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Wittry

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[45] **Apr. 2, 1974**

[54] **SCANNING ELECTRON MICROSCOPE OPERATING IN AREA SCAN AND ANGLE SCAN MODES**

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[52] **U.S. Cl.**..... **250/306,** 250/310, 250/396

[51] **Int. Cl.**..... **H01j 37/26,** G01n 23/04

[58] **Field of Search**... 250/49.5 A, 49.5 PE, 49.5 C, 250/49.5 D, 49.5 P

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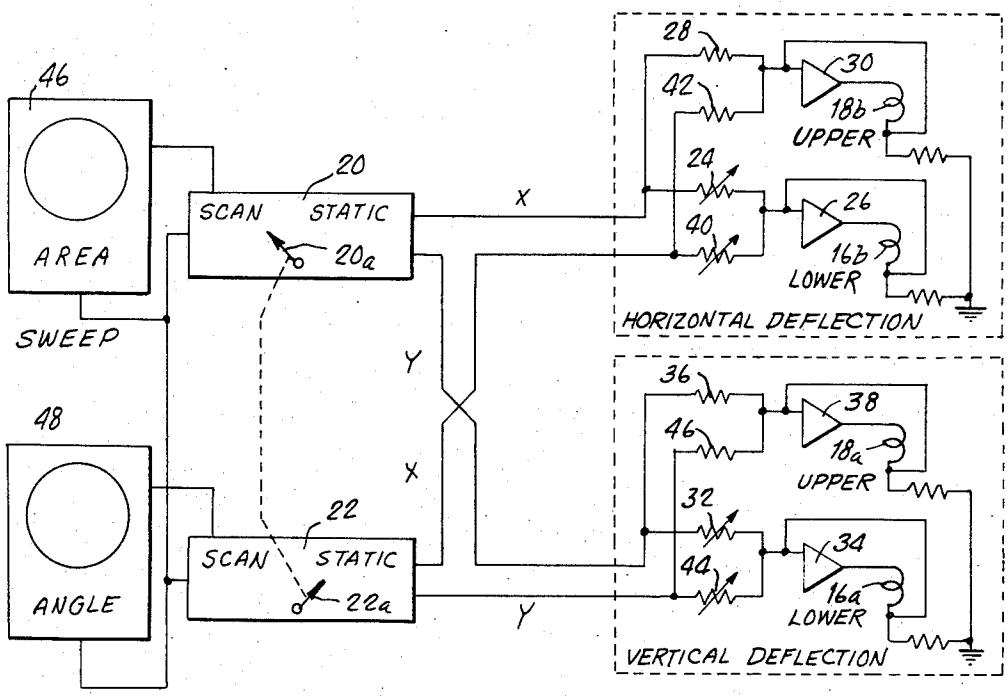
Primary Examiner—James W. Lawrence

Assistant Examiner—C. E. Church

[57] **ABSTRACT**

Methods and means for operating a scanning electron microscope in an area scan mode in which an area of the specimen is scanned at a selected constant angle of incidence of the beam probe on the specimen, or in an angle scan mode in which the beam probe is kept at a selected point of incidence on the specimen but the angle of incidence is varied in a scanning pattern. Convenient and rapid switching between the area scan mode and the angle scan mode is provided for fully utilizing the benefits of each mode. The capability for switching between these two modes of operation is particularly useful in crystallographic studies.

24 Claims, 11 Drawing Figures



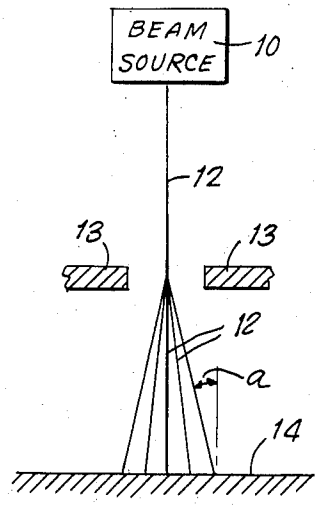


Fig. 1.
(PRIOR ART)

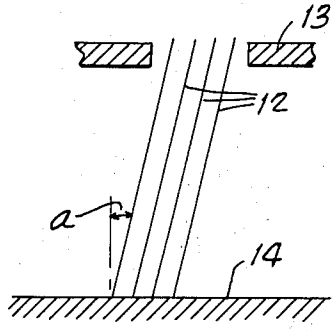


Fig. 2.

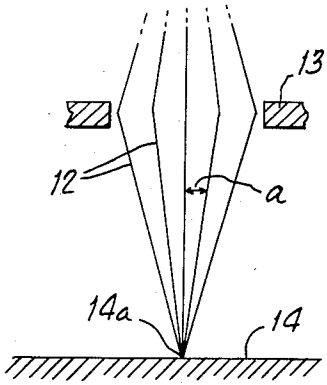


Fig. 3.

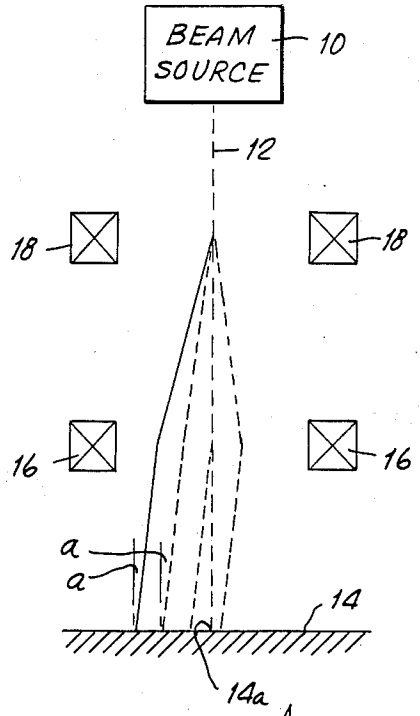


Fig. 4.

