April 6, 1954 J. L. DANFORTH ET AL 2,674,698

BEAM DEFINING APPARATUS

Filed July 2, 1952

3 Sheets-Sheet 1

FIG. 1.

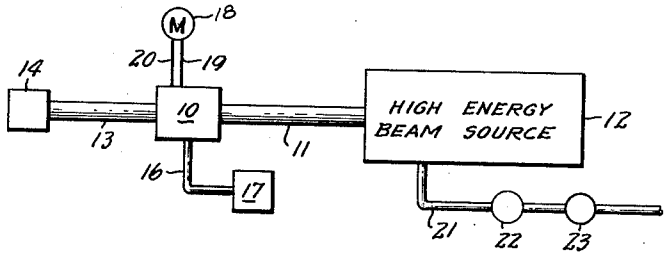
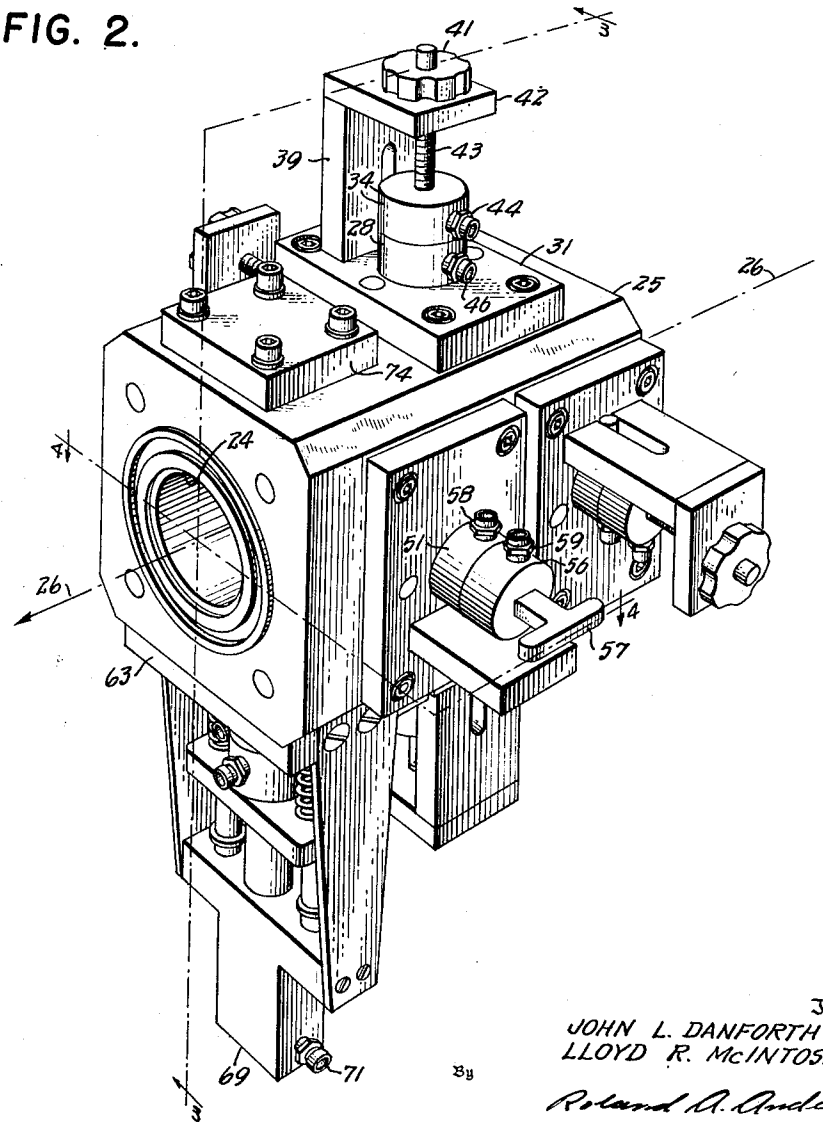


FIG. 2.



