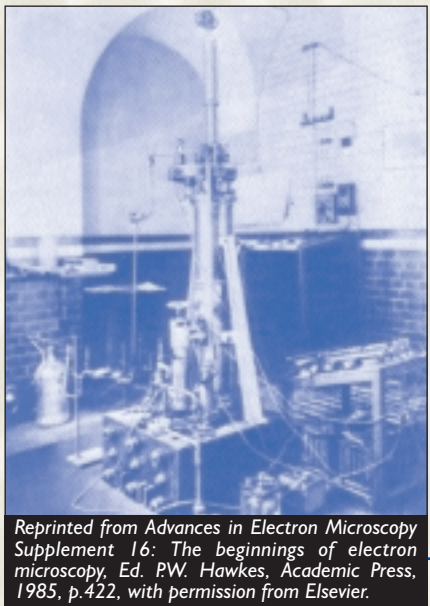




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RCA publication, image supplied by Wil Bigelow.

Dry-stripping replica (Barrett, C.S.)²⁹
Shimadzu - SM-1 completed (40kV x20,000, 5-10nm).
Cinematography in EM (von Ardenne, M.)²⁸
Re-sectioning (Sjostrand, F.)²⁷

HUI (Hitachi's first EM).
Hitachi EM Horizontal column on an optical bench.²³
Surface replica (Mahl, H.)²²
Specimen heating (von Ardenne, M.)²¹
RCA 'B' (Zworykin, V.K. et al.)²⁰
RCA 'A' (Marton, L.)¹⁹

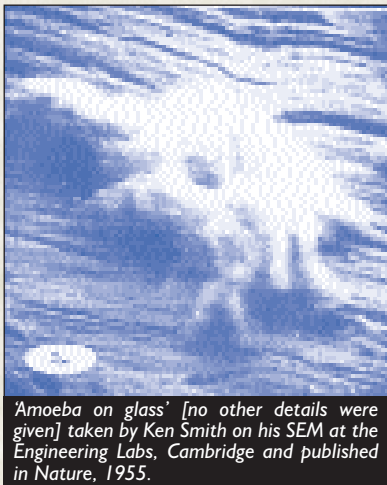
JEOL JEM 2.
Glass knife (Latta, H. & Hartmann J.F.)³⁹
A modification to Gabor's proposed diffraction microscope (Haine, M.E. & Dyson, J.)³⁸

Proposal for use of holography to improve resolution (Gabor, D.)³⁵
Photo-lithographic grids (Smethurst Highlight)³⁴

Instrumentation Biological Samples Materials Samples

Diamond knife (Fernandez-Moran, H.)⁴⁵
First Reflexion microscopy facility in a TEM - EM3A (Page)⁴⁴
First solid state TEM produced by Philips, the EM 75.
Microtome (Porter, K.R. & Blum, J.)⁴³

Scherzer proposes a corrector for spherical aberration using octupoles and quadrupoles (Scherzer, O. & Seeliger, R.)⁴²



'Amoeba on glass' [no other details were given] taken by Ken Smith on his SEM at the Engineering Labs, Cambridge and published in *Nature*, 1955.

Ion getter pump (Varian Bros. USA)⁴⁷
Axial turbomolecular pump (Becker)
Freeze substitution, (Fernandez-Moran, H.)⁵⁰

Ferritin/antibody conjugates (Singer, S.J.)⁵²

Calibration/lattice-planes (Dowell, W.C.T.)⁵⁹

X-ray analyser attachment to a transmission electron microscope (Neff & Herrmann)⁵⁸

First EFTEM (Castaing, R. & Henry, L.)⁵⁴

HRP/DAB/OsO₄ labelling (Graham, R.C. & Karnovsky)⁶²

(LaB₆) thermionic cathodes developed for use in electron microscopy.

Z-contrast STEM imaging of single atoms (Crewe, A.V. et al.)⁷¹

Re-introduction to STEM (Crewe, A.V.)⁷⁰

UHVEM (3MV) (Dupouy, G. et al.)⁶⁹

Acrylic (LR White) resin (Causton, B.)⁷⁶

Single atom imaging by TEM (Haga, Y. & Takayanagi, K.)⁷⁹

Ruska wins Nobel prize in Physics for constructing the first electron microscope.

