as shown in Figure 1.

In all the embodiments of the feed means, the particulate material is preferably fed at a relatively slow speed so that it will have a long residence time in the high magnetic field region. This was not possible in known methods where the magnet was held in a vertical position because the particles had to be dropped from a height to give them sufficient momentum to prevent the stronger magnetics from being trapped on the magnet face and clogging it. This is not necessary with the inclined arrangement

because the magnet can be arranged so that the strongest magnetics follow a path parallel to the magnet or a belt can be used to carry the strongest magnetics away.

Referring now to Figures 5 and 6, a magnet 2 in accordance with the invention is shown.

The magnet 2 comprises a linear race track solenoid mounted in a cryostat vessel 35. The solenoid coil 36 is shown in Figure 6 from which it can be seen that the coil 36 has two parallel straight sections 38 joined by curved ends 40. Another smaller coil could be provided inside the coil 36. The solenoid is held by a G or C shaped clamp 42 in a helium reservoir 41 which is conveniently at a temperature of 4K, the void between the coil windings being filled with a potting medium, such as epoxy resin. The coil is positioned with its long axis horizontally and the clamp 42 surrounds one side and two edges of the coil to provide a magnetic separation zone on the free side of the coil. The helium reservoir 41 is surrounded by two radiation shields 46 of which the inner radiation shield is preferably held at 16K while the outer radiation shield is preferably held at 60 K. The radiation shields are kept at these temperatures by cooling pipes 48 and are enclosed by a layer of super-insulating material 50. The cryostat vessel is closed by a front cover plate 52, which is made as thin as is practical, a rear cover plate 54 and two edge plates 56 to form a generally rectangular shaped magnet.

The gap 56 between the straight sections 38 of the solenoid coil is 50 mm while the overall distance 60 between the outer windings of the solenoid coil is 180 mm. The distance from the side of the solenoid coil to the front of the cryostat vessel is 7 to 20 mm. The overall length 58 of the coil may typically vary between 150 mm and 4 m. All these values are given by way of example only.

The magnet 2 is powerful, robust and has a long range. Since there is only one coil, the cooling system can be arranged so that there are only minimal heat losses on all sides of the magnet except for the side which provides the magnetic separation zone. The clamp can securely hold the coil and its full theoretical field strength can be realised.

Figure 7 shows a typical force profile of the magnet 2, the y axis representing the distance from the surface of the magnet and the x axis representing the distance from the centre line of the magnet. The lines 62 and 64 depict contours of constant magnitude force as would be experienced by a particle of particular mass and magnetic susceptibility when it approaches the magnet, the force at 64 is less than that at 62.

The magnet 2 shown in Figure 5 may be employed in the magnetic separator shown in Fig-

ures 1 and 2.

When the magnet is used in the inclined arrangement the feed position shown in Figures 1 and 2 means the material is fed at 66 on Figure 7 and the ore experiences a much higher field than if it is fed at 68 as it would be in previous methods of magnetic separation. Furthermore it can be seen that this higher field strength acts over a longer distance. The inclined position of the magnet therefore allows separation of even very weak magnetic particles. In addition any magnetic particles trapped in the non-magnetic stream have a greater chance of being diverted since the force on them acts over a much larger portion of their path.

The magnet 2 shown in Figure 5 may also be employed in the magnetic separators shown in Figures 8 and 9, where the magnet is supported with its sides horizontal. The particulate material is fed below the magnet into the magnetic separation zone by a belt 70. In the arrangement shown in Figure 8 the feed direction is the same as the direction of movement of the belt 10. The magnetic particles are attracted vertically upwards and captured on the belt 10 which carries them past the magnet and away from the non-magnetics which simply fall under gravity. Splitters 11 may be provided either to separate magnetic and non-magnetic particles or, as shown in the drawing to separate the particles in fraction A, B and C by degree of magnetic susceptibility.

The arrangement shown in Figure 9 differs only from that shown in Figure 8 in that the movement of the belt is in the opposite direction to that in which the particles are fed. The magnetic particles therefore have their direction of movement reversed and are again carried away by the belt until they fall in the direction of arrow 74. The non-magnetics fall in the direction of arrow 76.

