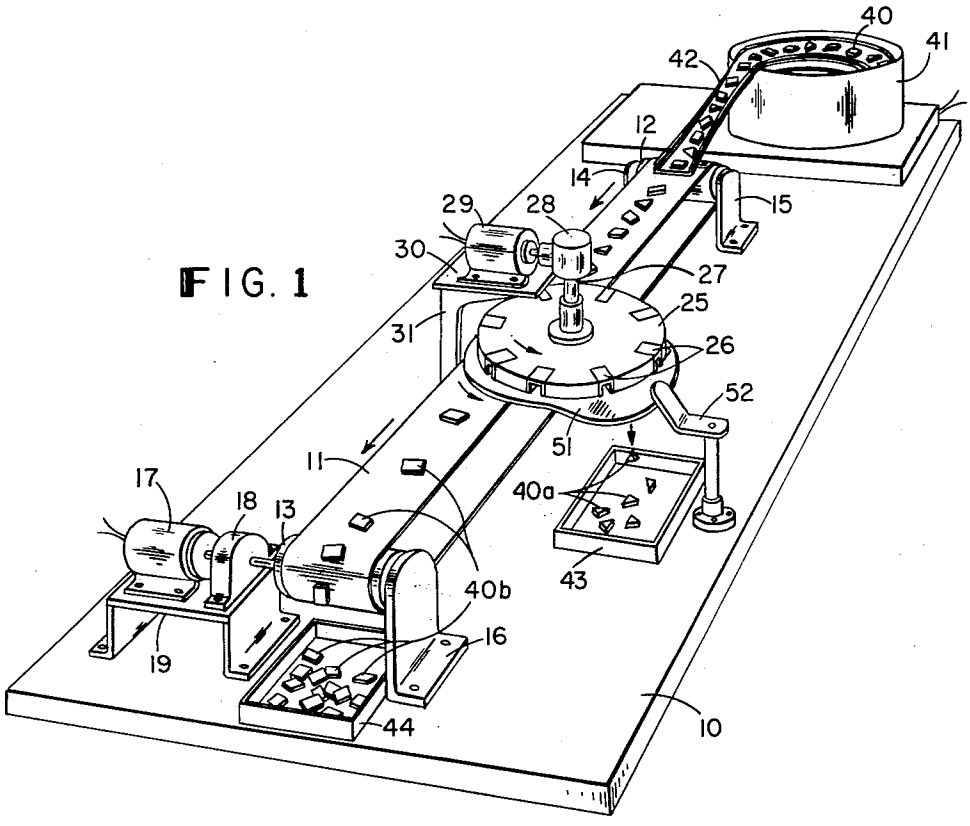
Jan. 2, 1962 W. C. WOODS 3,015,394

MAGNETIC CONVEYING APPARATUS

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FIG. 1



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FIG. 2

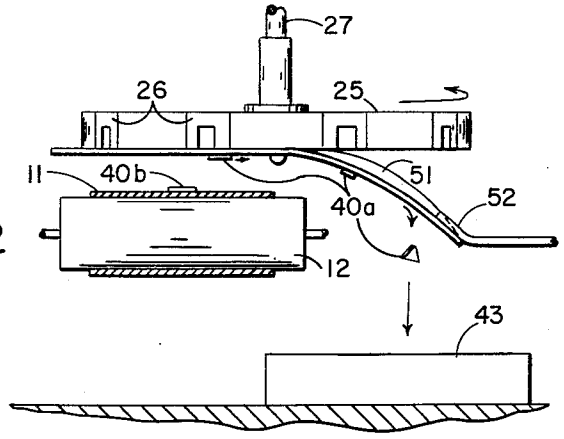
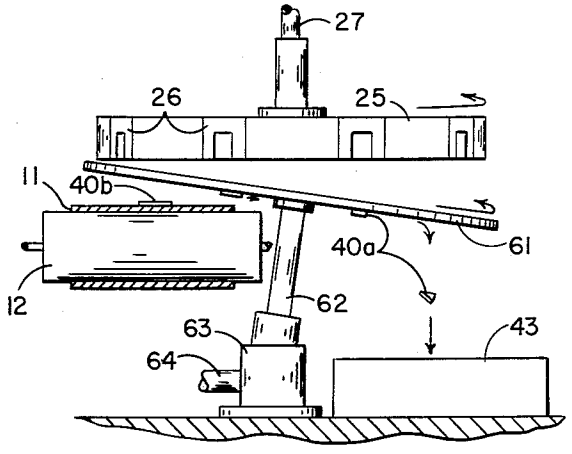


FIG. 3



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MAGNETIC CONVEYING APPARATUS

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3 Claims. (Cl. 209—222)

This invention relates to the conveying of magnetic materials by the use of magnetic attraction. More particularly, it is concerned with apparatus for automatically transferring small magnetic elements and for automatically separating small magnetic elements from a quantity of magnetic and non-magnetic elements.

