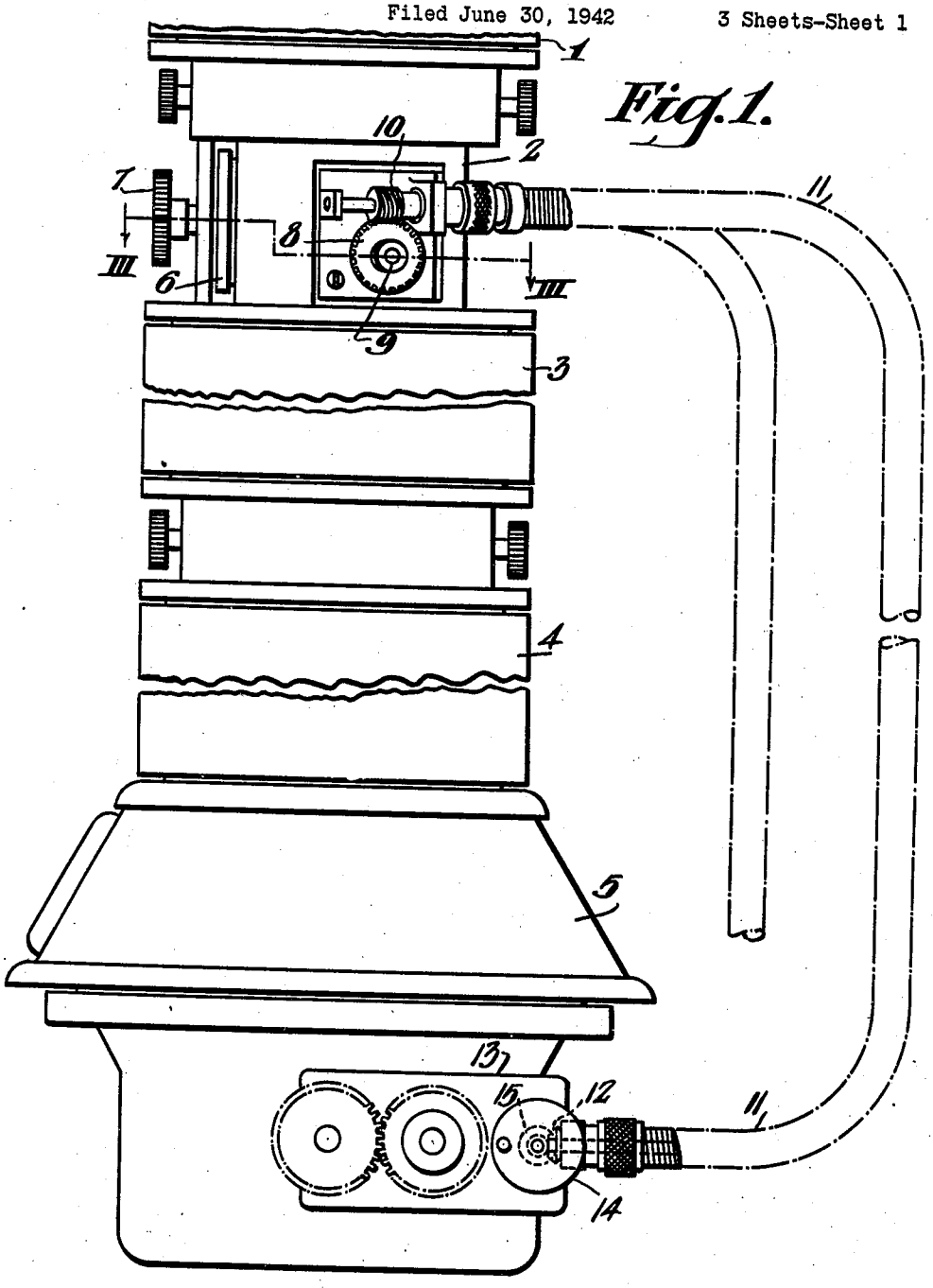
April 25, 1944. C. J. YOUNG 2,347,348

ELECTRON MICROSCOPE OBJECT CHAMBER

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Fig. 1.



Inventor
Charles J. Young

By C. D. Puska

Attorney

April 25, 1944. C. J. YOUNG 2,347,348

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Fig. 2.

