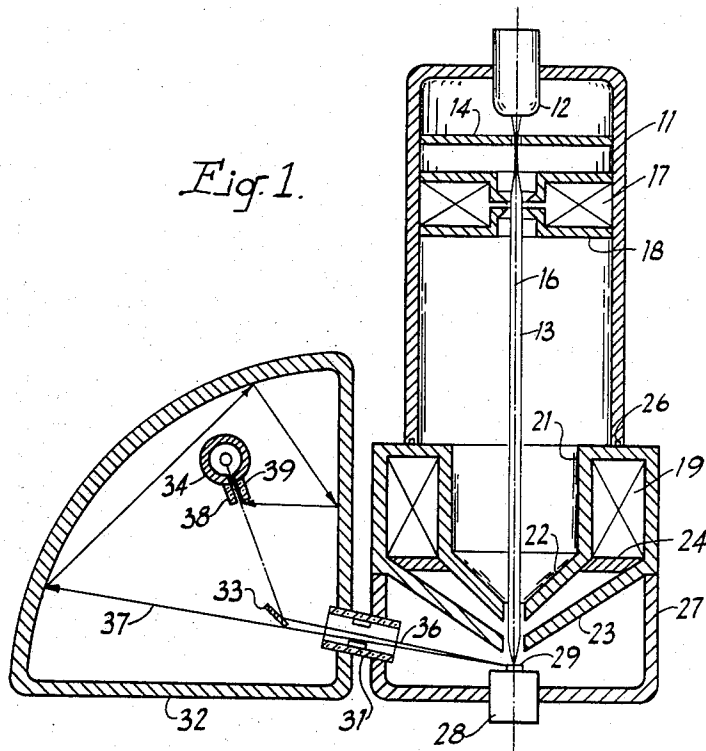
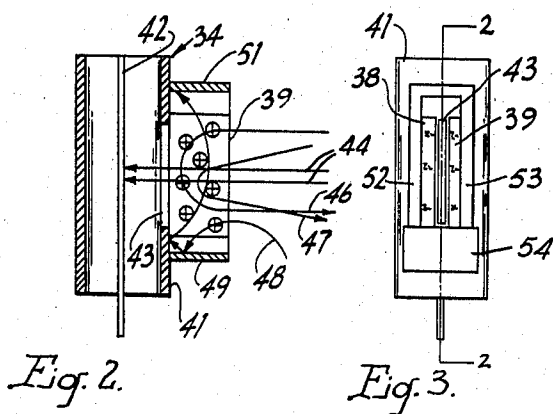
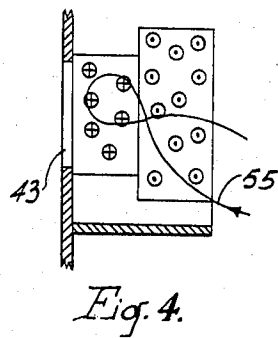


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FOR REMOVING ELECTRONS FROM AN X-RAY BEAM
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CHARGE PARTICLE BARRIER CONSISTING OF MAGNETIC MEANS FOR REMOVING ELECTRONS FROM AN X-RAY BEAM

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ABSTRACT OF THE DISCLOSURE

A magnetic slit forming a charged particle barrier in electron beam apparatus by a magnetic field across the slit. The strength of the field is sufficient to deflect even the electrons with the highest energy in the apparatus so that they cannot penetrate entirely through the field but will be returned to the same side of the field from which they came. A transverse wall beyond the end of the slit toward which the charged particles are deflected prevents such particles from entering along the only path by which they would be deflected directly through the slit.

This invention relates to means for deflecting undesired charged particles while permitting desired radiation to pass along the same path in an evacuated system. In particular, it relates to magnetic means for substantially completely removing charged particles, such as electrons, from continuing along a common path with X-rays.

