No. 691,007.

Patented Jan. 14, 1902.

F. A. M. SCHIECHEL.

MAGNETIC SEPARATOR.

(Application filed Nov. 26, 1898.)

(No Model.)

Fig. 2.

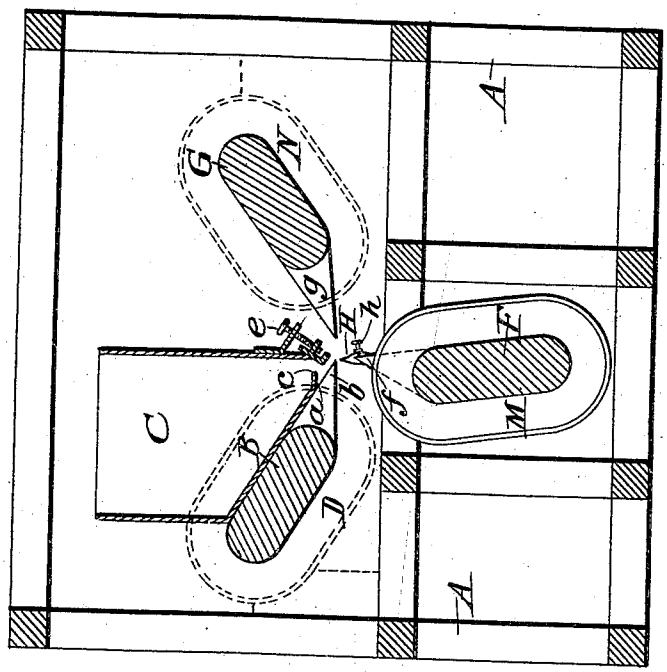


Fig. 1.

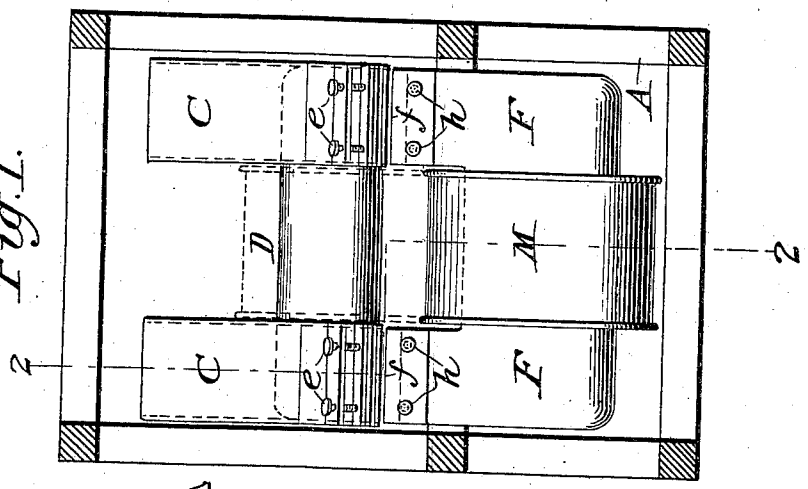
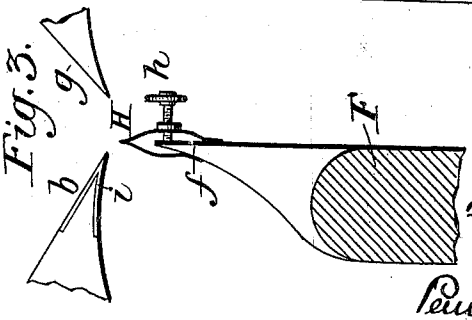


Fig. 3.



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UNITED STATES PATENT OFFICE.

FRIEDRICH ARTHUR MAXIMILIAN SCHIECHEL, OF FRANKFORT-ON-THE-MAIN, GERMANY.

MAGNETIC SEPARATOR.

SPECIFICATION forming part of Letters Patent No. 691,007, dated January 14, 1902.

Application filed November 26, 1898. Serial No. 697,534. (No model.)

