July 25, 1944. J. HILLIER 2,354,263

ELECTRON MICROSCOPE

Filed May 30, 1942

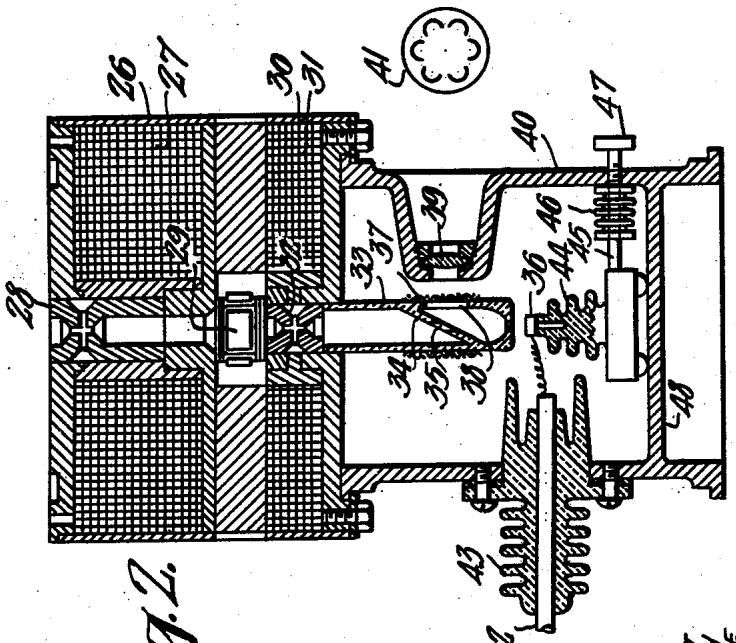

Fig. 2.

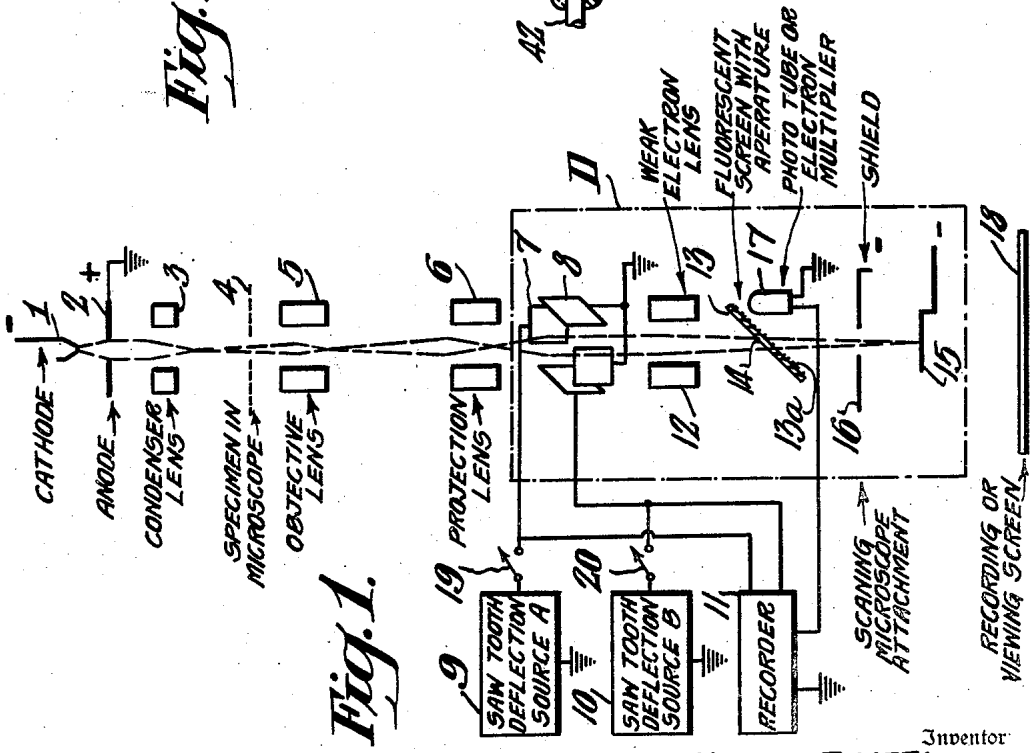

Fig. 1.

Inventor
James Hillier
By
C. D. Tuska
Attorney

Patented July 25, 1944 2,354,263

UNITED STATES PATENT OFFICE

2,354,263

ELECTRON MICROSCOPE

James Hillier, Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application May 30, 1942, Serial No. 445,181

9 Claims. (Cl. 178—6.6)

This invention relates generally to electron microscopes and particularly to means for converting conventional electron microscopes for use as scanning microscopes.

The invention includes an attachment adapted to be mounted upon a standard electron microscope column. Electron beam deflection elements, auxiliary electron beam focusing means, an apertured fluorescent screen, an apertured shield, an auxiliary specimen chamber and light responsive means are supported in the path of the electron beam and interposed between the microscope electron projection lens and the microscope recording film or viewing screen. Preferably provision should be made for selectively removing the entire attachment, or if desired, only the apertured fluorescent screen and the auxiliary specimen holder, for utilizing the microscope in a conventional manner.