High resolution electron holography (Lichte, H.)⁷⁷

Commercial TEM with FEG, (Hitachi)

Ultracryotomy of cells and tissues (Tokuyasu, K.T.)⁷³

FEG (Crewe, A.V. et al.)⁶⁷

Combined TEM-Microanalyser (EMMA) (Cooke, C.J. & Duncomb, F.)⁶⁶

3-D Tomography (De-Rosier, D.J. & Klug, A.)⁶⁵

Superconducting lens (Dietrich, I. et al.)⁶³

Lanthanum hexaboride (LaB₆) source (Broers, A.)⁶⁴

First commercial EMMA - EMMA-4 (Cooke, C.J. and I.K. Openshaw)⁶⁸

Immunogold (Faulk, W.P. & Taylor, G.M.)⁷²

First computer control and adjustment of an electron microscope (Unitt, B.M. & Smith, K.C.)⁷⁴

Hyperbaric cooling of samples (Moor, H., Bellin, G., Sandri, C.)⁷⁵

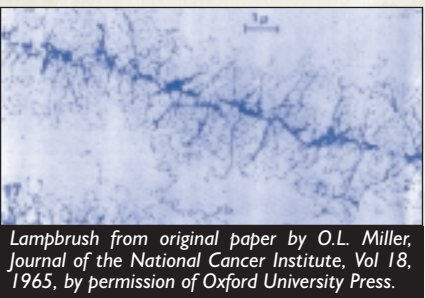
Commercial EFTEM with in-column Ω filter, Zeiss.

ESEM, first production model (Electroscan)⁷⁸

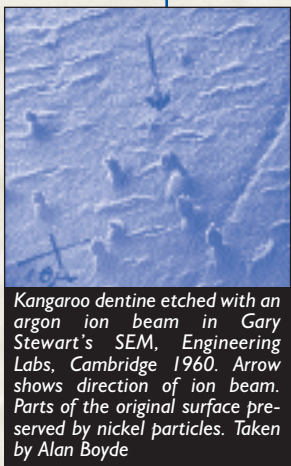
E. Ruska dies.



SEMI from Breton PJ, 1999 Scanning Microscopy 13 1, courtesy CUED.



Lampbrush from original paper by O.L. Miller, Journal of the National Cancer Institute, Vol 18, 1965, by permission of Oxford University Press.



Kangaroo dentine etched with an argon ion beam in Gary Stewart's SEM, Engineering Labs, Cambridge 1960. Arrow shows direction of ion beam. Parts of the original surface preserved by nickel particles. Taken by Alan Boyde

Epoxy resin (Araldite) (Glauert, A.M. & Glauert, R.H.)⁵¹

First electron microprobe instrument, produced by Cameca, the MS85.

Thin-metal foil preparation (Bollman, W.)⁴⁸

First Lattice images (Menter, J.)

Autoradiography (Liquier-Milward, J.)⁴⁹

Carbon support films, (Bradley, D.E.)⁴⁶

Carbon replicas (Bradley, D.E.)

Telefocus gun in CSF model M III electrostatic microscope (Grivet, P. & Regenstreif, E.)⁴⁰

Buffered OsO₄ fixation (Palade, G.E.)⁴¹

Focus Wobbler. A new electron microscope with continuously variable magnification (Le Poole)³¹

Objective stigmator/Asigmatism correction (Hillier, J. & Ramberg, E.G.)³²

Objective stigmator/Asigmatism correction (Berstein, F.)³³

Osmium Fixation by Claude.

Denshi Kagatu Lab founded as EM supplier.

Butyl methacrylate resin (Newman, S.B. et al.)³⁶

Japan Electron Optics Laboratory Co (JEOL) formed from en bloc resignation of staff from Denshi Kagatu leading to the instrument JEM-1.

X-ray microprobe (Castaing, R.)³⁷

Specimen cooling (von Ardenne, M.)²⁴

RCA 'B' (x6) (Darwin, C.G.)²⁵

Shadowing (Muller, H.O.)²⁶

PTA negative stain (Schmitt, F.O. et al.)³⁰



Phage from Fernandez-Moran H in The interpretation of ultrastructure Ed R/C Harris Academic Press 1962 p415.