In apparatus for the measurement of various types of electromagnetic radiation, such as X-rays for example, it may happen that there are undesired charged particles, such as electrons or ions or other particles, which, if they impinge upon the detector, will produce a result like that of the desired radiation and hence will give a false reading of the intensity of the desired radiation. The present invention provides means to prevent such undesired charged particles from impinging upon the detector of a system of this type. The means for barring the undesired charged particles by deflecting them aside includes a magnetic field formed by suitable means immediately adjacent to the entryway by which both the charged particles and the desired radiation enter the detector. This magnetic field diverts the charged particles along curved lines away from the detector proper. In addition, a wall impervious to the charge particles is set up in such a location as to prevent such particles from entering along the limited number of pathways, which would permit them to pass through the magnetic field and into the detector.

The invention will be described in greater detail in connection with the drawings in which:

FIG. 1 shows a simplified and schematic form of microprobe analyzer, using a charged particle trap constructed according to the invention;

FIG. 2 shows a cross-sectional view of a detector of the type shown in FIG. 1;

FIG. 3 shows a modified form of magnetic structure for use in connection with detectors of the type shown in FIG. 2; and

FIG. 4 shows a still different form of magnetic structure for use in connection with the detector shown in FIG. 2.

The microprobe analyzer of FIG. 1 has a vacuum-tight casing 11 of generally cylindrical shape with an electron source 12 at one end thereof producing a beam 13 of electrons. This beam is partially formed with the aid of an anode 14 having a central aperture along the axis 16 through which the beam 13 can pass. The electrons in the beam 13 are initially partially focused by a mag-

netic lens formed by current passing through a coil 17 surrounded by a suitable magnetic structure 18.

Near the lower end of the casing 11 is a second coil 19 enclosed within a suitable ferromagnetic structure 21, having conical extensions 22 and 23 which cooperate to form a second magnetic lens. An annular disc 24 holds the coil 19 within the proper space within the ferromagnetic structure 21. The ferromagnetic structure 21 may be sealed vacuum-tight to the casing 11 by any suitable means, the means here being an O-ring 26, although other means will serve equally well.

The lower end of the microprobe analyzer is closed vacuum-tight by a short hollow closed cylinder 27 through which a structure 28 is inserted to hold the material 29 to be analyzed. Commonly, the structure 28 is capable of being rotated or translated in any direction laterally with respect to the axis 16 of the beam 13.

In operation, the electrons of the beam 13 are focused to a very fine point on the specimen 29, causing this specimen to emit X-radiation along with charged particles (usually electrons) which may be reflected from the sample 29 or may be knocked out of the sample 29 by the impinging electrons of the beam 13. The X-radiation along with some of the electrons passes out of the microprobe section by way of a hollow tube 31 sealed vacuum-tight into the wall of the cylinder 27.

The tube 31 is also connected vacuum-tight to a second housing, sometimes referred to as a goniometer, 32 which contains an analyzing crystal 33 and a detector 34. In accordance with the well-known principles of X-ray spectroscopy, the crystal 33 and the detector 34 are usually arranged to rotate about a common axis, with the rate of rotation of the detector being twice that of the crystal in accordance with the well-known Bragg law.

In addition to the X-rays generated by the sample 29 when struck by the electron beam 13 and which travel along an axis 36 through the tube 31 to be reflected from the crystal 33 and into the detector 34, there are also electrons that follow more or less the same path as indicated by reference character 37. These charged particles may rebound many times from the inner walls of the chamber 32, as indicated by the path of arrows, until they reach the detector 34. The path indicated is only exemplary and is by no means the only possible path. These charged particles have the same effect on the detector 34 as a photon of X-radiation and, therefore, they produce a false signal in the detector which is indistinguishable from the desired signal produced by the X-radiation. The undesired signal may be thought of as background noise. In order to avoid this background noise, the present invention provides means for producing a magnetic field immediately outside of and adjacent to the detector 34. This magnetic field is formed between two magnets 38 and 39 or, alternatively, by using electromagnets, as will be described more fully in connection with FIG. 2.

