June 3, 1969 HIROSHI AKAHORI 3,448,262

DEVICE FOR EXCHANGING POLE PIECE ASSEMBLIES OF AN ELECTRON LENS IN AN ELECTRON MICROSCOPE

Filed March 11, 1966 Sheet 1 of 2

FIG. 1

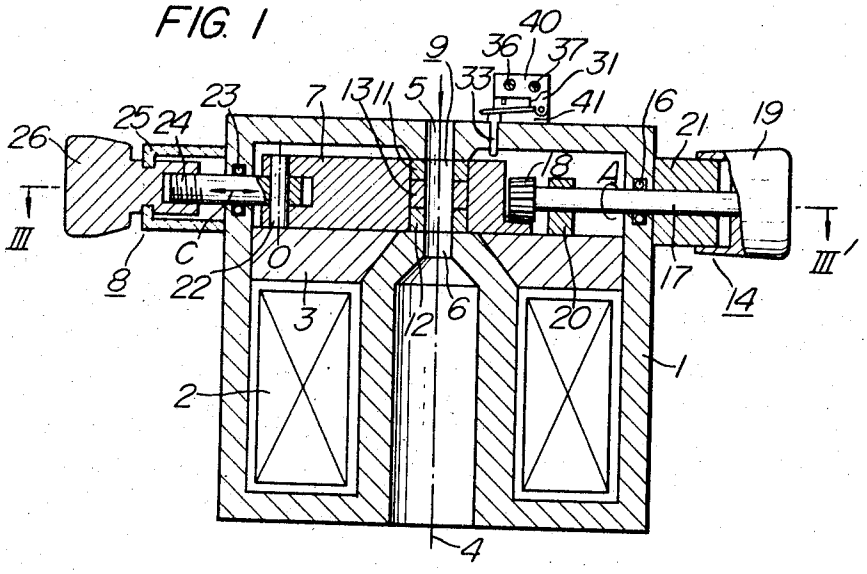
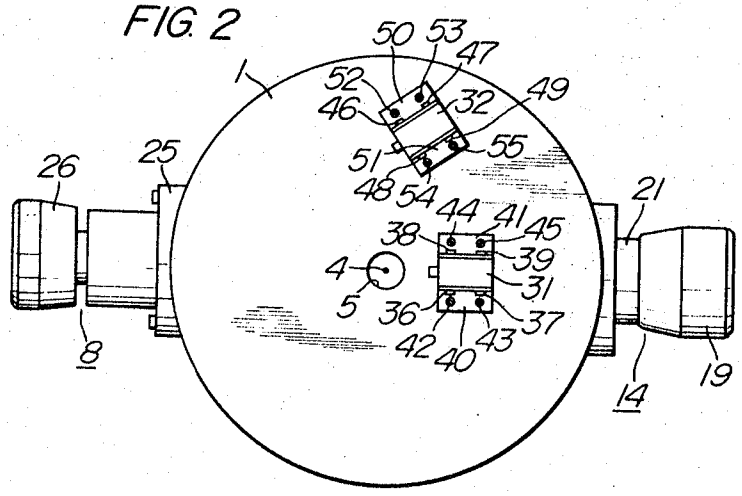


FIG. 2



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FIG. 3

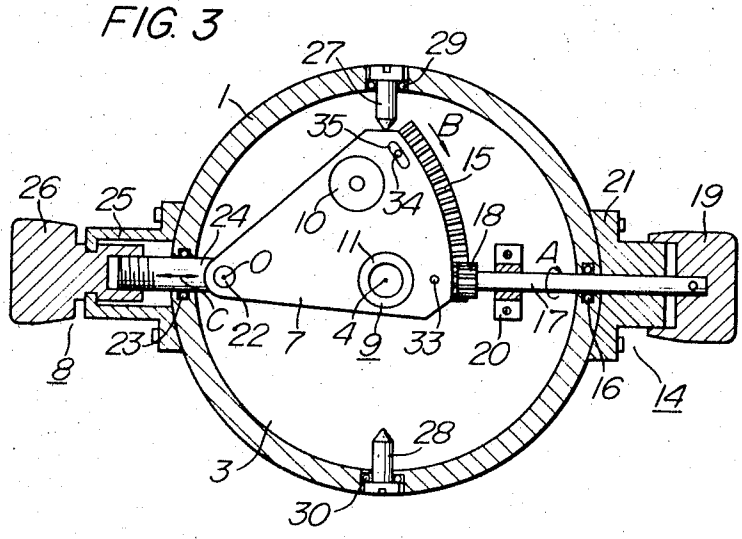
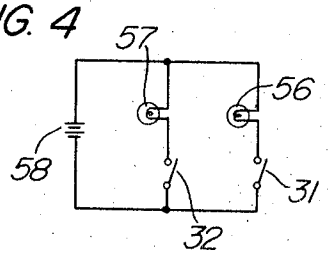


