July 29, 1947. C. H. BACHMAN ET AL 2,424,791

ELECTRON MICROSCOPE APPARATUS

Original Filed Dec. 1, 1942 6 Sheets-Sheet 1

Fig. 1.

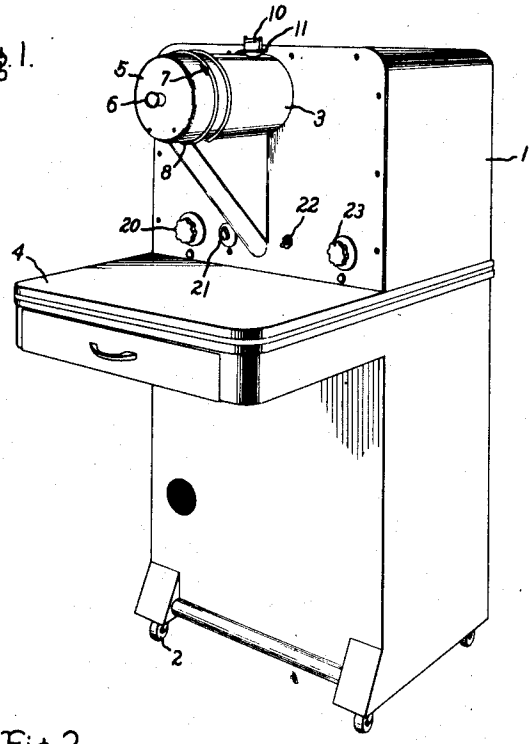
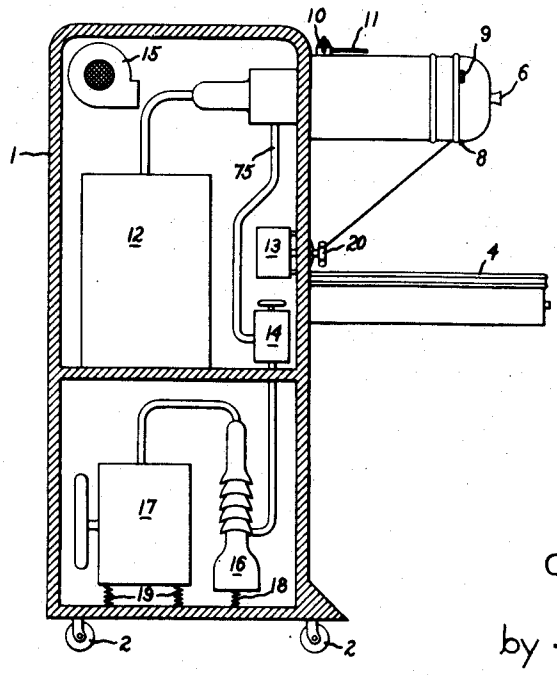


Fig. 2.



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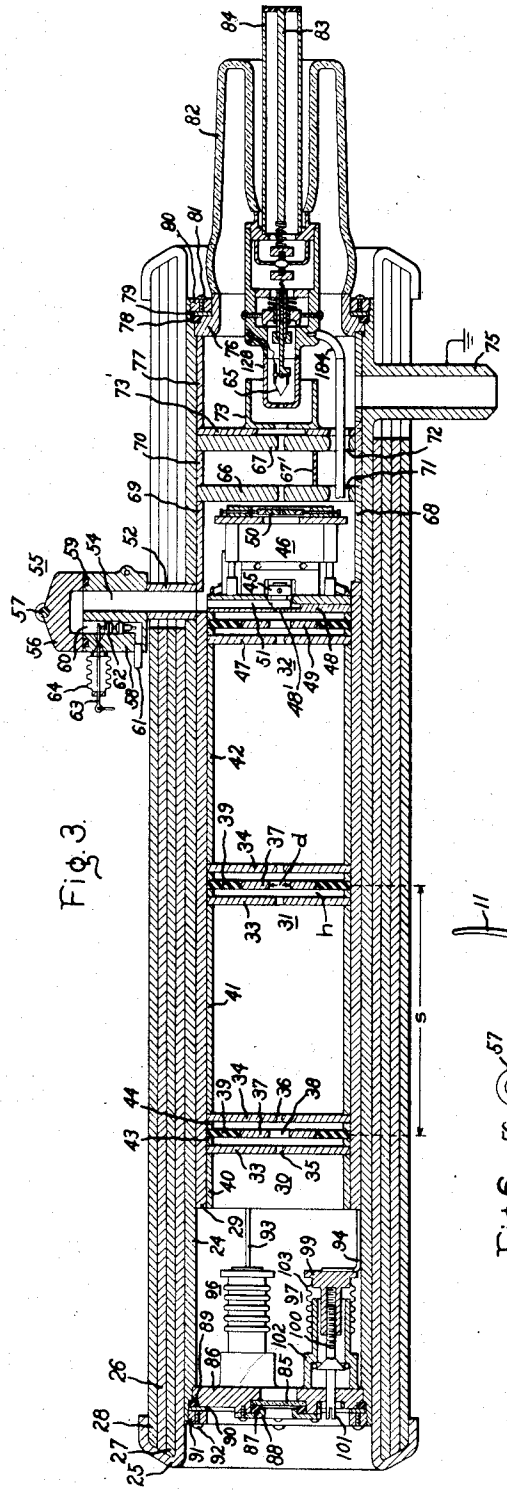


Fig. 3.

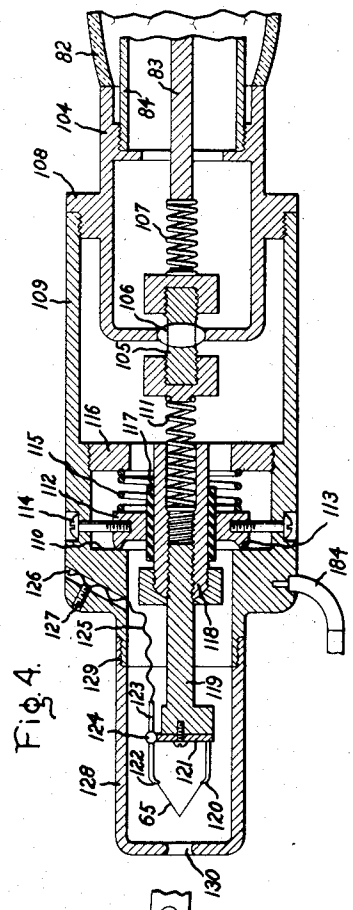


Fig. 4.

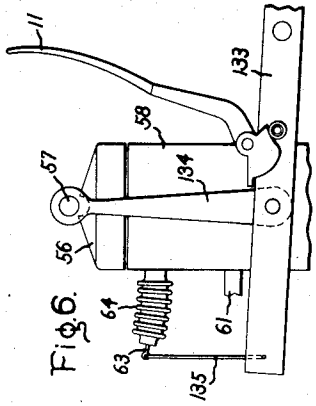


Fig. 6.

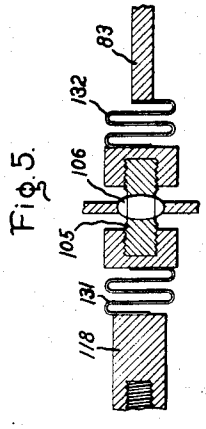


Fig. 5.

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ELECTRON MICROSCOPE APPARATUS