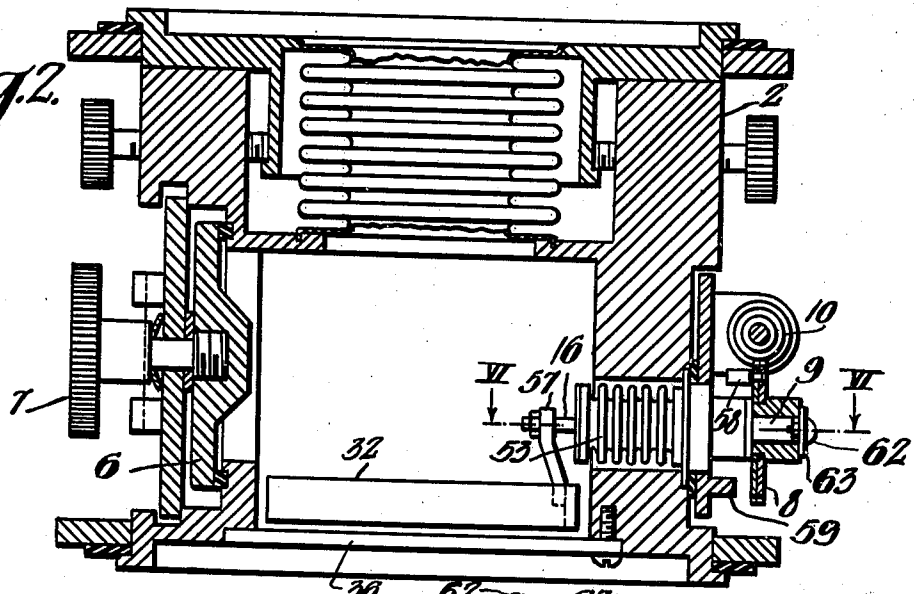
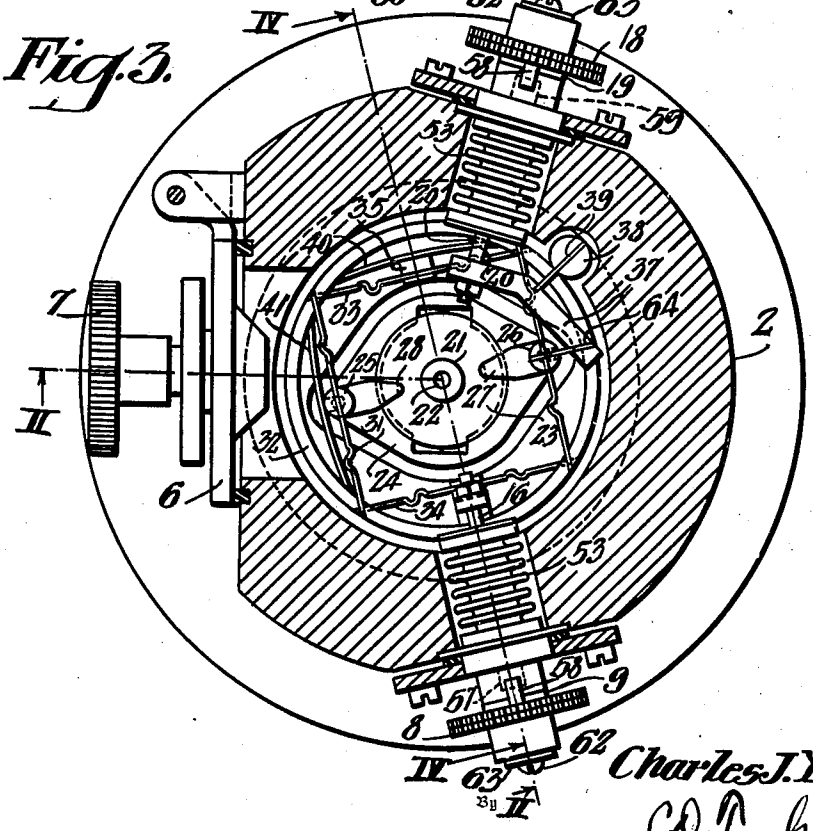


Fig. 3.



Inventor

Charles J. Young

C. D. Tuska

Attorney

April 25, 1944. C. J. YOUNG 2,347,348

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Fig. 4.