FIG. 4



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DEVICE FOR EXCHANGING POLE PIECE ASSEMBLIES OF AN ELECTRON LENS IN AN ELECTRON MICROSCOPE

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U.S. Cl. 250—49.5 11 Claims

ABSTRACT OF THE DISCLOSURE

Device for exchanging pole piece assemblies of an electron lens in an electron microscope including a rotatable sector carrying the pole piece assemblies for pivoting movement into alignment with the electron beam passage with means for adjusting the position of the sector with respect to its pivot point both radially and angularly.

This invention relates to a device for exchanging the pole pieces of projection electron lenses in an electron microscope.

It has been often desired to exchange the pole pieces of projection electron lens in an electron microscope to vary its magnification.

Such a device including a rotatable disc having therein a plurality of projection electron lens pole pieces arranged along a circle so that a desired one of the pole pieces may be put in alignment with the axis of the electron beam through rotation of the disc has been proposed. Although it is an inherent object of the exchange device to set selected one of projection electron lens pole pieces in alignment with the beam axis, it is desirable moreover that the alignment operation be carried out so as to put the optical center of the selected pole piece in accurate alignment with the beam axis. To this end, a projection electron lens exchange device of the type that such alignment is obtained by displacing the whole mechanism including the above mentioned rotatable disc and a mechanism for rotating the disc in a plane perpendicular to the beam axis has been proposed. Such a projection electron lens exchange device, however, has a disadvantage that not only its construction becomes complex but its alignment operation is troublesome.

Accordingly, an object of the present invention is to provide a device for exchanging pole pieces in an electron microscope which is of simple construction and easily operable.

Another object of the invention is to provide a device of the kind described wherein the accuracy to which the selected pole piece is set in alignment with the beam axis can be ascertained.

These and other objects and advantages of the present invention will be more apparent from the following description with reference to the annexed drawings in which:

FIG. 1 shows a longitudinal section of an electron lens of an electron microscope incorporating an embodiment of a device for exchanging the pole piece of the projection electron lens according to the present invention; FIG. 2 is a plan view of the electron lens shown in FIG. 1; FIG. 3 shows a cross section of the device shown in FIG. 1 taken along line III–III'; and FIG. 4 shows a circuit diagram for the exchange device shown in FIG. 1.

Referring to the drawings, especially to FIG. 1, a projection electron lens is constructed substantially symmetrically to the axis of electron beam **4** and includes a casing **1** for providing passage of magnetic flux, an electromagnetic coil **2** enclosed in the casing **1** and a base plate **3** for supporting a device according to the present invention. The casing **1** is provided with upper and lower passages **5** and **6**, respectively for passing the electron beam. Between the upper and lower passages, there is disposed a pivotable sector **7** mounted movably in a plane perpendicular to the beam axis. The upper surface of the base plate **3** lies substantially in a plane of the top surface of the lower passage **6** so that the pivotable sector **7** may slide along the top surface of the lower passage and the upper surface of the base plate **3**. The pivotal point **0** of the sector **7** is supported by a displacing mechanism **8**. The sector **7** has two projection electron lens pole piece arrangements **9** and **10** arranged along a circle with the pivotal point **0** as the center of the circle, as seen in FIGURE 3.

