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F. R. WEBER, JR

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TARGET FOR PARTICLE ACCELERATORS

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2 SHEETS—SHEET 2

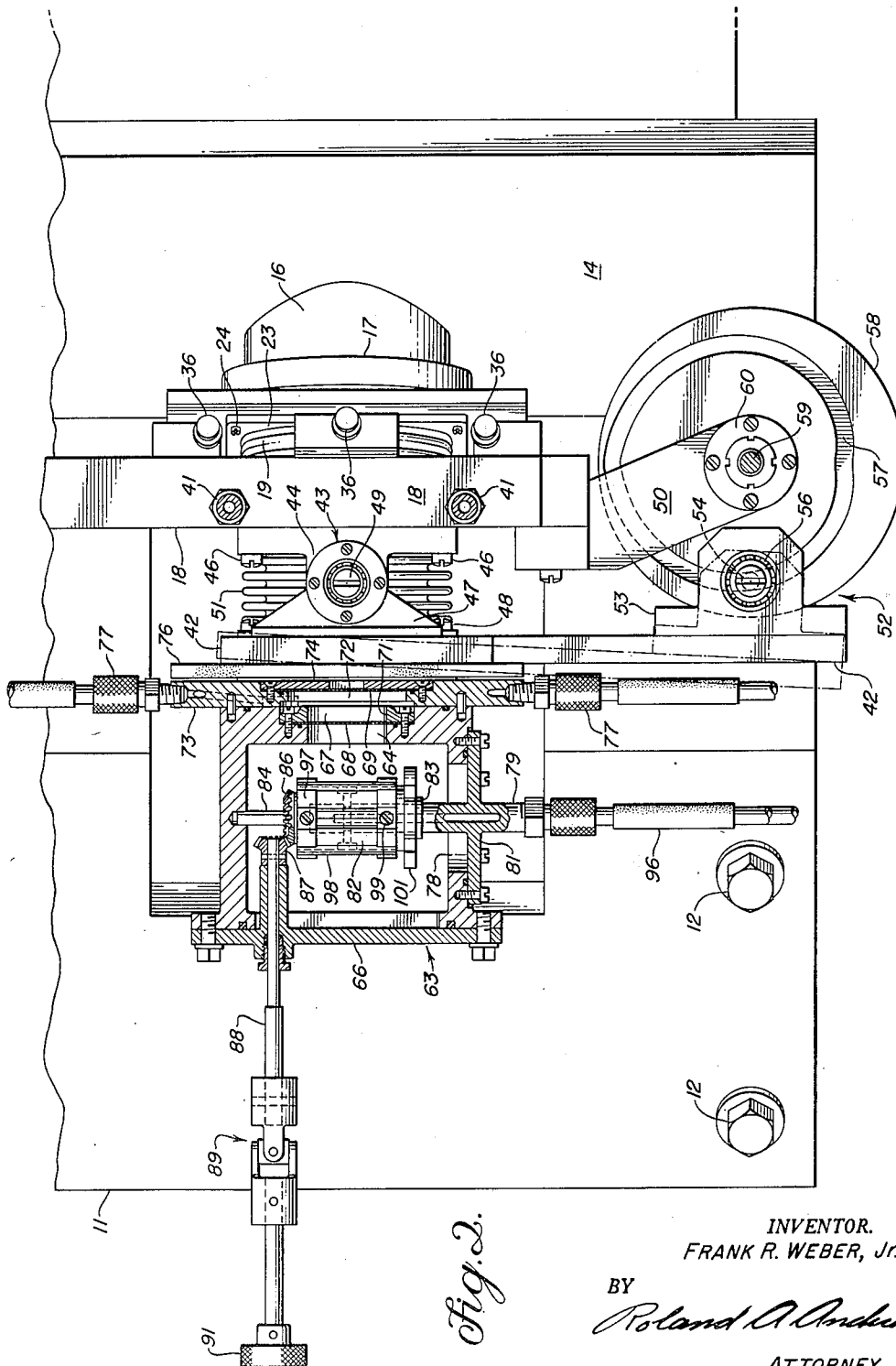


Fig. 2.