FIG. 2 shows simply the detector 34 of FIG. 1 together with one of the magnets 39, the other magnet being omitted because of the cross-sectional view. The detector includes a cylindrical outer shell 41 and a central wire 42. A suitable gas within the cylinder 41 is ionized by X-radiation to produce an electrical signal detectable at the central wire 42 by a suitable electric circuit of the type well-known in the art. The radiation, together with undesired charged particles, enters the outer cylinder 41 through a slit 43 that extends longitudinally along the cylinder 41. The path desired is indicated by arrows 44, while some typical paths of the undesired charged particles are indicated by arrows 46-48. The magnet 39 is so polarized that the surface facing upward, that is out of the plane of the paper, is a south magnetic pole, as indi-

cated conventionally by the crosses which represent lines of magnetic flux going into the south pole, i.e., into the plane of the paper. In this kind of a field negatively charged electrons traveling along parallel to the plane of the paper as indicated by arrow 46 would be deflected along partial circular paths and would turn back out of the magnetic field as indicated. The radius of the circle would depend upon the energy of the electrons, the higher energy electrons, traversing paths having larger radii of curvature, as indicated by the arrow 46, and lower energy electrons, traversing paths having smaller radii of curvature, as indicated by arrow 47. For the sake of simplicity, the electrons are all considered as if they were moving in or parallel to the plane of the paper. This, of course, is not always the case as indicated by the path traversed by the series of arrows indicated by reference character 37 in FIGURE 1 but the basic effect of the magnetic field of the magnet 39 is the same in any event.

There is a region centered at the middle of the slit 43 within which the barrier effect of the magnetic field is at a maximum. Assuming that the magnetic field is uniform in a direction perpendicular to the plane of the drawing, this field of maximum barrier effect extends throughout a semicircular region having a radius R. The magnetic field must, of course, extend out beyond the radius R by a distance sufficient to cause even the electrons with the highest energy to make a complete circle before penetrating the region within the radius R. The electrons that penetrate the greatest distance into the magnetic field are those that pass through the edge of the magnetic field substantially tangentially. Of course, this is a simplification because the actual magnetic field has no sharp boundaries. However, accepting this simplification as being at least generally true, the magnetic field will have to extend a distance d beyond the radius R, where d is the diameter of the circular path that would be followed by an electron having the highest energy and passing through the edge of the magnetic field at grazing incidence.

Even with this magnetic barrier, some electrons will follow a path indicated by reference number 48 and will strike the wall 49 and drive off secondary electrons that will enter the slit 43. However, these electrons will be relatively few in number in comparison to the electrons that are barred from entry into the slit by means of the magnetic field.

FIG. 3 shows a view of the detector looking directly into the slit 43 of the cylinder 41 with both of the magnets 38 and 39 in view. These magnets are held between the opposite legs 52 and 53 of two yokes, each of which is generally U-shaped and which has a high magnetic permeability. Such a yoke may be made out of soft steel or the like. This yoke, in addition to holding the magnets 38 and 39, forms part of a magnetic return path between the outwardly facing surfaces of the two magnets so as to reduce the total reluctance of the field. In order further to limit the paths along which the undesired charged electron particles might enter the slit 43, a short cover of non-magnetic material 54 may be placed across the closed end of the U-shaped yoke joining the two legs 52 and 53.

In determining the strength of the magnetic field between the magnets 38 and 39, the length of the slit 43 must be taken into account. Mathematically, the radius of curvature of the electrons having the highest energy, as illustrated in the case of the ray path 46, may be determined and this will form the limiting condition since the magnetic field must be strong enough to deflect such high energy electrons along a semicircular path and back away from the detector. For an anode voltage of the anode 14 in FIG. 1, and a separation between the magnets 38 and 39 of approximately 1 mm., it has been found that a field of approximately 1500 gauss achieved by ferroxcube magnets having dimensions of about 12 x 34 mm. is sufficient

to repel all electrons away from a detector tube having a slit 43 with a length of about 20 mm.

Electrons entering with a component of velocity parallel to the magnetic field may strike the surfaces of magnets 38 or 39 and either be scattered or cause secondary electrons to be released. The effect of this can be limited by coating the magnetic pole pieces 38 and 39 with carbon and by placing a slit in front of the magnetic field.

FIG. 4 shows a further refinement of the invention with an additional pair of magnets, only one of which is shown, located adjacent to the magnets 38 and 39 on the side thereof away from the cylindrical wall 41 of the detector 34. As may be seen by the arrow 55 representing the path of an electron, the additional magnets produce a field which makes it even less likely that an electron will be able to find its way into the slit 43.