The projection electron lens pole piece arrangement **9** is composed of an upper magnetic pole piece **11**, a lower magnetic pole piece **12** and a nonmagnetic member **13** interposed between the pole pieces **11** and **12**. The projection electron lens pole piece arrangement **10** is constructed similarly but of inner diameter different from that of the pole piece arrangement **9**. The rotatable sector **7** is adapted to be rotated about the pivotal point **0** by means of a rotating mechanism **14** which comprises a rack **15** formed on a portion of the periphery of the rotatable sector **7**, and a pinion **18** which engages with the rack **15** and is fixedly secured to a shaft which extends through the side of the casing **1** with a vacuum packing being interposed between the shaft **17** and the side of the casing **1**. The shaft **17** is journalled by bearings **20** and **21** fixedly secured to the top surface of the base plate **3**, and the side of the casing **1**, respectively, and has a knob **19** formed on its outer end. The displacing mechanism **8** includes a displacing shaft **24** which is supported rotatably by a pin **22** disposed at the pivotal point **0** of the rotatable sector **7** and extends through a vacuum packing mounted in the diametrically opposite side of the casing **1** and a knob **26** which is threaded over the outer end of the displacing shaft **24** and supported rotatably by a bearing **25** mounted in the side of the casing **1**. The rotating shaft **17** and the displacing shaft **24** are arranged substantially symmetrically with respect to the beam axis **4**. Stoppers **27** and **28** extend through vacuum packings **29** and **30**, respectively, into the interior of the casing **1** at points spaced 90 degrees in arc from the shaft **17** and **24** and are fixedly mounted on the casing **1**.

Two electrical switches **31** and **32** are arranged on the top surface of the casing **1** and actuating members **33** and **34** for the switches **31** and **32**, respectively, extend through the top wall of the casing **1** and are adapted to be moved vertically. A projection **35**, as seen in FIGURE 3, is provided on the upper surface of the pivotable sector **7**. The actuating members **33** and **34** are arranged below the switches **31** and **32**, respectively. The switches **31** and **32** subtend at the pivotal point **0** of the pivotable sector **7** the same angle as that subtended by the pole piece arrangements **9** and **10** at the point **0** so that when the pole piece arrangement **9** is set in alignment with the beam axis **4** the actuating member **34** is moved upward by means of the projection **35** to close the switch **32** and when the pole piece arrangement **10** is set in alignment with the beam axis **4** the actuating member **33** is moved upward by means of the projection **35** to close the switch **31**. The upper parts of the actuating members **33** and **34** are enlarged to provide stops for preventing the members to move downward excessively. The switch **31** is rigidly mounted on supports **40** and **41** by means of screws **36**, **37** and **38**, **39**, respectively, and the supports **40** and **41** are secured rigidly to the upper surface of the casing **1** by means of screws **42**, **43** and **44**, **45**, respectively.

The switch **32** is mounted rigidly on supports **50** and **51** by means of screws **46, 47** and **48, 49**, respectively, and the supports **50** and **51** are secured rigidly to the upper surface of the casing **1** by means of screws **52, 53** and **54, 55.**

Referring to FIG. 4, the switch **31** is connected in series with a pilot lamp **56** and the switch **32** is connected in series with a pilot lamp **57**. The series connection of the switch **31** and the pilot lamp **56** and the series connection of the switch **32** and the pilot lamp **57** are connected in parallel to the power source **58.**

Operation of the device according to the present invention will be now described with reference to FIG. 3 which illustrates a situation wherein the pole piece arrangement **9** is set in accurate alignment with the beam axis **4.** If the shaft **17** is rotated in the direction represented by an arrow A from the illustrated position by means of the knob **19,** the pivotable sector **7** is pivoted in the direction represented by an arrow B about the pivotal point **0** through engagement of the pinion **18** and the rack **15** to bring the pole piece arrangement **10** in alignment with the beam axis and to accomplish exchange of the pole piece arrangements **9** and **10.** After the electron lens **10** is set in approximate alignment with the beam axis **4,** the optical center of the lens **10** may be easily put in accurate alignment with the beam axis **4** by finely adjusting the shaft **17** through rotation of the shaft **17** in the direction represented by the arrow A or in the opposite direction.

The pivotable sector **7** and the pole piece arrangement **10** may be finely displaced as a unit to accomplish setting of the pole piece arrangement in the direction represented by an arrow C in respect to the beam axis **4** by finely adjusting the displacing shaft **24** in the direction represented by the arrow C by means of the knob **26.** Thus, by effecting the movement of sector **7** in the direction represented by the arrow B and in the opposite direction and that in the direction represented by the arrow C by amounts X and Y, respectively, the optical center of the projection electron lens **10** can be set in accurate alignment with the beam axis **4,** the aligning operation being performed with accuracy by properly selecting the values of X and Y. It will be understood that the optical center of the pole piece arrangement **9** may be set in alignment with the beam axis **4** in a similar manner.

When the pole piece arrangement **9** is in alignment with the beam axis **4** as shown in FIG. 3, the switch **32** is closed as a result of upward movement of the actuating member **34** to energize the pilot lamp **57** to indicate alignment of the pole piece arrangement **9** with the beam axis **4.** It will be understood that the pilot lamp **56** is not lit at this moment.