To all whom it may concern:

Be it known that I, FRIEDRICH ARTHUR MAXIMILIAN SCHIECHEL, mining engineer, residing at Frankfort-on-the-Main, Germany, have invented new and useful Improvements in Magnetic Separators, of which the following is a specification.

My invention relates to improvements in the separation of magnetic materials from non-magnetic ones, and is especially adapted for the separation of the so-called "weakly" magnetic materials from quite non-magnetic ones or such of lower magnetic susceptibility. The improvements are more particularly adapted to be applied to the apparatus shown in the United States Patents Nos. 555,792, 555,793, and 555,794, of March 3, 1896, granted to John Price Wetherill, and in my United States application, Serial No. 679,030, of April 26, 1898.

Heretofore the strongest magnetic concentration of the lines of force has been produced by arranging a south pole close to and opposite each sharpened north pole. This has been effected either by means of the two poles of one and the same electromagnet or by means of alternating poles of a group of single electromagnets, which of course had to be arranged in such a manner that the path of the magnetic lines of force takes its course as in a so-called "closed" or "annular" magnet—that is to say, with the exception of the interruptions where north and south poles face each other (*i. e.*, the fields of operation of the magnetic separator) there must be at all points of the path of the lines of force sufficient iron masses to allow the lines of force which are produced in the magnet-coils to return back into themselves without any considerable loss by dispersion into the surrounding medium. The fields which are thus formed at the places of interruption had their greatest density at the polar edges and there was therefore nothing to prevent the magnetic materials which were supplied to one pole edge from jumping over to the other pole edge and becoming attached thereto, so that it was necessary to provide stripping-bands running around both pole edges for the purpose of removing the adhering particles in order to keep the edges always clean for the continuance of the operation. An essential improvement in this respect is embodied in the new magnetic separator of this invention, in which there are arranged opposite to the magnetic edge over which the material to be separated is supplied two separate wedge-shaped magnets having polarities opposed thereto. Thus when the material is supplied, for instance, to one north pole two south poles are arranged opposite to the said north pole. The two south poles are preferably mounted so that one south pole is higher than the north pole, while the other south pole is situated almost vertically below the north pole, so that the said north pole will serve in a well-known manner at the same time as a partition, on one side of which the magnetic material falls, while the non-magnetic material falls on the other side. The result of such an arrangement of poles is that the sum of the lines of force which issue from the north pole divides or spreads itself into the two south poles, so that the magnetic field thus produced is most concentrated at the supply-pole and is considerably weaker at the two other poles, the result being that no material can adhere to the latter and the stripping-belts can be dispensed with entirely.

A further great advantage consists also in the influence which can be exerted upon the form and position of the magnetic field. The amount of the force of magnetic attraction depends not only on the number of the lines of force, (intensity of the field), but also on the position and direction of the lines of force relatively to one another. A paramagnetic body is moved from a place of lower intensity to a place of higher intensity, and the motive force is greater under conditions otherwise equal the greater the difference of intensities of the two places is. Consequently there would be the greatest force of attraction in the magnetic field in which, other circumstances being equal, the lines of force have the greatest difference in direction one to the other. In the separating-machine of this invention this object is effectually attained by the lines of force issuing from the point of one magnet being torn apart, so to speak, by the points of the two other magnets, whereby the magnetic field receives an advantageous bunch-like shape.

Experiments made with a three-magnet machine and with a two-magnet machine which operated under otherwise completely-identical conditions have proved that the three-magnet machine consumed only forty per cent. of the electrical energy which was required by the two-magnet machine to effect the separation of one and the same mixture of ore.

A third advantage may be obtained with mixtures of minerals which are to be separated and which are of that kind that are free from strong magnetic constitutents—iron, magnetic iron, magnetic pyrites, roasted spathose ironstone, &c.—namely, that also the last stripping-band over the supplp-pole may be dispensed with.