In addition to the above described attachment to the microscope frame, the invention includes a recorder having tracking means synchronized with the electron beam deflection means, and connections to the light responsive means, thereby providing a recorded image of an object located in the auxiliary specimen holder or object chamber.

The particular arrangement of the component elements of the attachment may be arranged as hereinafter described or may be of the general type described by Manfred von Ardenne in U. S. Patent 2,257,774 granted October 7, 1941, for Electronic-optical device.

Among the objects of the invention are to provide improved and simplified means for converting a conventional electron microscope for use as a scanning electron microscope. Another object is to provide means for observing alternatively a specimen in different object chambers of an electron image device, for producing either an electron image or a recorded image of an electron scanned specimen. Still another object of the invention is to provide a removable electron microscope attachment which includes electron deflection elements, auxiliary electron focusing means, an apertured fluorescent screen, a light responsive device associated with the apertured screen, an apertured shield, and a second object chamber, all included within a common frame and adapted to be supported on the conventional electron microscope column between the microscope projection lens and the microscope viewing screen. Another object of the invention is to provide recording means responsive to the voltages derived from the above mentioned light responsive means to obtain a recorded image of the electron scanned object.

The invention will be described by reference to the drawing of which Fig. 1 is a schematic diagram of a complete electron microscope including the scanning microscope attachment, and Fig. 2 is an elevational view of a preferred embodiment of the scanning attachment.

Referring to Fig. 1, a conventional electron microscope includes the following elements: An electron source 1 which is at high negative potential. An anode 2 which includes a suitable aperture and which is ground potential with respect to the electron source, accelerates and concentrates the electrons emitted from the electron source 1 into a suitable beam. An electron condenser lens 3, which may be of either the electrostatic or electromagnetic type, is disposed in the path of the electron beam between the anode 2 and a conventional object chamber containing a specimen 4. Electrons transmitted by, or reflected from, the specimen 4 are focused by the objective lens 5 and the projection lens 6 to form an image on the recording or viewing screen 18. The apparatus thus described comprises a conventional electron microscope of the type well known in the art. This apparatus may be converted for use as an electron scanning microscope after removal of the specimen 4, by means of the attachment D, which is interposed between the projection lens 6, and the recording or viewing screen 18.

The scanning attachment includes electron beam deflecting elements 7 and 8 which may be of either the electrostatic or the electromagnetic type. The deflecting elements are connected to suitable sources of deflecting voltages derived from the saw-tooth deflection voltage sources 9 and 10 respectively, to provide beam deflection similar to the type utilized in conventional television systems. The greatly reduced image of the electron source 1, which image is deflected by the potentials applied to the deflection elements 7 and 8, is focused to form an electron probe of small cross-sectional area, by means of an auxiliary electron lens 12 through an apertured screen 13, upon a specimen located in the second object chamber 15. The second object chamber should preferably be insulated from the remainder of the microscope structure, and connected to a suitable source of high negative potential. An electrostatic shield 16, which is held at some predetermined positive potential with respect to the cathode, and which includes an aperture to permit the electron beam to pass to the specimen in

the second object chamber 15, is interposed between the fluorescent screen 13 and the specimen. Under electron bombardment by the deflected electron beam, the specimen in the chamber 15 emits secondary electrons which are accelerated by the charge on the shield 16. Some of these electrons pass through the shield aperture and impinge upon the fluorescent screen 13a producing fluorescence thereof. The intensity of the light emitted by the screen 13a varies with the surface characteristics of the specimen. A phototube or electron multiplier 17, disposed adjacent the fluorescent screen 13a, is responsive to the light emitted from the screen 13a and generates potentials which are a function of the secondary electrons emitted by the object in the auxiliary chamber 15.

A recorder 11, which may be of the conventional type used for facsimile purposes, is connected to the deflection voltage sources 9 and 10, whereby the recorder tracking is synchronized with the electron beam deflection provided by the deflection elements 7 and 8. The recorder stylus is connected to the output of the electron multiplier 17 whereby a recorded indication of the surface characteristics of the object in the auxiliary chamber 15 is derived. It will be apparent that by disconnecting the sources of deflection voltage by opening the switches 19 and 20 in the output circuits of the deflection voltage sources 9 and 10, and by selectively removing the apertured devices 13 and 16 and the auxiliary object in the chamber 15 from the path of the electron beam, that the complete assembly may be utilized as a conventional electron microscope. In a preferred arrangement, however, the entire scanning attachment is removed from the microscope assembly when the apparatus is to be used as a conventional microscope.

