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SPATIAL DISCRIMINATOR FOR PARTICLE BEAMS

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Fig. 1

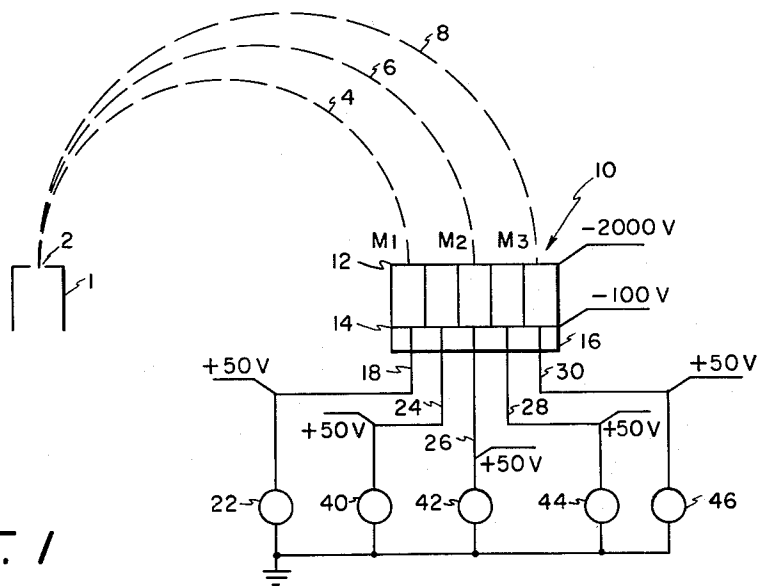
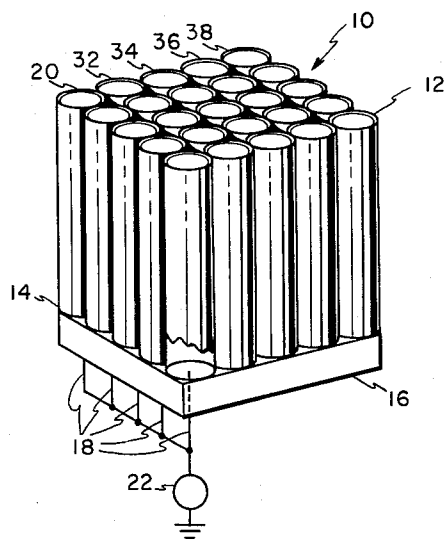


Fig. 2



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SPATIAL DISCRIMINATOR FOR PARTICLE BEAMS

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2 Claims. (Cl. 250-41.9)

This invention relates to a high resolution spatial discriminator for particle beams.

Many situations arise in physics and engineering where one has a beam of particles which must be detected. Mass spectrometers, particle accelerators, vacuum tube investigations and molecular beam experiments are but a few such cases. Often, it is desirable to have a detector which permits easy determination of the cross-sectional spatial distribution of the beam. One method which has been employed for this purpose in the past is the use of nuclear emulsion films. Another method is the use of phosphor screens. These methods are disadvantageous in that they are slow, insensitive, or work only for high energy particles.

This invention provides improved means for detecting and measuring the cross-sectional spatial distribution of particle beams. In accordance with the invention an array of "channel" electron multipliers, hereinafter described, are positioned to receive the particles in a beam. The particles of the beam are received in different channels depending on their spatial distribution, are multiplied in the channels through secondary emission and are detected at the output of these channels to provide an indication of the content of the beam. Because of the small size of the channels, very accurate determination can be made of the cross section of the beam and further, because of the multiplication provided low intensity and low energy beams can be analyzed.

Other objects and advantages will become apparent from the following detailed description and from the appended drawings and claims.

In the drawings:

FIGURE 1 is a schematic diagram illustrating an embodiment of the invention and a source for providing a beam of particles.

FIGURE 2 is a perspective view, partly broken away, of the multipliers shown in FIGURE 1. It also shows a portion of the electrical circuitry connected to the multipliers.

In the embodiment illustrated, a particle beam is obtained from the ion source 1 of a magnetic mass spectrometer. The ions exit through the slit 2 with equal velocities and a magnetic field deflects them spatially according to mass. The ions of different mass will travel different circular paths. The radius of travel of each ion is determined by the following equation:

$$r = \frac{v}{\frac{e}{m}B}$$

where

r =radius

v =velocity of the ion

e =charge of the ion

B =magnetic field strength

m =mass of ion

For example, as shown in FIGURE 1, ions of a given mass M_1 may travel along path 4, ions of heavier mass M_2 may travel along path 6 and ions of still heavier mass M_3 may travel along path 8. The ions in each path will

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be distributed in a plane perpendicular to the direction of travel.