The magnetic separators shown in Figures 8 and 9 are particularly suited when a high capacity process is required because the long reach and high strength of the magnet designed as described above ensures that the magnetic particles will be lifted out even from a large mass of mineral ore.

The magnetic separators described above are not limited to the separation of magnetic particles from an ore and may be equally successfully employed for other particulate mixtures from which it is desired to remove a magnetic component.

## Claims

1. A magnetic separator comprising a linear superconducting magnet (2) having a single magnetic coil (36) with two generally straight parallel sections (38) joined by curved ends (40), a clamp (42) surrounding both longitudinal straight outer edges of the coil and one

- face thereof, the clamp (42) supporting the coil (36) in a cryostat vessel (35) so that the major axis of the coil is orientated substantially horizontally therein and so that the other face of the magnetic coil (36) is located adjacent a first outer wall of the cryostat vessel (35), at least one radiation shield (46) between the clamp (42) and the walls of the cryostat vessel (35) and means (4) for feeding a mixture of magnetic and non-magnetic particulate material to a magnetic separation zone provided by the magnet (2) such that the particulate material mixture is separated into fractions and thereafter falls freely under the action of gravity, characterised in that the or each radiation shield (46) surrounds the clamp (42) and magnetic coil (36) and a reservoir (41) is provided between the clamp (42) and the other outer walls (54, 56) of the cryostat vessel (35) which is filled with helium, whereby a single magnetic separation zone is provided at the said first outer wall (52) of the cryostat vessel (35).
2. A magnetic separator as claimed in Claim 1, wherein the feed means (4) is arranged to feed the mixture of particulate material adjacent the magnet (2) in the region of high magnetic field and then allow the mixture of material to fall under the action of gravity.
  3. A magnetic separator as claimed in Claim 2, wherein the feed means (4) is arranged to carry the mixture of magnetic and non-magnetic particulate material past the face of the magnet (2) through at least part of the region of high magnetic field before allowing the mixture to fall under gravity.
  4. A magnetic separator as claimed in either Claim 2 or 3, wherein the minor axis of the coil of the magnet (2) is positioned at an acute angle (3) to the vertical, the magnetic separation zone being below the magnet (2), whereby when the mixture of material is allowed to fall under gravity the non-magnetic particles (C) fall vertically under the action of gravity alone, whereas the magnetic particles (A, B) are diverted towards the magnet (2) and follow a generally parabolic path until the gravitational force exceeds that exerted by the magnet (2).
  5. A magnetic separator as claimed in either Claim 2 or 3, wherein the magnet is positioned such that the minor axis of the coil is horizontal and the magnetic separation zone is below the magnet (2).
  6. A magnetic separator as claimed in any preceding Claim, wherein the feed means (4) comprises a belt (18).
  7. A magnetic separator as claimed in Claim 6, wherein the belt (18) carries the mixture of particulate material through at least part of the region of high magnetic field in a direction parallel to the major axis of the coil and then allows the material to fall under gravity.
  8. A magnetic separator as claimed in any preceding Claim, wherein a belt (10) is provided which moves past the magnet (2) closely adjacent the face thereof on which the magnet separating zone is provided between the magnet (2) and the particulate material.
  9. A magnetic separator as claimed in Claim 8, wherein the speed of movement of the belt (10) is greater than the feed speed of the particulate material.
  10. A magnetic separator as claimed in either Claim 8 or 9, wherein the belt (10) moves in the same direction as that in which the particles are fed.
  11. A magnetic separator as claimed in either Claim 8 or 9, wherein the belt (10) moves in the opposite direction to that in which the particles are fed.
  12. A magnetic separator as claimed in any preceding Claim, wherein the feed means (4) includes a hopper (13).
  13. A magnetic separator as claimed in any preceding Claim, wherein at least one splitter plate (11) is provided in the lower portion of the falling particles paths to separate the particles according to degree of magnetic susceptibility.
  14. A magnetic separator as claimed in any preceding Claim, wherein a potting medium is provided around the windings of the coil.