INVENTOR.
FRANK R. WEBER, Jr.

BY
Roland A. Anderson
ATTORNEY.

UNITED STATES PATENT OFFICE

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TARGET FOR PARTICLE ACCELERATORS

Frank R. Weber, Jr., Alameda, Calif., assignor,
by mesne assignments, to the United States of
America as represented by the United States
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The present invention relates generally to an improvement in targets for particle accelerators and in more particular to an improved method and means for target handling to obtain a substantially uniform irradiation thereof and to rapidly change targets.

Conventional particle accelerators operate upon a beam of relatively small cross section and produce a high energy beam of charged particles having a non-uniform intensity in cross section. Commonly, high energy beams have a maximum intensity at the center of the cross section thereof and the intensity falls off with increasing cross sectional radius.

In the applications of particle accelerators for bombarding test samples it is often desirable to uniformly bombard a sample having an area in excess of the cross section of the available charged particle beam. Because of the above-noted cross sectional non-uniformity in the intensity of conventional beams, it is not feasible to expand the beam to a larger cross section as the non-uniformity remains. Another approach to the problem is to sweep the beam across the sample to successively irradiate adjacent portions thereof with the most intense portion of the beam. This may be accomplished either by deflecting the beam so that it precesses in a predetermined manner or may be accomplished by moving the target. The former of these alternatives requires the use of magnetic or electrostatic fields which must vary in space and time to produce the required precession and consequently need employ somewhat bulky and expensive equipment. The present invention operates to carry out the latter of the two above-noted alternatives with a minimum of equipment and cost and a maximum of simplicity and dependability.

It is further advantageous in the bombardment of samples with high energy charged particles to be able to change samples without disrupting the charged particle beam and with utmost dispatch in order that maximum beam use may be realized. While numerous target changing methods are feasible, the use of at least some of these is precluded when the target is to be moved for uniform irradiation of the sample thereon. The present invention includes a simple means for successively irradiating a plurality of samples without time delay and without requiring a cessation of beam production.

It is an object of the present invention to provide an improved target for particle accelerators.

It is another object of the present invention to provide an improved method and means for

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uniformly irradiating a sample with a beam of atomic particles.

It is still another object of the present invention to provide an improved method and means for successively irradiating a plurality of samples with a beam of charged particles.

It is a further object of the present invention to provide an improved target which is reciprocated with respect to a beam of charged particles to produce substantially uniform irradiation of a sample thereon and rotated to successively position different samples in the beam path.

It is a still further object of the present invention to provide an improved particle accelerator target assembly having a plurality of removable samples thereon and including means for successively positioning individual samples in a position to be irradiated and for cooling the sample in position for irradiation.

Numerous other objects and advantages of the invention will become apparent to those skilled in the art from the following description taken together with the accompanying drawings, wherein:

Figure 1 is a sectional plan view of one embodiment of the invention attached to the vacuum tank of a cyclotron;

Fig. 2 is a vertical elevational view of the invention, partially in section as shown by the line 2—2 of Fig. 1, and showing in phantom the target rocker plate in displaced position; and

Fig. 3 is a projected view of the sample holder.

Before proceeding with a description of the invention it is to be noted that the present invention may be employed in connection with any beam of atomic particles or ions, as for example charged particles, rays, electrons, or neutrons; however, in the interest of clarity the invention is shown in connection with a cyclotron. In this respect, it will be appreciated that certain elements, connections, and adjustments shown in the illustrated embodiment of the invention are particularly adapted for use with a cyclotron and may, of course, be modified to conform to any desired application of the invention.