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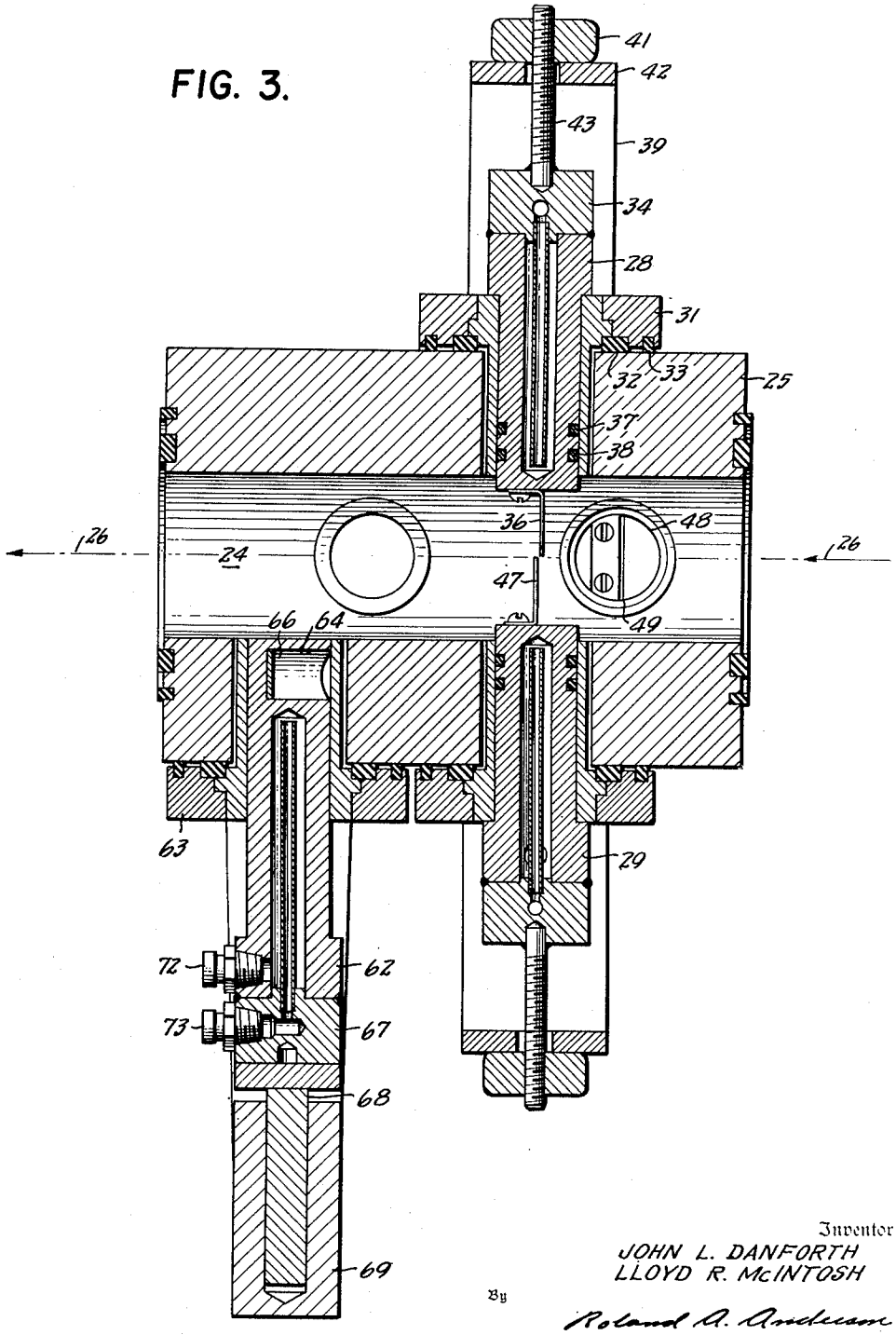
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FIG. 3.