Apparatus which utilize the phenomenon of magnetic attraction for sorting material having magnetic properties from material not having magnetic properties are widely used in certain industrial applications. In these well known types of magnetic separators a mixture of materials generally proceeds along a path. A magnetic field is applied to the mixture in a region of the path whereby magnetic material is attracted out of the path. The magnetic material is then deposited at a point removed from the path. Non-magnetic material proceeds along the path unaffected by the presence of the magnetic field. Apparatus of this general type have found widespread use in the segregation of magnetic ores and in the separation of magnetic and non-magnetic scrap metals. Of necessity, apparatus employed in these applications are of large capacity for handling mixtures of materials in bulk. Magnetic separators similar to those employed for these applications but of a scale and nature to handle extremely small, fragile, discrete elements individually have not been found to be completely satisfactory.

In one form of magnetic separating apparatus of well known type a mixture of materials is carried along a first conveyor belt. A second conveyor belt running transverse to the first belt passes over a region of the first belt. A magnet is located over the region of intersection of the two belts. Magnetic material moving along on the first belt is attracted by the magnetic field as it passes under the second belt. It is held up against the underside of the second belt by the magnetic force, and is moved by the second belt transversely to the direction of movement of the first belt and of the magnetic field. When the magnetic material has been moved to a region of sufficiently reduced magnetic influence, the magnetic material drops from the second belt into a suitable receptacle. However, if the mixture of materials consists of a quantity of small, discrete elements advancing along the first conveyor belt, the individual magnetic pieces tend to skid back along the underside of the second belt in seeking to remain in the strongest portion of the magnetic field. This tendency for the elements to accumulate is particularly troublesome with very light, discrete elements because there is no bulk flow of material to force the particles along and the particles are readily pulled back into the magnetic field as soon as they start to fall from the belt.

Another form of apparatus also employs a conveyor belt for carrying the mixture of materials. A set of electromagnets is affixed to a rotating support so that each magnet passes over the belt and over a suitable depositing receptacle removed from the belt. Each magnet is energized as it passes over the belt and de-energized as it passes over the depositing receptacle. In scaling apparatus of this type down to handle small, discrete elements individually, extremely small electromagnets and commutating systems are required. With elements of this nature, the slightest amount of residual magnetism

present after cessation of the magnetizing current is sufficient to prevent some elements from dropping.

Therefore, it is an object of the present invention to provide an improved apparatus for conveying magnetic elements by the use of magnetic attraction.

It is a more specific object of the present invention to provide automatic magnetic separating apparatus for precisely and accurately sorting magnetic elements from a mixture of magnetic and non-magnetic elements which are small, fragile, and discrete.

Briefly, in accordance with the foregoing objects of the invention, apparatus is provided wherein a quantity of elements is subjected to a moving magnetic field which attracts any elements which are magnetic in nature and transports them to a depositing area where they are forced out of the magnetic field into the depositing area by separating means lying interposed between the source of the magnetic field and the magnetic elements.

More particularly, in apparatus of the invention elements are carried along a path, as for example, by a conveyor belt. A plurality of magnets mounted in a carrier pass in sequence over a portion of the belt and over a depositing area removed from the belt. A non-magnetic separator plate or baffle is located beneath the magnets and carrier over the belt and the depositing area. The distance between the magnets and the separator plate in the region over the depositing area is greater than the distance between the conveyor belt and the magnets in the region over the aforementioned portion of the belt.

Elements carried along the conveyor belt pass under the carrier and through the magnetic field created by one of the magnets. Magnetic elements are attracted by the magnet and are held up against the underside of the separator plate. The magnetic elements move along with the magnet while maintaining contact with the underside of the separator plate. As the magnet and magnetic elements approach the depositing area, the interposed separator plate causes them to diverge along a direction generally transverse of their direction of movement. When the magnetic elements and the magnet are separated by a distance great enough for the force of gravity on the elements to overcome the force of the magnetic field, the elements drop into the depositing area.

Additional objects, features, and advantages of the apparatus of the invention will be apparent from the following discussion and the accompanying drawings wherein:

FIG. 1 is a perspective view of apparatus according to the invention having a flexible separator plate rotating with the magnet carrier;

FIG. 2 is an elevational view partially in cross-section showing portions of the apparatus of FIG. 1; and

FIG. 3 is an elevational view partially in cross-section showing portions of a modification of the apparatus of FIGS. 1 and 2 having a tilted separator plate mounted independently of the magnet carrier but rotating in synchronism with the carrier.