Considering now the illustrated embodiment of the invention in some detail and referring to the drawings, it will be seen that there is provided a mounting plate 11 which is rigidly secured as by bolts 12 to the tank wall 13 of a cyclotron 14. Forming a part of cyclotron 14 is an outlet port 16 which is secured to tank wall 13 to provide an egress aperture for the cyclotron beam and having a flange 17 at the outer end thereof for connection to appropriate target equipment. Cyclo-

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tron 14 produces a high energy beam of charged particles which escapes the magnetic field influence of the cyclotron at such a point that it travels substantially tangentially with respect to the outer orbit thereof through outlet port 16, and this beam B is depicted in Fig. 1 by a dashed line having arrows thereon indicating the direction of travel of the beam.

The target assembly is supported by frame 18 which is securely joined to mounting plate 11 as by bolts or screws, and frame 18 may have a triangular cross section, as illustrated in Fig. 1, for the purpose of aligning the various elements of the target assembly with the beam B and cyclotron outlet port 16. Attached to the side of frame 18 adjacent outlet port 16 is a flexible coupling, such as Sylphon bellows 19, which is secured to frame 18 by screws 21 in a vacuum-tight relation. At the opposite end of bellows 19 there is provided a connecting plate 23 which is secured to bellows 19 by screws 24 in vacuum-tight relation, and which in turn connects with flange 17 of cyclotron outlet port 16. Vacuum-tight connection is made between flange 17 and connecting plate 23 by any suitable means, such as for example the arrangement shown, which includes an annular ring 26 secured upon the face of flange 17 by screws 27 and having on the face thereof annular corrugations 28. An annular gasket or washer 29 of lead or the like is disposed in a slot about the face of connecting plate 23 and engages the corrugations on ring 26. Meshing of corrugations 28 and washer 29 is produced by controllable expansion means between frame 18 and plate 23 and which may consist of a shaft 31 threaded into plate 23 and having a bevel gear 32 secured to the other end thereof and facing toward the threaded end of shaft 31. The unthreaded end of shaft 31 is held in bearing relationship to frame 18 and a second bevel gear 33 attached to the end of a rotatable shaft 34 engages gear 32. A knurled knob 36 at the end of shaft 34 is provided for rotating threaded shaft 31 through gears 32 and 33 and thereby changing the distance between fixed frame 18 and connecting plate 23 to crush washer 29 against corrugated ring 26 and provide a vacuum-tight connection. A uniform pressure on washer 29 is obtained by providing a plurality of expansion means such as described above and generally satisfactory results are obtained by the use of three such means, disposed equidistant about the circumference of connecting plate 23.

Each of the above-identified elements extending from cyclotron outlet port 16 to and including frame 18 is apertured to provide free communication therethrough and is aligned so that beam B passes substantially through the centers thereof. Secured to the side of frame 18 there is a collimating plate 37 which has an elongated slit 38 in the center thereof to trim the beam B and reduce its dimension in a vertical direction. Collimator 37 may be formed with a stepped periphery which mates with similar indentations on frame 18 and defines an annular cavity 39 between collimating plate 37 and frame 18. Piping means 41 are provided to communicate between cavity 39 and an external cooling system, not shown, whereby water or the like is circulated about cavity 39 to dissipate the heat appearing in collimating plate 37 as a result of portions of the beam striking the plate.

Disposed a short distance from collimating plate 37 is a rocker plate 42 which is vertically

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elongated and has an aperture near the top thereof substantially in line with the aperture in frame 18. Provision is made for accommodating an oscillatory motion of rocker plate 42 and at the same time preserving a vacuum seal between rocker plate 42 and frame 18. In this respect there is provided pivot means 43 including a pair of arms 44 extending perpendicularly from frame 18 toward rocker plate 42 and secured to frame 18 as by screws 46. A second pair of arms 47 are secured to rocker plate 42 as by screws 48 and extend normal thereto toward frame 18 past the ends of arms 44 and adjacent thereto. A pair of short pivot shafts 49 are mounted in bearings in arms 44 and extend perpendicularly thereto through adjacent arms 47 and are rotatably secured thereto as by threaded engagement therewith whereby rocker plate 42 is free to oscillate about pivot shafts 49 and is mounted through arms 47, pivot shafts 49, and arms 44 to frame 18. The vacuum seal between rocker plate 42 and frame 18 is maintained by Sylphon bellows 51 secured at one end to rocker plate 42 and at the other end to frame 18 and having gaskets included in these connections.