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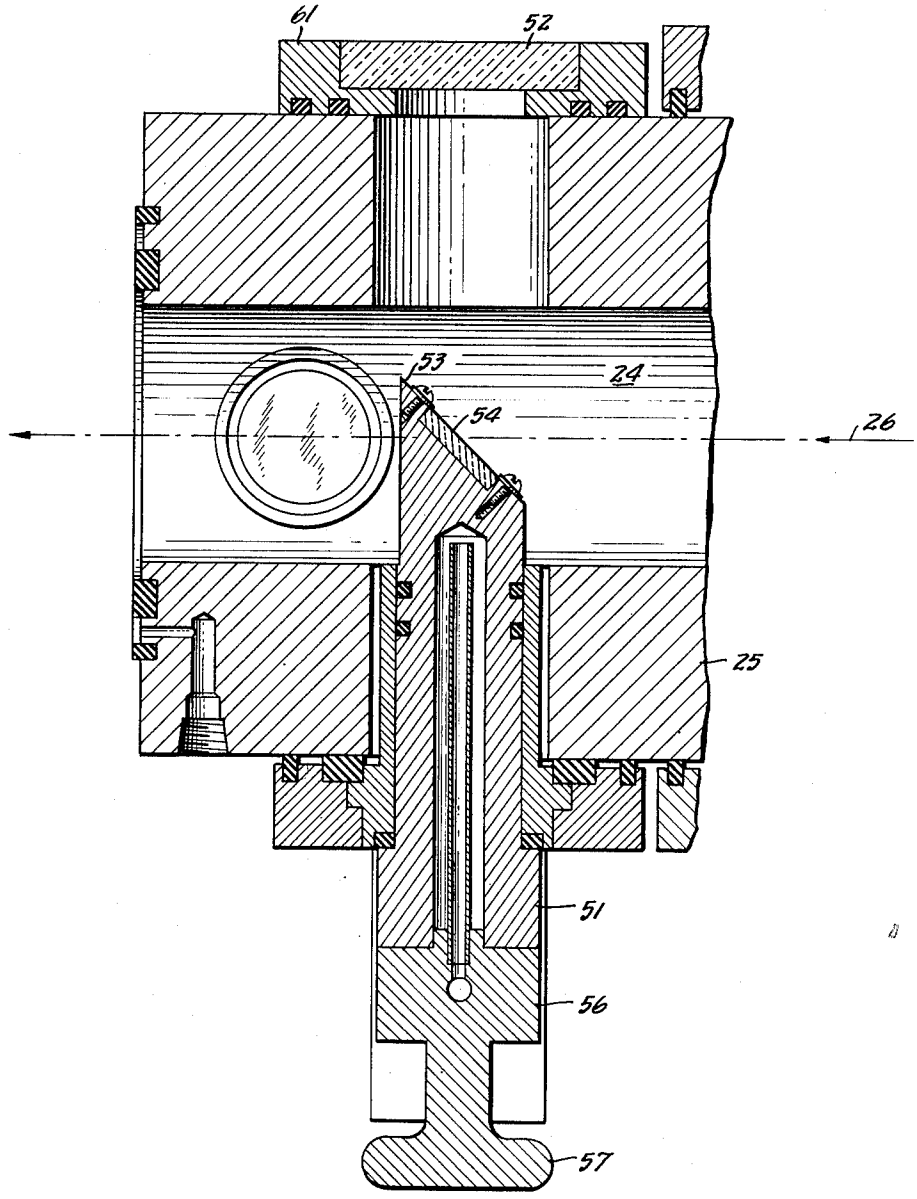
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Filed July 2, 1952 3 Sheets-Sheet 3

FIG. 4.



