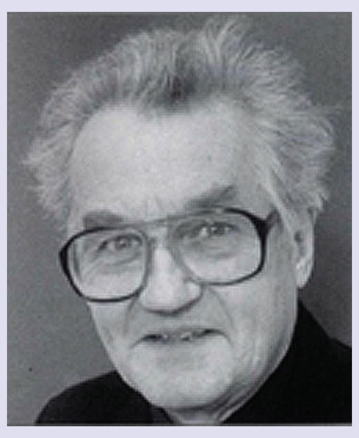
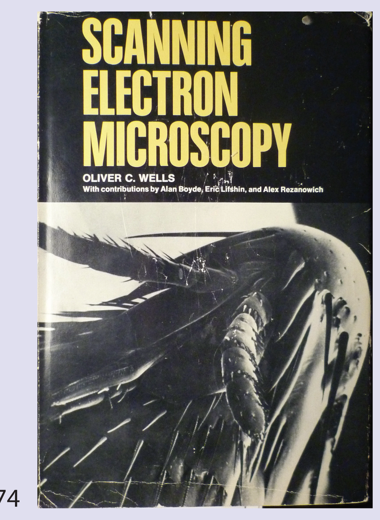


Oliver C. Wells
1931-2013



Wells, 1974

Brief Bio

Cave diving in the 1950s (courtesy of James Wells)

Oliver Wells was born in London, England in 1931. He was the grandson of early science-fiction writer H.G. Wells. After going to Marlborough College, he attended Cambridge University, earning his PhD as one of the early pioneers of SEM, with a speciality in electron detectors. During his college years, Wells was an avid cave explorer and cave diver (Wells, 1981). Later, he worked as a part-time ski instructor at Hunter Mountain in the Catskills of New York. He was involved in the Yorktown Volunteer Ambulance Corps, serving as an EMT volunteer in the ambulance and in the Hudson Valley Hospital Center emergency room.

Positions

1949-1950 British Army
- Sergeant instructor in radar techniques.
- Developed pulse-shaping circuits (Wells, 1952)

1953-1957 Cambridge PhD work
- Invented precursor scintillator backscattered ("Robinson") detector.
- Developed the theory of atomic number contrast
- Developed the technique of stereo imaging in the SEM
- Developed methods to image non-conducting specimens in the SEM.
- Use of positive ions for charge compensation.

1957-1959 Ericsson Telephone Co, Nottingham, UK
- Designed transistor circuits for information storage

1964-1965 CBS Laboratories Stamford, Conn
- Deposition of epitaxial Si films by ultra-high vacuum evaporation.
- E-beam machining (Wells, 1965).

1959-1964 Westinghouse, Pittsburgh, Pa
- Designed and built an SEM.
- Invented SEM-type registration for e-beam lithography (Wells et al., 1965).
- First electron-beam-induced image of a semiconductor device (Wells et al., 1965)

1964-1965 CBS Laboratories Stamford, Conn
- Deposition of epitaxial Si films by ultra-high vacuum evaporation.
- E-beam machining (Wells, 1965).

1966-2011 Thomas J. Watson Research Center - Research Staff Member
- Installed the second commercial SEM shipped to the USA.
- Developed low-loss electron imaging for high-resolution imaging.
- Extensive testing of microelectronic devices by various e-beam methods.
- Developed advanced backscattered electron imaging.
- Retired in 1993, unpaid Emeritus Research Staff Member until 2011.