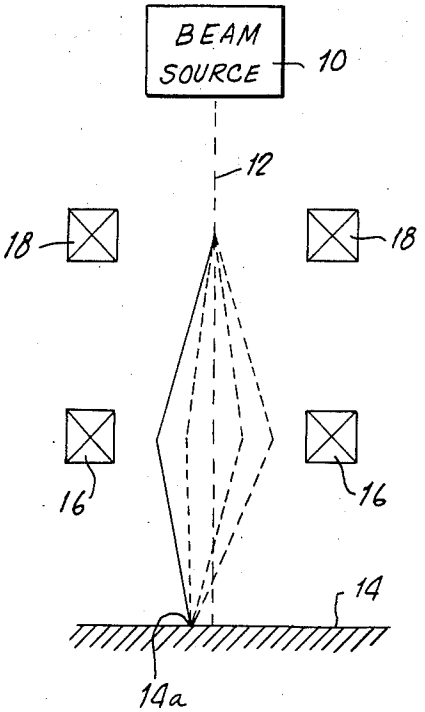
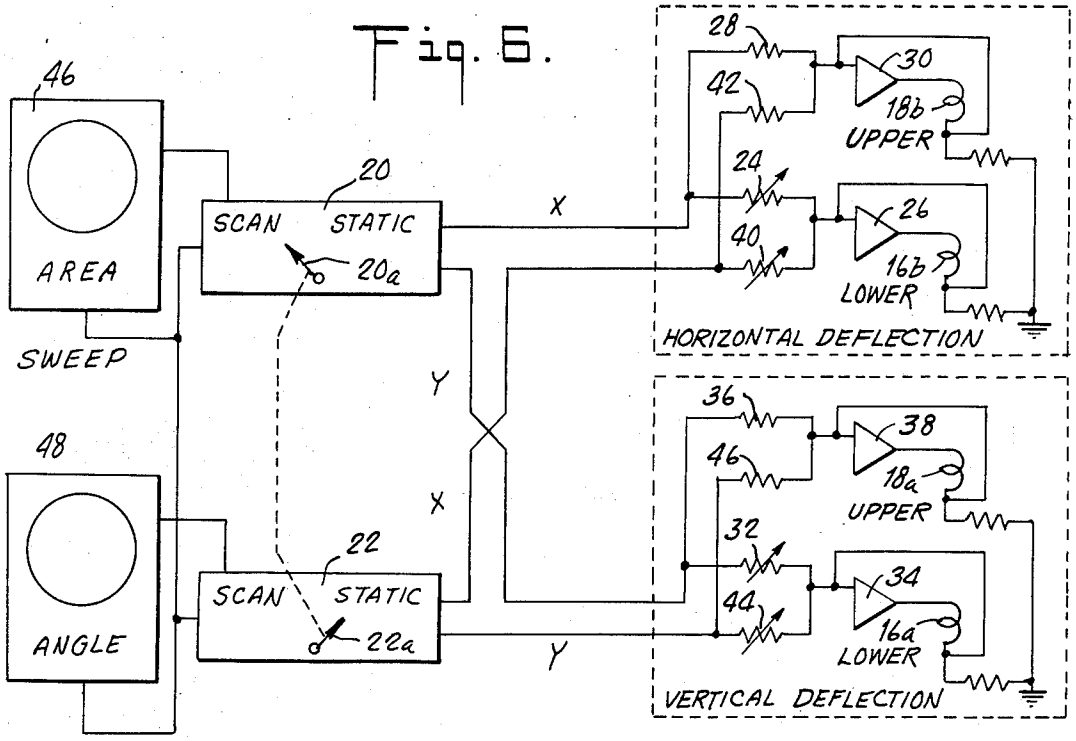


Fig. 5.

Fig. 6.


46
AREA
SWEEP
48
ANGLE
20
SCAN
STATIC
20a
22
SCAN
STATIC
22a
X
Y
X
Y
28
42
30
18b
UPPER
24
40
26
16b
LOWER
HORIZONTAL DEFLECTION
36
46
38
18a
UPPER
32
44
34
16a
LOWER
VERTICAL DEFLECTION

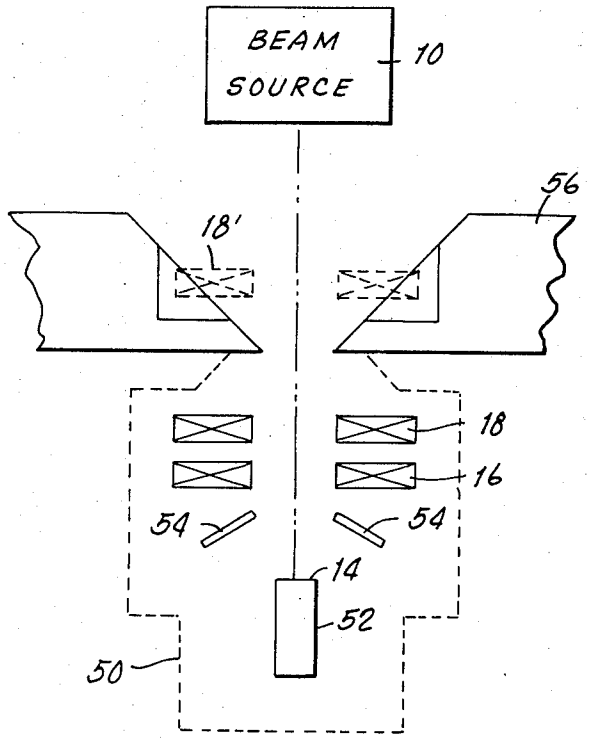

BEAM SOURCE
10
56
18'
18
16
54
54
14
52
50

Fig. 7.

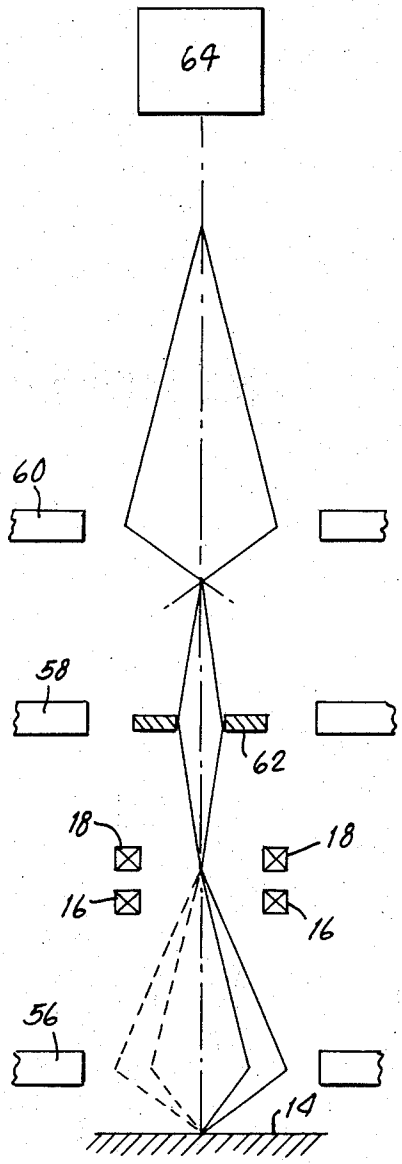


Fig. 8a.