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UNITED STATES PATENT OFFICE

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BEAM DEFINING APPARATUS

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Application July 2, 1952, Serial No. 296,966

5 Claims. (Cl. 250—49.5)

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The present invention relates to a unitary beam defining apparatus for observing, controlling and measuring a beam of high energy, charged atomic particles in a vacuum preparatory to using said defined beam upon a target. High energy beam sources are now being constructed and used in many parts of the world. These sources are primarily utilized for bombarding a suitable target with a high energy beam of charged atomic particles to produce and study nuclear reactions.

The construction of such a high energy particle accelerator represents a large financial undertaking and once the accelerator has been built, it is common practice to make use of it twenty-four hours a day where possible. Ordinary maintenance down time and the setup time between experiments are the primary factors decreasing the productive capacity of the machine. Therefore, any improvement in an accelerator which will permit the output beam thereof to be defined rapidly as to location, shape and intensity in order to accommodate it to different types of experiments will increase the productive capacity of the machine by decreasing the experimental setup time.

Also, today some positive-ion accelerators, such as the well-known Van de Graaff generator, are used as an initial source for a higher energy accelerator, such as the proton synchrotron. The Van de Graaff generator provides a proton beam in the order of two million electron volts which will be accelerated in the proton synchrotron chamber up to energies approaching three billion electron volts. When used in this way, it is necessary that the output beam of the Van de Graaff accelerator be accurately focused to enter the proton synchrotron chamber at the required position. Prior art devices have been built to carry out the beam defining function but they do not permit simultaneous operation of the various elements. Also each of the elements is not as maneuverable as the elements of the present invention.

It is accordingly an object of the present invention to provide a new and improved beam defining apparatus including collimating means and adapted for use in the evacuated output tube of a high energy particle accelerator.

A second object of the present invention is to provide a new and improved high energy beam defining apparatus which includes means for viewing the high energy beam as well as means for measuring the beam.

Still another object is to provide a new and

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improved unitary beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator and which can be easily adjusted without affecting the high vacuum present in the output tube.

More particularly, the apparatus is adapted for use in the evacuated output tube of a high energy particle accelerator and includes a hermetically sealable mounting block containing a bore through which the high energy beam is transmitted, reciprocally movable means mounted on the block and communicating with said bore for shaping the beam as it passes therethrough, reciprocally movable means mounted on said block in communication with said bore for viewing the shaped beam, means mounted on said block in communication with said bore for measuring the intensity of the shaped beam and reciprocally movable into and out of the path of said beam and separate means sealing each of said reciprocating means in order to maintain a common vacuum in the apparatus.

The many objects and advantages of the present invention may best be appreciated by reference to the accompanying drawings, the figures of which illustrate apparatus incorporating a preferred embodiment of the present invention and capable of carrying out the method of the invention. In the drawings:

Figure 1 is a schematic representation of the apparatus shown in its relationship to the high energy beam source and output tube.

Figure 2 is a perspective view of a preferred embodiment of the apparatus.

Figure 3 is a transverse sectional view taken along the line 3—3 of Figure 2.

Figure 4 is a transverse sectional view taken along the line 4—4 of Figure 2.

Referring to Figure 1, the unitary beam defining means 10 is diagrammatically shown mounted on the output tube 11 of a high energy beam source 12. Connected to the opposite side of the assembly 10 is an evacuated tube 13 for transmitting the beam to the target 14. Also connected to the assembly 10 by means of conduit 16 is a compressed air source 17 and further connected to the assembly 10 is a microammeter 18 as by means of conductors 19 and 20. Attached to the beam source 12 is a vacuum line 21 connected to vacuum pumps 22 and 23 in tandem. Pumps 22 and 23 may be used for evacuating the beam source 12, output tubes 11 and 13, the assembly 10 and the chamber including the target 14. Microammeter 18 and compressed air source

17 are used for purposes more fully described hereinbelow with respect to Figure 3.