Rocker plate 42 is vertically elongated as noted above and extends below the previously described elements and later disclosed target housing and associated elements, and provision is made for movement of rocker plate 42 by attaching a cam follower 52 thereto at the lower end thereof. Cam follower 52 may consist of a bracket 53 extending at right angles to the face of rocker plate 42 and having a pin 54 protruding normal thereto and mounted therein as by a bearing 56 retained in bracket 53. Pin 54 engages a groove 57 in a rotary cam 58 that is mounted upon a rotatable cam shaft 59; shaft 59 being connected through coupling 61 to a prime mover, such as a constant speed motor 62. Cam shaft 59 is supported by a bracket 59 secured to frame 18 as by screws and extending downward therefrom with a bearing 60 disposed in the end thereof in which rotates cam shaft 59. The groove 57 in rotary cam 58 has the proper width to accommodate pin 54 on cam follower 52, and cam follower 52 and rotary cam 58 are disposed adjacent each other with pin 54 disposed in groove 57. The configuration of groove 57 in rotary cam 58 may be varied to produce the desired motion of rocker plate 42, and it will be appreciated that rotation of cam shaft 59 and rotary cam 58 thereon causes cam follower 52 to move in accordance with the configuration of groove 57 and to thus pivot about pivot shafts 49 in pivot means 43.

Attached to rocker plate 42 is target housing 63 which encloses the samples to be irradiated. Target house 63 may be formed with an aperture 64 in the front wall thereof facing rocker plate 42 and providing communication between the interior of housing 63 and the vacuum system through the above-described elements and may also have a removable rear end wall 66 for access to the interior thereof. Connected between target house 63 and rocker plate 42 is an intermediate vacuum chamber 67 defined by a pair of foils or windows 68 and 69. Window 68 is disposed across target house aperture 64 and maintained in position by a retainer plate 71 secured to target house 63, and window 69 is disposed across an aperture 72 in a spacer plate 73 and maintained in position by retainer plate 74; spacer plate 73 is secured to target house 63 and separates window 69 from window 68 to thereby define inter-

mediate vacuum chamber 67. Retainer plate 74 has an aperture therethrough which may have limited dimensions as shown to further trim beam B and support window 69. There may be further provided an apertured insulating plate 76 of plastic or the like disposed intermediate spacer plate 73 and rocker plate 42 which provides electrical insulation between target house 63 and rocker plate 42. Connections between all of the above elements are made vacuum tight by suitable gaskets and sealing means appropriate to the types of materials joined and the configurations thereof.

The purpose of vacuum chamber 67 is to protect the vacuum of cyclotron 14 inasmuch as the interior of target house 63 may be maintained at approximately atmospheric pressure and for this purpose the pressure in vacuum chamber 67 is maintained intermediate atmospheric pressure and the pressure in cyclotron 14, which may be about 10^{-5} mm. Hg. A pair of pump-out connections 77 communicate with vacuum chamber 67 through spacer plate 73 and lead to an external vacuum system, not shown, for maintaining the desired pressure in chamber 67.

Target house 63 is provided with an aperture 78 in the bottom wall thereof through which extends a hollow cylinder 79. A flange 81 formed upon or secured about cylinder 79 closes aperture 78 in target house 63 and is secured to target house 63 in gas-tight relation thereto and maintains hollow cylinder 79 in position. A sample holder formed as an hexagonal barrel 82 is disposed upon hollow cylinder 79 interior to target house 63 and has a cylindrical center bore which slip fits the exterior of hollow cylinder 79. A small flange or protuberance 83 is formed about cylinder 79 interior to target house 63 and barrel 82 rests upon this flange, while a short shaft 84 extending from the top of barrel 82 mates with a depression in the top wall of target house 63 so that barrel 82 is free to rotate upon hollow cylinder 79 but is restrained from any other motion except upon disassembly. About the top of barrel 82 there is formed or secured a bevel gear 85 which mates with another bevel gear 87, preferably smaller, that is mounted on a control shaft 88 extending through end wall 66 of target house 63 with a gas-tight seal thereabout. A universal joint 89 in control shaft 88 accommodates the oscillatory motion of target house 63 and at the end of control shaft 88 there may be provided a knob 91, the rotation of which produces through the medium of meshing bevel gears 86 and 87 a rotation of barrel 82 on hollow cylinder 79.