Fig. 2 shows a preferred embodiment of the scanning microscope attachment, which is adapted to be mounted upon the lens column of a conventional electron microscope. The unit includes an electromagnetic type of projection lens 26 including the winding 27 and the pole piece 28, all of which are of conventional design. A pair of electromagnetic type deflection coils 29 are axially disposed below the pole piece 28 in the path of the electron beam. These deflection coils may be of the type described by W. A. Tolson et al. in U. S. Patent 2,155,514, granted on April 25, 1939, or of any other type well known in the television art. A second electromagnetic electron lens 30, of comparatively weak magnifying power, consisting of the winding 31 and the pole piece 32, is disposed beneath the magnetic deflection coils 29 in the path of the electron beam.

A tubular structure 33, axially disposed in the path of the electron beam below the second magnetic electron lens 30, includes an angularly disposed fluorescent screen 34 having an aperture 35 which permits the passage of the electron beam to the object stage 36. The object stage 36 is located directly beneath the fluorescent screen. The tubular structure 33 is shielded by an electrostatic shielding screen 37, which is preferably formed as a contacting sleeve. Electrons, impinging upon the fluorescent screen 35 from the object on the object stage 36, cause fluorescence of the screen. Light emitted therefrom passes through an aperture 38 in the tubular structure 33 to a lens 39 sealed in a depression in an outer cylindrical structure 40 which surrounds the object stage 36 and cylindrical support 33. A phototube or electron multiplier 41 is supported in proximity to the lens 39. The light falling on the multiplier 41 establishes an electric current proportional to the intensity of the light emitted by the fluorescent screen 34.

The object stage 36 is connected to a rod-like conducting member 42 which is connected to a source of high negative potential. The object stage 36 supported by a high voltage insulator 44 which is adjustably supported by a base member 48 mounted to the frame 40. An adjusting element 45 connects the insulator 44 to an adjusting knob or other device 47, and is sealed in the frame 40 by a conventional sylphon device 46. The adjustment may be accomplished in any manner known for electron object stages. The conductor member 42 is surrounded by a high voltage insulator 43 which is supported within a suitable aperture in the cylindrical structure 40. The upper portion of the projection lens 26 is adapted for support to the microscope lens column in the same manner as provided for the conventional microscope projection lens. The entire unit should preferably be of suitable size and structure to be interchangeable with the standard microscope projection lens assembly. It should also be of suitable length to permit mounting between the lens column and the viewing or recording screen of the conventional microscope.

I claim as my invention:

1. In combination, an electron image device and an electron scanning microscope, including an object, means for forming an enlarged electron image of said object, alternative means selectively interposed between said image device and said image means and selectively cooperative with said image device for forming a sharply defined electron probe, means for deflecting said electron probe along a predetermined path, means including said deflected probe for irradiating progressive points of said object, recording means synchronized with said deflecting means and indicating means responsive to the secondary electron emission from said object points.

2. Apparatus of the type described in claim 1 including viewing means for observing said electron image.

3. An electron microscope including an electron beam, an object, an electron objective lens, an electron projection lens, means for irradiating said object, a viewing screen, and means including said objective lens and said projection lens for forming an enlarged image of said object at said viewing screen; alternative means selectively interposed between said projection lens and said viewing screen and selectively cooperative with said electron beam including electron beam deflecting elements, supplementary beam focusing means, an apertured fluorescent screen, light responsive means disposed adjacent said screen, and a second object; means including said deflecting elements for deflecting said beam along a predetermined path across said second object to provide secondary electronic emission from said second object, voltage generating means responsive to said light emission, a recorder, tracking means for said recorder synchronized with the deflection of said electron beam and means including said voltage generating means connected to said recorder for deriving a recorded image of said second object.

4. An attachment for an electron microscope having an electron beam, an electron projection lens and an image screen, including object supporting means adapted to be interposed between said lens and said screen, beam deflecting means for electron scanning an object supported by said object supporting means to provide secondary electron emission therefrom, auxiliary focusing means interposed between said deflecting means and said object supporting means to provide an electron probe of extremely small cross-section at the plane of said object, means including an apertured fluorescent screen in the path of said deflected probe, the axes of said deflected electron probe and said aperture coinciding, and light responsive means disposed adjacent said fluorescent screen for generating voltages which are a function of said secondary electron emission from said object impinging upon said fluorescent screen.

5. Apparatus of the type described in claim 4 including recording means, tracking means for said recorder, means for synchronizing said tracking means with said probe deflecting means, and means for applying said generated voltages to said recorder for deriving a recorded image of said object.

6. Apparatus of the type described in claim 4 including a common frame for said deflecting elements, auxiliary focusing means, apertured fluorescent screen, object and light responsive means, and mounting means on said frame for supporting said frame between said electron projection lens and said image screen of said electron microscope.

7. Apparatus of the type described in claim 4 including an apertured shield interposed in the path of said electron beam between said object and said fluorescent screen, said shield and screen apertures coaxially coinciding.

8. Apparatus of the type described in claim 3 including an apertured shield interposed in the path of said electron beam between said object and said fluorescent screen, said shield and screen apertures coaxially coinciding.

9. An attachment of the type described in claim 4 including an auxiliary projection lens adapted to replace said first mentioned projection lens of said electron microscope mounted in cooperative relation with said deflecting means.

JAMES HILLIER.