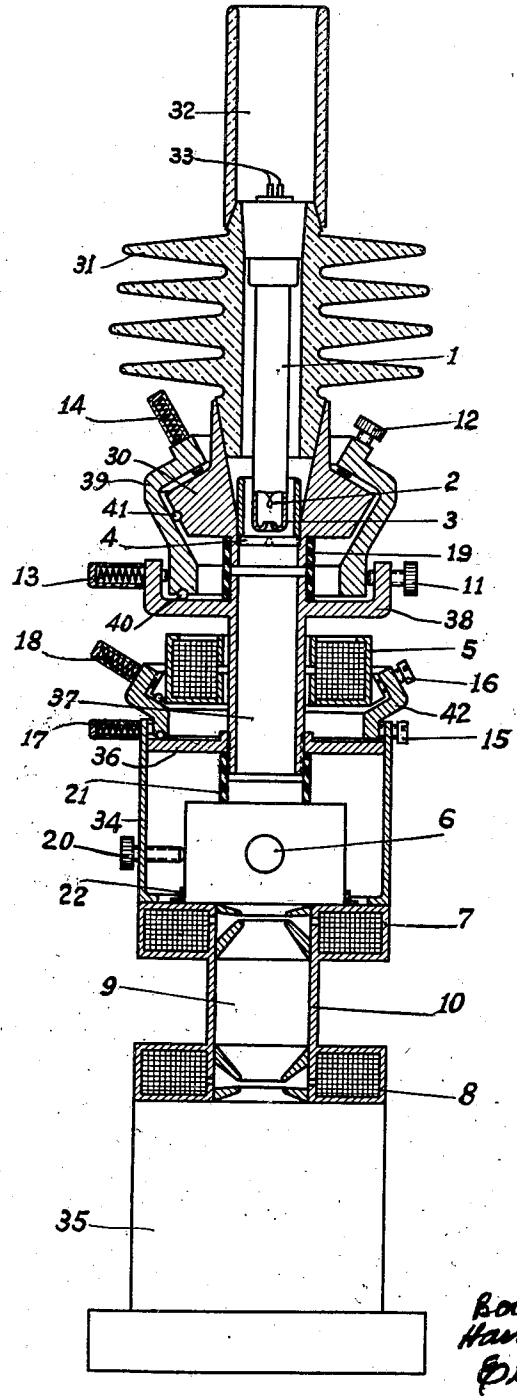
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ELECTRON MICROSCOPE

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Bodo von Borries
Hans Schuchmann
Ernst Ruska
Inventors
by Knight Bros
attys.

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ELECTRON MICROSCOPE

Bodo Von Borries, Hans Schuchmann, and Ernst Ruska, Berlin-Spandau, Germany, assignors to Fides Gesellschaft für die Verwaltung und Verwertung von gewerblichen Schutzrechten mit beschränkter Haftung, Berlin, Germany, a corporation of Germany

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The present invention relates to electron microscopes and to new improvements therein.

The electron microscopes of the known type consist of a radiating apparatus including an incandescent cathode, a Wehnelt cylinder and an anode diaphragm for producing an electron beam which is directed through a field coil acting as a condensing lens, an object support and one or more magnifying field coils so as to form a highly enlarged image of the object to be studied. It is also known to tilt or shift the coil forming the condensing lens in order to direct the electron beam onto the object. This leads to adjustments in which the electron beam does not coincide with the optical axis of the enlarging system. As a result the image formed on the fluorescent screen is subjected to shifting movements if fluctuations occur in the current of the condensing lens or the voltage of the radiating apparatus. Such fluctuations however, can not be entirely avoided, and a shifting of the image constitutes a very disturbing factor particularly if the image is to be reproduced photographically.

It is the principal object of the present invention to prevent such undesired shifting of an image formed in an electron microscope and, in particular, to render the electron microscope insensitive to fluctuations of the current and voltage, as mentioned above.