It is important for the separation of weak magnetic materials that they should be supplied in direct proximity to the pole edges and with the least possible velocity to the gap between the pole edges. This has heretofore been effected chiefly by means of bands which passed around the pole edges, but which were liable to very rapid wear and which necessarily kept the material distant from the magnetic edge to the extent of the thickness of the band. The conveyer bands can now be dispensed with, as the mixture is supplied directly onto the surface of the magnet toward its edge and is left free at the edge without being conveyed by artificial means around the edge. For this purpose either the surface must have a suitable inclination, in order to allow the material to move by its own weight and overcome its own friction on the said surface, or artificial means of movement must be employed which remain above and do not move around the edge of the magnet. The material is preferably supplied close behind the magnet edge onto the surface of the magnet in regulated quantity and in such manner as to meet the said surface with the least possible velocity and then move along on the said surface. For this purpose a feed-hopper is preferably employed the delivery-aperture of which is directly behind the magnet edge, and whence the comminuted material falls out in such manner that it strikes at a small distance above the surface of the magnet first upon a transverse lip and then passes from the latter on the magnet. This admits of the magnet edge being made as sharp as possible, so as both to concentrate the lines of force as much as possible and prevent the magnetic particles from permanently adhering, since the adhesion is greater to a broad than to a very narrow edge. The operation of separation then takes place, as follows: The non-magnetic particles flow at once over the pole edge and fall off, while the magnetic particles have at first a tendency to adhere to the magnet edge, but are pushed onward by the material following and carried around the edge, whence they drop off.

In machines for the separation of weak magnetic mixtures of ore in which minerals of comparatively great susceptibility—for example, garnet, raw spathose ironstone, &c.—are to be extracted the cost of manufacture of the apparatus may be reduced, as in this case only the magnet onto whose poles the material is supplied need be provided with an electric coil, the two other cores then forming merely the iron masses necessary for the return of the lines of force produced in the magnet. These iron masses must be present in order that the lines of force shall not become dispersed into the air from the whole surface of the exciting-magnet, but shall be concentrated at and pass over thereto from the point of the magnet. By thus determining the direction of passing over they fulfil the function of imparting the bunch-like shape to the magnetic field before referred to.

It is obvious that the shape of the magnetic field may be varied at will and that by shifting the two magnets opposite to the supply-pole both the divergence of the bunch of lines of force and the position of the apex or crown of the bunch on the supply-pole can be altered. It is to be noted that, instead of two, three or more magnets might be arranged opposite to the supply-pole.

The accompanying drawings illustrate a mode of carrying out the invention which combines all the improvements.

Figure 1 is a front elevation of the apparatus. Fig. 2 is a section on the line 2 2 of Fig. 1. Fig. 3 is a separate view of the poles on a larger scale.

The upper stirrup-shaped magnet B is mounted in an inclined position in the wooden framing A. It is provided with the charging hoppers or trunks C C and is energized by means of the coil D. The mixture charged into either hopper C impinges upon and is arrested by a horizontal lip *a*, whence it falls between the front edge *c* of this lip and the gage-bar E onto the magnet B, down which it slides toward the edge *b*, which I call the "supply-pole," the gage E being adjustable by means of screws *e* to regulate the amount of the material supplied. It is important that this pole edge *b* be as sharp as possible in order to prevent a long beard of magnetic particles from adhering thereto. This pole edge is brightly polished or covered with a brightly-polished steel plate in order that the particles slipping over it shall be hindered as little as possible by friction. In many cases this covering may be made of non-magnetic material *i*, as shown in Fig. 3, in order to prevent the undermost particles in the stream of material being permanently retained by the magnet. Vertically below the pole edges *b b* are the pole edges *f f* of the magnet F, which are covered by caps of non-magnetic material adjustable by means of set-screws *h* to suit the various materials. In consequence of this arrangement the non-magnetic particles fall over the cap H, while the magnetic particles are drawn through the gap or interval. Opposite to, but slightly higher than the pole

edges *b b*, are the pole edges *g g* of the magnet G. The coils M N of magnets F and G may be dispensed with in the case of materials of magnetic properties, such as those of garnet and spathose ironstone.