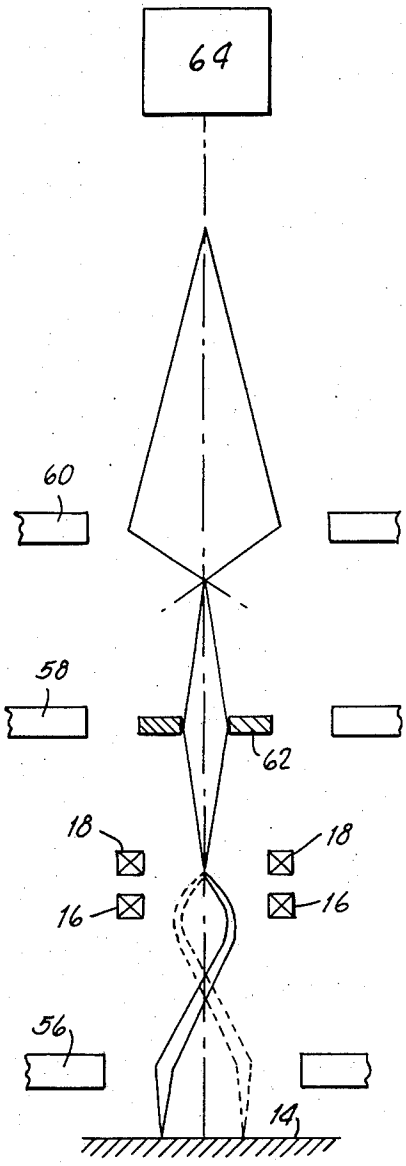


Fig. 8b.

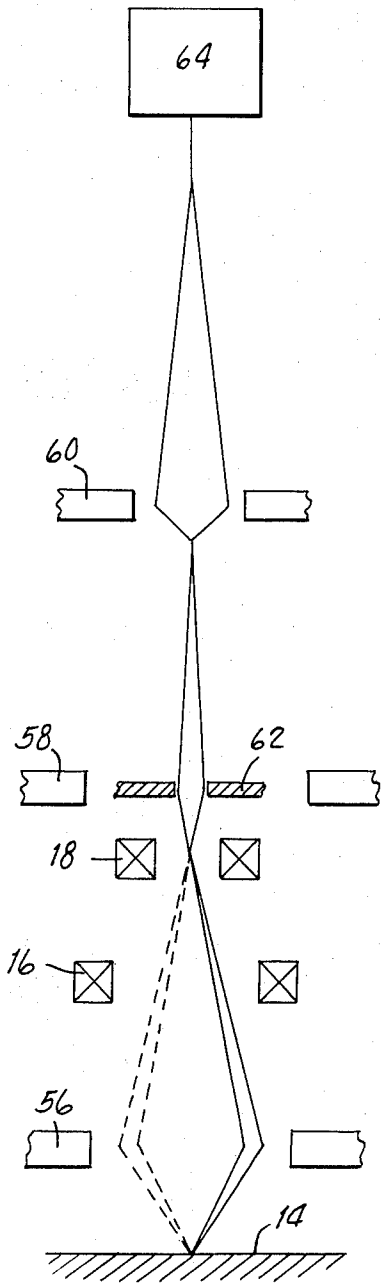


Fig. 9a.

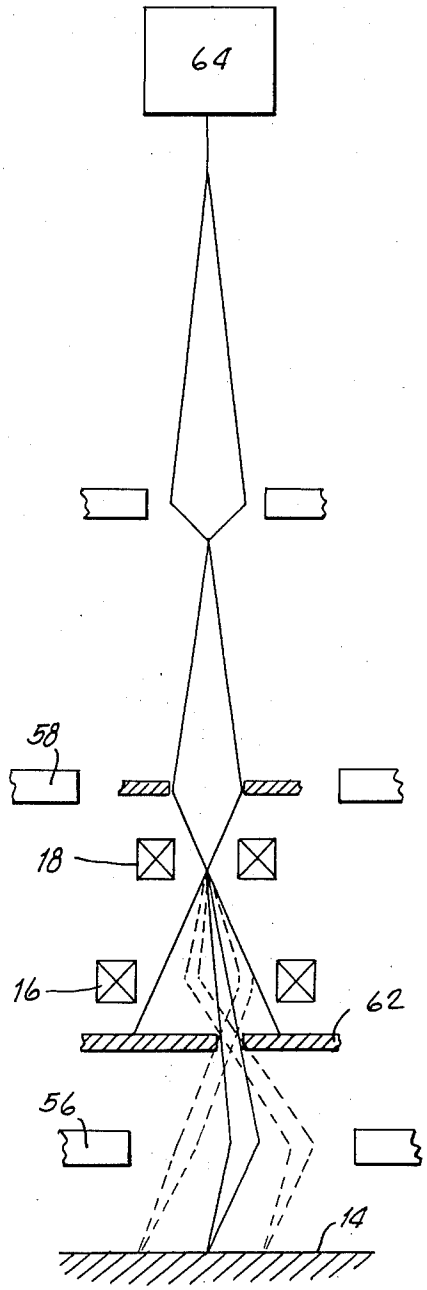


Fig. 9b.

SCANNING ELECTRON MICROSCOPE OPERATING IN AREA SCAN AND ANGLE SCAN MODES

BACKGROUND OF THE INVENTION

The invention is in the field of scanning electron microscopes which generally comprise a microscope column having an electron beam source at one end and a specimen chamber at the other end. Magnetic lenses image the beam crossover at a greatly reduced scale on the specimen. Deflection coils serve to deflect the electron probe formed by the lenses over the surface of the specimen in a scanning pattern. The specimen and a cathode ray tube display are scanned in synchronism. Secondary electrons generated at the point of impact of the electron beam on the specimen, or other impact effects, are detected by suitable detectors whose output modulates the cathode ray tube display.