#### Patentansprüche

1. Magnetscheider mit einem linearen superleitenden Magneten (2), der eine einzige Magnetspule (36) aufweist, mit zwei im wesentlichen geraden parallelen Abschnitten (38), die durch gekrümmte Enden (40) verbunden sind, einer Klampe (42), die beide längsverlaufenden geraden äußeren Kanten der Spule und eine Stirnseite davon umgibt, wobei die Klampe

- (42) die Spule (36) in einem Kälte reglerbehälter (35) aufnimmt, so daß die Hauptachse der Spule darin im wesentlichen horizontal orientiert ist und so, daß die andere Stirnseite der Magnetspule (36) nahe einer ersten äußeren Wand des Kälte reglerbehälters (35) angeordnet ist, mit wenigstens einem Strahlungsschild (46) zwischen der Klampe (42) und den Wänden des Kälte reglerbehälters (35) und Mitteln (4) zum Zuführen einer Mischung von magnetischen und nichtmagnetischen vereinzelttem Material zu einer Magnettrennzzone des Magneten (2), so daß die vereinzeltte Materialmischung in Fraktionen getrennt wird und anschließend frei unter der Wirkung der Schwerkraft fällt, dadurch gekennzeichnet, daß das oder jedes Strahlungsschild (46) die Klampe (42) und die Magnetspule (36) umgibt und ein Reservoir (41) zwischen der Klampe (42) und den äußeren Wänden (54, 56) des Kälte reglerbehälters (35) geschaffen wird, das mit Helium gefüllt ist, wobei eine einzige Magnettrennzzone geschaffen wird an der äußeren Wand (42) des Kälte reglerbehälters (35).
2. Magnetscheider nach Anspruch 1, wobei das Zuführungsmittel (4) so angeordnet ist, daß die Mischung von Material nahe dem Magneten (2) im Bereich des starken Magnetfeldes zugeführt wird und die Mischung des Materials unter der Wirkung der Schwerkraft fallen kann.
  3. Magnetscheider nach Anspruch 2, wobei das Zuführungsmittel (4) so angeordnet ist, daß die Mischung von magnetischen und nichtmagnetischen vereinzelttem Material hinter der Stirn des Magneten (2) durch wenigstens einen Teil des Bereiches des starken Magnetfeldes bewegt wird, bevor die Mischung unter der Wirkung der Schwerkraft fallen kann.
  4. Magnetscheider nach einem der Ansprüche 2 oder 3, wobei die Spiegelachse der Spule des Magneten (2) unter einem spitzen Winkel (3) zur Vertikalen angeordnet ist, daß die Magnettrennzzone unter dem Magneten (2) liegt, wobei, wenn die Mischung des Materials unter der Schwerkraft fällt, die nichtmagnetischen Teilchen (C) allein vertikal unter der Wirkung der Schwerkraft fallen, während die magnetischen Teilchen (A,B) in Richtung des Magneten abgelenkt werden und einer im wesentlichen parabolischen Bahn folgen, bis die Gravitationskraft die Kraft des Magneten (2) übersteigt.
  5. Magnetscheider nach einem der Ansprüche 2 oder 3, wobei der Magnet so angeordnet ist, daß die Spiegelachse der Spule horizontal ist und daß die magnetische Trennzzone unter dem Magneten (2) ist.
  6. Magnetscheider nach einem der vorstehenden Ansprüche, wobei das Zuführungsmittel (4) einen Bandförderer (10) aufweist.
  7. Magnetscheider nach Anspruch 6, wobei der Bandförderer (10) die Mischung aus vereinzelttem Material durch wenigstens einen Teilbereich des starken Magnetfeldes in einer Richtung parallel zur Hauptachse der Spule fördert und das Material dann unter der Wirkung der Schwerkraft fallen kann.
  8. Magnetscheider nach einem der vorstehenden Ansprüche, wobei ein Bandförderer (10) vorgesehen ist, der sich am Magneten (2) nahe dessen Stirnfläche vorbeibewegt, dort wo die Magnettrennzzone vorgesehen ist, zwischen dem Magneten (2) und dem vereinzeltten Material.
  9. Magnetscheider nach Anspruch 8, wobei die Geschwindigkeit der Bewegung des Bandförderers (10) größer ist als die Zuführungsgeschwindigkeit des vereinzeltten Materials.
  10. Magnetscheider nach einem der Ansprüche 8 oder 9, wobei der Bandförderer (10) sich in derselben Richtung bewegt wie das Material zugeführt wird.
  11. Magnetscheider nach einem der Ansprüche 8 oder 9, wobei der Bandförderer (10) sich in entgegengesetzter Richtung zu der Zuführung des Materials bewegt.
  12. Magnetscheider nach einem der vorstehenden Ansprüche, wobei das Zuführungsmittel (4) einen Einfülltrichter (13) aufweist.
  13. Magnetscheider nach einem der vorstehenden Ansprüche, wobei wenigstens eine Teilerplatte (11) vorgesehen ist in dem unteren Bereich des Weges der fallenden Teilchen, um diese nach dem Grad ihrer Magnetisierbarkeit zu trennen.
  14. Magnetscheider nach einem der vorstehenden Ansprüche, wobei ein Abschirmmedium um die Windungen der Spule vorgesehen ist.