To this end, the invention provides means for adjusting the position and the direction of the electron beam and for adjusting one or more parts of the radiating apparatus relative to the system of field coils serving as magnifying lenses. These means are designed so that they permit adjusting one or more parts of the radiating apparatus relative to the lens system by shifting and tilting the parts, or by either of these methods. By the use of such adjusting means, it is possible to direct the electron beam produced by the radiating apparatus so as to coincide precisely with the optical axis of the magnifying lens system. As a result, fluctuations in the current of the condenser coil or the voltage of the radiating apparatus modify only the cross-sectional area of the beam without causing changes in the direction thereof. Consequently, a shifting of the image through such fluctuations is entirely prevented.

The adjusting means according to the invention may be designed for adjusting the incandescent cathode relative to the Wehnelt cylinder. The advantage hereby obtained is that one freedom of movement, that is, a mere shifting movement, will be sufficient for performing the adjustment.

Another possibility according to the invention consists in providing means for adjusting the incandescent cathode and the Wehnelt cylinder together relative to the anode diaphragm.

Still another way of designing a microscope according to the invention consists in the provision of means for tilting and shifting the entire radiating apparatus, that is, the incandescent cathode, the Wehnelt cylinder and the anode diaphragm, relative to the condenser lens and the other stationary parts of the electron microscope. The advantage of the last mentioned device consists in that the adjusting means may easily be formed so as to be electrically on ground potential.

Another object of the invention is to overcome the effect of deviations of the optical axis of the condensing lens from the geometrical axis, which in the manufacture may sometimes not be avoided. This object may be attained by providing means for tilting and shifting the condensing lens relative to the other stationary lenses which are mounted on the supporting frame structure. For this purpose, the condenser lens is preferably made adjustable independent of the means for adjusting the elements of the radiating apparatus. The advantage is hereby obtained that once the condenser lens has been correctly adjusted, no further adjustment need be made, even if certain parts of the radiating apparatus as such must be exchanged, for example, if the incandescent cathode is burnt out. The newly inserted parts of the radiating apparatus are then again placed in the correct position relative to the lens system which has been once fixedly adjusted. It is, however, advisable that the adjusting mechanism of the condenser coil be so constructed that, after being once adjusted, further adjustments cannot be easily made during the operation of the microscope.

After finally adjusting the electron beam so as to point in the desired direction, it is advisable to maintain such adjustment even if in the operation of the microscope a new portion of the object is to be studied. It is, therefore, another object of the present invention to provide means for adjusting or selecting the desired portion of the object to be studied by shifting the object support in a plane transverse to the electron beam. If a new portion of the object is to be studied, only the support of the object need be adjusted in transverse direction relative

to the electron beam, whereas the latter, once it has been finally adjusted, requires no further adjustment. This method of operating has the particular advantage that, regardless of which portion of the object is to be examined, always the optically most favorable part of the portraying system is used for forming the image.

These and other objects, features and advantages of the present invention will be understood from the following description of the mechanism diagrammatically illustrated in the accompanying drawing which shows an axial cross section through the main elements of an electron microscope according to the present invention.

The radiating apparatus 1 of the electron microscope, as shown in the drawing, includes an incandescent cathode 2, a Wehnelt cylinder 3 and an anode diaphragm 4. These parts are firmly mounted in a rigid structure consisting of a supporting body 30, an insulator 31 secured to the body 30 and enclosing the apparatus 1, and an insulating sleeve 32 surrounding the terminals 33 of the apparatus 1. The electron beam produced by the radiating apparatus passes through a condensing coil 5, a sluicing device 6 for inserting and supporting the object to be studied, an objective coil 7 and a projecting coil 8. The objective coil and the projecting coil form the magnifying lens system of the microscope. They are both stationary and firmly connected with the wall portion 9 of the microscope vessel in whose lower portion 35 the magnified image is produced on a fluorescent screen or a photographic layer (both not illustrated). A partition 36 and a tubular extension 37 are firmly secured to each other and connected with the other parts of the stationary vessel structure by means of a connecting structure 34. The interior of the composite microscope vessel is hermetically sealed and evacuated. For precisely adjusting the position and direction of the electron beam, the entire radiating apparatus carried by support 30 may be adjusted relative to the stationary portion of the electron microscope. For this purpose, the stationary tubular part 37 is provided with an extension 38 carrying adjusting screws 11 and countersprings 13 (one of each being illustrated) which bear against an intermediate rigid member 39. This member also has adjusting screws 12 and counteracting springs 14 (one of each being illustrated) which bear against the supporting body 30 of the radiating unit. Ball bearings, as indicated at 40 and 41, may be provided between elements 38 and 39 and between elements 39 and 30, respectively. As apparent from the drawing, an adjustment of screws 11 effects a displacement of the intermediate member 39 and the entire radiating unit in a direction transverse to the optical axis, while the adjustment of screws 12 causes the supporting body 30 of the radiating unit to tilt relative to the optical axis of the stationary lenses 7 and 8. Hence, by turning the adjusting screws 11 and 12 in one or the other direction, the electron beam may be easily adjusted so as to coincide precisely with the optical axis of the magnifying lens system. A rubber sleeve 19 serves for tightly connecting the movable part of the microscope with the stationary part 9.