In conventional scanning electron microscopes of the type discussed above, the angle of incidence of the beam on the specimen varies as the beam scans an area of the specimen. In the case of crystallographic studies utilizing such conventional scanning electron microscopes, information due to crystallographic effects is mixed with information due to non-crystallographic effects such as changes in composition or topography of the specimen. The crystallographic effects information is a function of the angle of incidence of the beam, while the non-crystallographic effects information is a function of the point of incidence of the beam on the specimen. Since the overall value of the information resulting when crystallographic effects information and non-crystallographic effects are inseparably mixed is inferior to separately available crystallographic effects information and non-crystallographic effect information, it is desirable to provide scanning electron microscopes which can selectively provide either only crystallographic effects information or only information due to effects other than crystallographic effects. However, prior to the subject invention, no convenient methods and means have existed for doing so.

There have been suggestions to operate scanning electron microscopes for obtaining defraction or channeling patterns by changing the angle of incidence of the beam on the specimen while the point of impact of the beam on the specimen remains fixed. These suggestions have included rocking the specimen mechanically (D.G. Coates, Proc. 2nd Annual SEM Symposium, IITRI, Chicago, Illinois, 1969, pp. 29–40), double deflection of the incident beam (C. G. Van Essen and E. M. Schulson, J. Matl's Science 4, 336–339, 1969), single deflection of the incident beam combined with the converging action of the objective lens (C. G. Van Essen, E. M. Schulson and R. H. Donaghay, Nature 225, 847–848, 1970), and using scan coils to rock the beam while its tip remains on the same specimen point (D. C. Joy and G. R. Booker, J. Phys. E. 4, 837–842, 1971).

There have also been suggestions for operating scanning electron microscopes to obtain information which is not dependent on the angle of incidence of the beam on the specimen. For example, in the case of a scanning mirror microscope, it has been suggested to scan a specimen with a beam which remains perpendicular to the specimen for the purpose of keeping the beam perpendicular to an equipotential plane (J. R. Garrood and W. C. Nixon, Electron Microscopy 1968) (Tipogratia Poliglotta Vaticana, Rome 1968, pp. 94–95). A specimen has been scanned by mechanical displacement of the specimen in one direction such that the angle of incidence of the beam on the specimen remains constant (J. Philibert and R. Tixier, Micron 1, 174–186 (1969). Other suggestions have been made for changing the angle of incidence of the beam on the specimen in a controlled manner by using an offset of the objective aperture between exposures (H. Okano, S. Hosoki, and T. Tomura, Proc. Fourth National Conference on Electron Microprobe Analysis, Pasadena, Cal., 1969, paper No. 65), or by using a post-lens double deflection system (A.R. Dinnis, Proc. Fourth Annual Scanning Electron Microscope Symposium, ITT Research Institute, Chicago, 1971, pp. 41–48).

The suggestions discussed above do not provide for scanning electron microscopes which can operate alternately in the angle scan mode and in the area scan mode and which can be switched conveniently and rapidly between the two modes to fully utilize the benefits of the types of information provided by the two different modes. Additionally, the prior art systems discussed above do not provide for a convenient indication of the constant angle of incidence during area scan, and of the constant point of incidence during angle scan. A need therefore remains for scanning electron microscopes capable of conveniently switching between either of the two modes discussed above, and for providing convenient indication of the constant angle during area scan, and of the constant point during angle scan.

SUMMARY OF THE INVENTION

The invention is in the field of scanning electron microscopes and relates to methods and means for operating such microscopes in an area scan mode in which an area of the specimen is scanned at a selected constant angle of incidence of the beam on the specimen and in an angle scan mode in which the beam is kept at a selected point of incidence on the specimen while the angle of incidence is varied in a scanning pattern, and for convenient and rapid switching between the two modes.

An illustrative embodiment of the invention comprises a deflection coil set disposed in the path of the beam to act on the beam, scan control units for driving the deflection coils for area scanning and area scanning of the specimen, and means for switching between angle scanning and area scanning. The control units generate scanning AC signals and positioning DC signals. In area scanning, a positioning DC signal selects the angle at which the beam strikes the specimen and an AC signal causes scanning the specimen at that angle. In angle scanning, a positioning DC signal selects the point at which the beam strikes the specimen, and an AC signal causes varying the angle of incidence. Switching means are provided for applying to the deflection coils either the DC and AC signals causing area scanning of the specimen, or the DC and AC signals causing angle scanning of the specimen.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a prior art scanning electron microscope.

FIG. 2 is a schematic diagram illustrating scanning a specimen in an area scan mode in which the angle of

incidence of the beam on the specimen remains the same.

FIG. 3 is a schematic diagram illustrating scanning a specimen in an angle scan mode in which the point of incidence of the beam on the specimen remains the same.

FIG. 4 is a schematic diagram illustrating carrying out an area scan of a specimen by use of deflection coils.

FIG. 5 is a schematic diagram illustrating angle scanning of a specimen by means of deflection coils.

FIG. 6 is a partly schematic, partly block diagram of an electronic system associated with the deflection coils.

FIG. 7 is a schematic diagram illustrating the placing of the deflection coils in one embodiment of the invention.

FIGS. 8*a* and 8*b* are schematic diagrams illustrating another embodiment of a system for carrying out respectively angle scanning of a specimen and area scanning of a specimen.

FIGS. 9*a* and 9*b* are schematic diagrams of an alternative system for carrying out respectively angle scanning and area scanning of a specimen.

DETAILED DESCRIPTION

In a conventional scanning electron microscope, such as the Cambridge Company, Ltd. microscope illustrated schematically in the McGraw-Hill Encyclopedia of Science and Technology, 1971, Volume 8, page 448, the beam probe scans the specimen in pendulum-like fashion, and the angle of incidence of the beam probe on the specimen keeps changing as the beam sweeps the specimen. This prior art mode of scanning is illustrated schematically in FIG. 1 where the microscope portion which is above the final lens is shown as a beam source **10** which generates a beam **12** passing through the aperture of a final lens **13** to scan the surface of a specimen **14** such that the angle of incidence of the beam **12** tip on the specimen **14**, designated as the angle a keeps changing as the beam **12** sweeps the surface of the specimen **14**.