Thesis Work

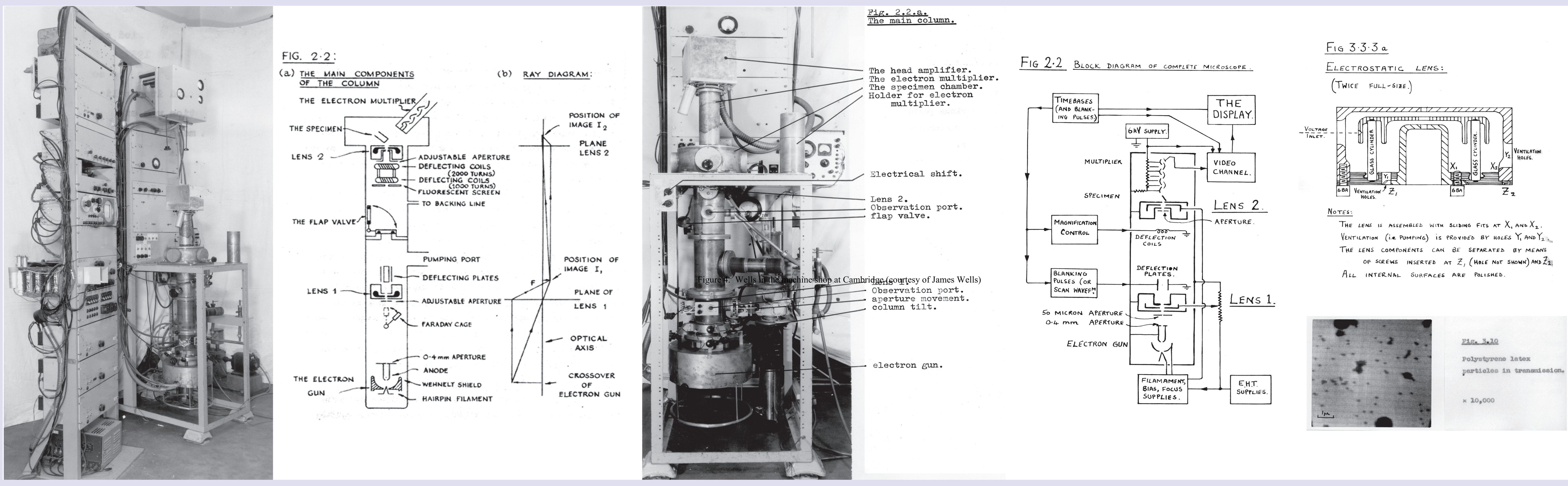


Figure 1. Wells' PhD thesis work (Wells, 1957) was both pioneering and extensive. He built his first instrument as a student of Sir Charles Oatley at Cambridge. This was the second Cambridge instrument, the first having been built by Dennis McMullen in 1953. While his SEM was similar to McMullen's, it was unique in having the electron gun at the bottom in order to provide convenient access to the sample chamber. It also differed from most modern SEMs in having electrostatic lenses. The resolution was better than 100 nm, at first limited by the 50 Hz mains field, which caused the 100-nm particles to appear elliptical. Wells designed and built every part of his SEM from scratch. The line of SEMs from Cambridge led directly to the SEMs we use today, the most ubiquitous electron-beam instrument after television and the oscilloscope. [The first SEM was built by Manfred von Ardenne in 1938, and another by James Hillier in 1942, but neither continued development toward a commercial instrument.]

Figure 2. Wells in the machine shop at Cambridge (courtesy of James Wells)

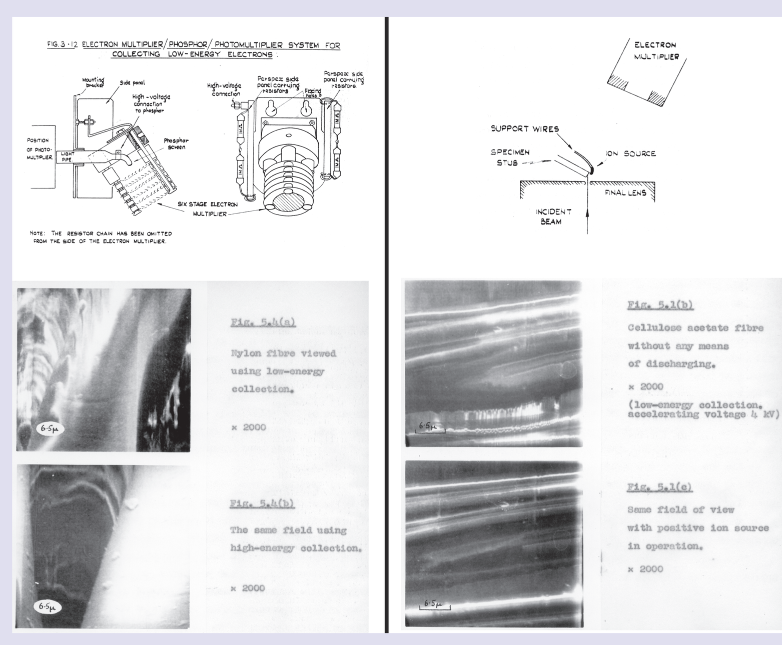


Figure 3. Left panel: Wells' first SEM used a phosphor / electron-multiplier type of detector, predating the scintillator / photomultiplier (Everhart-Thornley) type. This detector could be biased to collect primarily low-loss electrons (LLE), which originate very close to the surface of the specimen. The LLE image clearly showed the true surface of insulators, even in the prewence of severe charging. Right panel: Wells employed charge compensation using a low-energy ion source created by heating and a potential difference. He also discussed the use of water vapor, ionized by high-energy incident electrons, to reduce specimen charging, perhaps the first to envision VPSEM. He developed a detector arrangement that permitted high-magnification examination of the bores of small holes, for which no other method existed (Wells, 1957).