Apparatus according to the invention as shown in FIGS. 1 and 2 includes a conveyor belt **11** supported between two revolving drums **12** and **13**. The axle of drum **12** is supported at either end in bearing mounts **14** and **15** secured in spaced relation on base member **10**. The axle of the second drum is supported at one end in a bearing mount **16**, and the other end is attached to an electric motor **17** through reduction gears **18**. The motor and reduction gears are supported on a platform **19**. The electric motor rotates the drum **13** and thus drives the conveyor belt in the direction indicated by the arrows.

A generally cylindrical support or carrier **25** of a non-magnetic material such as, for example, aluminum is located above the conveyor belt. The diameter of the carrier is approximately twice the width of the belt, and the

carrier is positioned with its center over one edge of the belt. A plurality of small permanent magnets **26** are set at equal intervals around the periphery of the carrier in order to provide a plurality of individual magnetic fields. The carrier has a central shaft **27** which is attached to a set of reduction gears **28** which in turn is coupled to an electric motor **29**. Both the motor and the reduction gears are mounted on a platform **30** which is supported on base plate **10** by a bracket **31**. The motor rotates the magnet carrier in the direction indicated by the arrow. Each magnet passes in sequence over a portion of the conveyor belt and over an area removed from the belt. The relative rates of travel of the conveyor belt and the magnet carrier are such that all of the belt is subjected to a magnetic field during some part of its traverse under the carrier.

As can best be seen in FIG. 2 a circular separator plate **51** of a flexible non-magnetic material is attached to the magnet carrier **25** at their centers. A deflector arm **52** holds the edge of the separator plate in the region over the depositing area below the level of the surface of the conveyor belt **11**. As the carrier rotates, the separator plate rotates with it and as each portion of the plate approaches the deflector arm it is bent downward.

A vibrating bowl type of feeder **41** and a track **42** connecting the feeder to the conveyor belt provide for feeding elements onto the conveyor belt. A receptacle **43** for magnetic elements is located in the depositing area under the separator plate in the region removed from the conveyor belt. A second receptacle **44** for non-magnetic elements is located at the end of the conveyor belt.

When employing the apparatus described hereinabove for sorting small, discrete elements according to their magnetic properties, a mixture of elements **40** is placed in the bowl of the vibrating feeder **41**. These elements are fed to the edge of the feeder and down the track **42** onto the conveyor belt **11**. They are fed onto the belt one at a time as discrete, individual elements. As each element passes along on the conveyor belt to the region where the magnet carrier **25** overlies the conveyor belt, it is subjected to the field of one of the revolving magnets **26**. Magnetic elements **40***a* attracted by a magnet are held against the underside of the separator plate; and magnet, separator plate, and elements follow the motion of the carrier with no relative movement horizontally. As the magnetic elements are moved beyond the edge of the conveyor belt, the portion of the separator plate which they contact is deflected downward by the arm **52** thus carrying the elements farther away from the magnet in the direction of the vertical axis of the magnet. When the elements are deflected into a region of the magnetic field which is not sufficiently strong, the elements drop into the receptacle **43**. Non-magnetic elements **40***b* continue on their path along the conveyor belt unaffected by the magnetic fields to which they are subjected. These elements reach the end of the belt and drop into a receptacle **44**.

The apparatus described hereinabove has found particular utility in the sort of the whole pieces of semiconductor material from scrap material according to a method of rendering the scrap pieces magnetic as disclosed by Ralph B. Soper and Richard C. Tonner in application Serial No. 754,859 filed August 13, 1958, now Patent No. 2,978,804 issued April 11, 1961, and assigned to the assignee of the present invention. Scrap pieces of semiconductor material are formed from material along the edges of wafers which are subdivided to form the desired whole pieces of semiconductor material. These scrap pieces are rendered magnetic by virtue of a layer of magnetic material placed along the edges of the wafer prior to subdivision into pieces. The whole pieces of semiconductor material typically are from .025 to .240 inch square and from .0025 to .008 inch thick. These pieces are fragile and subject to breakage and abrasion if tumbled or otherwise roughly handled in bulk. In addition, it is considered extremely desirable to insure that complete separation of whole pieces and scrap pieces is achieved. In employing the apparatus described, a mixture of non-magnetic whole pieces and magnetic scrap pieces is placed in the feeder bowl **41**. The pieces are fed onto the belt one at a time as discrete elements thus eliminating rough handling and insuring that each piece will be individually subjected to a magnetic field. Magnetic scrap pieces are picked up by the magnets **26** mounted in the carrier **25** and are forced out of the magnetic field by the separator plate **51** to drop into the receptacle **43** located in the depositing area. Non-magnetic whole pieces pass from the feeder to the receptacle **44** at the end of the conveyor belt unaffected by the action of the magnets.