In the prior art type of scanning illustrated in FIG. **1**, angle-dependent information about the specimen **14** is inseparably mixed with position-dependent information about the specimen **14**.

In order to obtain purely position dependent information about the specimen **14**, the specimen **14** may be scanned in an "area scan mode" which is illustrated schematically in FIG. **2**. In the area scan mode, the beam **12** sweeps an area of the specimen **14** at a constant angle of incidence of the beam **12** on the specimen **14**, i.e., a constant angle between the tip of the beam **12** and a line normal to the specimen **14**. This angle of incidence, designated *a* in FIG. **2**, does not change as the beam sweeps a given area of the specimen **14**.

In order to obtain purely angle-dependent information about the specimen **14**, the specimen **14** may be scanned in an "angle scan mode," which is illustrated schematically in FIG. **3**. In the angle scan mode, the beam **12** strikes the specimen **14** at a constant point **14***a*, but the angle of the tip of the beam **12** with respect to a line normal to the surface of the speciment **14**, i.e., the angle designated *a* in FIG. **3**, is varied in a scanning pattern.

A very simplified schematic showing of an exemplary system for operating a scanning electron microscope in the area scan mode is shown in FIG. **4** and comprises a beam source **10** which represent the column of a scanning electron microscope generating a beam **12** suitably focused on a specimen **14**, and a lower deflection coil **16** and an upper deflection coil **18** positioned between the beam source **10** and the specimen **14**. When the deflection coils **16** and **18** are not operating, the beam **12** impinges on the specimen **14** at a point **14***a*. When the deflection coils **16** and **18** are driven by suitable signals for effecting area scanning of the specimen **14**, the beam **12** impinges on the specimen **14** at a selected constant angle *a* of the beam tip wih respect to a line normal to the specimen **14**. This is contrasted with a conventional scanning electron microscope where the angle *a* keeps changing as the beam scans the specimen.

For operating a scanning electron microscope in the area scan mode, as shown in FIG. **4**, a positioning D.D. signal applied to the deflection coils **16** and **18** selects the angle *a* at which the beam **12** strikes the specimen **14** from a defined range of angles of the beam tip with respect to a line normal to the specimen **14**, and a scanning AC signal is applied to the deflection coils **16** and **18**, superimposed on the positioning DC signal, to cause scanning of a defined area of the specimen **14** with the beam **12** while the angle a at which the beam **12** strikes the specimen **14** remains constant.

For operating a scanning electron microscope in the angle scan mode, as shown in FIG. **5**, an arrangement similar to that of FIG. **4** may be used, but the deflection coils **16** and **18** are driven by different signals. In particular, the deflection coils **16** and **18** are driven by a positioning DC signal to select a point **14***a* at which the beam **12** strikes the specimen **14**, and a scanning AC signal is superimposed on the positioning DC signal to vary in a scanning pattern the angle of incidence of the beam **12** on the specimen **14** while keeping the point of incidence **14***a* the same.

The positioning DC signals and the scanning AC signals which drive the deflection coils **16** and **18** in the area scan mode and in the angle scan mode may be derived from a pair of scan control units of the type used in conventional scanning electron microscopes or from other means for generating positioning DC signals of controllable amplitude and scanning AC signal which are sawtooth waves of controllable amplitude and frequency.

An exemplary embodiment of an electrical system for driving deflection coils in the area scan mode and in the angle scan mode, and for switching between the two modes, is shown in schematic form in FIG. **6**. In FIG. **6**, each of the two scan control units **20** and **22** may be, for example, based on the type used for scan control in a commercially available scanning electron microscope identified as model EMX-SM and made by Applied Research Laboratories, Inc. Each of the scan control units **20** and **22** has two outputs labelled X and Y, and has the usual facilities for switching between two-axis scanning, static position with two-axis manual position control, line scans along either axis and line profiles on either axis. The scan control unit **20** has a switch **20***a* that has a position labelled "scan" and a position labelled "static." When the switch **20***a* is at the static position, the scan control unit **20** applies to its X and Y outputs DC voltages whose amplitudes (and

signs) are controlled by suitable knobs (not shown) on the unit **20.** When the switch **20***a* is at its scan position, the scan control unit **20** applies to its X and Y outputs sawtooth voltage signals whose amplitudes, signs and frequencies are controlled by suitable knobs (not shown) on the unit **20.** The switch **22***a* of the scan control unit **22** has the same function with respect to the X and Y outputs of the unit **22.**

The lower deflection coils **16** discussed in connection with FIGS. **4** and **5** actually consist of a lower deflection coil **16***a* for vertical deflection and a lower deflection coil **16***b* for horizontal deflection, and the upper deflection coils **18** actually consist of an upper deflection coil **18***a* for vertical deflection and an upper deflection coil **18***b* for horizontal deflection. The terms "horizontal" and "vertical" in this context refer to two orthogonal directions on the surface of the specimen **14.** Accordingly, FIG. **6** shows separately the coils **16***a*, **16***b*. **18***a* and **18***b*.

In the schematic diagram shown in FIG. **6,** the scan control unit **20** is connected to define the point at which the beam **12** strikes the specimen **14,** while the scan control unit **22** is connected to define the angle at which the beam **12** strikes the specimen **14.** When the switch **20***a* is at its scan position, the scan control unit **20** generates an AC signal for driving the deflection coils **16** and **18** to scan an area of the specimen with the beam tip, and when the switch **20***a* is at its static position, the scan control unit **20** generates a DC signal for positioning the beam tip at a selected point on the specimen **14.** Similarly, when the switch **22***a* is at its scan position, the scan control unit **22** generates an AC signal driving the deflection coils **16** and **18** for angle scanning of the specimen **14,** and when the switch **22***a* is at its static position, the scan control unit **22** generates a DC signal defining a selected angle of incidence of the beam **12** on the specimen **14.** The switches **20***a* and **22***a* are ganged such that when one switch is in its scan position the other switch is in its static position.