Wedge-cut microtome (von Ardenne, M.)¹⁴

First production electrostatic electron microscope AEG EM5 (Golz & Schliebe)¹⁵

Stereo-pairs (von Ardenne, M.)¹⁶

HVEM (>200kV) One of Siemens UM in the first batch of 38 operated at 220kV.¹⁷

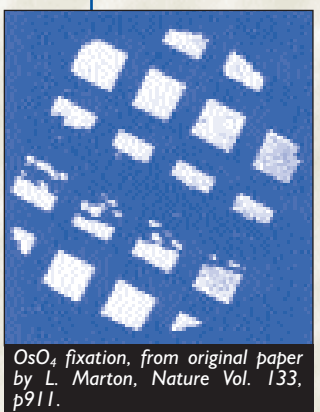
Kodak EM (Hall, C.E.)¹⁸

Toronto TEM (Hillier & Prebus)

Prototype S(T)EM (von Ardenne, M.)¹⁰

Convergent beam electron diffraction (Kossel, W. & Mollenstedt, G.)¹¹

OsO₄ fixation (Marton, L.)⁸



OsO₄ fixation, from original paper by L. Marton, Nature Vol. 133, p911.

Ernst Ruska imaged a cathode at ~3.5 magnification during a student project, thereby creating the first electron microscope.

Wavelength of electrons (de Broglie)¹

Magnetic lens (Busch, H.)²

Prototype TEM, Ruska E. et al.³

Rudenberg of Siemens publishes what is accepted to be the first patent related to electron microscopy. Some controversy surrounds his invention

Knoll & Ruska publish a paper in which the term 'electron microscopy' was first used.⁴

E. Ruska achieved 2-stage imaging of a grid in transmission at ~16x magnification.



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Studies of biomedical materials, mainly in the area of characterising bioactive materials such as hydroxyapatite.

Scanning electron microscopy

The characterisation of biomedical polymers and other biomaterials, tissue engineering and drug delivery.

Applications of EM to forensic science.

Mechanisms of cell injury, both apoptosis and oncosis. Correlation of morphological changes and immunogold cytochemistry with data from other disciplines.

Application of Field Emission SEM to biological material; cryo techniques, including freeze substitution; backscattered electron imaging; image analysis.

The characterisation of metals and ceramics at high spatial resolution using high resolution electron microscopy and electron spectroscopic imaging.

Energy-dispersive and wavelength dispersive X-ray microanalysis in SEM and TEM.

In Vitro confocal microscopy, 2-photon excitation microscopy, immunogold labelling, stereology, Energy-dispersive X-ray microanalysis.

Energy Filtering Electron Microscopy and Imaging

The application of EPXMA to biological specimens. Current projects include: The role of potassium in the development of apoptosis. Subsarcolemmal gradients in ischaemia reperfusion injury. The speciation of iron in ferritin cores after the development of liver disease.

Advances in imaging and electron physics, vol 96; The growth of electron microscopy, editor Tom Mulvey, Academic Press 1996, London.

History of Electron Microscopes – Editor Hiroshi Fujita, International Congress on Electron Microscopy, 1986, ISBN 4-930813-17-4.