Referring now to Figure 2, the entire apparatus is shown assembled on a mounting block 5 containing a centrally disposed bore 24 through which the high energy beam can be transmitted. Laterally extending from the central bore is a plurality of spaced cylinders formed therein and adapted to receive sealed pistons movable within removable flange inserts suitably affixed in sealed relation upon the mounting block 25. Two pairs of oppositely disposed inserts are provided to mount suitable means for collimating the beam, another insert is provided to mount a viewing means and still another insert is provided to mount a collecting means. As will be apparent, it is essential that suitable adjustment of the several means be provided without leakage into the evacuated system, and that means for carrying away heat be established. In normal operation, the mounting block 25 is hermetically sealed to the output tube 11 of the high energy beam source 12 and to the tube 13 leading to the target so that the beam is transmitted in the direction indicated by the arrow 26.

Referring now to Figures 2 and 3, it will be noted that the beam collimating portion of the beam defining assembly comprises two pairs of oppositely disposed pistons extending into bore 24 and adapted to support adjustably the beam collimating clipping plates. In Figure 3 two such pistons 28 and 29 are shown, conveniently called the "vertical pair" although the invention is in no way limited to any particular angular disposition of the same.

Considering first the upper piston assembly which is typical of each of the three companion piston assemblies in the collimating portion, there is provided a cylinder wall insert having a flange 31 and with one or more seals 32 and 33 between the inserts and the external wall of block 25. Adapted for slow movement within the insert is a hollow stepped piston 28 having at its outer end a hollow piston head 34 and at its inner end a suitably affixed beam clipping plate 36 of an appropriate material such as tantalum. Sealing means 37 and 38 may be provided between the piston and the cylinder insert.

Accordingly, when installed within the operating system, both the cylinder insert and the stepped piston are fully held by the pressure differential in the position as shown. Suitable bolts or other means are provided, however, to hold the flanged insert 31 in desired position upon the mounting block. From the flange a slotted bracket 39 extends and by means of a suitable pin rigidly affixed to the piston and engaging in the slot, rotation between the piston and the bracket may be prevented while longitudinal movement therebetween is effected.

For adjusting the position of clipping plate 36 there is provided a manually operable nut 41 contacting the surface of a laterally extending ledge 42 on the bracket and engaging a threaded rod 43 rigidly affixed to piston head 34. Suitable flexible conduits, not shown, may be attached to a first connection 44 leading into the interior of the piston head 34 and to a second connection 46 leading from the hollow space within piston 28 thereby to circulate a suitable cooling medium while the apparatus is being subjected to the heating effect caused by the beam from the accelerator.

Similarly, the lower piston 29 of the "vertical pair" has a suitably affixed beam clipping plate 47 at its inner end. Plate 36 is shown to be substantially parallel to plate 47 in Figure 3, but this configuration is not essential for the proper carrying out of the invention. A "horizontal pair" of oppositely disposed pistons is also mounted on the block 25 adapted for reciprocal movement into and out of the path of the high energy beam. The inner end of one piston 48 of the "horizontal pair," together with its beam clipping plate 49, may be seen in Figure 3. The horizontal pistons may be mounted in the manner hereinabove described with respect to piston 28.

In operation, the beam coming in the direction of the arrow 26 may be intercepted by clipping plates 36 and 47 to properly limit and shape the beam in the vertical dimension. Also, the horizontal pistons may be inserted or withdrawn to properly shape the beam in the horizontal direction. In order to properly shape the beam, however, it is necessary that some means for viewing and measuring the shaped beam be provided during the beam defining process.

Referring now to Figures 2 and 4, it will be noted that the beam viewing portion of the beam defining assembly comprises a hollow stepped piston 51 and an oppositely disposed transparent window 52. At the inner end of piston 51 is an inclined surface 53 containing a luminescent material 54 suitably affixed thereto. At the outer end, piston 51 has a hollow piston head 56 connected to a handle 57. Piston 51 is mounted in a manner similar to that described above for piston 28 and independent communication to the cooling medium may be made by suitable connectors 58 and 59. Opposite inclined surface 53 is shown the transparent window 52 mounted on a flange 61.