The X output of the scan control unit **20** is applied to the lower horizontal deflection coil **16***b* through a variable resistor **24** and an amplifier **26,** and is applied to the upper horizontal deflection coil **18***b* through a fixed resistor **28** and an amplifier **30.** The Y output of the scan control unit **20** is applied to the lower vertical deflection coil **16***a* through a variable resistor **32** and an amplifier **34** and is applied to the upper vertical deflection coil **18***a* through a fixed resistor **36** and an amplifier **38.**

Similarly, the X output of the scan control unit **22** is applied to the horizontal deflection coil **16***b* through a variable resistor **40** and through the amplifier **26** and is applied to the upper horizontal deflection coil **18***b* through a fixed resistor **42** and through the amplifier **30.** The Y output of the scan control unit **22** is applied to the lower vertical deflection coil **16***a* through a variable resistor **44** and the amplifier **34** and is applied to the upper deflection coil **18***a* through a fixed resistor **46** and through the amplifier **38.**

For operating a scanning electron microscope in the area scan mode by means of the exemplary embodiment of the invention shown in FIG. **6,** the switch **22***a* of the scan control unit **22** is turned to the static position such that the scan control unit **22** generates a positioning DC signal which defines the angle of incidence of the beam **12** on the specimen **14.** A selected angle is defined by suitably adjusting the output signal level of the scan control unit **22** by means of its standard output level controls. Since the switches **20***a* and **22***a* are ganged to be in complementary positions, the switch **20***a* is now in its scan position, and the scan control unit **20** is driving the set of deflection coils **16** and **18** with a scanning AC signal for scanning an area of the specimen **14** at the angle of incidence of the beam **12** defined by the static output of the scan control unit **22.** The level of the AC signal from the scan control unit **20** defines the area of the specimen **14** which is scanned; it is adjusted by means of suitable conventional controls on the scan control unit **20.**

For operating a scanning electron microscope in the angle scan mode by means of the exemplary embodiment illustrated in FIG. **6,** the positions of the switches **20***a* and **22***a* shown in FIG. **3** are reversed, namely, the switch **20***a* is set to its static position and the switch **22***a* is set to its scan position. With such setting, the scan control unit **20** generates a positioning DC signal which determines the position at which the beam **12** strikes the specimen **14,** and the scanning AC signal from the scan control unit **22** varies the angle at which the beam **12** strikes the specimen **14** in a scanning pattern while the point at which the beam **12** strikes the specimen **14** remains the same. Conventional output signal level controls on the scan control units **20** and **22** may be used to define the point of incidence of the beam and the range of scanned angles.

Separate cathode ray tube displays **46** and **48** may be provided for displaying area scan and angle scan information respectively. The vertical and horizontal deflection inputs of the cathode ray tube display **46** are driven by the suitably amplified X and Y outputs, respectively, of the scan control unit **20** while the Z input is modulated in a conventional manner with the signal obtained from suitable detectors associated with the specimen **14.** Alternately, a single cathode ray tube display may be used to display area information and angle information either simultaneously or alternately. However, the use of two separate cathode ray tube displays is preferable to allow for rapid switching between area scan and angle scan mode of operation without waiting out the decay time of the cathode ray tube displays.

It is important that the lower deflection coils **16** and the upper deflection coils **18** are driven with signals having the proper ratios to provide correctly the area scan and angle scan modes of operation described above. The ratios between the DC positioning signals are generally different from the ratios between the AC scanning signals.

Referring to FIG. **6,** the proper ratios of the signals for driving the coils **16** and **18** are set by suitably adjusting the variable resistors **24, 40, 32** and **44.** The variable resistors **24** and **32** determine the ratio of coil drives for the area scan mode, and the variable resistors **40** and **44** determine the ratio of coil drives for the angle scan mode. Note that the X and Y outputs of each of the scan control units **20** and **22** are separately adjustable to compensate for distortion. To adjust the drive ratios, the following procedure is used. First, the static position control of the conventional drives of the cathode ray tubes **46** and **48** are set to zero. The scan control units **20** and **22** are set for the area scan mode, i.e., as shown in FIG. **6,** with the switch **20***a* at its scan position and with the switch **22***a* in its static position. Then the outputs of the scan control units **20** and **22** are reversed such that the X and Y outputs of the scan

control unit **20** are applied to the left side of the variable resistor **40** and to the left side of the variable resistor **44** respectively. Then the variable resistors **40** and **44** are adjusted by observing the display scope for the area scan, i.e., the display scope **46**, and using as a specimen **14** a test object consisting of a fine mesh screen. When the magnification of the image is maximum and equal in the X and Y directions, the adjustments are correct for the angle scan mode.

Adjustment of the resistors **24** and **32** is carried out in a similar manner. The scan control unit **20** is placed in the static mode, i.e., the switch **20***a* is at its static position, and the scan control unit **22** is placed in the scan mode, i.e., the switch **22***a* is at its scan potition. Then the outputs of the scan control units **20** and **22** are reversed such that the X and Y outputs of the scan control unit **22** are applied, respectively, to the left side of the variable resistor **24** and the left side of the variable resistor **32.** A single crystal specimen with smooth damage-free surface is used as the specimen **14** and the image thereof is observed on the display scope for angle scans, namely, display scope **48.** The contrast observed on the display scope **48** is therefore only crystallographic contrast and a channeling pattern is seen. The variable resistors **24** and **32** are adjusted for maximum magnification of this channeling pattern. This means that the incident beam **12** is scanning the specimen **14** at a constant angle of incidence. A channeling pattern with certain symmetry is desirable, so that the X and Y deflections can be balanced (e.g., a cubic crystal with (**111**) or (**100**) orientation.

The design of the coils **16***a*, **16***b*, **18***a*, and **18***b* is generally not critical. One possible design is aircore coils each containing approximately 320 turns of No. 26 wire and having a resistance of approximately 2.2 ohms and driven with a maximum current of about 1 ampere. Coils wound on a ferrite square provide greater drive and higher frequency response. Coils of other designs are possible so long as they satisfy the requirements of minimum size so they fit within the limited space available in scanning electron microscopes and producing a large angle of deflection of the beam **12** with minimum drive.