Considering sample holder or barrel 82 in more detail as shown in Fig. 3, it will be seen that each of the flat sides thereof has a central aperture 92 therein extending into the central bore of barrel 82. Apertures 92 are provided to conduct the flow of a cooling medium, such as helium, upon the samples secured to the faces of barrel 82 and this coolant is supplied through hollow cylinder 79 from an exterior reservoir. In this respect it is noted that hollow cylinder 79 is closed at the top and is provided with a small opening leading from the internal chamber thereof to the exterior in the direction toward rocker plate 42, and disposed to communicate with aperture 92 in the face of barrel 82 in the path of cyclotron beam B. An outlet pipe 93 is connected to target house 63 and communicates through aperture 94 in a wall thereof to provide gas exhaust means, and flexible connections 96 are provided in out-

let pipe 93 and hollow cylinder 79 to accommodate the motion of target house 63. Barrel 82 has a plurality of clips 97 removably secured thereon to hold samples 98 for beam irradiation. As an aid to positioning samples 98, barrel 82 may have longitudinally milled slots on each face thereof in which samples 98 fit. Clips 97 may be formed of spring metal or the like and have an initial deformation so that with samples 98 in place the securing of a clip 97 to the top and one to the bottom of barrel 82 at an edge thereof by screws 99 threaded into barrel 82 clamps the samples in place by the contact of the two clips with the top and bottom of each sample. Samples 98 as illustrated are merely small flat pieces of metal or other material which may themselves be under test or may hold another material to be irradiated. It will, of course, be appreciated that the form of samples 98 may be varied and also the exterior configuration of barrel 82 and the size and shape of clips 97 may be changed to suit the samples to be irradiated.

About the bottom of barrel 82 there is provided a cam 101 which consists of a flange having notches cut in the periphery thereof, one notch being provided for each flat side of barrel 82. Engaging cam 101 is a roller 102 mounted upon an arm 103 which is pivot mounted on a removable side wall 104 of target house 63. Removable wall 104 is secured in gas-tight relation to target house 63 and a small spring 106 is disposed between side wall 104 and the free end of arm 103 adjacent roller 102 and urges roller 102 against cam 101 on barrel 82. With the foregoing cam arrangement, rotation of barrel 82 causes roller 102 to rotate as the periphery of cam 101 moves past roller 102 and, because of the spring loading of roller arm 103, roller 102 presses against cam 101 and enters the notches therein, thus making the rotation of barrel 82 past each face difficult and indicating to the operator manually turning barrel 82 when a face thereof is in line with beam B. It will, of course, be appreciated that roller 102 and the notches in cam 101 are so oriented that roller 102 enters a notch when a face of barrel 82 is in line with beam B, as illustrated.

The foregoing has described the elements and connections of the illustrated target assembly in some detail and the operation of the invention is believed clear therefrom; however, there follows a brief description of operation. Assuming the target assembly is to be employed with a cyclotron having an outlet port, as shown in the drawings, the assembly is first mounted on the cyclotron tank wall 13 by bolts 12 through mounting plate 11. A washer 29 is then placed in the slot in the face of connecting plate 23 and knobs 36 are turned to operate the expansion means and force washer 29 into corrugations 28 in ring 26 of outlet port flange 17. After insuring a vacuum-tight connection at this joint, water is circulated about cavity 39 adjacent collimating plate 37, and intermediate vacuum chamber 67 is connected to an external vacuum system which is energized to maintain a desired intermediate pressure therein. Hollow cylinder 79 and outlet pipe 93 are connected to an external coolant supply system and rotary cam shaft 59 is connected to a motor 62 through coupling 61. With samples 98 held in position upon barrel 82 by clips 97 and all connections gas tight, the target apparatus is thus ready for use.