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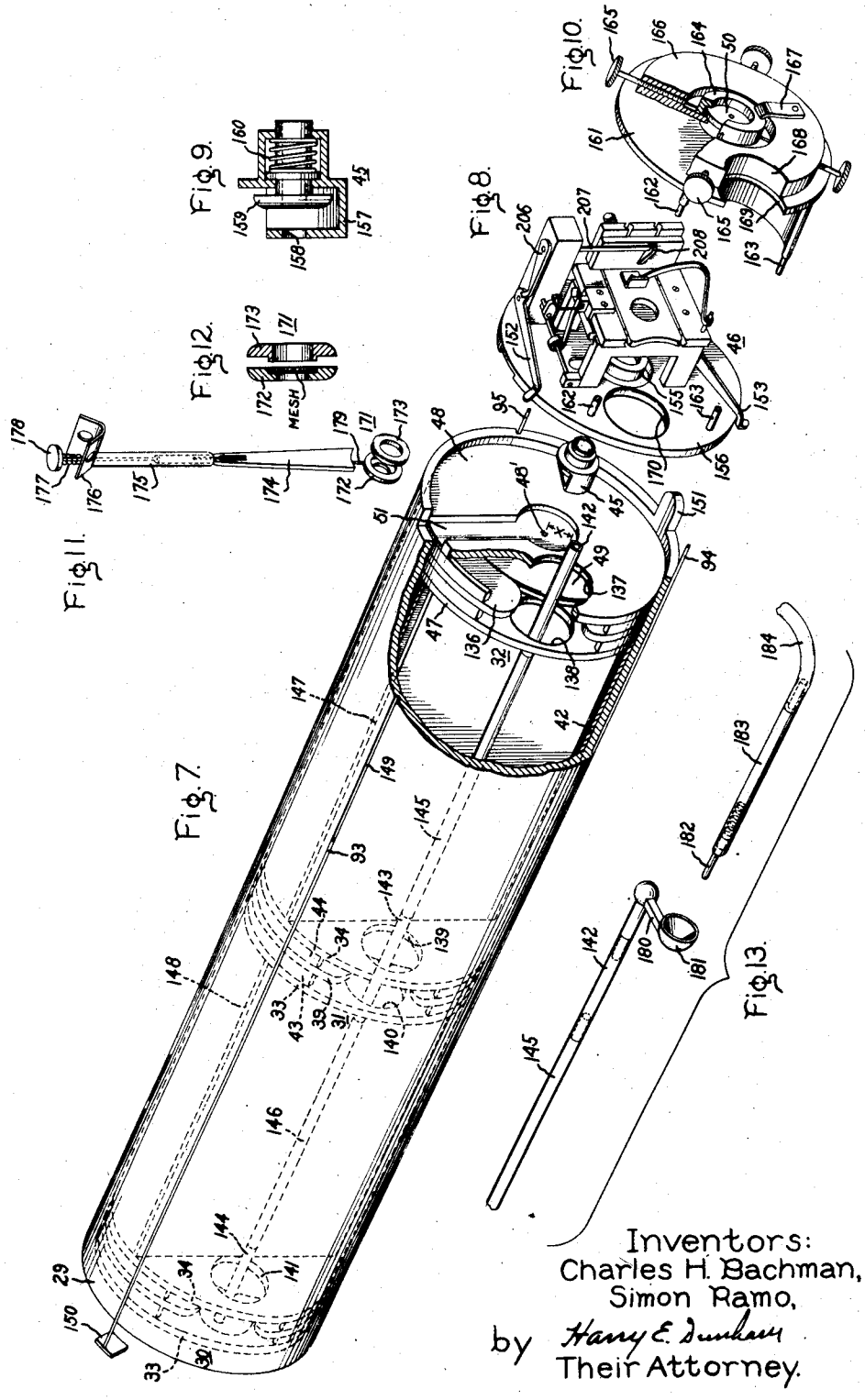


Fig. 7.

Fig. 10.

Fig. 9.

Fig. 8.

Fig. 12.

Fig. 11.

Fig. 13.

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ELECTRON MICROSCOPE APPARATUS

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Fig. 14.

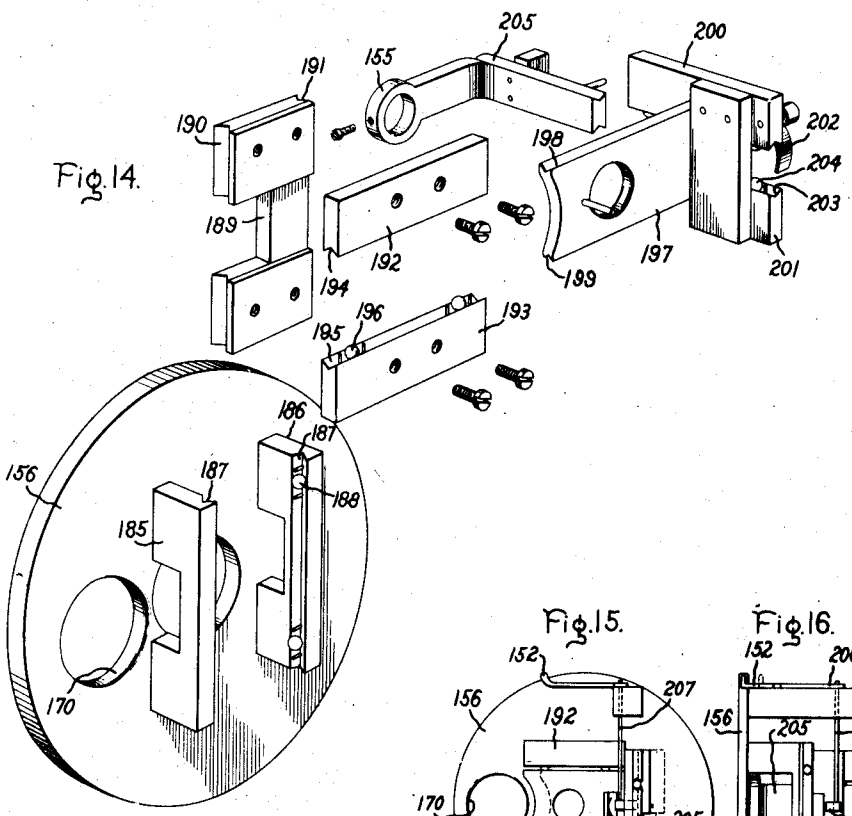


Fig. 15.

Fig. 16.

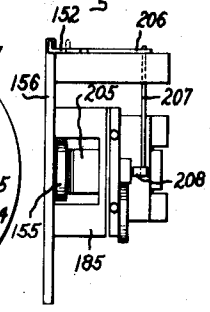


Fig. 17.

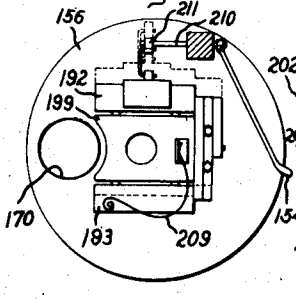


Fig. 18.

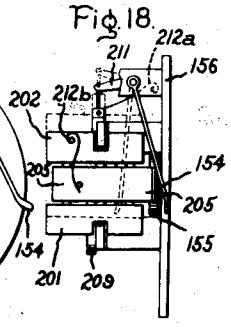


Fig. 19.

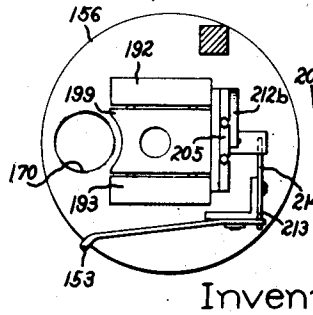
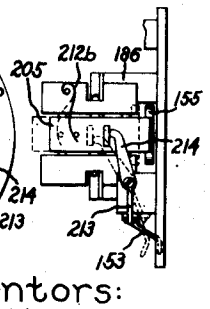


Fig. 20.



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ELECTRON MICROSCOPE APPARATUS

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Fig. 21.

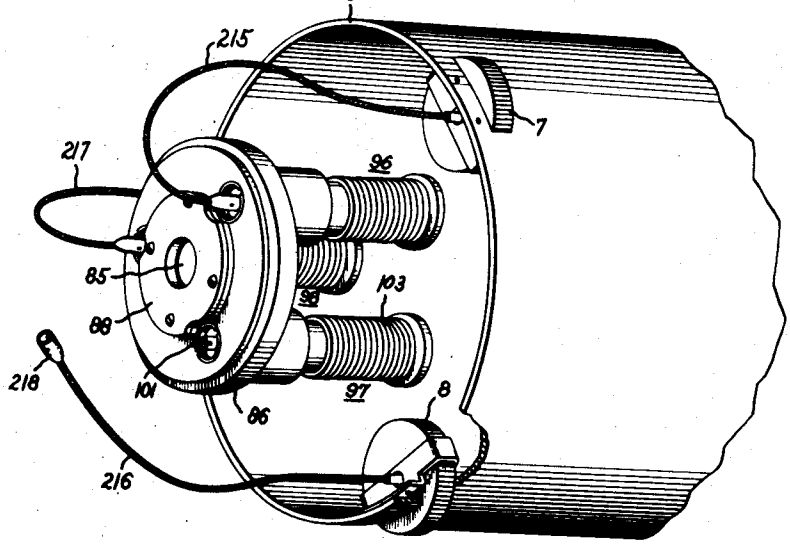


Fig. 23.

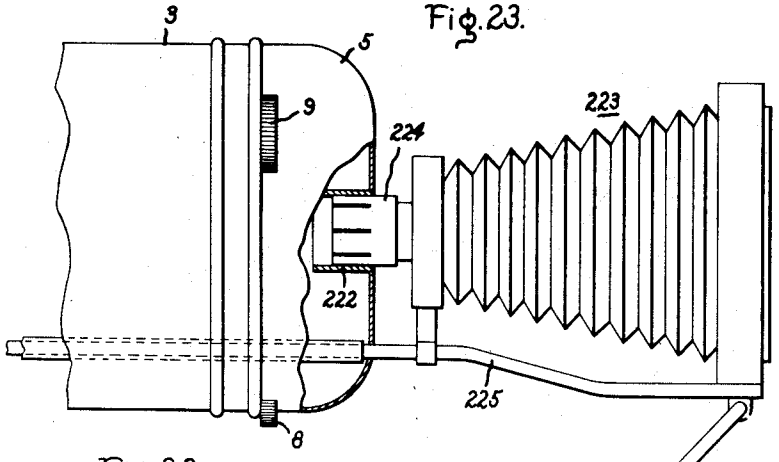
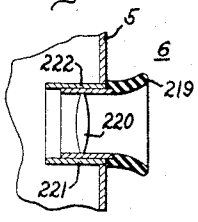


Fig. 22.