In order to compensate for variations resulting in the manufacture of the condensing lens 5, this lens may also be adjusted relative to the vacuum vessel of the electron microscope. For this purpose, adjusting screws 15 co-operating with resilient holding means 17 are provided in the stationary vessel portion 34 so as to bear against an intermediate ring 42 which in turn carries adjusting screws 16 and counteracting springs 18 bearing against the lens structure 5. The screws 15 and 16 permit shifting and tilting the condensing lens 5.

For shifting the sluicing device 6 relative to the vessel portion 10 within a plane transverse to the direction of the electron beam, adjusting screws 20 may be provided. Rubber sleeves 21 and 22 on the sluicing device 6 are used for connecting the movable sluice tightly to the stationary parts so as to preserve the vacuum in the interior of the microscope. As shown in the drawing, the upper sleeve 21 is of smaller size than the upper surface of the sluicing device 6 and the lower sleeve 22, so that the external pressure may exert a considerable force upon the sluicing device and press the latter against the objective coil 7, thus holding the device 6 in a fixed position. However, the difference in dimension between the sleeve 21 and the upper surface of the sluicing device 6 is preferably dimensioned so that the latter can be shifted relatively easily and with great accuracy without losing the vacuum in the interior of the microscope. As apparent from the drawing, all of the aforementioned adjusting screws are arranged so as to be accessible from the outside and serviceable during the operation of the microscope.

The present invention is not limited to the particular embodiment shown in the drawing and is susceptible of various modifications. For example, the sleeves 19 and 21 may consist of a single corrugated tube of tombac or the like which connects the radiating apparatus 1 with the sluicing device 6. In this case, the adjusting means 11, 13, 15, 16, 17 and 18 may be mounted on a rigid upward extension of the vessel portion 10 of the electron microscope.

We claim:

1. An electron microscope having means for holding the object to be studied, a magnifying lens system for producing an image of the object, a radiating unit for producing an electron beam, a condensing lens between said radiating unit and said object-holding means, said radiating unit being tiltable and shiftable in a transversal plane relative to said condensing lens, adjusting means for varying the angular position of said radiating unit relative to said condensing lens, and means for adjusting the transversal position of said radiating unit in any direction along said plane, said different adjusting means being operable independently from one another.

2. An electron microscope having a stationary rigid vessel structure, means associated with said structure for holding the object to be studied, magnifying lens means mounted on said structure, a condensing lens also associated with said structure, a radiating unit for producing an electron beam, joint means for vacuum-tightly connecting said unit with said vessel structure so as to permit said unit a tilting and transverse shifting movement relative to said structure, an intermediate rigid member slidably arranged on said structure and engaging said radiating unit so as to permit an angular displacement of said unit relative to said member, adjusting means for varying and fixing the position of said intermediate member relative to said structure, and further adjusting means in transversal directions

for varying and fixing the angular position of said unit relative to said member.