In operating, the piston 51 may be inserted so that the luminescent material 54 is in the path of the high energy beam. The impingement of the beam will cause the material 54 to fluoresce and properly outline the shape of the beam. With a high energy beam, material 54 will become incandescent due to the local heating. This emission of light in the visible range may be viewed through window 52. A material that has been found suitable is "Vycor," a quartz made by the Corning Glass Works, Corning, New York, and containing 98% silica. This material may also be used for window 52.

Therefore, with the above-described piston assemblies of the beam defining apparatus, it is possible to obtain a beam shaped in two dimensions. However, for most experimental setups, it is also necessary to know the intensity of the beam to be used as well as its shape and location.

Referring again to Figures 2 and 3, it can be seen that the collecting piston 62 is mounted in a cylindrical wall insert having a flange 63. At its inner end, piston 62 has a cup-shaped extension 64, at the bottom of which is an electrically conductive plate 66. At its outer end, piston 62 has a hollow piston head 67 which is connected to a reciprocally movable plunger 68 mounted within a cylinder 69. Communicating with the interior of cylinder 69 is an external fluid connection 71. Communicating with the interior of the hollow stepped piston 62 and the hollow piston head 67 are fluid connections 72 and 73, respectively.

In operation, a flexible conduit may be attached to a connection 71 from a conventional compressed air source and the application of the compressed air causes the plunger 68 to force the piston 62 into the bore 24 of the block 25.

The cup-shaped extension 63 intercepts the beam 26 which impinges upon the electrically conductive plate 66. The high energy beam imparts a charge to the conductive plate 66 which charge can be measured by a suitable, conventional microammeter 18 connected between the piston 62 and ground. Since the collecting portion of the beam defining apparatus may be operated by compressed air, it may be remotely operated and the microammeter may also be remotely connected. Similarly, the interior of cylinder 69 may be connected to a vacuum pump, not shown, to remove the compressed air in the cylinder, thereby remotely returning plunger 68 to the position shown in Figure 3. Therefore, the beam emerging from the high energy beam particle accelerator may be properly defined by use of the beam defining apparatus herein described.

In use, the mounting block 25 is attached to the output tube of the accelerator and the interior thereof is evacuated by the same evacuating means used for the particle accelerator. When the accelerator is ready for use, the four reciprocally movable pistons of the beam collimating portion of the beam defining assembly are fully inserted as is the beam viewing piston 51. The collecting piston 62 of the beam defining assembly is withdrawn. The "vertical pair" of beam collimating pistons 28 and 29 is slowly withdrawn until the proper vertical dimension is obtained as seen on the luminescent material 54. Then the "horizontal pair" of beam collimating elements of the beam defining apparatus is withdrawn until the desired horizontal dimension is obtained.

To determine whether the beam as shaped is providing the proper intensity, the beam viewing piston 51 is withdrawn and the beam collecting piston 62 inserted. Since the collecting cup is electrically insulated from the grounded mounting block 25, it is possible to provide more accurate current readings by applying a positive bias voltage in the order of 50 to 100 volts to the cup. This will prevent high current readings due to secondary electrons being knocked off by the impact of the high energy beam. If the beam is of the desired intensity, as measured on the microammeter, piston 62 is withdrawn. The beam is now properly defined as to its location, shape and intensity according to the desired experimental setup for which it is to be used.

It is apparent that the beam may be shaped to have a circular or rectangular cross-section by using properly shaped beam clipping plates. Also, if any of the elements of the beam defining apparatus have to be repaired or replaced when not in use, it can be quickly dismounted and a mounting flange such as the flange 74 shown in Figure 2 inserted. In this manner, the removed element can be repaired without further disturbing the evacuated parts of the accelerator.

While the salient features of this invention have been described with respect to one embodiment, it will of course be apparent that numerous modifications may be made within the spirit and scope of this invention and it is, therefore, not desired to limit the invention to the exact details shown except in so far as they may be defined in the following claims.