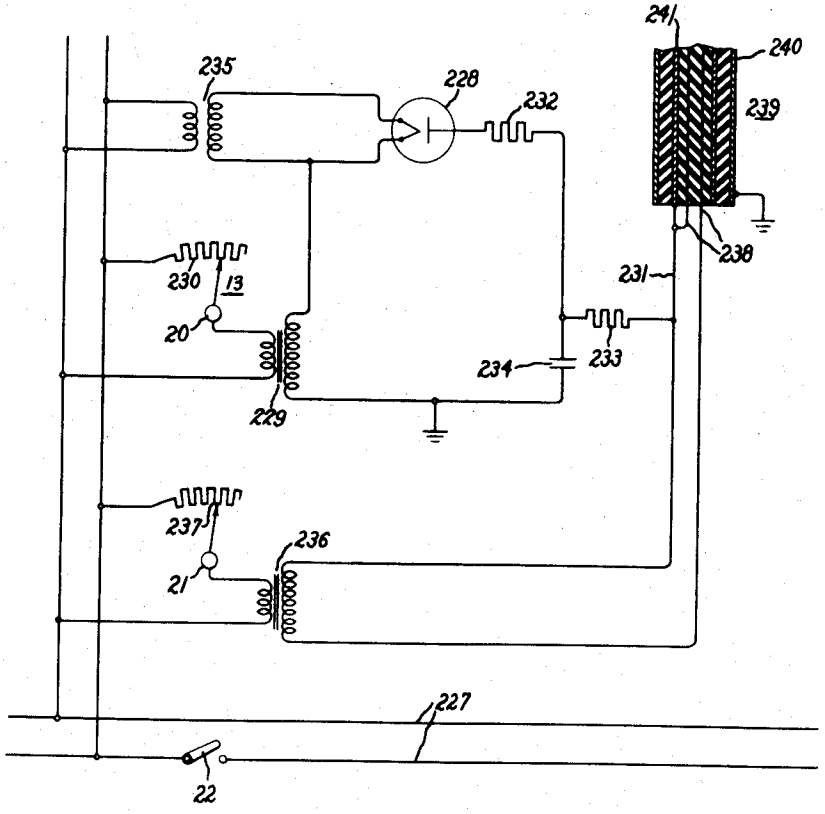
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ELECTRON MICROSCOPE APPARATUS

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Fig. 24.



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UNITED STATES PATENT OFFICE

2,424,791

ELECTRON MICROSCOPE APPARATUS

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Original application December 1, 1942, Serial No. 467,530. Divided and this application January 26, 1944, Serial No. 519,774

19 Claims. (Cl. 250—49.5)

1

The present invention which is a division of our copending application S. N. 467,530, filed December 1, 1942, relates to electron microscopes, and more particularly to new and improved structure for electron microscopes of the electrostatic type.

In electron microscopes of the prior art, and particularly those which have been constructed in accordance with the prior art arrangements and teachings, the structures thereof, particularly the evacuated chamber within which the elements are placed, have not been readily adaptable or susceptible to widespread application due to the fact that the evacuated chambers have been of relatively large size because of the type of the electron lens systems employed, thereby involving relatively large time intervals between examinations of different specimens.

The prior art arrangements have also been subject to the disadvantage of requiring the services of skilled operators to effect frequent realinement of the electrodes or focusing apparatus. Where, in the prior art, the magnetic type of electron microscope has been employed, in order to obtain accuracy of the image produced and to retain a desired degree of precision in the focusing effect, it has been necessary to use a large number of regulating or controlling elements for controlling the voltage or current supplied to the electrical elements of the microscope. Due to the above factors the size of the prior art microscopes has been inordinately large, thereby restricting the degree of portability and thereby limiting the field of application.

In accordance with the teachings of our invention described hereinafter, we provide a new and improved electron microscope which obviates the disadvantages of the prior art arrangements and which affords simplicity of construction and operation, and adaptability to a wide field of application. The electron microscope which we provide is adapted and arranged to permit frequent opening of the evacuated chamber for the insertion and extraction of specimens to be investigated and which entails only the lapse of a relatively short interval of time between examinations due to the fact that the chamber is relatively small. In addition, the specimen insertion chamber and sealing structure thereof are arranged to permit ease of insertion and extraction of the specimen. Furthermore, the essential elements of the electron microscope, such as the cathode construction and the electron lens system, are readily demountable for inspection and replacement. Lastly, a unitary electron lens

2

assembly is provided so that the alinement of the electrodes thereof may be initially made at the factory, thereby obviating the necessity for frequent and time consuming realinement during use after manufacture.

It is an object of our invention to provide a new and improved electron microscope.

It is still another object of our invention to provide new and improved structure for an electron microscope wherein the essential elements are readily demountable and available for inspection and replacement.

It is a further object of our invention to provide a new and improved electron microscope wherein specimens may be inserted and extracted without involving the lapse of undesirable periods of time between examinations of different specimens.

It is a still further object of our invention to provide a new and improved specimen carrier for an electron microscope.

It is still another object of our invention to provide a new and improved means for adjusting the position of a specimen in an electron microscope.

For a better understanding of our invention, reference may be had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. Fig. 1 diagrammatically illustrates an embodiment of our invention wherein the evacuated chamber containing the lens system is horizontally disposed and wherein the actuating means for moving the specimen are located within the vicinity of the viewing aperture. Fig. 2 is a cross-sectional view of the cabinet supporting the microscope and shows the disposition of associated or auxiliary apparatus. Fig. 3 is a cross-sectional view of the electron microscope showing the evacuated chamber, electron lens system and cathode supporting structure; Fig. 4 is a cross-sectional view of the cathode supporting structure; and Fig. 5 is an alternative form of the flexible connection which may be employed therein. Fig. 6 is a view of the actuating structure for the sealing valve adapted to open and close the specimen insertion chamber. Fig. 7 is a partially perspective and cut-away view of the electron electrostatic lens system; Fig. 8 is a perspective view of a manipulator which may be employed in our electron microscope, and Fig. 9 represents the cartridge type specimen carrier. Fig. 10 represents the structure for holding and positioning an electron beam restricting means such as a positional apertured disk. Fig. 11 is

a view of the specimen insertion member; Fig. 12 is a detailed view of the locket which is supported at one end of the holder shown in Fig. 11; Fig. 13 is a view of the sectionalized horizontal conductor which connects corresponding electrodes of the various horizontally disposed electrostatic lens system. Fig. 14 is an exploded view of the manipulator; Figs. 15 and 16 are front and side views, respectively, of the manipulator showing the horizontal motion produceable thereby; Figs. 17 and 18 are front and side views, respectively, showing the vertical transverse motion produceable thereby, and Figs. 19 and 20 are front and side views, respectively, of the manipulator showing the longitudinal or focusing action produceable by the manipulator. Fig. 21 is a detailed view of the externally accessible actuating means or wheels which control the specimen manipuator. This figure also shows bellows-type sealing structure and the member for supporting a viewing screen or fluorescent screen. Fig. 22 is a detailed view of the insertable optical or glass lens which may be used in conjunction with our electron microscope. Fig. 23 illustrates the manner in which a camera may be used to photograph the image produced upon the fluorescent screen of the electron microscope, and Fig. 24 is a simplified circuit diagram showing the controllable source of voltage for the electron microscope and the cathode filament supply.

Prior to a detailed description of the embodiment of our invention illustrated, it is believed that it may be helpful to present generally certain fundamental aspects of the electron microscope disclosed herein. Generally speaking, the electron microscope which we provide is one employing an electrostatic type lens. The microscope comprises essentially an electron gun which produces an electron beam to illuminate or irradiate a specimen to be investigated and an imaging system which magnifies the image produced by the impingement on the specimen into a larger image on a viewing screen such as a fluorescent screen, or upon the surface of a photographic plate.

In an electron microscope of the electrostatic type which we provide, the lens focal length is a function of its physical size and configuration since an increase or decrease in the electron velocity is always accompanied by a change in the electric field focusing action of just such magnitude or strength as to yield precisely the same electron paths. By the use of such a system it is then not necessary to employ a closely regulated source of supply voltage for the microscope.

Of course, as is well known, the desirability of employing an electron microscope in place of a light microscope for many applications is the greater resolving power incident to the use of electron irradiation as contrasted with the smaller resolving power of light microscopes. Although not limited to a particular resolving power or magnification, an electron microscope built in accordance with our invention operates satisfactorily having a 200 Angstrom units resolution and a useful magnification of about 10,000×. As pointed out hereinafter, this magnification may be obtained either exclusively by the design of the electron lens system itself, or by the combination of a suitable electron electrostatic lens and an associated light microscope or lens which is placed in the vicinity of the fluorescent screen at one end of the electron microscope.