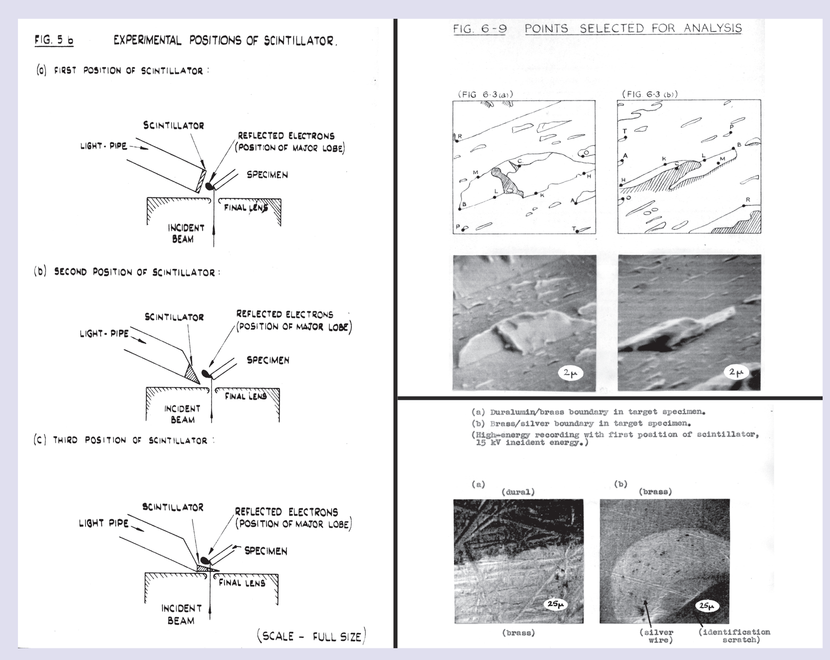
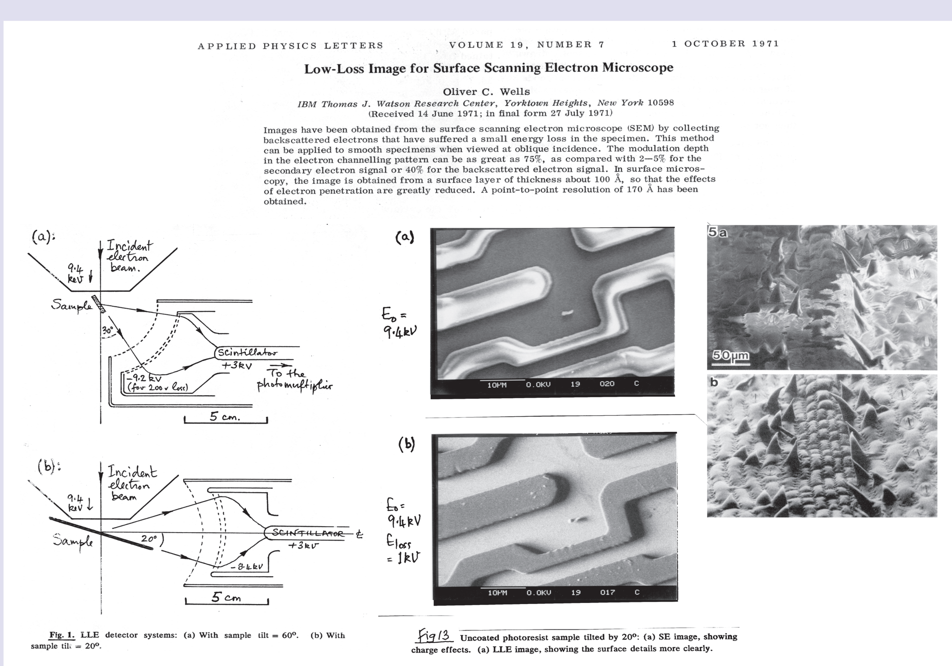


Figure 4. The many and varied innovations found in Wells thesis included the precursor of the "Robinson" type of scintillator-photomultiplier backscattered-electron (BSE) detector (left panel, later developed as Wells, 1960), quantitative surface measurement from tilted images (top right panel), and atomic-number-contrast imaging.