## Revendications

1. Séparateur magnétique comportant un aimant linéaire superconducteur (1) ayant une bobine magnétique unique (36) en deux éléments généralement rectilignes parallèles (38) reliés par deux extrémités incurvées (40), une pince (42) entourant les deux bords longitudinaux extérieurs de l'enroulement et une de ses faces, la pince (42) soutenant la bobine (36) dans une cuve de cryostat (35) de telle façon que l'axe principal de bobine soit orienté essentiellement de façon horizontale et de telle façon que l'autre face de la bobine magnétique (36) soit située à proximité d'une première paroi extérieure de la cuve de cryostat (35), au minimum un écran de protection contre le rayonnement (46) entre la pince et les parois de la cuve de cryostat (35) et les moyens d'apport d'un mélange de matière magnétique et non-magnétique en particules dans une zone de séparation magnétique assurée par l'aimant (2) de telle façon que le mélange de matière en particules soit séparé en fractions et tombe librement par la suite par effet de gravité, caractérisé en ce que l'écran contre le rayonnement (46) ou chacun d'entre eux entoure la pince (42) et la bobine magnétique (36) et un réservoir (41) est prévu entre la pince (42) et les autres parois extérieures (54, 56) de la cuve de cryostat (35) qui est remplie d'hélium, une seule zone de séparation magnétique étant prévue à ladite première paroi extérieure (52) de la cuve de cryostat (35). 5 10 15 20 25 30 35
2. Séparateur magnétique tel que revendiqué à la revendication 1, dont les moyens d'apport (4) sont agencés pour l'apport du mélange de matière en particules à proximité de l'aimant (2) dans la région des champs magnétiques élevés puis permettent la chute du mélange de matière par effet de gravité. 40
3. Séparateur magnétique tel que revendiqué à la revendication 2, dont les moyens d'apport (4) sont agencés pour transporter le mélange de matière magnétique et non-magnétique en particules devant la face de l'aimant (2) au minimum au delà d'une partie de la région de champ magnétique élevé avant de permettre la chute du mélange par effet de gravité. 45 50
4. Séparateur magnétique tel que revendiqué à la revendication 2 ou 3, dont le petit axe de bobine de l'aimant (2) est situé à un angle aigu (3) par rapport à la verticale, la zone de séparation magnétique étant située sous l'aimant (2), de façon telle que lors de la chute du mélange de matière par gravité les particules non-magnétiques (C) tombent verticalement seulement sous l'effet de gravité, alors que les particules magnétiques (A, B) se trouvent déviées vers l'aimant (2) et suivent un parcours généralement parabolique jusqu'à ce que la force de gravité dépasse celle exercée par l'aimant (2). 55
5. Séparateur magnétique tel que revendiqué soit à la revendication 2 ou 3, dont l'aimant (2) est situé de façon telle que le petit axe de l'enroulement soit horizontal et la zone de séparation magnétique se trouve sous l'aimant (2). 5
6. Séparateur magnétique tel que revendiqué en l'une ou l'autre des revendications précédentes, dont les moyens d'apport (4) comportent une bande transporteuse (18). 10
7. Séparateur magnétique tel que revendiqué à la revendication 6, dont la bande (18) porte le mélange de matière en particules qui traverse au minimum une partie de la région de champ magnétique élevé en sens parallèle avec l'axe principal de bobine puis permet à la matière de tomber sous l'effet de gravité. 15 20 25 30 35
8. Séparateur magnétique tel que revendiqué en l'une ou l'autre des revendications précédentes, prévoyant une bande (10) se déplaçant devant l'aimant à proximité étroite de la face sur laquelle la zone de séparation magnétique est prévue entre l'aimant (2) et la matière en particules. 40 45
9. Séparateur magnétique tel que revendiqué à la revendication 8, dont la vitesse de déplacement de la bande (10) est supérieure à la vitesse d'apport de la matière en particules. 50
10. Séparateur magnétique tel que revendiqué soit à la revendication 8 ou 9, dont la bande (10) se déplace dans le même sens que celui de l'apport des particules. 55
11. Séparateur magnétique tel que revendiqué soit à la revendication 8 ou 9, dont la bande (10) se déplace en sens opposé à celui de l'apport des particules. 60
12. Séparateur magnétique tel que revendiqué en l'une ou l'autre des revendications précédentes, dont les moyens d'apport (4) prévoient une trémie (13). 65
13. Séparateur magnétique tel que revendiqué en l'une ou l'autre des revendications précédentes. 70