While this invention has been described in terms of a specific embodiment, those skilled in the art will recognize that modifications may be made without departing from the true scope of the invention, as defined by the following claims.

What is claimed is:

1. In an evacuated system comprising a detector to detect a desired radiation, and a source of the desired radiation and of undesired charged particles, having a known maximum energy, said detector having a wall with edges defining an entryway through which said radiation and said particles enter said detector, means for preventing said undesired particles from passing through said entryway, said means comprising: magnetic poles immediately adjacent to said entryway for producing a magnetic field substantially transverse to the path of said radiation into said entryway, the length of said poles along said path being at least as great as the diameter of the circular path of the maximum energy particles in said magnetic field; and a wall impervious to said particles at one side of said field toward which said particles are deflected upon entering said field.

2. In an evacuated system comprising a detector to detect a desired radiation, and a source of the desired radiation and of undesired charged particles having a known maximum energy, said detector having a wall with edges defining an elongated slit entryway through which said radiation and said particles enter said detector, means for preventing said undesired particles from passing through said entryway, said means comprising: a pair of flat magnets adjacent to said entryway and extending in the direction of said slit and on each side thereof for producing a magnetic field substantially perpendicular to said slit and transverse to the path of said radiation into said slit, the length of said magnets along said path being at least as great as the diameter of the circular path of the maximum energy particles in said magnetic field; and a wall impervious to said particles at one side of said field toward which said particles are deflected upon entering said field.

3. The invention of claim 2 in which one edge of each of said magnets is in contact with one edge, respectively, of said slit,

4. An X-ray detector system comprising: an evacuated chamber; an X-ray detector tube therein, the wall of said tube having edges defining an elongated slit; and means for trapping charged particles having a known maximum energy to prevent their entering said slit, said means comprising a pair of flat magnets spaced apart to provide a channel therebetween substantially in line with said slit, said magnets being magnetized to provide a magnetic field substantially perpendicular to the facing surfaces of said magnets and substantially transverse to the channel between said magnets and through said slit and having a length perpendicular to said edges greater than the diameter of the circular path of the maximum energy particles in said magnetic field whereby charged particles entering the channel between said magnets are magnetically deflected back out of said channel in the

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direction away from said slit, and a U-shaped yoke of material having high magnetic permeability, one of the legs of said yoke being against the surface of one of said magnets on the side thereof away from said channel, and the other of said legs of said yoke being in contact with the other of said magnets on the side thereof away from said channel, said legs being joined by an end wall portion impervious to said particles at one end of said channel toward which said particles are deflected upon entering said channel.

5. The invention of claim 4 comprising, in addition, a closed cover over the outwardly facing edge of said yoke near the closed end thereof.

6. The invention of claim 5 in which said end wall of said yoke is spaced from the proximal ends of said magnets by the length of said cover.

7. In an evacuated system comprising: a detector to detect X-radiation, and a source of X-radiation and of undesired electrons having a known maximum energy, said detector having a wall with edges defining an elongated slit entryway through which said X-radiation and said electrons may enter said detector, means for preventing said undesired electrons from passing through said entryway, said means comprising: a pair of members having high magnetic permeability adjacent to said entryway and on either side thereof to form juxtaposed magnetic pole surfaces, said members extending in the direction of said slit and also extending in a direction substantially perpendicular to said wall of said detector to form an elongated passageway directly outside of, and in line with, said slit, said members extending beyond one end of said slit; and a magnet joining the ends of

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said members extending beyond said end of said slit, the end of said magnet joining one of said members having a permanently magnetized north pole and the end of said magnet joining the other of said members having a permanently magnetized south pole therein to produce a magnetic field between the juxtaposed magnetic pole surfaces of said members, which field is substantially perpendicular to said slit and the dimension of said juxtaposed magnetic pole surfaces in the direction perpendicular to said edges is at least as great as the diameter of the circular path of the maximum energy electrons in said magnetic field to cause said electrons to follow circular paths upon entering said passageway whereby said electrons will be directed away from said slit, said magnet forming a wall impervious to electrons in the direction toward which said electrons are deflected by said magnetic field.

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