A modification of the apparatus is shown in FIG. 3. The separator plate **61** is a rigid, flat, circular disc of non-magnetic material having its center directly beneath the center of the magnet carrier **25**. It is tilted at an angle to the conveyor belt **11** and magnet carrier so that in the region over the depositing area it extends below the surface of the conveyor belt. A driving shaft **62** is attached to the center of the separator plate and is mounted in a gear box **63**. A motor (not shown) is connected to a drive shaft **64** to rotate the separator plate through the gear box and shaft **62**. The magnet carrier **25** and the separator plate are rotated at the same rate. Magnetic elements **40***a* attracted by a magnet **26** are held against the underside of the separator plate. The magnet, separator plate, and magnetic elements move together as the separator plate and carrier rotate in synchronism. As the magnetic elements are moved beyond the edge of the conveyor belt, they are forced farther away from the magnet along the direction of the vertical axis of the magnet while maintaining the same horizontal position relative to the magnet. The elements drop from the separator plate into the receptacle **43** when they have been moved sufficiently far from the magnet.

Although two embodiments of the invention have been shown and described hereinabove, other modifications of the apparatus are also possible without departing from the spirit and scope of the invention. Various combinations of the features disclosed may be employed by those skilled in the art while following the teachings set forth. For example, the apparatus may be modified to be used for transferring magnetic elements from one point to another. It may also be adapted for separating magnetic elements according to a range of magnetic properties by providing for a set of depositing areas along the contour of the separator plate.

What is claimed is:

1. Apparatus for handling magnetic elements including conveying means for moving a quantity of elements along a path, carrier means supporting a plurality of magnets in a horizontal circular array in a plane generally parallel to said path, driving means for rotating said carrier means and passing each magnet in sequence above a portion of said path and subsequently above an area removed from said path, a separator plate of non-magnetic material interposed between said magnets and said path and between said magnets and said area, said separator plate lying adjacent the magnets in the region above said path and below the level of said path in the region above said area removed from the path, and means for rotating said separator plate about a point directly below the center of the circular array of magnets in synchronism with the rotation of said carrier means, whereby magnetic elements attracted by a magnet as the magnet passes over the path are held in contact with the underside of the separator plate by magnetic attraction and are moved laterally with the rotation of the carrier means and the separator plate from over said path to over said area removed from the path, the vertical distance between said elements and said magnet increasing as the elements and

the portion of the separator plate in contact with the elements pass over said area removed from the path until the magnetic attraction is not sufficient to hold the elements against the underside of the separator plate.

2. Apparatus for handling magnetic elements including conveying means for moving a quantity of elements along a path, a carrier supporting a plurality of magnets in a circular array in a plane generally parallel to said path, driving means for rotating said carrier and passing each magnet in sequence over a portion of said path and subsequently over an area removed therefrom, a flexible circular disc of non-magnetic material coaxial with and extending at least to the periphery of said array of magnets lying interposed between said magnets and said path and extending also between said magnets and said area removed from the path, said disc being mounted at its center to rotate with the array of magnets, and deflecting means for continuously distorting said disc during rotation so that the disc in the region over said area is at a distance from said magnets greater than the distance between said path and the plane of said array of magnets, whereby magnetic elements attracted by a magnet as it passes over said portion of the path are held against the underside of the disc and are moved laterally with the rotation of the carrier and the disc from over said path to over said area removed from the path, the vertical distance between said elements and said magnet increasing as the elements and the portion of the disc in contact with the elements approach the region over said area until the magnetic attraction in said region is not sufficient to hold the elements against the underside of the disc.

3. Apparatus for handling magnetic elements including conveying means for moving a quantity of elements along a path, a carrier supporting a plurality of magnets in a horizontal circular array in a plane generally parallel to said path, driving means for rotating said carrier and passing each magnet in sequence over a portion of said path and subsequently over an area removed therefrom, a flat, circular disc of non-magnetic material lying interposed between said magnets and said path and between said magnets and said area removed from the path and having its center beneath the center of said carrier, the plane of said flat disc lying at an angle to the plane of said magnets, so that the disc is more closely adjacent said carrier in the region above said path than in the region above said area removed from the path, a portion of the disc in the region above the area removed from the path lying below the level of the path, and driving means for rotating said disc about its center in synchronism with the rotation of said carrier, whereby magnetic elements attracted by a magnet as it passes over said portion of the path are held against the underside of the disc and are moved laterally with the rotation of the carrier and disc from over said path to over said area removed from the path, the vertical distance between said elements and said magnet increasing as the elements and the portion of the disc in contact with the elements pass over said area removed from the path until the magnetic attraction is not sufficient to hold the elements against the underside of the disc.

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