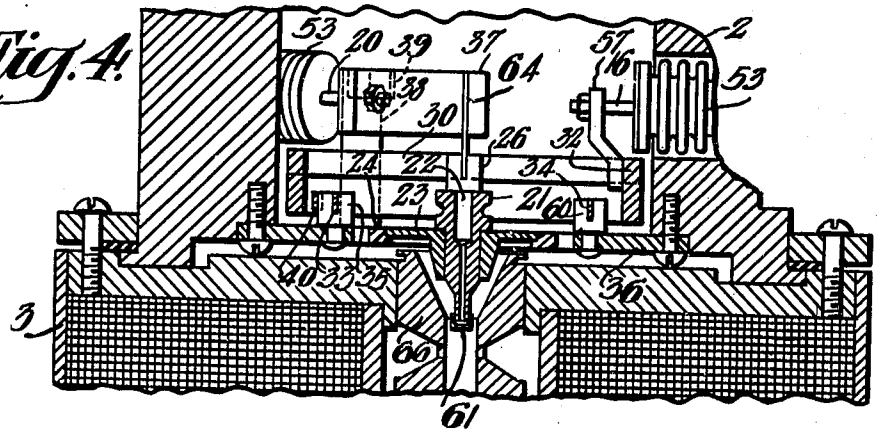


Fig. 5.

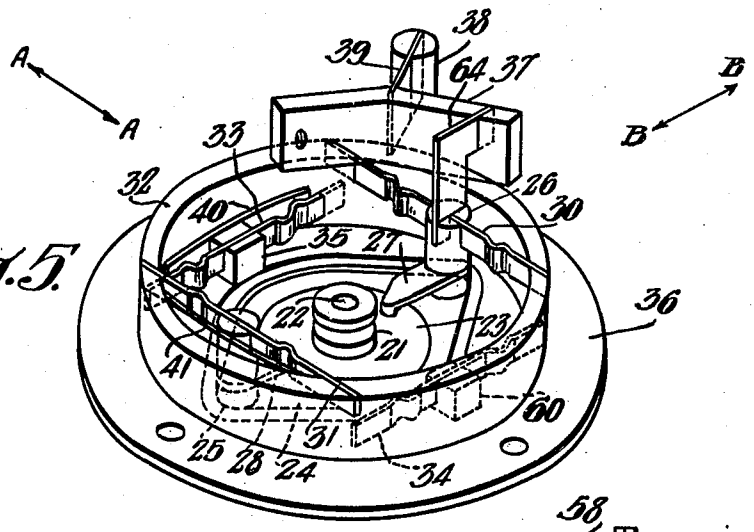
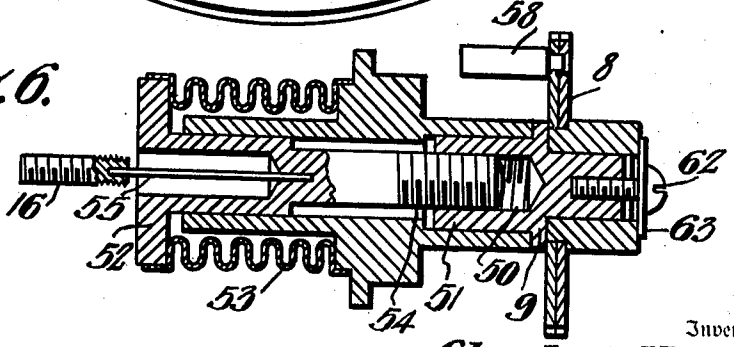


Fig. 6.



Inventor

Charles J. Young

By C. D. Puska

Attorney

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2,347,348

UNITED STATES PATENT OFFICE

2,347,348

ELECTRON MICROSCOPE OBJECT CHAMBER

Charles J. Young, Ardmore, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application June 30, 1942, Serial No. 449,051

7 Claims. (Cl. 250—49.5)

This invention relates generally to electron microscopes and particularly to an improved object chamber for an electron microscope which includes means for moving accurately a specimen in the path of the microscope electron beam.