Reference List

- Thesis, Paris
 - Theoretical dissertation
 - Resolution = LM
 - Ann. Phys. Vol. 12*, pp.601-640, 1932
 - Patent (B154,916)
 - Ann. Phys. Vol. 12*, p. 607; *Z. Phys. Vol. 78*, p. 318
 - Described in Finch and Quarrell 1934
 - Nature Vol. 133*, p. 911
 - 1st (single) commercial installation
 - Z. Tech Phys. Vol. 19*, p. 407
 - Ann. d. Physik Vol. 36*, p.113 and others
 - 1st of a series of commercial instruments
 - Z. Tech. Phys. Vol. 20*, p. 316
 - Electronen-Übermikroskopie (Springer-Verlag)
 - This microscope also included a specimen tilting mechanism for stereo pairs. Recorded in Ramsauer C. 'Elektronmikroskopie. Bereich Über Arbeiten des AGE Forschungs-Institut 1930 bis 1942' Springer Verlag, Berlin
 - Naturwissenschaften Vol. 28*, pp. 248
 - Described by Wolpers C. Electron Microscopy in Berlin 1928-1945 *Adv. Electronics and Electron Phys. Vol. 81*, pp. 211-229
 - Approx. date
 - Production cancelled
 - Starts production
 - Kolloid Z. Vol. 97*, p. 257
 - Z. Metallkde Vol. 33*, p. 68
 - Starts production
 - Z. Phys. Chem. Abt. B Vol. 52*, p. 61
 - Arranged lend-lease to UK, from USA
 - Kolloid Z. Vol. 99*, p. 6
 - Ark. Zool. Vol. 35A*, p. 1
 - Z. Phys. Vol. 120*, p. 397
 - Met Tech 10 (Publ.#1637, 5)*
 - J. Appl. Phys. Vol. 16*, p. 263
 - Philips Tech. Rev. Vol. 9*, pp. 33-46
 - J. Appl. Phys. Vol. 18*, p. 48
 - On some defects in electron optical instruments and on their correction. *Ann Radioelectr. 2*, No 10
 - Approx. date
 - Nature Vol. 161*, p.777
 - J. Res. Natl. Bur. Stand. (US) Vol. 43*, p. 183
 - Proc. Electron Microscopy meeting, Delft, 1949
 - Nature Vol. 166*, p. 315
 - Proc. Soc. Exp. Biol. Med. Vol. 74*, p. 436
 - Rev. Opt. Theor. Instrum. Vol. 31*, p. 230
 - J. Exp. Med. Vol. 95*, p. 285
 - Paper read at UK EM conference
 - Anat. Rec. Vol. 117*, p. 685
 - (Private Communication)
 - Exp. Cell. Res. Vol. 5*, p. 255
 - Br. J. Appl. Phys. Vol. 5*, p. 65
 - Development of Penning manometer
 - Phys. Rev. Vol. 103*, p. 1588
 - Nature Vol. 177*, p. 619
 - Metabolism of the nervous system, Ed D. Richter pp1-34 Pergamon, Oxford
 - J. Biophys. Biochem. Cytol. Vol. 4*, pp. 191
 - Nature Vol. 183*, p. 1523
 - C R Hebd. Seances. Acad. Sci. Vol. 251*, p. 2836
 - C R Sci. Paris B, Vol. 255*, p. 76
 - J. Cell Biol. Vol. 17*, pp. 609-628
 - J. Cell Biol. Vol. 17*, p. 19
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 - Read atACHEMA- Tagung, 25 June 1964
 - Optik Vol. 21*, p. 26
 - Adv. Electron. Phys. Vol. 21*, p. 181
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 - J. Histochem. Cytochem. Vol. 14*, p. 291
 - Cryogenics Vol. 7*, p. 178
 - J. Appl. Phys. Vol. 38* p.1991
 - Nature Vol. 217*, p. 130
 - Proc 5th Int. Conf. on X-ray optics and microanalysis, Tübingen
 - Rev. Sci. Inst. Vol. 39*, p. 576
 - Proc. Electron Probe Soc. of America, 4th National Conference
 - C R Hebd. Seances. Acad. Sci. Vol. 270*, p. 41
 - Quart. Rev. Biophys. Vol. 31*, p. 137
 - Science Vol. 168*, p. 1338
 - Immunochemistry Vol. 8*, p. 1081
 - J. Cell Biol. Vol. 57*, pp. 551-565
 - Proc. Eur. Cong. Electron Microsc. Jerusalem 1976
 - The influence of high pressure freezing on mammalian nerve tissue. *Cell Tiss. Res. Vol. 209*, pp. 201-216
 - London Resin Company
 - 1986
 - GE laboratories
 - Ultramicroscopy Vol. 45*, p. 95

Timeline

Electron Microscopy

For sometime we have planned to create a series of timelines based on themes in microscopy. This turned out to be a more demanding task than at first predicted, because references are not always accurate and claims to be the first to achieve something are sometimes misguided! As such, we present the first of these timelines for the readership to study and make comment. We have tried our best to make it accurate, and have sort input from numerous experts in the field. In particular we thank the EM Section for their time in collating and reviewing much of the information. In the future we plan to publish similar timelines with input from the other RMS Sections, and in doing so, build a detailed historical perspective of the achievements in microscopy. Please, therefore, feedback comments or revisions, and highlight any references you feel ought to have been made but were omitted through oversight. We look forward to your response and a lively debate in the Forum section of future issues.

Adrian Burden

Electron Microscopy: from birth to maturity

Electron microscopy rapidly developed from a novelty to a highly fashionable discipline before maturing to its current role in providing essential insights into the fundamental structure of all materials, both inorganic and biological.

The EM Section of the Royal Microscopical Society, serves to foster interest in all types of electron microscopy and analysis in academia and industry in the UK and beyond. Electron microscopy in materials and biological science applications are the topics of various meetings and courses. These cater for all levels of electron microscope user, from the beginner through to the expert, and often consider emergent techniques and novel instrumentation. Current techniques in SEM, TEM, STEM and EFTEM for imaging and diffraction are among the interests of group members, plus elemental analysis and cryotechniques. Committee members represent a cross-section of electron microscopists and attempt to represent the user interest of the wider EM community.