There are several possible ways of positioning the lower deflection coils **16** and the upper deflection coils **18** with respect to the other parts of a scanning electron microscope. One exemplary embodiment is shown in FIG. 7 where the deflection coils **16** and **18** are disposed in a sample holder **50** which includes a suitable support **52** for the specimen **14** and back scatter detectors **54.** The sample holder **50** is disposed directly below the objective lens **56** of a commercially available electron probe microanalyzer (e.g., EMX-SM) using a smaller objective aperture than normally employed (50 microns instead of 300 microns). The sample holder **50** includes a suitable support (not shown) for the lower deflection coils **16** and for the upper deflection coils **18.** The deflection coils **16** and **18** are shown mounted in the specimen holder **15,** but they could also be mounted to the objective lens if suitable provisions are made for the air lock gate valve. It is important that the coils are properly oriented as in aximuthal angle relative to each oher. This can be done by using mechanical or electronic rotation of one deflection in the double deflection system.

An alternative embodiment of the one illustrated in FIG. 7 is to mount one set of deflection coils in the gap of the lens **56** and to mount another set of deflection coils on the object side of the lens **56.** In particular, the coil **18** may be mounted at the location labeled **18'**, i.e., in the gap of the lens **56,** while the coil **16** is mounted in the sample holder **50.** Then, angle adjustment between the coils **16** and **18** is carried out by rotating the sample holder **50.**

An alternative embodiment of a system incorporating the subject invention is shown schematically in FIG. **8***a* as operating in the angle scan mode and is shown in FIG. **8***b* as operating in the area scan mode. The system shown in FIGS. **8***a* and **8***b* employs lower deflection coils **16** and upper deflection coils **18** suitably mounted on the source side of the objective lens **56** of a scanning electron microscope which includes conventional lenses **58** and **60,** an aperture plate **62** and a beam source **64.**

Another embodiment incorporating the subject invention is shown in FIGS. **9***a* and **9***b* where FIG. **9***a* represents operation in the angle scan mode and FIG. **9***b* represents operation in the area scan mode. Referring to FIG. **9***a*, a scanning electron microscope including a beam source **64,** lenses **60, 58** and **56** and a suitable holder for the specimen **14,** is provided with deflection coils **16** and **18** positioned on the source side of the final objective lens **56.** In the angle scan mode shown in FIG. **9***a*, the effective size of the region examined is determined by a combination of the deflection aberrations due to the deflection coils **16** and the spherical aberration of the objective lens **56.** The aperture plate **62** defines the electron beam generated by the source **64.** The lower deflection coils **16** are used to sweep the beam about an angle defined by the angle of the beam with respect to the center of the deflection coils. If the lens action of the objective lens **56** were perfect, and if the intermediate image of the electron source **64** were exactly at the mid plane of the deflection coils, the cross-over of the beam would occur exactly at the specimen. In practice, however, it does not occur in this position for all angles of deflection; this is partly due to improper location of the deflection coil and partly due to the spherical aberration of the objective lens. To correct this, the deflection coils **16** are positioned at the optimum position for minimum objective lens aberration and then the upper coils **18** are used for correction of residual aberrations. In the angle scan mode shown in FIG. **9***a*, the lower deflection coils **16** are driven by a scanning AC signal and the upper deflection coils **18** are driven by positioning DC signals to select a point of incidence of the beam on the specimen **14.**

In the area scan mode shown schematically in FIG. **9***b*, the configuration is the same as in FIG. **9***a* except that a movable aperture plate **62** is used in the back focal plane of the objective lens **56.** This aperture **62** defines more accurately the angle of incidence of the beam on the specimen **14.** In the area scan mode shown in FIG. **9***b*, the upper deflection coils **18** are driven by AC signals while the lower deflection coils **16** are driven by positioning DC signals. The AC signals driving the upper coil **18** cause the electron beam to scan the specimen over a given area while the angle of incidence of the electron beam on the specimen **14** remains fixed. In this mode of operation astigmatism may be produced by large displacements of the aperture **62.** To correct this astigmatism, a stigmator may be used in the lens **58.**

The lower deflection coils **16** and the upper deflection coils **18** shown in FIGS. **7**, **8***a*, **8***b*, **9***a* and **9***b* are driven by signals generated by circuitry of the same type as shown in FIG. **6**, but suitable adjustments may be made in the signal levels to accommodate each particular configuration.

I claim:

1. A scanning electron microscope having a beam source and means for focusing the beam to a probe impinging on a specimen, wherein the improvement is in a combination of: area scan means comprising means for selecting an angle of incidence of the beam probe on the specimen from a defined range of angles and means for scanning the specimen with the beam probe while maintaining said selected angle of incidence, thereby operating the microscope in an area scan mode; angle scan means comprising means for selecting a point of incidence of the beam probe on the specimen and means for automatically scanning the angle of incidence of the beam probe on the specimen in a scanning pattern while maintaining the beam probe at the selected point of incidence on the specimen, thereby operating the microscope in an angle scan mode; switch means for causing the microscope to operate the area scan means and the angle scan means in a selected sequence; and first means for displaying area dependent information about the specimen obtained in the course of said area scan mode of operating the scanning electron microscope and second means for displaying angle dependent information about the same specimen obtained in the course of said angle scan mode of operating the scanning electron microscope.

2. A scanning electron microscope as in claim **1** including a deflection coil set disposed in the path of the beam to act thereon, wherein the area scan means includes means for driving the deflection coil set with a positioning signal to define said selected angle of incidence and with a scanning signal to scan the specimen with the beam while maintaining said selected angle of incidence.

3. A scanning electron microscope as in claim **2** wherein the area scan means includes means for driving the deflection coil set with a DC positioning signal to define the selected angle of incidence and means for driving the deflection coil set with an AC scanning signal to carry out said scanning of the specimen with the beam probe while maintaining the selected angle of incidence of the beam probe.

4. A scanning electron microscope as in claim **1** including a deflection coil set disposed in the path of the beam to act thereon, wherein the area scan means includes means for driving the deflection coil set to carry out area scan of the specimen and the angle scan means includes means for driving the deflection coil set to carry out angle scan of the specimen.

5. A scanning electron microscope as in claim **4** wherein the area scan means includes means for driving the deflection coil set with a DC signal to define said selected angle of incidence of the beam probe and for driving the deflection coil set with an AC signal to carry out scanning of an area of the specimen, and wherein the angle scan means includes means for driving the deflection coil set with a DC signal to define said selected point of incidence of the beam probe and for driving the deflection coil set with an AC signal to carry out angle scanning of the specimen.