Production of a beam of atomic particles by cyclotron 14 causes the beam B to pass through

outlet port 16 and thus through the open central portion of the target assembly into the target house where the beam B strikes sample 98 which is aligned with beam B. In passing through collimating plate 37, beam B is trimmed to a desired dimension and may be further trimmed by retaining plate 74. While beam B is striking sample 98, rocker plate 42 is oscillating about pivot means 43 as directed by rotary cam 58 and cam follower 52 engaging the groove therein. This oscillatory motion is imparted to target house 63 and all of its contents, as target house 63 is mounted upon rocker plate 42 and thus sample 98 oscillates vertically with respect to beam B and there results a substantially uniform irradiation of sample 98.

After one sample has been sufficiently irradiated another sample may be rotated in front of beam B by the simple expedient of turning knob 91 until there is felt a marked resistance to further turning, which signifies the entrance of roller 162 into the next adjacent notch in barrel flange 101 and which means that the next adjacent sample 98 is aligned with beam B. Because of the universal joint 89 in control shaft 88 and the manner of joining cooling and vacuum lines to the target assembly there is no need to stop the motion of rocker plate 42 until all of the samples have been irradiated.

During irradiation of samples 98 by beam B there may be maintained a steady flow of coolant upon the sample aligned with beam B. The coolant, preferably a gas such as helium, is fed through hollow cylinder 79 from an external reservoir, not shown, and passes through the horizontal opening at the top of the bore in cylinder 79 and through the aperture 92 in barrel 82 behind the sample aligned with beam B. The coolant escapes about the sample and is exhausted from the interior of target house 63 through aperture 94 in the wall thereof and communicating outlet pipe 93. A greater distribution of coolant may be accomplished if desired by the provision of an annular depression about the exterior of hollow cylinder 79 at the location of the horizontal opening in cylinder 79.

It will be appreciated from the above description that the present invention is effective and dependable in operation and is so constructed as to be easily disassembled. For example, access to barrel 82 may be had by removal of target house end wall 66, side wall 104, or by removal of hollow cylinder 79 by uncoupling flange 81 whereupon cylinder 79 and barrel 82 may be entirely removed from target house 63.

The area of sample 98 which is subjected to substantially uniform bombardment or irradiation may be changed by varying the groove pattern on rotary cam 58 and, of course, maximum intensity bombardment of a small sample area may be obtained by maintaining rocker arm 42 stationary.

While the invention has been described with respect to but a single preferred embodiment it will be apparent to those skilled in the art that numerous modifications are possible within the spirit and scope of the invention and thus it is not intended to limit the invention except by the terms of the following claims.

What is claimed is:

1. An improved target assembly for particle accelerators comprising connecting means adapted to be rigidly attached to a particle accelerator at the point where a beam of charged particles emerges therefrom, a plate pivotably mounted

upon said connecting means, a sample holder mounted upon said plate, and means attached to said plate and imparting a reciprocating motion thereto whereby said plate oscillates about said pivotal mounting and said sample is oscillated with respect to a beam of charged particles from said accelerator.

2. An improved target assembly for use with a beam of atomic particles comprising a hollow stationary element aligned with a beam of particles, an apertured rocker plate pivotably mounted upon said stationary element, a rotary cam, means rotating said cam, a cam follower contacting said cam and secured to said rocker plate whereby said rocker plate oscillates about said pivotable mounting as directed by said rotary cam, and a sample holder mounted on said rocker plate and oscillating through the beam of particles to provide uniform beam irradiation thereof.