tes, dans lequel une tôle de tri (11) au minimum est prévue dans la portion inférieure du parcours des particules tombantes de manière à séparer les particules selon leur niveau de susceptibilité magnétique.

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14. Séparateur magnétique tel que revendiqué en l'une ou l'autre des revendications précédentes, dont les enroulements de bobine sont entourés d'une matière d'isolement.

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Fig. 1.

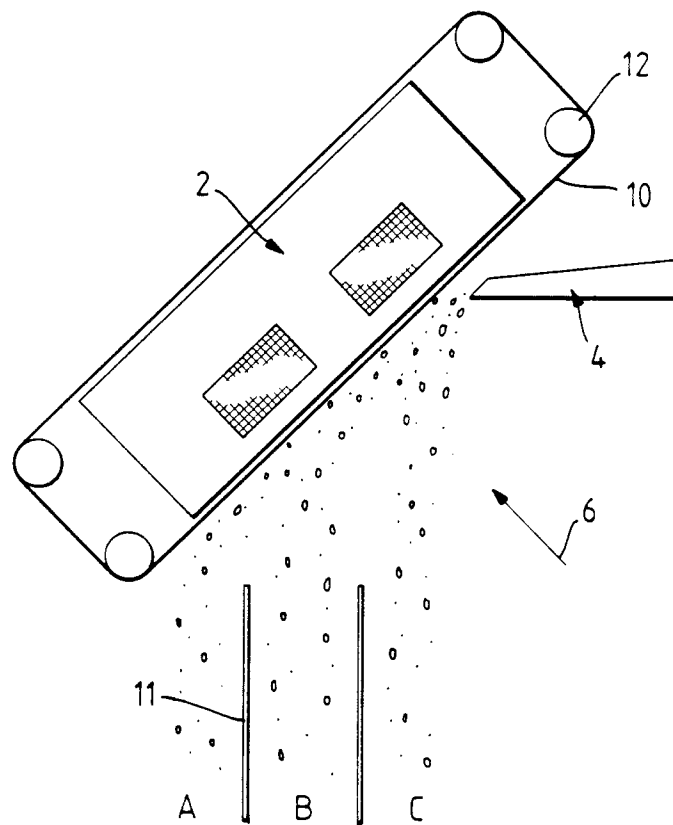


Fig. 2.