In the electron microscope described hereinafter, certain features are incorporated by virtue of the configuration and position of the elements to obtain the desired operation of the electron gun, the irradiation of the specimen, and the desired focusing action of the electrostatic lens. As concerns the electron gun, this element is constructed to produce sufficient current density at the specimen without involving an appreciable heating of the specimen by the electron beam. On the other hand, the image is illuminated to a sufficient degree of brightness for visual observation with a minimum of current striking the specimen. It will be apparent that there is no advantage to irradiate a large part of a specimen if only a small portion on the axis is to be imaged. Furthermore, there is no reason to direct electrons at the specimen if their incident angle is such that in the absence of deflection they will consequently be rejected by the objective lens aperture stop. The contrast obtained at the viewing screen or fluorescent screen is the result of distribution of the electrons arriving there. We have found that for very thin specimens the majority of the electrons which pass through the specimen do so with their slope substantially unchanged; consequently, the limiting angle of the electron bundle leaving the objective lens can be established principally by the electron gun apparatus rather than by the apertures of the objective lens system. This type of limiting is generally easier to accomplish mechanically by the necessary aperture in the electron gun, and this necessary aperture may be more favorably located than the objective lens stop so as to obviate the need of punching exceedingly small diameter holes in the lens electrodes. Of course, the lens aberrations as well as the particular thickness and material of the specimen that is under examination, play an important part in determining whether the gun angle can serve as an effective stop for the system, or whether that limit is determined by the first imaging or objective lens. It has been found that highly successful results are obtained with a small gun angle, and the gun angle produces a more readily discernible effect upon the resolving power than does the lens aperture.

The electron microscope described hereinafter is constructed to afford proper relationship between the cathode filament point location, the filament shield aperture diameter, anode-filament spacing and the spacing and size of the other apertures. The spacing and size of the other apertures of the system depend upon a number of factors such as the location of the imaging lens system and the specimen, the filament life, the accelerating voltage, the electron beam angle at the specimen and the extent of magnetic shielding of the field due to the filament current.

As concerns the electrostatic electron lenses which magnify the electron image produced by the impingement of the electron beam on the specimen, the electrostatic lens system of the electron microscope which we provide possesses the following general characteristics. The focal length of the system is positive and relatively short without involving the use of excessively small parts. The "in-focus" position of the specimen is external to the high field region of the lens and the specimen is in a region substantially entirely free from electric fields. The electrodes of the lens system are finely machined or ground and highly polished to minimize the insulation problem and field emission at the operating voltage. The lenses are of symmetrical

configuration with a single negative potential to ground, namely the cathode potential, serving to energize the lens. The axial voltage drop in the central region of the lens is maintained at an optimum value, thereby minimizing strong magnetic fields and chromatic aberration effects.

Fig. 1 of the drawings represents a perspective view of a cabinet 1, which is of a portable nature being mounted on castors 2, and which houses associated auxiliary apparatus for an electron microscope, and on the front of which the electron microscope is horizontally positioned within a cylindrical cover 3. There is provided a desk or table part 4 integral with the cabinet 1 to facilitate use of the microscope. An end cover 5 encloses the end of cylindrical cover 3 and is provided with a viewing aperture through which an eye-piece 6 extends. This eye-piece is shown in detail in Fig. 22. There is also positioned within the vicinity of the eye-piece or viewing aperture a plurality of externally accessible actuating means, such as knurled wheels 7, 8, and 9 which serve to operate a manipulator (described hereinafter) to position a specimen or object to be examined. A specimen insertion chamber terminates in a sealing valve 10 and having an actuating member 11 is conveniently located within easy reach of the operator at the top of cover 3 and is shown in detail in Fig. 6.

Fig. 2 is a side view showing the disposition of the associated auxiliary or control apparatus within the cabinet 1. A suitable power supply means 12, including a rectifier and a transformer, is employed in an upper compartment together with voltage controlling means such as a rheostatic regulator 13 and a vacuum valve 14. Cooling means for the electron gun, such as a centrifugal blower 15, is also positioned in this compartment of the cabinet. In the lower compartment of the cabinet, we employ an evacuation means such as a pair of serially connected pumps 16 and 17, both of which are supported by vibration absorption means such as springs 18 and 19. Pump 16 is preferably a high vacuum two-stage oil diffusion pump which operates in series with a mechanical pump, the latter of which furnishes the "rough" vacuum. Control means for the electrical apparatus and for the pumping apparatus may be positioned within the front of the cabinet 1. For example, the rheostatic regulator 13 of the voltage supply for the electron gun of the microscope may be provided with a handle or knob 20 which extends through the wall of the cabinet to make it readily accessible to the operator. In like manner, referring to Fig. 1, the filament supply for the cathode of the electron gun may be controlled by a knob or dial 21 also positioned on the front of the cabinet. Likewise, a main power switch 22 and a handle 23 connected to the vacuum valve 14 through gearing (not shown) may be made easily accessible to the operator by mounting as indicated.

In Fig. 3 there is illustrated a cross-sectional view of the evacuated chamber, electron gun, the electrostatic lens system, and the specimen carrier manipulator and actuating means thereof. The evacuated chamber within which the microscope elements described above are positioned is defined in part by a metallic cylinder, such as a brass cylinder 24, the interior surface of which may be adapted to closely engage an insertable unitary electron lens assembly to be described more in detail hereinafter and which is shown in Fig. 7. As a means for shielding cylinder 24, we provide a laminated metallic shielding structure which includes alternate layers of copper and a high permeability iron. For example, we may employ cylindrical sheaths of copper 25 and 26 and alternate layers of high permeability iron 27 and 28. The sheath which is adjacent cylinder 24 may be either iron or copper and may be turned over at its ends in order to secure the other layers in the position illustrated.

A unitary electrostatic electron lens assembly is defined externally by means of a metallic cylinder 29, preferably constructed of brass, the inner surface of which is finely ground and highly polished to closely engage cylinder 24 and to support therein the elements of the electrostatic lens system. The inner surface of cylindner 24 and the outer surface of cylinder 29 need not be as precisely machined as the inner surface of cylinder 29. Within the cylinder 29 we provide an electrostatic lens system which includes a plurality of generally similar lenses 30, 31 and 32. This lens assembly may be arranged to have a total magnification of about 1500. Lenses 30 and 31 each comprise a pair of longitudinally spaced wafer-like electrodes 33 and 34 maintained at a common or anode potential and which are provided with apertures 35 and 36, respectively. We provide an intermediate electrode 37 also of wafer or disk-like configuration in spaced relation between outer electrodes 33 and 34 and which is provided with an aperture 38 of substantially larger diameter than the apertures 35 and 36. Electrodes 33 and 34 are constructed to have their peripheries finely ground and polished to closely engage the inner surface of cylinder 29, thereby establishing satisfactory mechanical and electrical connection to the system. Intermediate electrode 37 is electrically insulated from cylinder 29 and is maintained at cathode potential by means of a horizontal conductor connected thereto and shown in Figs. 7 and 13. Electrode 37 is maintained in the position illustrated by means of a split insulating spacer or washer 39 which is supported by and in engagement with the inner surface of cylinder 29. The insulating washer or spacer 39 may be split, constituting two segmental parts to facilitate assembly thereof with the intermediate electrode 37.

It will be noted that the peripheries of apertures 35, 36, and 38 are convex, thereby reducing to a minimum the tendency to establish undesired voltage gradients within the vicnity of the apertures or along the electron lens system.

The various elements of the unitary electron lens assembly are susceptible of precise alinement and locking, thereby permitting an initial alinement of the electrodes at the time of manufacture and obviating the necessity of realinement in the field. For example, the electrodes of the lenses 30—32 may be maintained and locked in the desired illustrated position by means of a plurality of principal longitudinal and annular spacers 40–42 inclusive. In addition, the intermediate electrode and the outer electrodes may be maintained in the desired spaced relation by means of smaller annular spacers 43 and 44 preferably of metal.

In accordance with our invention, there is provided also a unitary structure comprising the aforementioned electron lens system and a specimen carrier 45, shown in Fig. 9, and a specimen manipulator 46, shown in Fig. 8. The elements 45 and 46 will be explained hereinafter in detail. The specimen carrier 45 is supported by manipulator 46 which in turn is supported from one end of the lens assembly.

The objective electron lens 32 is essentially of the same electrical characteristics as electron lenses 30 and 31 and comprises a pair of spaced outer electrodes 47 and 48 and an intermediate electrode 49. Outer electrode 48 is provided with an aperture 48' and a radial recess 51 adapted to receive a specimen holder shown in Fig. 11, and is also provided with an enlarged aperture adapted to receive one part of the cartridge-type specimen carrier shown in Fig. 9.

As a part of the unitary construction comprising the electron lens assembly and the carrier and manipulator, we also may add an electron beam defining means, such as an apertured disk 50 and supporting structure therefor shown in Fig. 10. This supporting structure includes means for centering and positioning the disk 50 which may be constructed of molybdenum and which serves to produce a well defined beam for the desired illumination of the specimen or object which is held by carrier 45. The apertured disk 50 is preferably of such dimension to subtend at the specimen a solid angle in the neighborhood of 10^{-5} radians.

A radial specimen insertion chamber 54 is provided in alinement with slot 51 to permit ready insertion and extraction of a specimen in carrier 45. The insertion chamber may be defined by a radial tubular member 52 preferably constructed of nonmagnetic material and supporting at its upper end a valve 55 for sealing the insertion chamber 54 and also for sealing the main evacuated chamber of the microscope. Valve 55 comprises a removable cover 56 which is engaged by a cross rod which when pressure is exerted thereagainst maintains the cover firmly against the upper surface of a cylinder 58, constituting the side wall defining means of the valve. If desired, a suitable gasket 59, such as a rubber gasket, may be employed to seal the juncture of the cover 56 and cylinder 58.