Now what I claim as my invention, and desire to secure by Letters Patent, is the following:

1. In a magnetic separator, the combination of a supply-magnet having a tapered pole-piece, a plurality of magnets the pole-pieces of which are of like polarity with respect to each other, but of unlike polarity with respect to the supply-magnet, the pole-pieces of similar polarity facing the pole-piece of the supply-magnet with an intervening space between, and mechanism for feeding the material to be treated over the edge of the supply-magnet and between it and the other two magnets.

2. In a magnetic separator, the combination of a supply-magnet having a tapered pole-piece, and arranged in a horizontally-inclined position so that the material to be treated will gravitate over its edge, and a plurality of magnets the pole-pieces of which are of like polarity with respect to each other, but of unlike polarity with respect to the supply-magnet, the pole-pieces of similar polarity facing the pole-piece of the supply-magnet with an intervening space between through which the material passes from the supply-magnet.

3. In a magnetic separator, the combination of a supply-magnet having a tapered pole-piece over the edge of which the material to be treated passes, and a plurality of magnets the pole-pieces of which are of opposite polarity to that of the supply-magnet, one of said last-named magnets having its pole-piece arranged in substantially the vertical plane of the pole-piece of the supply-magnet, and below the same, and the pole-piece of another of the last-named magnets being arranged in substantially the horizontal plane of the supply-magnet with intervening spaces between the respective pole-pieces.

4. In a magnetic separator, the combination of a supply-magnet having a tapered pole-piece and arranged in a horizontally-inclined position so that the material to be treated will gravitate over its edge, and a plurality of magnets whose pole-pieces are of opposite polarity to that of the supply-magnet, one of said last-named magnets having its pole-piece arranged below and in substantially the vertical plane of that of the supply-magnet, and another of said last-named magnets being arranged in a horizontally-inclined position with its pole-piece in substantially the horizontal plane of that of the supply-magnet with intervening spaces between the respective pole-pieces.

5. In a magnetic separator, the combination of three magnets having tapered pole-pieces pointing toward one another with intervening spaces between the respective pieces, and over the edge of one of which pieces the material to be treated is adapted to pass into and through the space between the other pieces.

6. In a magnetic separator, the combination of three magnets having tapered pole-pieces pointing toward one another with intervening spaces between the respective pieces, over the edge of one of which pieces the material to be treated is adapted to pass into and through the space between the other pieces, and an energizing-coil on that magnet only from which the material passes to the intermediate space.

7. In a magnetic separator, the combination of three magnets having tapered pole-pieces pointing toward one another in a substantially radial arrangement, and a central space intermediate the respective pole-pieces, and means for passing the material to be treated from the edge of one of the pole-pieces into the intermediate space.

8. In a magnetic separator, the combination of three magnets having tapered pole-pieces pointing toward one another in a substantially radial arrangement, some of said magnets having energizing-coils, and others consisting of cores only.

9. In a magnetic separator, the combination of a magnet having a tapered pole-piece arranged in a horizontally-inclined position, a feed-hopper located above said magnet and having its outflow near the edge of the pole-piece, and a horizontal lip or flange projecting within the hopper to deflect the material slightly just before its passage out of the hopper.

10. In a magnetic separator, the combination of a magnet having a tapered pole-piece and arranged in a horizontally-inclined position, a feed-hopper located above said magnet and having its bottom inclined and its outflow near the edge of the pole-piece, a horizontal lip or flange on one side of said outflow to deflect the material slightly just prior to its passage out of the hopper, and an adjustable gage at the opposite side.

11. In a magnetic separator, the combination of a vertically-disposed magnet having a tapered pole-piece, and arranged in the path of delivery of the material to be treated, said magnet being adapted to receive the separated constituents of the material on opposite sides thereof, and an adjustable cap of non-magnetic material secured to the edge of the pole-piece.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRIEDRICH ARTHUR MAXIMILIAN SCHIECHEL.

Witnesses:

OTTO FELLNER,

JEAN GRUND.