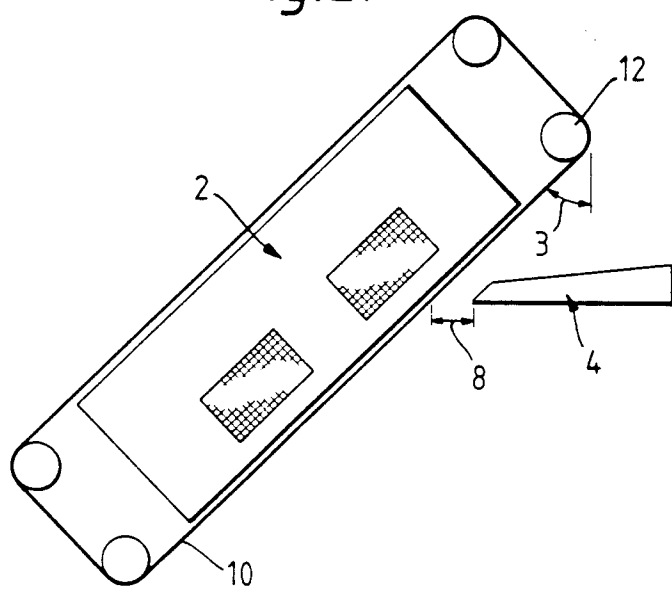


Fig. 3.

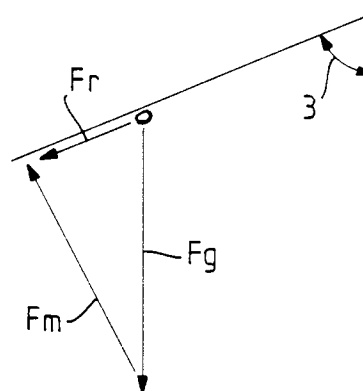


Fig. 4a.

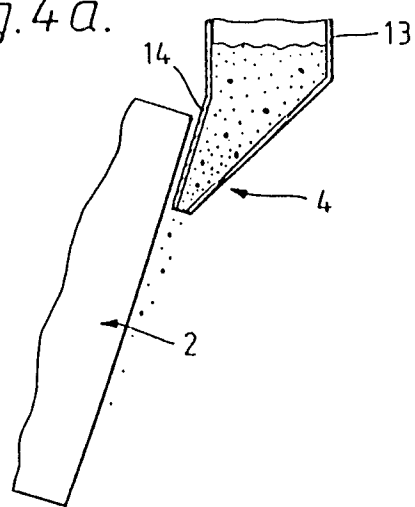


Fig. 4b.

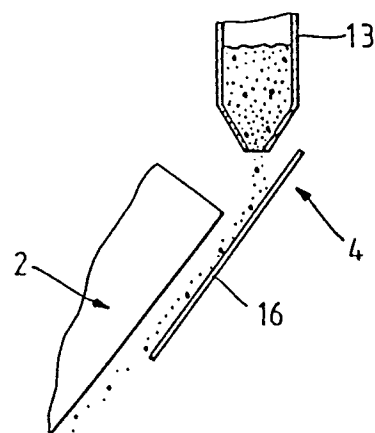


Fig. 4c.

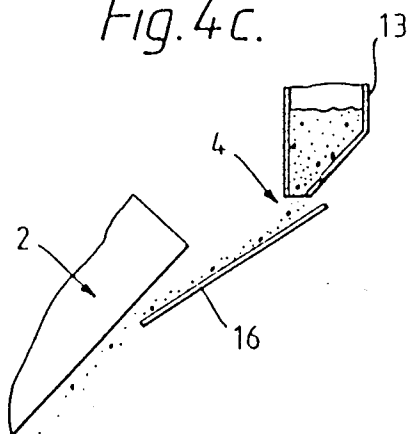
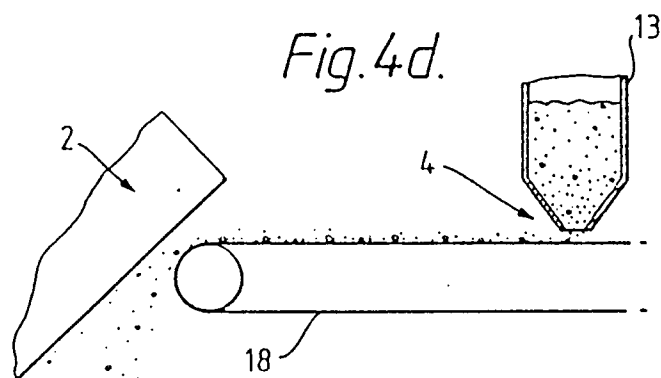


Fig. 4d.