We claim:

1. Beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator which comprises in combination a hermetically sealable mounting block having a bore therein through which the high energy beam is transmitted, reciprocally movable collimating means mounted on said block and communicating with said bore, said collimating means including independently movable elements for shaping the beam in either of two directions as it passes therethrough, means mounted on said block in communication with said bore and reciprocally movable for viewing the shaped beam, means mounted on said block in communication with said bore for measuring the intensity of the shaped beam and reciprocally movable into and out of the path of said shaped beam and separate means sealing each of said reciprocating means in order to maintain a common vacuum in said apparatus.

2. Beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator which comprises in combination a hermetically sealable mounting block having a bore therein through which the high energy beam is transmitted, a first pair of reciprocally movable beam shaping elements mounted on said block diametrically disposed about said bore, each of said elements having a plate at one end for intercepting said beam, a second pair of reciprocally movable beam shaping elements mounted on said block diametrically disposed about said bore and perpendicular to said first pair, each of said second elements having a plate at one end for intercepting said beam, all of said plates being substantially parallel to one another, means mounted on said block in communication with said bore and reciprocally movable for viewing the shaped beam, means mounted on said block in communication with said bore for measuring the intensity of the shaped beam and reciprocally movable into and out of the path of said beam and separate means sealing each of said reciprocating means in order to maintain a common vacuum in said apparatus.

3. Beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator which comprises in combination a hermetically sealable mounting block having a bore therein through which the high energy beam is transmitted, reciprocally movable collimating means mounted on said block and communicating with said bore for shaping the beam in either of two directions as it passes through the block, means mounted on said block in communication with said bore and reciprocally movable for viewing the shaped beam, a reciprocally movable element mounted on said block in communication with said bore for measuring the intensity of said beam, said element having a cup shaped extension for projection into and out of the path of said shaped beam, said cup shaped extension including an electrically conductive plate insulated from ground, means for measuring any difference in potential between said conductive plate and ground and separate means sealing each of said reciprocating means in order to maintain a common vacuum in said apparatus.

4. Beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator which comprises in combination a hermetically sealable mounting block having a bore therein through which the high energy beam is transmitted, reciprocally movable collimating means mounted on said block and communicating with said bore for shaping the beam in either of two directions as it passes through the block, means mounted on said block in communication with said bore and reciprocally movable for viewing the beam, a water cooled reciprocally movable

element mounted on said block in communication with said bore and adapted for remote operation for measuring the intensity of said beam, said element having a cup shaped extension for projection into and out of the path of said beam, said cup shaped extension including a tantalum plate insulated from ground, means for measuring any difference in potential between said tantalum plate and ground and separate means sealing each of said reciprocating means in order to maintain a common vacuum in said apparatus.

5. Beam defining apparatus for use in the evacuated output tube of a high energy particle accelerator which comprises in combination a hermetically sealable mounting block having a bore therein through which the high energy beam is transmitted, a first pair of cylindrical water cooled reciprocally movable beam shaping elements mounted on said block diametrically disposed about said bore and communicating therewith, each of said elements having a tantalum plate at one end for intercepting said beam, a second pair of cylindrical water cooled reciprocally movable beam shaping elements mounted on said block diametrically disposed about said bore and communicating therewith, said second

pair of elements being perpendicular to said first pair and having a tantalum plate at one end of each element for intercepting said beam, all of said plates being substantially parallel to one another and electrically insulated from the mounting block, a reciprocally movable element mounted on said block in communication with said bore and having one surface thereof inclined to the path of said beam, a luminescent material mounted on said inclined surface, a transparent window mounted on said block diametrically opposite said inclined surface, means mounted on said block in communication with said bore for measuring the intensity of the beam and reciprocally movable into and out of the path of said shaped beam and separate means sealing each of said reciprocating means in order to maintain a common vacuum in said apparatus.

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