Heretofore, various devices used for varying the position of a specimen in the object chamber of an electron microscope have involved expensive and complicated mechanical construction to avoid reaction between the various object stage adjustment devices, or have been not entirely satisfactory because of irregular movement due to the variable static and running frictions of sliding mechanisms. At magnifications of 10,000 times, for example, slight irregularities in adjustment are very disturbing to the operator, since such irregularities, for example, only .0001 inch provide movement of one inch of the enlarged image. The instant invention provides a comparatively simple and inexpensive arrangement for adjusting the object stage, in which adjustment thereof is provided along two axes perpendicular to each other and to the electron beam axis. In addition, provision is made for removing easily the object stage, and for mounting suitably the specimen thereon, without disturbing the positioning devices for the object stage. The adjustment devices are also adapted for remote control from a central control position on the microscope column.

The invention has the additional advantage that movement of the object along the electron beam axis is substantially prevented, without reducing the flexibility of the system in the desired adjustment plane normal to the beam axis.

Among the objects of the invention are to provide a new and improved means for adjusting the position of the object stage in an electron microscope. Another object is to provide new and improved means for adjusting the position of the object stage in an electron microscope along two axes, normal to each other and to the axis of the electron beam. Another object is to provide improved means for adjusting the position of an object stage within an electron microscope along desired axes, normal to the axis of the electron beam, while having substantial rigidity in all planes intersecting the plane of adjustment. Still another object is to provide new and improved means for controlling remotely the positioning of an object stage within an electron microscope. A still further object is to provide a new and improved means for reducing substantially all sliding and static frictions in the adjustment of a microscope object stage. Another object is to provide a new and improved means for adjusting the position of a specimen in a microscope in which the adjustments are substantially independent of small eccentricities in the control mechanism.

The invention will be described by reference to the accompanying drawings of which Fig. 1 is an elevational view of a portion of a typical electron microscope column, including the object chamber; Fig. 2 is a cross sectional view of the object chamber taken along the lines II, II; Fig. 3 is a cross sectional plan view of the object chamber taken along the lines III, III; Fig. 4 is a fragmentary cross sectional elevational view taken along the lines IV, IV; Fig. 5 is a perspective view of the object stage and its associated adjustment devices, and Fig. 6 is a cross sectional view of a portion of one of the adjustment devices taken along the lines VI, VI.

Referring to Fig. 1, the microscope column includes, from top to bottom: a condenser lens 1, which may be of either the electromagnetic or electrostatic type; the improved object chamber 2, supporting the condenser lens 1 and coaxial therewith; an objective lens 3, a projection lens 4, which may be of the same types as the condenser lens 1; and a viewing chamber 5, which contains a suitable fluorescent viewing screen, and an electron sensitive photographic surface, not shown.

The object chamber 2 includes a vacuum-tight door 6, having a suitable lock operated by a knob 7. The object chamber 2 is sealed by vacuum-tight joints to the condenser lens 1, above the chamber, and to the objective lens 3, below the chamber. One adjustment of the position of a specimen within the object chamber 2 is provided by means of a first split gear 8, mounted upon a first shaft 9, and engaged with a first worm 10, which is connected to one end of a first flexible shaft 11. The remaining end of the flexible shaft 11 terminates in a first beveled gear 12 suitably supported on an adjustment panel supported by the microscope column. An adjustment knob 14 is connected to a second beveled gear 15, which is arranged to mesh with the first beveled gear 12. A similar arrangement of gears and flexible shafting terminates in a second control knob, not shown, for a second adjustment of the object stage within the object chamber 2, in a direction substantially normal to the direction of adjustment provided by rotation of the first shaft 9.

Referring to Figs. 2, 3 and 4, rotation of the split gear 8 provides rotation of the shaft 9 and a longitudinal movement of a rod 16, which is threaded to internal threads in a hole in the first shaft 9. Likewise rotation of the second split gear 18 provides rotation of a third shaft 19 and a longitudinal movement of a second rod 20 which is threaded to the third shaft 19. The object stage includes a cylindrical member 21 having an axial aperture 22 for the microscope

electron beam. The cylindrical member 21 is mounted upon a disc shaped first base member 23 which is adapted to fit a suitable aperture in a second base member 24. The two base members should preferably be easily separable, to provide for removal of the objective lens pole piece 66 from the microscope, through the aperture in the second base member 24 and for mounting the specimen in the path of the electron beam on the lower surface 61 of the cylindrical member 21. The second base member 24 includes two perpendicularly disposed stud members 25 and 26 having circumferential slots adapted to receive respectively, two spring members 27 and 28, for holding the first base member 23 in position in the aperture of the second base member 24. The first stud 26 is connected, by soldering for example, to the center of a first spring strip 30. The second stud 25 is connected to the center of a second spring strip 31. The first and second spring strips 30 and 31 are supported substantially parallel to each other by the studs 25 and 26 and are rigidly connected at their ends to a supporting ring 32.