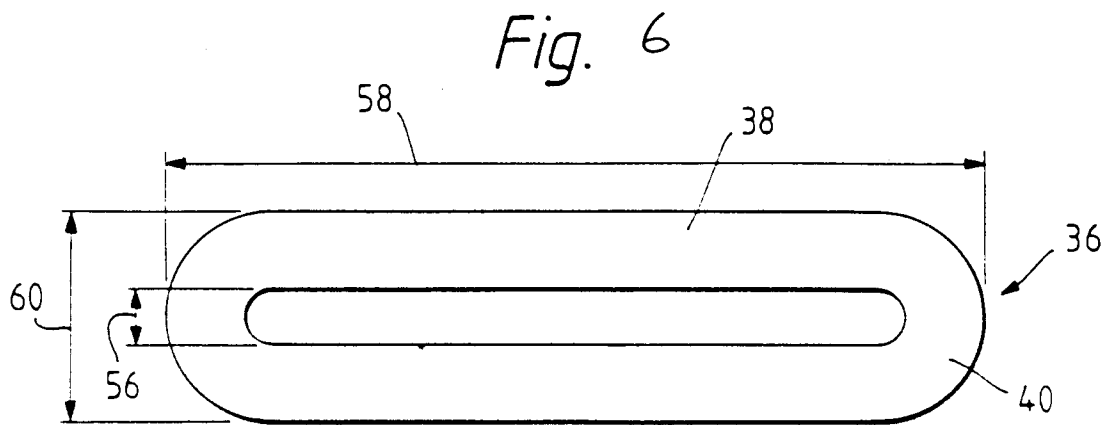
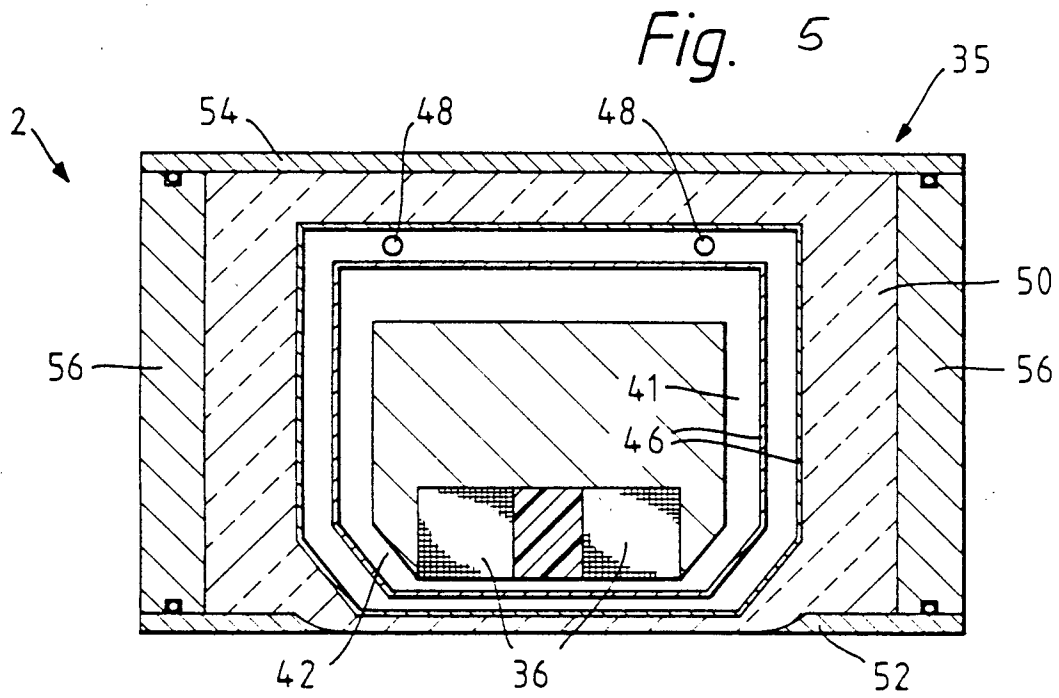