6. A scanning electron microscope as in claim **5** including an objective lens wherein said deflection coils are disposed between the objective lens and the specimen.

7. A scanning electron microscope as in claim **6** including a specimen holder disposed below the objective lens and including means for supporting a specimen and means for supporting said deflection coils.

8. A scanning electron microscope as in claim **7** wherein said deflection coil set includes a lower deflection coil and an upper deflection coil.

9. A scanning electron microscope as in claim **5** including an objective lens having an aperture through which the beam passes wherein said deflection coil set is disposed at least partly within said objective lens aperture.

10. A scanning electron microscope as in claim **5** including an objective lens wherein said deflection coils are disposed between the objective lens and the beam source.

11. A scanning electron microscope as in claim **10** including a movable aperture plate disposed between the deflection coils and the objective lens.

12. A scanning electron microscope having a beam source and means for focusing the beam to a probe impinging on a specimen, comprising:

area scan means comprising means for selecting an angle of incidence of the beam probe on the specimen and means for scanning in a defined pattern a selected area of the specimen with the beam probe while maintaining said selected angle of incidence to thereby operate the microscope in an area scan mode;

angle scan means comprising means for selecting a point of incidence of the beam probe on the specimen and means for automatically scanning the angle of incidence of the beam probe on the specimen in a defined scanning pattern while maintaining the beam probe at the selected point of incidence on the specimen to thereby operate the microscope in an area scan mode;

switch means for causing the scanning electron microscope to operate the area scan means and the angle scan means in a selected sequence so as to obtain both area dependent and angle dependent information about the same specimen; and

first means for displaying said area dependent information about the specimen obtained in the course of said area scan mode and second means for displaying angle dependent information about the same specimen obtained in the course of said angle scan mode of operating the scanning electron microscope.

13. A scanning electron microscope as in claim **12** including means for generating a positioning signal and means for generating a scanning signal, said positioning signal defining the selected angle of incidence of the beam probe on the specimen when the microscope is operating in the area scan mode and defining the selected point of incidence of the beam on the specimen when the microscope is operating in the angle scan mode, and said scanning signal defining the scanning pattern in either mode.

14. A scanning electron microscope as in claim **13** wherein said positioning signal is a DC electrical signal and said scanning signal is an AC electrical signal.

15. A scanning electron microscope as in claim 14 including a deflection coil and means for applying said positioning and scanning signal to the deflection coil.

16. A scanning electron microscope as in claim 15 wherein the deflection coil comprises a first coil for selectively deflecting the beam in a first direction along the specimen and a second coil for selectively deflecting the beam in a second direction along the specimen, said first and second direction intersecting each other, and wherein each of the first and second coil comprises an upper and a lower coil, means for applying said positioning and scanning signals to each of the upper and lower coils in ratios defining the scanning mode, the angle of incidence and the scanned area in the area scan mode, and the point of incidence and the scanning pattern in the angle scan mode.

17. A scanning electron microscope as in claim 16 wherein the first display means provides an area scan display of an electron microscope image of the scanned area of the specimen and the second display means provides an angle scan display of an electron microscope image of the scanned point of the specimen, and including means for displaying on the second display means the angle of incidence of the beam while the microscope is operating in the area scan mode, and for displaying on the first display means the point of incidence of the beam on the specimen while the microscope is operating in the angle scan mode.

18. A scanning electron microscope as in claim 12 including deflection coil means for selectively deflecting the beam with respect to the specimen, wherein the area scan means includes means for driving the deflection coil means with a positioning signal defining the angle of incidence of the beam probe on the specimen and with a superimposed scanning signal defining the scanning pattern of the beam probe over a selected area of the specimen, and wherein the angle scan means includes means for driving the deflection coil means with a positioning signal defining the point of incidence of the beam probe on the specimen and with a superimposed scanning signal defining the pattern of scanning a selected range of angles of incidence of the beam probe on the specimen.

19. A scanning electron microscope as in claim 18 wherein the deflection coil means includes electromagnetic coils and wherein said positioning signal is a DC signal and said scanning signal is an AC signal.

20. A scanning electron microscope as in claim 19 including means interposed between the area scan and the angle scan means on the one hand and the deflection coil means on the other hand for selectively varying the power of the DC signal to thereby select an angle of scanning in the area scan mode and a point of incidence in the angle scan mode, and for selectively varying the power of the AC signal to thereby select the size of the scanned area in the area scan mode and the range of scanned angles in the angle scan mode.

21. A method of operating a scanning electron microscope having a beam source and means for focusing the beam to a probe impinging on a specimen, and having area scan means for selecting an angle of incidence of the beam probe on the specimen and scanning a selected area of the specimen while maintaining said selected angle of incidence to thereby operate the microscope in an area scan mode, and angle scan means for selecting a point of incidence of the beam probe on the specimen and automatically scanning the angle of incidence of the beam probe on the specimen in a scanning pattern while maintaining the beam probe at the selected point of incidence on the specimen to thereby operate the microscope in an area scan mode, said method comprising the steps of:

scanning the specimen in a selected one of said area scan mode and angle scan mode to obtain area dependent information about the specimen when scanning in the area scan mode and angle dependent information about the specimen when scanning in the angle mode; and

scanning the same specimen in the other one of said area scan mode and angle scan mode, with a defined parameter of said scanning selected on the basis of information about the specimen obtained in the preceding step.

22. A method as in claim 21 including the steps of:

displaying an area scan image of the specimen and an angle scan image of the specimen, said angle scan image of the specimen representing the angle of incidence of the beam probe on the specimen during area scan and said area scan image of the specimen representing the point of incidence of the beam on the specimen during angle scan.

23. A method as in claim 21 wherein the specimen is scanned first in an angle scan mode and is then scanned in an area scan mode, with the angle of incidence of the beam probe on the specimen during said area scan mode selected on the basis of the angle dependent information obtained in the course of the preceding angle scan mode scanning of the specimen.

24. A method as in claim 21 wherein the specimen is scanned first in an area scan mode and is then scanned in an angle scan mode, with the point of incidence of the beam during said angle scan mode being selected on the basis of area dependent information obtained in the course of said preceding area scan mode scanning of the specimen.

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