3. An improved target assembly in combination with a particle accelerator and comprising an apertured stationary frame secured to said accelerator in line with the particle beam therefrom, vacuum connections between said stationary frame and said particle accelerator, an apertured rocker plate pivotably mounted upon said stationary frame, flexible bellows connecting said rocker plate and stationary frame, a motor connected to said rocker plate and oscillating said rocker plate about the pivotable mounting thereof, a sample to be bombarded by said beam, and a sample holder having said sample secured to a face thereof and mounted upon said rocker plate in line with the beam from said particle accelerator whereby said sample is oscillated through said beam to provide uniform bombardment of said sample.

4. An improved target assembly as defined in claim 3 further characterized by said sample holder being rotatably mounted and having a plurality of faces thereon, and a plurality of samples secured one to each face of said sample holder whereby rotation of said sample holder changes the sample aligned with and bombarded by said beam.

5. In combination a particle accelerator producing a beam of charged particles in a vacuum and an improved target assembly comprising a rotatably mounted sample holder having a plurality of faces and aligned with one face intercepting the beam from said particle accelerator, a plurality of samples secured one to each face of said sample holder, a bevel gear secured to said sample holder, a mating bevel gear engaging the gear on said sample holder, and a shaft on said mating gear extending from said sample holder and providing remote control means for rotating said sample holder and aligning successive faces thereof and attached samples with said particle beam.

6. In combination with a particle accelerator producing a beam of charged particles in a vacuum, an improved target assembly comprising a rotatably mounted sample holder having a plurality of faces thereon and one of said faces being disposed to intercept said beam, a plurality of samples disposed one on each face of said sample holder, a target house about said sample holder and supporting said sample holder, a first bevel gear on said sample holder, a second bevel gear meshing with said first bevel gear, a shaft on said second bevel gear extending exterior to said target house whereby rotation of said shaft rotates said sample holder to dispose another face thereof in line with said beam, a flange about said

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sample holder and having a plurality of notches therein with one disposed adjacent each face of said sample holder, and a spring loaded roller bearing upon said sample holder flange and entering a notch therein each time that a face of said sample holder is aligned to intercept said beam.

7. A combination including the target assembly claimed in claim 6 further defined by a vacuum connection between said target house and said particle accelerator and an intermediate vacuum chamber disposed in the wall of said target house where said vacuum connection is made, said vacuum chamber having a pair of separated walls formed of thin foil and being maintained at a lesser vacuum than the vacuum of said particle accelerator.

8. An improved target assembly for use with a beam of charged particles and comprising a target house having an aperture in one wall thereof aligned with a beam of particles, a hollow cylinder extending into said target house parallel to the apertured wall thereof and having the end internal to said target house closed with an opening from the interior of said cylinder through the wall thereof near the closed end and directed toward the apertured wall of said target house, a sample holder having a central bore fitting over said hollow cylinder interior to said target house, said sample holder having a plurality of faces about the exterior thereof and an aperture in each of said faces extending to the interior bore thereof at the same height as the opening in said hollow cylinder whereby the aperture in the face of said sample holder adjacent the apertured wall of said target house is aligned with the open-

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ing in said hollow cylinder for the flow of coolant therethrough, a plurality of samples secured one to each face of said sample holder, and means engaging said sample holder and extending exterior to said target house for rotating said sample holder on said hollow cylinder to successively position adjacent faces of said sample holder in line with the aperture in said target house for irradiation of the sample thereon by a beam of charged particles entering said target house through the aperture in the wall thereof.

9. An improved target assembly for use with a beam of particles and comprising a stationary member, a rocker plate pivotably mounted upon said stationary member, means oscillating said rocker plate about the pivotal mounting thereof, a target house mounted upon said rocker plate and having an aperture in a wall thereof aligned with a beam of particles, a sample holder rotatably mounted within said target house adjacent the aperture therein, a sample holder rotation means engaging said sample holder and extending exterior to said target house, and a plurality of samples to be bombarded secured about said sample holder in position to be successively aligned with a beam of particles upon rotation of said sample holder and each passing back and forth through the beam entering said target house with the oscillation of said rocker plate whereby a substantially uniform beam bombardment of each sample is obtained.

FRANK R. WEBER, Jr.

No references cited.