Means are provided for supplying to the evacuated chamber of the microscope air at atmospheric pressure prior to the opening of cover 56. This means may comprise a passage 60 fed by a conduit 61 through which preconditioned or heated air may flow to prevent the condensation of appreciable moisture on the internal parts of the microscope when it is desired to extract or insert a specimen. As a means for selectively controlling the flow of the heated air, we provide a valve 62 seated in passage 60 and actuated by a member 63. A bellows-type sealing member 64 is sealed around the adjacent area of cylinder 58 and arm 63. The actuating mechanism for cover 56 and valve 62 is shown in Fig. 6.

At one end of the cylinder 24 there is located a sealing and supporting structure for a filamentary cathode comprising one of the electrodes of an electron gun, which comprises a filamentary pointed cathode 65 of the hairpin type. There is also provided magnetic shielding structure comprising apertured wafer-like metallic members or disks 66 and 67 which are firmly positioned against the inner surface of the cylinder 24. Electrostatic shielding means, such as a transverse metallic planar member 67' is positioned between members 66 and 67 intermediate the electron beam apertures of the latter members and the position of a longitudinal conductor to be described presently, thereby defining a substantially field-free region through which the electron beam passes. Locking means are provided for maintaining all the elements of the system in a fixed longitudinal and angular position with respect to the unitary assembly described hereinafter. This locking means may comprise a longitudinal key 68 which engages an abutment of cylinder 29 or extends into a recess provided thereby, and also extends axially through openings at the peripheries of disks 66 and 67. Key 68 may also extend through annular spacers 69 and 70 which maintain disks 67 and 68 and the unitary assembly in the desired spaced relation.

Disks 66 and 67 are provided with apertures 71 and 72 through which a horizontal conductor shown in Fig. 13 extends to impress on the intermediate electrodes of electron lenses 30, 31 and 32 a potential corresponding to the cathode potential. That is, the cathode structure to be described hereinafter and the intermediate electrodes are all maintained at the same potential.

If desired, there may be employed an accelerating anode cup structure 73 supported by a transverse disk 73' and extending an appreciable distance longitudinally around the filamentary cathode 65 so that a suitable accelerating electric field is provided for the electrons emitted by the cathode.

Exhaust apparatus for the evacuated chamber of the electron microscope may be connected to a tubular conduit 75 in communication with the chamber and which is also connected to the pumps 16 and 17 shown in Fig. 2.

In order to support the cathode structure and to seal one end of the evacuated chamber defined by cylinder 24, we provide a supporting ring 76 which is seated upon a shoulder provided by cylinder 24 and which also engages an annular spacer 77. A sealing structure is employed and comprises a compressible washer, such as a rubber washer 78, a metallic compression ring 79, a threaded retaining ring 80 adapted to engage threads provided at the end of cylinder 24, and a plurality of circumferentially displaced means, such as screws 81, for exerting longitudinal or axial pressure against the retaining ring 79, thereby compressing washer 78.

A vitreous part 82 is sealed to the supporting ring 78 and serves to support and seal the cathode structure. The vitreous part 82 may be of the re-entrant type through which a concentric transmission line comprising an inner conductor 83 and a tubular outer conductor 84 extends. The details of the cathode and supporting structure will be discussed with respect to Fig. 4.

At the other end of the evacuated chamber, particularly at the left-hand end of cylinder 24, there is provided an end wall for sealing that end of the chamber and for supporting a viewing screen, such as a fluorescent screen 85 coated on the inner surface with a suitable fluorescent material and upon which the magnified image is produced by the impingement of the electron beam. This end wall comprises an apertured disk 86 which seats the viewing screen or fluorescent screen 85. A suitable seal for the screen 85 may be obtained by means of a rubber washer 87 which is compressed by means of a flanged annular ring 88, the latter being attached to disk 86. The outer periphery of disk 86 is also sealed in a similar manner by means of a compressible rubber washer 89, a metallic compression ring 90, and a retaining ring 91, and pressure exerting means such as screws 92 which exert an actual pressure on compression ring 90, thereby compressing the washer 89 and sealing the juncture.

Means for actuating or controlling the speci-

men manipulator 46 are also positioned at this end of the evacuation chamber within the vicinity of the viewing screen. The manipulator 46 may be of the type designed to produce three degrees of motion mutually at right angles to each other, and may comprise three separate actuating means such as longitudinal extending rods 93, 94, and 95, only two of which are shown in Fig. 3 and which are controlled by means of a plurality of screw-thread devices 96, 97, and 98, only two of which are shown in Fig. 3. The screw-thread device 97 is shown in cross-sectional detail and is also representative of the other two devices. For example, screw-thread device 97 comprises a head 99 which engages the associated longitudinal actuating rod 94 and is controlled in its longitudinal position by means of a screw 100 which is provided with an actuating pin 101 and which has one end thereof extending through disk 86 to effect an externally accessible connection adapted to receive a flexible cable shown in Fig. 21. Each screw-thread device may be supported by a cylindrical member 102 formed integral with or attached to disk 86 which is sealed to its associated head 99 by a deformable member such as a bellows 103 sometimes defined as a Sylphon bellows.

Reference is now made to Fig. 4 in which the cathode supporting structure is shown in greater detail. Means are provided for positioning, that is for centering the point or hairpin-type filamentary cathode 65 with respect to the alined apertures of the electron optical system. This means is of demountable character permitting rapid replacement of the filament and also permits the use of different types of filaments in connection with the other elements of the electron microscope. A further advantage of the cathode supporting structure is the unique arrangement by virtue of which certain portions of the structure not only serve as a mechanical support for the cathode but also serve as electrical conducting paths for the conduction of cathode heating current.

A metallic base 104 is sealed at one end to the vitreous part 82 and is provided with threads to engage threads at one end of the outer tubular conductor 84 to the base 104 which not only transmits power to the filament 65 but also serves to impress through the longitudinal conductor shown in Fig. 13 a negative potential on the filament and the intermediate electrodes of electron lenses 30—32. Base 104 is constructed to afford a flexible mechanical connection between the inner conductor 83 of the concentric line and the base. A conductive connecting member 106 is mechanically supported by base 104 but is electrically insulated therefrom by means of a glass bead or seal 106 which rigidly supports member 105. At one end of member 105 we provide a flexible connection such as a coil spring 107 attached to the inner conductor 83.

The base 104 is also provided with a threaded flange 108 which supports a metallic thimble 109 provided with a shoulder 110 which longitudinally positions the cathode positioning or centering means to be described immediately. This cathode centering means is flexibly connected to member 105 by means of a flexible connection such as a coil spring 111 and comprises an annular centering ring 112 having near the periphery thereof a restricted region 113 to obtain a substantial line engagement with shoulder 110. Ring 112 may be positioned by a suitable mechanical expedient such as a plurality of circumferentially displaced screws 114. Furthermore, the centering ring 112 is maintained in the desired longitudinal or axial position in firm engagement against shoulder 110 by means of a compression spring 115 which is supported at its right-hand extremity by means of a threaded collar 116 which engages threads on the inner surface of thimble 109. As a means for insulating the shell of thimble 109 and the centering means from the center conductor to the cathode, we employ a cylindrical insulator 117 placed between retaining ring 112 and a cylindrical cathode base 118 adapted to receive a rigid cathode stem 119. One terminal 120 of the point cathode 65 is connected to stem 119 through a face plate 121 which is attached to stem 119, the latter constituting an electrical path for the inner conductor 83 through coil spring 111, connecting member 105 and coil spring 107. The other terminal of the cathode 122 is connected to a metallic pin 123 supported by and electrically insulated from the face plate 121 by means of a glass bead 124.

As a means for facilitating ease of replacement of the cathode element 65 and to permit mechanical movement of the stem 119 and cathode 65 without disturbing the electrical connections to the cathode, we employ a flexible conductor such as a ribbon conductor 125 which extends into an opening 126 in the body of thimble 109. A screw 127 or any suitable mechanical expedient may be employed for retaining and removing the ribbon conductor 125 in opening 126. The electrical path from terminal 122 of cathode 65 comprises pin 123, conductor 125, thimble 109 and tubular conductor 84 of the concentric line. At the end of thimble 109 we provide a cap 128 which is removable or demountable and which is adapted to be supported by thimble 109 by a screw-threaded engagement at 129. This cap 128 is provided with an aperture 130 through which the electrons emerge upon acceleration due to the field produced by anode cup 73.

An alternative flexible connection for the cathode supporting structure is shown in Fig. 5 and corresponding elements have been assigned like reference numerals. Instead of employing coiled springs as the flexible connection and extending one of the springs through member 118, we may employ folded strips 131 and 132 of resilient metal, respectively, connected to members 118, 105 and 105, 83.

The actuating mechanism for releasing the pressure on cover 56 of the valve 55 closing the specimen insertion chamber is shown in Fig. 6. Rod 57 which exerts pressure against cap 56 may be removed therefrom by movement of handle 11 in a clockwise direction, causing the clockwise rotation of a pivoted actuating arm 133 which is pivoted at some point to the right of the figure and which is connected to rod 57 through a crank 134. Member 63 which actuates valve 62 is also connected to actuating arm 133 by means of a connecting rod 135 which is positioned to actuate valve 62, thereby admitting air to the insertion chamber and the main evacuation chamber so that the cover 56 may be removed.