Fig. 7

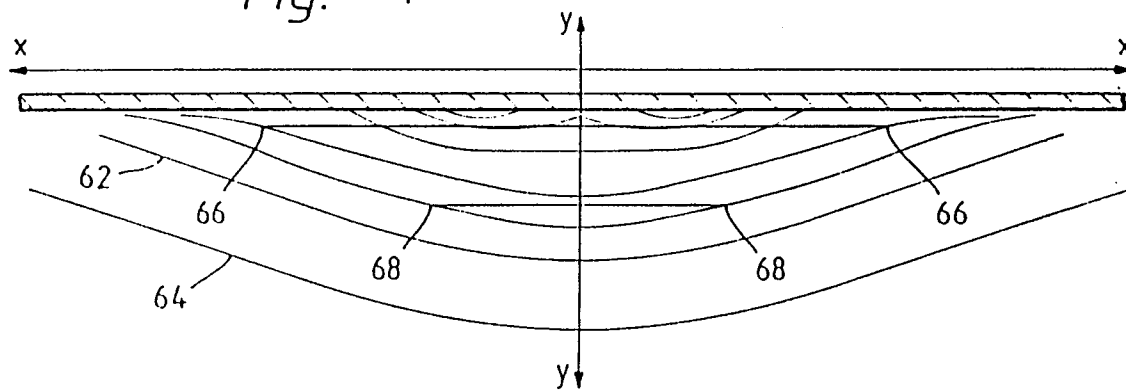


Fig. 8

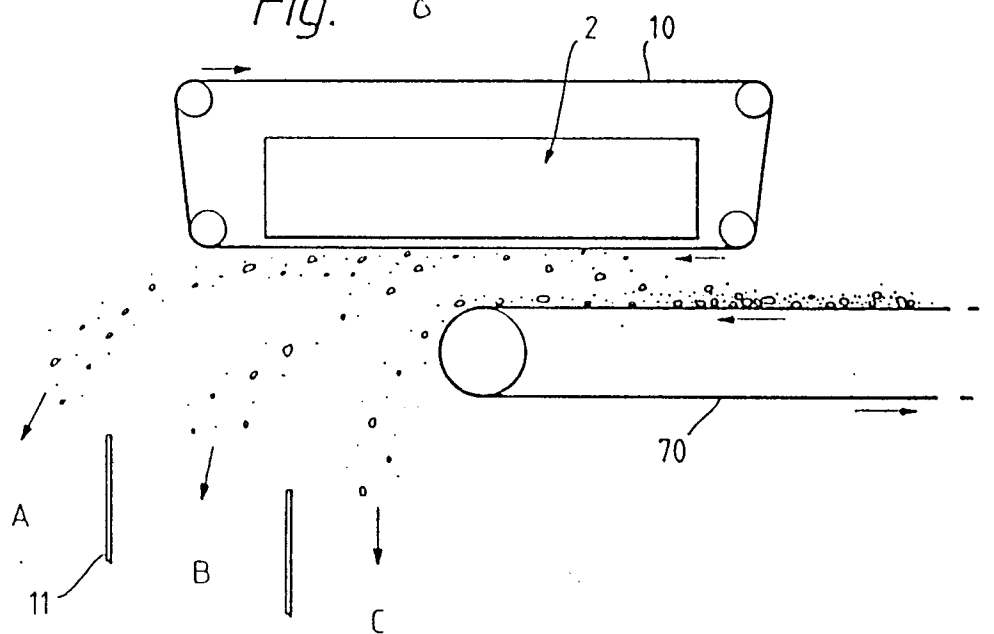


Fig. 9