Adjacent and between the junctions of the first and second spring strips 30 and 31 respectively and the supporting ring 32, third and fourth spring strips 33 and 34 are also disposed parallel to each other and normal to the first and second spring strips. The third and fourth strips, 35 and 60 respectively, are also rigidly connected to the supporting ring 32 in quadrature to the first and second spring strips. The center of the third spring strip 33 is supported by a third stud 35 which is connected to a sub base element 36. A bracket 57, mounted on the supporting ring 32 opposite the center of the fourth spring strip 34 is connected to one end of the longitudinally adjustable rod 16.

The first stud 26 is flexibly connected by a spring element 64 to one end of a lever device 37, the fulcrum of which is flexibly supported by a fourth stud 38 through a flexible connection 39. The remaining end of the lever 37 is connected to the end of the second adjustable rod 20. It should be understood that the lever mechanism may be eliminated, and the shaft 20 connected similarly to the rod 16 at right angle thereto.

Rotation of the first split gear 8 will provide longitudinal adjustment of the rod 16 which will, in turn, move the supporting ring 32, the second base member 24 and the object stage 21 parallel to the rod 16. Rotation of the second split gear 18 will provide longitudinal adjustment of the second rod 20. Movement of the second rod 20 will provide, through the means of the lever 37, movement of the second base member 24 and the object stage 21, in a direction normal to the direction of adjustment provided by the movement of the first rod 16. Rotation of the split gear 8 will therefore provide adjustment along one axis for the object stage 21, while rotation of the second split gear 18 will provide adjustment along a second axis substantially normal to the first axis. The adjustment along either axis, however, will be substantially independent of the adjustment along the other axis.

Since the gear ratio between the control knob 14 and the shaft 9 may be of any desired value, extremely fine longitudinal adjustment of the rod 16 may be obtained. In one embodiment of the invention, a complete turn of the adjustment knob provides a .001 inch movement of the object stage. Objectionable back-lash in the worm gear drive may be substantially eliminated by means of the split gears utilized for engagement with the worms mentioned heretofore.

Any objectionable back-lash of vibration which may be transmitted through the adjustment system described may be considerably reduced by the addition of a first curved spring 40, disposed between the stud member 35 and the supporting ring 32 and a second curved spring 41, disposed between the stud member 25 and the supporting ring 32.

In a preferred arrangement, the spring strips 30, 31, 33 and 34 should be of a corrugated form, shown in the accompanying drawings, in order to provide maximum resiliency along the desired adjustment axis, while providing maximum rigidity in all other directions, and at the same time preventing any tendency to "oil can" or snap at certain positions as will occur with a flat spring.

Fig. 5 is a fragmentary perspective view of the principal operating components of the object stage and its resilient supporting members previously described and illustrates the axes of adjustment AA and BB.

Figure 6 is a cross sectional view of a preferred means for attaching the split gear 8 to the frame of the object chamber 2. The split gear 8 is connected to a shaft 9 which includes a threaded hole 50 in one end thereof coaxial with the shaft. The shaft 9 is adapted to rotate within a bearing 51 sealed by a vacuum-tight joint in the frame of the object chamber 2. A longitudinally movable shaft 52 is connected to the object chamber frame by means of a bellows 53, and is adapted to move coaxially with the shaft 9. An elongated threaded portion 54 of the shaft 52 is adapted to engage the threads in the hole 50 of the rotatable shaft 9. A flexible connection 55 connects the shaft 52 to a suitably threaded ramrod 16 which is connected to a bracket 57 supported by the supporting ring 32. As the split gear 8 is rotated the threaded portion 54 of the shaft 52 will provide longitudinal adjustment of the ramrod 16, and corresponding movement of the supporting ring 32. A pin 58 connected to the split gear 8 provides a suitable stop for the gear by engagement with a projection 59 on the object chamber frame. A locking screw 62 and washer 63 are for setting the split gear and stop with respect to the projection 59 after preliminary adjustment.