In Fig. 7 there is diagrammatically illustrated, partially in perspective and partially in cross-section, the unitary electron lens assembly showing the plurality of spaced electrostatic lens systems 30, 31 and 32, and corresponding elements have been assigned like reference numerals.

Referring to the electron lens 32, it will be noted that the intermediate electrode 49 thereof, which corresponds to the intermediate electrodes 37 of

electron lenses 30 and 31, is supported by an insulator 136 which holds the intermediate electrode 49 firmly in position and alinement. Provision is made for the impression on the intermediate electrodes of each lens system of a potential corresponding to the cathode potential by means of the conductor shown in Fig. 13. This conductor extends longitudinally the electron gun and is placed within the cylinder 29 extending through apertures 137—141. These apertures are also finely machined or ground to have convex peripheries to minimize high electric field gradients.

The conductor is a sectionalized conductor to facilitate assembly and disassembly of the electron lens unit, and comprises a plurality of conductors 142, 143 and 144 which are welded or otherwise attached to the intermediate electrodes and are provided with recesses to receive telescoping intermediate members 145 and 146.

There is also provided within the electron lens assembly electrostatic shielding means spaced longitudinally between the sectionalized conductor and the electron path. This shielding means may comprise a plurality of planar metallic shielding members 147 and 148 which closely engage the inner surface of cylinder 29 and abut facing outer electrodes of the electron lenses 30—32 inclusive.

As means for facilitating assembly of the entire electron lens unit and for positioning the actuating rods 93—95 in a position which is mechanically expedient and which will not deleteriously affect the operation of the electron lens system, we provide longitudinal grooves lying in cylinder 29 and adapted to receive and permit longitudinal movement of rods 93—95. Only one of these grooves, that is groove 148 which receives rod 93, is shown in Fig. 7. Each of rods 93—95 is terminated in a foot 150 which engages heads 99 of the screw-thread devices 96—98 shown in Fig. 3.

As a means for locking or keying the electron lens assembly in the desired or fixed angular position within cylinder 29 there may be employed suitable means such as a tongue 151 constituting an integral part of or attached to the cylinder, and which may be adapted to engage one of the annular spacing rings such as ring 69 shown in Fig. 3.

The manipulator 46 is shown in detail in Fig. 8 and constitutes a system of multiple ways which are mutually adjustable or controllable to produce three independent movements at right angles to each other. That is, the manipulator 46 upon actuation by rods 93—95 produces independent horizontal-transverse, vertical-transverse and longitudinal or axial motion. The transverse longitudinal and vertical motions are employed for scanning purposes and the axial motion is employed for focusing purposes, the latter being necessary in view of the fact that the focal length of the electrostatic lens system provided by the microscope is fixed by the geometry of the electrodes or lenses thereof.

The manipulator shown in Fig. 8 is provided with three actuating levers 152, 153 and 154, only two of which are shown in Fig. 8. The details of construction and operation of the manipulator will be explained in connection with Figs. 14–20 inclusive. As to the general features of operation, it may be said here that the specimen carrier 45 is supported at one end by an annular ring 155 constituting a part of the manipulators, and this ring by virtue of the aforementioned ways moves the carrier 45 for scanning and focusing purposes. The entire manipulator is supported by a face plate 156 which is maintained in the desired axial position by engagement with the inner surface of cylinder 29.

Fig. 9 is a detailed cross-sectional view of the specimen carrier 45 which may be of the cartridge type comprising a retaining shell 157 having a longitudinal opening 158 through which the electron beam passes, and having a resilient holding or positioning member such as a plunger 159 also apertured. The plunger 159 may be biased by means of a compression spring 160. The carrier 145 is adapted to receive a locket shown in Fig. 12 which holds a specimen, and the distance between the inner vertical surface of shell 157 and the face of plunger 159 is such that a slight pressure must be exerted upon the locket to obtain an insertion and in order firmly to hold the locket during adjustment of the manipulator 46.

In Fig. 10 there is illustrated the structure for supporting the beam limiting disk 50. This structure comprises a face plate 161 which is supported from face plate 156 by means of a plurality of spaced supporting rods 162 and 163. Other rods, not shown, may also be employed to afford a firm support. Molybdenum disk 50 is held in position by a shroud ring 164, the latter of which is positioned by a plurality of thumbscrews 165 which may be adjusted to obtain the desired alinement of the aperture in disk 50 with respect to the electron gun and the apertures of the electrodes constituting the electron lens system. Thumb-screws 165 are supported by an annular member 166 having a central aperture within which shroud ring 164 and disk 50 are positioned and is provided with a clamp 167 to control the axial displacement of these members. Face plate 161 and annular member 166 are provided with apertures 169 and 168 which, however, for the purpose of construction and arrangement are not in alinement with the corresponding apertures 137—141 in the disks or electrodes of the electron lens assembly or aperture 170 of face plate 166 shown in Fig. 8. These latter mentioned apertures are provided for the purpose of receiving the sectionalized horizontal conductor shown in Fig. 13 and which will be described in detail hereinafter.

A specimen holder is shown in Fig. 11 and is arranged to be inserted through the specimen insertion chamber 54 shown in Fig. 3 and into slot 51 and includes a locket 171 comprising a recessed ring 172 adapted to receive a fine removable mesh upon which the specimen is placed and a locking and retaining ring 173. Rings 172 and 173 are shown in cross-sectional detail in Fig. 12.

In Fig. 11 there is also shown a suitable specimen holder which comprises a stem 174 springbiased to the position illustrated with respect to a cylinder 175. Stem 174 telescopes cylinder 175 and the latter is attached to a curved holding plate 176 whereby spring 177, in the absence of pressure on knob 178, draws the stem 175 upwardly. The recessed disk 172 is flexibly connected to the stem 174 by suitable means such as a fine link chain 179. The lower end of stem 174 is provided with a curvature to engage the periphery of disk 172 upon depression of member 178, thereby firmly holding the locket in engagement for the purpose of extending and positioning the locket in carrier 45 shown in Fig. 9.

In Fig. 13 there is shown a portion of a longitudinal sectionalized conductor for impressing cathode potential on the intermediate electrodes of the various electron lenses 30—32 and corresponding elements have been assigned reference numerals employed in Fig. 7. Due to the fact that the apertures 168 and 169 of the beam limiting structure are not in alinement with apertures 137—141 of the lens assembly and aperture 170 of the manipulator faceplate 156, we provide an elbow 180 which telescopes section 142 of the conductor and which is provided with a highly polished and finely ground cup 181 adapted to receive a resiliently mounted pin 182 constituting a part of section 183 and which in turn telescopes a second elbow section 184 which is in electrical contact with and received by thimble 109 of the cathode supporting structure shown in Fig. 4.

Referring now to the details of the specimen manipulator shown in Fig. 8, reference is here had to the exploded view of the manipulator shown in Fig. 14. The only elements there illustrated are the face plate and supporting ways. The manipulator per se is disclosed and claimed in U. S. Letters Patent No. 2,380,209, granted July 10, 1945, to Charles H. Bachman and Jacob Tschopp.

There is provided on face plate 156 a pair of vertical ways 185 and 186 having therein races 187, preferably of V-shaped configuration to support a plurality of friction reducing bearings such as miniature ball bearings 188. A vertical transversing member 189 is also provided with races 190 and 191 to engage the ball bearings 188. Attached to the transversing member 189 there is provided a pair of horizontal ways 192 and 193 also comprising V-shaped races 194 and 195 adapted to receive miniature ball bearings 196. A horizontal transversing member 197 provided with suitable races 198 and 199 engages the ball bearings 196. A third set of ways, namely the horizontal or axial ways for focusing purposes comprising ways 200 and 201, are supported by the horizontal transversing member 197 and also comprise V-shaped races 202 and 203 likewise provided with miniature ball bearings 204 for reducing friction. Ring 155 constitutes a part of an L-shaped member 205 provided with races to engage the ball bearings held by races 202 and 203 and is ultimately supported by ways 200 and 201.

Appreciation of the manner of operation of the manipulator shown in detail may be obtained by referring to Figs. 15–20 inclusive. Figs. 15–20, inclusive, do not show all of the elements of the manipulator 4a. The associated groups 15, 16; 17, 18 and 19, 20 show only those elements deemed necessary in order to emphasize the various independent movements produceable by the manipulator, the complete perspective view being shown in Fig. 8. Figs. 15 and 16, which are front and side views respectively of the manipulator, when operated to produce horizontal transverse motion by actuation of lever 152, indicate that upon movement of lever 152 forward, that is away from the drawing, lever 152 actuates crank 206 (shown in Fig. 8) which in turn rotates connecting rod 207 to move cam 208, thereby exerting a pressure against the structure for transversing member 197, and thereby moving the horizontal transversing member 199 to the right. There is also provided means in connection with each of the movements for substantially eliminating or reducing back-lash which, in connection with the arrangements shown in Figs. 15 and 16, comprises a spring 209 which biases member 199 towards the left observed from the front view shown in Fig. 15.

Operation of the vertical transverse motion produced by the manipulator may be obtained by referring to Figs. 17 and 18 which are, respectively, front and side views showing additional structure for obtaining this motion. Lever 154 is connected to rod 210 which in turn operates a cam 211 connected to the way 192.