3. An electron microscope comprising a stationary rigid vessel structure having a tubular vessel portion, means for holding the object to be studied, a magnifying lens system, a condensing lens consisting of a magnet coil and arranged on and around said tubular vessel portion, a radiating unit for producing an electron beam, said radiating means being substantially in alignment with said tubular vessel portion so as to form an extension of said vessel structure, a sleeve of yielding material hermetically joining said unit with said tubular vessel portion to allow said unit tilting and shifting movements relative to said vessel portion, an intermediate annular member concentrically surrounding said sleeve and engaging said radiating unit so as to permit said unit angular displacements relative to said member, means for guiding said member relative to said vessel portion so as to permit said member shifting movements in transversal directions with respect to said vessel portion, adjusting means for varying and fixing the transversal position of said intermediate member relative to said structure, and further adjusting means for varying and fixing the angular position of said unit relative to said member.

4. An electron microscope comprising a composite vessel structure, a magnifying lens system, a condensing lens, and radiating means for producing an electron beam, said vessel structure having a first vessel portion provided with said magnifying lens system, a second vessel portion provided with said condensing lens and carrying said radiating unit, said second vessel portion being spaced from said first vessel portion and rigidly connected therewith so as to have said condensing lens and said unit substantially coaxial with said magnifying lens system, and an intermediate vessel portion shiftable transversely relative to said first and second vessel portions and vacuum-tightly joined therewith, said intermediate vessel portion forming a sluicing device for accommodating the object to be studied, and adjusting means for varying and fixing the position of said intermediate vessel portion relative to said other vessel portions, said adjusting means being arranged exteriorly so as to be serviceable during the operation of the electron microscope.

5. An electron microscope comprising a composite vacuum vessel having two fixed vessel portions spaced from each other in the direction of the optical axis and rigidly connected with each other, and an intermediate vessel portion arranged between and vacuum-tightly connected with said other vessel portions, said intermediate vessel portion forming a device for holding the object to be studied and being transversely displaceable relative to said other vessel portions, a radiating unit for producing an electron beam, said unit being arranged at the end of one of said fixed vessel portions so as to be displaceable transversely and angularly relative thereto, adjusting means for varying and fixing the position of said unit relative to said latter vessel portion in order to adapt said position to that of the object in said intermediate vessel portion, and a magnifying lens system arranged on the other of said fixed vessel portions.

6. An electron microscope comprising a composite vacuum vessel having two fixed vessel portions spaced from each other in the direction of the optical axis and rigidly connected with each other, and an intermediate vessel portion arranged between and vacuum-tightly connected with said other vessel portions, said intermediate vessel portion forming a device for holding the object to be studied and being transversely displaceable relative to said other vessel portions, a radiating unit for producing an electron beam and a lens for condensing said beam, said unit and said condensing lens being arranged on one of said fixed vessel portions and independently movable transversely and angularly relative to said vessel portions, independently operable adjusting means for varying and fixing the positions of said unit and said condensing lens respectively with respect to said latter vessel portion, and a magnifying lens system arranged on the other of said fixed vessel portions.

7. An electron microscope having a radiating device for producing an electron beam, a lens for condensing said beam, means for holding the object to be studied, a magnifying lens system for causing said condensed beam to produce an image of the object, said object holding means being displaceable relatively to and independently of said radiating device, condensing lens and magnifying lens system in the directions of a plane transversal to said beam, said radiating device being displaceable angularly and transversely with respect to said lens and lens system, and adjusting devices serviceable during the operation of the microscope for independently varying and fixing the positions respectively of said holding means and said radiating device.

8. An electron microscope having a radiating device for producing an electron beam, a lens for condensing said beam, means for holding the object to be studied, a magnifying lens system for causing said condensed beam to produce an image of the object, said object-holding means being displaceable relatively to and independently of said radiating device, condensing lens and magnifying lens system in directions of a plane transversal to said beam, said radiating device and said condensing lens being each separately displaceable angularly and transversely with respect to said lens system and independently of said radiating device, and adjusting devices for independently varying and fixing the position of each of said holding means, radiating device and condensing lens respectively.

BODO VON BORRIES.
ERNST RUSKA.
HANS SCHUCHMANN.