Thus, the invention described comprises means for adjusting the position of an object stage within the object chamber of an electron microscope. The object stage is supported by a pair of flat corrugated parallel spring members attached to a supporting ring, and the supporting ring is supported by a second pair of similarly formed spring members attached to studs mounted in a base member. The supporting ring and object stage may be moved along substantially only one axis normal to the electron beam axis by means of a longitudinally adjustable rod coupled to a gear drive through a vacuum-tight bellows. The object stage may be similarly moved along a second axis, substantially normal to both of the other axis, by means of a second longitudinally adjustable rod, coupled to a second gear drive through a second vacuum-tight bellows.

I claim as my invention:

1. An object stage for electron image apparatus having an electron beam including in combination a frame member, first suspension means,

means including said frame for resiliently supporting said first suspension means, first adjusting means for said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means, means including said first suspension means for resiliently supporting said second suspension means, second adjusting means for said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and means supported by said second suspension means for supporting said object in the path of said electron beam.

2. An object stage for electron image apparatus having an electron beam including in combination a frame member, first suspension means, means including said frame and at least two substantially parallel spring members connecting said frame and said suspension means for resiliently supporting said first suspension means, first adjusting means for said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means including said first suspension means and at least two substantially parallel spring members connecting said first and said second suspension means for resiliently supporting said second suspension means, second adjusting means for said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and means supported by said second suspension means for supporting said object in the path of said electron beam.

3. An object stage for electron image apparatus having an electron beam including in combination a frame member, a first and second bellows mounted in said frame member, first suspension means, means including said frame for resiliently supporting said first suspension means, first adjusting means including an externally geared mechanical drive coupled through said first bellows to said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means, means including said first suspension means for resiliently supporting said second suspension means, second adjusting means including an externally geared mechanical drive coupled through said second bellows to said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and means supported by said second suspension means for supporting said object in the path of said electron beam.

4. An object stage for electron image apparatus having an electron beam including in combination a frame member, a first and second bellows mounted in said frame member, first suspension means, means including said frame and at least two substantially parallel spring members connecting said frame and said suspension means for resiliently supporting said first suspension means, first adjusting means including an externally geared mechanical drive coupled through said first bellows to said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means including said first suspension means and at least two substantially parallel spring members connecting said first and said second suspension means for resiliently supporting said second suspension means, second adjusting means including an externally geared mechanical drive coupled through said second bellows to said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and means supported by said second suspension means for supporting said object in the path of said electron beam.

5. An object stage for electron image apparatus having an electron beam including in combination a frame member, first suspension means, means including said frame for resiliently supporting said first suspension means, first adjusting means for said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means, means including said first suspension means for resiliently supporting said second suspension means, second adjusting means for said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and removable means supported by said second suspension means for supporting said object in the path of said electron beam.

6. An object stage for electron image apparatus having an electron beam including in combination a frame member, first and second bellows mounted in said frame member, first suspension means, means including said frame and at least two substantially parallel spring members connecting said frame and said suspension means for resiliently supporting said first suspension means, first adjusting means including an externally geared mechanical drive coupled through said first bellows to said first suspension means for providing unidirectional adjustment thereof normal to said electron beam, second suspension means including said first suspension means and at least two substantially parallel spring members connecting said first and said second suspension means for resiliently supporting said second suspension means, second adjusting means including an externally geared mechanical drive coupled through said second bellows to said second suspension means for providing unidirectional adjustment thereof normal to said electron beam and normal to the direction of adjustment of said first suspension means, and removable means supported by said second suspension means for supporting said object in the path of said electron beam.

7. An object stage for an electron image device having an electron beam including in combination a frame member, an object support, first means extending through said frame for adjusting unidirectionally and normal to said electron beam the position of said object support in the path of said beam, second means extending through said frame for adjusting the position of said object support unidirectionally and normal to both said electron beam and the direction of adjustment provided by said first means, and resilient means for substantially preventing the movement of said object support in other directions.

CHARLES J. YOUNG.