Back-lash prevention means is also provided in connection with member 202 to bias this member downward and toward member 205, and may comprise a spring 212a. Forward motion, that is a motion to the left of lever 154 viewed from Fig. 18, raises ways 192 and 193 thereby raising ring 155 and the associated carrier 45.

The manner in which the focusing or longitudinal movement of ring 155 is obtained may be appreciated by referring to Figs. 19 and 20. Actuating lever 153 is connected to member 205 by means of a crank or connecting rod 213 and a cam 214, the latter of which engages member 205 to move it horizontally or longitudinally. The spring 212b serves to prevent back-lash.

The structure through which the actuating wheels, including illustrated wheels 7 and 8, for controlling the manipulator are joined to and operatively associated with the screw-thread devices may be more fully appreciated by referring to Fig. 21. Certain of the elements there illustrated have been described hereinbefore and corresponding elements have been assigned like reference numerals. The end plate or disk 86 shown at the left-hand part of Fig. 3 is presented in enlarged form in Fig. 21 and shows the manner in which the contact or connecting pins 101 extend through that disk affording suitable connections for a plurality of flexible cables 215, 216 and 217 which are provided with adaptors 218 and which are connected to the knurled wheels 7, 8, and 9.

A viewing aperture mounted at the end of the horizontally disposed cover for the electron gun, and represented by the reference numeral 6 in Fig. 22, may be designed to be removable and comprises an eye-piece 219, a light or glass lens 220 supported by a cylinder 221 which is attached to eye-piece 219 and which is insertable within a holding cylinder 222. The light lens 220 is in alinement with the fluorescent screen provided by disk 85 shown in Fig. 21 and serves to magnify the image appearing on this screen.

An arrangement is provided whereby in place of using a light magnifying lens a camera 223 may be supported at the end of the cover cap 6 as illustrated in Fig. 23. In such instances, the camera 223 which may also include a magnifying lens is provided with an adaptor 224 which is insertable within holding cylinder 222 and may also be provided with horizontal supporting members 225 and a further supporting member 226.

Fig. 24 diagrammatically illustrates an electric circuit diagram which may be employed for the application of anode-cathode voltage to the electron microscope and for the control of the cathode heating current. The electron microscope which we provide is capable of being energized from any suitable source of alternating current such as that readily available at the usual commercial power outlets. For example, the system may be energized from an alternating current circuit 227 of commercial frequency. The main switch 22 shown in Fig. 1 may be connected in

the position illustrated to control the application of voltage and current to the microscope as well as to control the application of power to the pumps 16 and 17 and centrifugal blower 15. A unidirectional voltage is produced by means of a rectifier circuit which may include a single unidirectional conducting device such as an electric discharge device 228 which is energized from a transformer 229. The voltage controlling means 13 may comprise means, such as a rheostat 230, connected in series relation with the primary winding thereof to control the magnitude of the unidirectional voltage applied to the microscope and may be actuated by knob 20 shown in Fig. 1. One terminal of the secondary winding of transformer 229 is connected to ground. By virtue of the polarization of the discharge device 228, conductor 231 is maintained at a negative potential with respect to ground. Current limiting resistances 232 and 233 may be connected in the positions illustrated not only to limit the current transmitted by discharge device 228 but also to limit the current supplied to the anode-cathode circuit of the electron microscope. In order to effect the application of a substantially constant unidirectional voltage to the microscope, there may be provided suitable filtering means such as a capacitance 234 which is connected between ground and the common juncture of resistances 232 and 233.

Transformer 235 is employed as a source of cathode heating current or filament current for the discharge device 228. Variation of the cathode heating current supplied to cathode 65 of the electron gun may be obtained by any suitable arrangement such as a transformer 236 controlled by means such as a rheostat 237, the latter of which may be actuated by switch or dial 21 shown in Fig. 1.

Conductors 238 constitute means for supplying cathode heating current to the concentric line comprising inner conductor 83 and the tubular outer conductor 84 shown in Fig. 3. An adaptor (not shown) may be employed for connecting conductors 231 and 238 to the elements of the electron gun through a shielded cable 239 comprising a grounded metallic shield 240, conductors 238 which extend therethrough centrally, and a tubular conductor 241, the latter of which is connected to the outer tubular conductor 84 of the concentric line.

In operation, the specimen or object to be investigated is placed upon a fine wire mesh which is inserted within the recess of ring 172 constituting one part of locket 171 shown in Fig. 12, and the locking or retaining ring 173 is employed to maintain the mesh firmly against the inner shoulder or ring 172. The holding plate 176 is grasped and the knob 178 is depressed, thereby extending the rigid stem 174 so that the curved lower portion thereof firmly engages the outer periphery of ring 172, thereby positively holding it. Cover 56 of valve 55 is removed and the specimen holder is extended through chamber 54 and slot 51 and the locket is inserted in specimen carrier 45, particularly between the inner vertical surface of shell 157 and the face of plunger 159, the latter serving to hold the locket firmly. The knob 178 is then released which permits retraction of the stem 174 upward into cylinder 175, which action renders the locket 171 free to be positioned by the carrier 45 and manipulator 46. The holder is then permitted to rest against the side or vertical wall of insertion chamber 54, the length of the holder being such that it does not extend sufficiently upward to prohibit the closing or placement of the cover 56.

The valve 55 is then sealed by placing the transverse rod 57 in the groove provided in cover 56, and handle 11 of the valve is moved in a clockwise direction, viewed from Fig. 6, to apply sealing pressure to the cover.

Evacuation of the chamber enclosing the electron gun, the lens system and other associated elements is then initiated by the operation of handle or knob 23 shown in Figs. 1 and 24. After the pressure within the chamber has been reduced to a suitable value, power may be applied to the electron microscope; that is, anode-cathode voltage may be applied to the electron gun by operation of knob or dial 20 and the filament current may be controlled by knob 21, both of which are illustrated in Figs. 1 and 24. Of course, rheostat 13 permits adjustment of the voltage applied to the anode and cathode of the electron gun, and correspondingly controls the magnitude of the voltage impressed across the outer electrodes and the intermediate electrode of each of the electrostatic lenses 30—32.

The electron image formed at the specimen plane is magnified by the electrostatic objective lenses 30—32 to produce an enlarged image on the fluorescent screen 85. Where desired, the light optical magnifying lens shown in Fig. 22 may be employed to obtain further magnification.

Movement of the object for viewing and focusing purposes may be effected through operation of the knurled wheels 7—9 within the vicinity of the eye-piece 6 which, in turn, position heads 99 of the screw-thread devices 96—98 inclusive which are operatively connected to levers 152—154 of manipulator 46 through rods 93—95.

The specimen may be removed in the following manner: Handle 11 shown in Fig. 6 is raised effecting release of the pressure on cover 56 so that this cover may be removed. However, prior to the removal of the cover, as stated above, heated air is admitted to the insertion chamber 54 and to the main evacuated chamber through passage 60 by means of valve 62 which is actuated by arm 133, connecting rod 135 and member 63. As soon as the differential between atmospheric pressure and the pressure within the chamber is sufficiently reduced, cover 56 is then readily removable.

Referring to Figs. 3 and 7, which indicate in detail certain aspects of the electron lens assembly, we have found that a high degree of precision is obtained by spacing the outer electrodes 33 and 34 at distances from the intermediate electrode 37 which are at least equal to or which approach the diameter d of the electron aperture of intermediate electrode 37. In addition, it has been found advantageous as concerns operation of the electron lens system as a whole, to make the distance s between center lines of each electron lens at least two times as great as the diameter d of the aperture of the intermediate electrode 37 or at least two times as great as the spacing h between the outer electrodes 33 and 34 and the intermediate electrode 37. As concerns the relative diameters of the apertures in the outer electrodes 33 and 34 and the aperture of the intermediate electrode, it has been found that the aperture of the inner electrode should have a diameter at least twice the value of the aperture diameters of the outer electrodes.

As a further matter, referring to Fig. 7 in conjunction with Fig. 3, we have found that in order

to obtain the desired electrostatic shielding between the longitudinal sectionalized conductor and the electron beam, the longitudinal conductor should be spaced at a distance x which is at least as great as the distance h between the intermediate electrode 37 and the outer electrodes 33 and 34.

Although in the illustrated embodiment of our invention we have shown the electrostatic lens of the type comprising an intermediate electrode having an aperture of larger diameter than the apertures in the outer electrodes, it will be appreciated that our invention is not limited to that particular type of electrostatic lens. It should be understood that the focal properties of a lens of this type are greatly determined by the distribution of potential along the axis and that the distribution of potential is readily determinable by the electrode position and configuration. A large variety of electrode constructions and placements may be utilized for attainment of a desired potential distribution. The structure which we provide is, therefore, readily adaptable to a wide variety of electrostatic lens assemblies and configurations.