On the other hand, when the pole piece arrangement **10** is set in alignment with the beam axis **4,** the switch **35** is closed by upward movement of the actuating member **33** as a result of displacing of the projection **35** to the position immediately below the actuating member **33** to energize the pilot lamp **50** to indicate alignment of the pole piece arrangement **10** with the beam axis **4.** The pilot lamp **57** is not, of course, lit at this moment.

The stoppers **27** and **28** prevent the pivotable sector **7** from striking and damaging the inner surface of the casing **1.**

As apparent from the foregoing description, according to the present invention, the exchange and alignment operation of the pole piece arrangement may be easily accomplished, a plurality of pole piece arrangements are carried by a pivotable sector, and a simple displacing mechanism provides simultaneously means for displacing the pivotable sector and means for supporting it to simplify the whole construction. Furthermore, it can be advantageously affirmed with ease that either of the pole pieces is aligned with the electron beam axis.

Thus the invention has many practical advantages.

What I claim is:

1. A device for exchanging pole piece assemblies in a projection electron lens arrangement of an electron microscope comprising

a casing containing means for generating a magnetic field and having an electron beam passage therethrough within which said magnetic field is generated,

a pivotable member mounted in said casing for pivotable movement across said beam passage and having a plurality of pole piece assemblies mounted thereon and arranged along an arc of a circle having its center at the pivot point of said member and having a radius equal to the distance between said pivot point and said beam passage,

first adjusting means connected to said pivotable member for moving said member in the direction of a line passing through said pivot point and said electron beam passage, and

second adjusting means engaging with said pivotable member for pivoting said member about said pivot point thereby placing a selective one of said pole piece assemblies in alignment with said electron beam passage.

2. A device as defined in claim **1** and further including a plurality of pilot lights, and switch means actuated by said pivotable member for energizing a respective one of said pilot lights as a corresponding pole piece assembly is moved into alignment with said electron beam passage by said second adjusting means.

3. A device as defined in claim **2** wherein said switch means includes a plurality of elective switches equal in number to the number of pole piece assemblies and corresponding pilot lights.

4. A device as defined in claim **1** wherein said pivotable member includes a pivot shaft essentially parallel to said beam passage and said first adjusting means includes a displacing shaft extending through said casing along said line through said beam passage and engaging with said pivot shaft and means for adjustably axially displacing and displacing shaft.

5. A device as defined in claim **1** wherein said pivotable member is in the form of a sector.

6. A device as defined in claim **5** wherein said second adjusting means includes a rack and pinion combination, the rack being formed along the arcuate edge of said sector shaped pivotable member and said pinion being formed on an actuating shaft extending through said casing.

7. A device for exchanging pole piece assemblies in a projection electron lens arrangement of an electron microscope comprising

a casing containing an electro-magnetic coil for generating a magnetic field and having an electron beam passage therethrough within which said magnetic field is generated,

a rotatable sector mounted on a pivot shaft in said casing for pivotable movement across said beam passage and having at least two pole piece assemblies mounted thereon and arranged along an arc of a circle having its center at the pivot point of said sector and having a radius equal to the distance between said pivot point and said beam passage,

first adjusting means connected to said pivot shaft for moving said sector in the direction of a line passing through said pivot point and said beam passage, and

second adjusting means engaging with said sector for pivoting said sector about said pivot shaft thereby placing a selective one of said pole piece assemblies in alignment with said electron beam passage.

8. A device as defined in claim **7** wherein said second adjusting means includes a rack and pinion combination, the rack being formed along the arcuate edge of said sector and said pinion being formed on an actuating shaft extending through said casing.

9. A device as defined in claim **7** wherein said first adjusting means includes a displacing shaft extending though said casing and engaging with said pivot shaft and means

for adjustably displacing said displacing shaft in the direction of said line through said pivot shaft and said beam passage.

10. A device as defined in claim **7** and further including first and second pilot lights, first and second electric switches connected respectively to said first and second pilot lights and means for selectively operating one of said pilot lights through actuation of the switch connected thereto as a corresponding pole piece assembly is moved into alignment with said electron beam passage.

11. A device as defined in claim **10** wherein said means for operating said pilot lights includes a projection on said

sector and switch actuating members mounted on said casing and engaged by said projection for actuating a selective one of said switches to operate the pilot light corresponding to the pole piece assembly in alignment with said beam passage.

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