Positioned to receive the ions from the source 1 is a substantially parallel array of channel electron multipliers generally indicated at 10. Tubular channel multipliers of the type used to construct the multipliers 10 are fully disclosed in copending U.S. application serial No. 23,574, filed April 20, 1960, by George W. Goodrich and William C. Wiley, and issued on April 7, 1964, as U.S. Patent No. 3,128,408. Such tube type multipliers are provided with an inside surface which is conductive and has secondary emission properties. Upon the application of a voltage difference between the ends of the tube, current flows through the tube and produces an electric field in an axial direction through the region defined by the tube. Electrons entering the input end of the tube are multiplied through secondary emission before they emerge from the output end of the tube.

The multipliers 10 are constructed with a plurality of bismuth-lead oxide glass tubes of very small inside diameter such as .001 inch. Initially, the glass tubes are placed in a hydrogen reducing furnace to reduce the bismuth and lead oxides. This converts the glass tubes from an insulator to a semi-conductor of relatively high resistance. Then a sufficient number of tubes are stacked in parallel relationship to one another and are fused together such as by heating them in a furnace to the softening point of the glass and allowing them to cool. A relatively small wafer, such as .050 inch., is then sliced from the fused tubes in a direction perpendicular to the axis of the tubes to form the multipliers 10.

A conductive coating 12, such as silver, is applied to the input ends of the multipliers 10 and a similar coating 14 is applied to the output ends to provide connecting terminals. Adjoining the output ends of the multipliers 10 is a base 16 of insulating material, such as glass. Potted in the base 16 are anode wires corresponding in number to the number of multipliers 10, each wire positioned at the output of a particular channel to provide a collecting anode for said channel. As clearly shown in FIGURE 2, anode wires 18 at the outputs of the channels in column 20 are connected through a common terminal to an ammeter 22 for providing an indication of the signal detected by the anodes 18. Similarly, anode wires 24, 26, 28 and 30 at the outputs of the channels in columns 32, 34, 36 and 38, respectively, are connected through common terminals to ammeters 40, 42, 44 and 46 respectively. The ammeters 22, 40, 42, 44 and 46 have their second terminal grounded.

Direct voltages of suitable magnitude are applied to the elements disclosed above from a direct voltage source (not shown). For example, as shown in FIGURE 2, direct voltages such as -2,000 volts and -100 volts are applied respectively to the coatings 12 and 14. Also direct voltages such as +50 volts are applied to the anodes 18, 24, 26, 28 and 30 from the voltage source.

It should be understood that the ion source 1, the multipliers 10 and the base 16 operate in a vacuum tube at a pressure of approximately 10^{-6} mm. Hg. Also, a magnetic field is provided in the vacuum tube to cause the ions to travel in the paths shown in FIGURE 2.

The multipliers 10 are positioned relative to the source 1 to receive the ions emerging from the source. As shown in FIGURE 1, the ions following paths 4, 6 and 8 will enter the channels in columns 20, 34, and 38 respectively. When the ions strike the internal surface of the channels, they will produce secondary emission of electrons which are multiplied through further secondary emission as they pass through the channels. The ion signals from masses M_1 , M_2 and M_3 multiplied in this manner are collected by the anode wires 18, 26, and 30 respec-

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tively, and the ammeters 22, 42 and 46 will provide an indication of the relative quantities of these different masses.

The discriminator disclosed above has definite advantages. It has extremely high resolution because of the small size of the channels which have a diameter on the order of .001 inch or less. Further, because of the multiplication produced in the channels, it can be very effectively used to determine the cross section of low intensity particle beams.

Although the description above relates to the detection of an ion beam from a magnetic mass spectrometer, persons skilled in the art will recognize the discriminator can be used for detecting particle beams of all types. For example, it can be used to determine the cross section of beams produced by particle accelerators and of experimental molecular beams. In such cases it may be desirable to have a separate indicator connected to the anode of each channel instead of having a plurality of anodes connected to a common indicator as shown in FIGURE 2. By providing a separate indicator for each channel, excellent analysis can be made of the cross section of a beam.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described our invention, we claim:

1. A spatial discriminator for determining the cross section of a particle beam comprising,
an array of channel electron multipliers positioned to receive the beam at its input, each channel receiving a different part of the beam, each channel having a diameter of less than .010 inch,
a separate anode positioned at the output end of each

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channel to detect the signal produced by the particles entering each channel,
insulating means for supporting the anodes at the outputs of their channels, and
means connected to the anodes to provide an indication of the detected signal.

2. A spatial discriminator for determining the cross section of a particle beam comprising,
an array of channel electron multipliers positioned to receive the beam at its input, different groups of the channels being positioned to receive different portions of the beam, each channel having a diameter of less than .010 inch,
a separate anode positioned at the output end of each channel to detect the signal produced by the particles entering each channel,
a common terminal for connecting the anodes of each different group of channels,
and means connected to each common terminal to provide an indication of the particles in the portion of beam received by the group of channels associated with the common terminal.

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