One of the important advantages afforded by the electron microscope which we provide and which contributes in a large measure to the desired precise operation thereof, by eliminating the effect of extraneous fields, is the substantially continuous shielding of the electron beam provided by the structure. For example, beginning at the electron gun as shown in cross-sectional view in Fig. 3, the disk-like members 66 and 67 which constitute the magnetic shielding means and the transverse electrostatic shielding member 67′ define a substantially field-free region through which the electron beam passes after being accelerated by the anode cup 73. It will be noted that the planar member 67′ is interposed between the electron path and the longitudinal conductor. Furthermore, the specimen carrier 46 may be constructed of a suitable shielding material such as brass, thereby affording the desired shielding of the specimen and the electron beam from the field due to the longitudinal conductor. As pointed out above in connection with Fig. 7, the planar members 147 and 148 also provide electrostatic shielding within the unitary electron lens assembly.

While we have shown and described our invention as applied to a particular device and as embodying various other devices, it will be obvious to those skilled in the art that changes and modifications may be made without departing from our invention, and we therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. In an electron microscope, the combination including an evacuated chamber, a unitary electron lens assembly adapted to be inserted within said chamber, a specimen carrier, means for manipulating said specimen carrier for scanning and focusing purposes, and means extending longitudinally of said chamber for actuating the last mentioned means for moving said carrier independently in three mutually perpendicular directions.

2. In an electron microscope, the combination including an evacuated chamber, an electron lens system comprising a metallic cylinder supported within said chamber and having therein electrostatic lenses, a specimen carrier, a manipulator supporting said carrier at one end of said system, rods positioned within said chamber in longitudinal grooves in the exterior surface of said cylinder for controlling said manipulator, and externally accessible actuating means for said rods.

3. In an electron microscope, the combination including an elongated evacuated chamber, a unitary electron lens assembly adapted to be inserted in said chamber, an electron gun, a specimen carrier intermediate said electron lens system and said gun, means for adjusting the position of said specimen carrier comprising a manipulator within said chamber and susceptible of three mutually perpendicular directions of motion, and longitudinally extending means positioned within said chamber for actuating said manipulator.

4. In an electron microscope, the combination including an evacuated chamber, an electron gun located at one end of said chamber, a unitary electron lens assembly inserted within said chamber and supporting a specimen carrier, a manipulator susceptible of positionlng said carrier, actuating rods positioned within said chamber and extending longitudinally therethrough, a viewing screen at the other end of said chamber, and externally accessible means at said other end of said chamber for operating said rods.

5. In combination, an electron microscope having an evacuated chamber, a unitary electron lens assembly comprising a metallic cylinder having therein an electrostatic lens, a specimen carrier, a manipulator within said chamber for supporting said carrier and for moving the specimen carrier for scanning and focussing purposes, a viewing aperture at one end of said chamber, a plurality of actuating rods within said chamber positioned in longitudinal slots in the exterior surface of said cylinder and engaging said manipulator, and a plurality of actuating means within the vicinity of said aperture for moving said rods.

6. In an electron microscope, the combination including an evacuated chamber, an electron lens assembly comprising a metallic cylinder having therein an electrostatic lens, a specimen carrier, a manipulator within said chamber for supporting said carrier, an actuating rod within said chamber extending longitudinally the axis of said cylinder and outside said cylinder for actuating said manipulator, a wall at one end of said chamber, and a screw-thread device supported by said end wall for actuating said rod.

7. In an electron microscope, the combination including an evacuated chamber defined by a metallic cylinder, an electron lens assembly comprising a second metallic cylinder having therein an electrostatic lens, a specimen carrier, a manipulator within said chamber for supporting said carrier and for moving it laterally, vertically and longitudinally, a plurality of actuating rods within said chamber extending longitudinally said lens assembly and engaging said manipulator, a wall sealing one end of the first mentioned cylinder and supporting a plurality of screw-thread devices for moving said rods, and sealing means for each of said screw-thread devices.

8. In an electron microscope, the combination including an evacuated chamber defined by a metallic cylinder, a unitary electron lens assembly comprising a plurality of electrostatic lenses, a specimen carrier supported at one end of said assembly, a manipulator for said carrier within said chamber, a plurality of actuating rods with-

in said chamber extending longitudinally said lens assembly and engaging said manipulator, a wall at one end of said cylinder for sealing that end and comprising a fluorescent viewing screen, a plurality of screw-thread devices positioned within said chamber about said screen for actuating said rods and each comprising a bellows-type member for sealing said device to said end wall, said devices being provided with pins extending through said wall, and externally accessible actuating means connected to said pins.

9. In an electron microscope, the combination including an evacuated chamber defined by a metallic cylinder, an electron lens assembly, a specimen carrier supported by said assembly, a specimen insertion chamber extending radially said cylinder, a sealing structure for said insertion chamber comprising a removable cover, and means for supplying preconditioned air to the first mentioned chamber prior to the removal of said cover and valve means for controlling the last mentioned means.

10. In an electron microscope, the combination including an evacuated chamber, an electron lens assembly within said chamber, a specimen carrier, a radial specimen insertion chamber, a valve sealing structure for said insertion chamber comprising a removable cover, means for exerting pressure on said cover, a passage for admitting air at atmospheric pressure and a valve in said passage, and means interconnecting said pressure exerting means and said last mentioned valve for actuating said last mentioned valve prior to the release of the pressure on said cover.

11. In an electron microscope, the combination including a horizontally positioned evacuated chamber, an electron lens assembly within said chamber, a specimen carrier positioned at one end of said assembly, a radial specimen insertion chamber in alinement with said carrier, a sealing valve for said insertion chamber and comprising a cover adapted to seal said chamber, a passage for the admission of air to the first mentioned chamber and a valve within said passage, and actuating means for said cover and said last mentioned valve comprising a lever mechanism for actuating said last mentioned valve prior to the release of pressure upon said cover.

12. In an electron microscope, the combination including a horizontally positioned evacuated chamber, an electron lens assembly within said chamber, a specimen carrier positioned at one end of said assembly, a radial specimen insertion chamber in alinement with said carrier, a sealing valve for said insertion chamber and comprising a removable cover, a passage for the admission of air to the first mentioned chamber and a valve within said passage, an actuating means for the second mentioned valve, a bellows-type diaphragm for sealing said actuating member, and means for actuating said member prior to the release of pressure on said cover comprising a pivoted actuating arm and a manually operable handle.

13. In an electron microscope, the combination including a horizontally disposed evacuated chamber defined by a metallic cylinder, an electron lens assembly within said cylinder, a specimen carrier at one end of said assembly, a radial specimen insertion chamber in alinement with said carrier, means including a valve sealing structure external to said cylinder for sealing said insertion chamber, and a specimen holder for placing a specimen in said carrier through said insertion chamber.

14. In an electron microscope including an evacuated chamber, an electron lens system, an electron gun and a viewing screen, the combination comprising a specimen carrier, evacuating means for said chamber, a specimen insertion chamber, sealing means for said insertion chamber, means for supplying preconditioned air to said first mentioned chamber to prevent the condensation of appreciable moisture upon the elements within said first mentioned chamber, and means for admitting the heated air prior to the opening of the insertion chamber.

15. In an electron microscope, the combination including an evacuated chamber, an electron lens assembly, a specimen carrier positioned at one end of said assembly, a specimen insertion chamber transverse to the longitudinal dimension of the first mentioned chamber, manipulating means for supporting and moving said carrier, and means for inserting a specimen through said insertion chamber into said carrier comprising a specimen holder having at one end thereof a locket, said manipulating means having a radial slot for guiding said locket to a desired position.

16. In an electron microscope, the combination including an evacuated chamber, an electron lens assembly comprising a plurality of disk-like electrodes constituting an electrostatic lens and having alined apertures, an electron gun for establishing an electron beam, a specimen carrier positioned adjacent said assembly, a manipulator for supporting said carrier, and means for inserting a specimen into said carrier comprising a specimen holder having at one end thereof a relatively movable locket, said manipulator having a radial slot for guiding said locket to a position of alignment with said apertures.

17. In an electron microscope, the combination including an evacuated chamber, an electron gun, a lens system comprising a plurality of apertured alined electrodes, a specimen carrier arranged to support a specimen within the path of the beam produced by said gun and to permit the passage of said beam therethrough, and a specimen holder for inserting a specimen to be examined in the path of said beam comprising a rigid member, a locket adapted to be inserted in said carrier and flexible means between said locket and said rigid member.

18. In an electron microscope, the combination including an evacuated chamber, an electron gun, an electrostatic lens system comprising a plurality of apertured alined electrodes, a specimen carrier having therein a longitudinal opening to permit the passage therethrough of the beam produced by said gun, and a specimen holder for inserting a specimen in the path of said beam comprising a rigid stem, a locket for supporting said specimen and adapted to be inserted in said carrier, a flexible connection between said stem and said locket and means for extending said stem to engage said locket for insertion of said locket into said carrier and for retracting said stem after insertion into said carrier whereby said locket is free to be positioned.

19. In an electron microscope, the combination including an evacuated chamber, an electron gun in said chamber, an electrostatic lens system within said chamber and comprising a plurality of apertured and alined electrodes, a specimen carrier provided with a longitudinal

opening to permit the passage of the electron beam produced by said gun therethrough and including a positioning ring, and means for positioning a specimen to be examined across said opening comprising a rigid stem, an apertured locket for supporting a specimen and a flexible connection between said locket and said stem, said stem being positionable to engage firmly said locket for insertion into said carrier against said positioning ring and for releasing said locket so that it is unrestricted in movement established by said carrier.

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