Detector Development



APPLIED PHYSICS LETTERS VOLUME 19, NUMBER 7 1 OCTOBER 1971

Low-Loss Image for Surface Scanning Electron Microscope

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(Received 14 June 1971; in final form 27 July 1971)

Images have been obtained from the surface scanning electron microscope (SEM) by collecting backscattered electrons that have suffered a small energy loss in the specimen. This method can be applied to smooth specimens when viewed at oblique incidence. The modulation depth in the electron channelling pattern can be as great as 75%, as compared with 2—5% for the secondary electron signal or 40% for the backscattered electron signal. In surface microscopy, the image is obtained from a surface layer of thickness about 100 Å, so that the effects of electron penetration are greatly reduced. A point-to-point resolution of 170 Å has been obtained.

Figure 5. Below-the-lens energy-filtered LLE detector. Left, original drawing for the above paper (Wells 1971). This was one of many papers on LLE detectors, preceded by Wells and Bremer, 1968;1969 and Wells, 1970; also see Wells, 1972). The great improvement in surface detail is shown in the middle panel. The right-hand panel shows how the surface structure of a botanical sample can be revealed by LLE imaging (Wells and Cheng, 1989).

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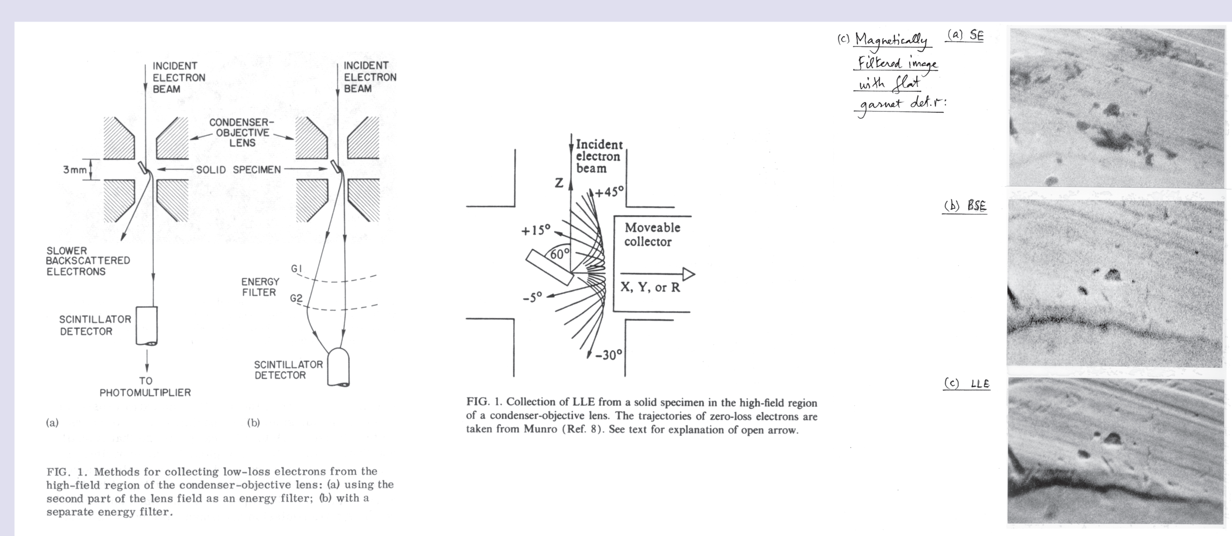
Figure 6. SEM LLE imaging with a condenser-objective "immersion" lens. Left diagram from Wells, Broers and Bremer, 1973. Center diagram from Wells, LeGoures and Hodgson, 1990, with original figure at right. The detector can be positioned to collect electrons with a given energy loss. This arrangement allows LLE imaging with higher beam energy and less specimen tilt. The sample is an abraded Pt surface. Scratches are revealed since LLE is sensitive to shallow topographic features. Also see Wells and Munro, 1992.



IBM

Figure 7. A display of artifacts of Wells' work, shown at IBM is on the left. The patents, listed below, reflect both his concentration on detectors and his contribution to metrology of semiconductor devices at IBM. An example of voltage measurement in the SEM is shown at the right (Wells and Bremer, 1968). Wells continued to make many contributions after retirement, with publications up until 2006. See the entries from 1999 to 2006 in the references.

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US Patents

- 1986 Low-energy scanning transmission electron microscope (with David A. Smith).
- 1987 Apparatus and method for displaying hole-electron pair distributions induced by electron bombardment (sole inventor).
- 1988 Method and apparatus for low-energy scanning electron beam lithography (with Rodney T. Hodgson, Jackson E. Stanland).
- 1990 Magnetically filtered low loss scanning electron microscopy (with Rodney T. Hodgson, Francoise K. LeGoues).
- 1991 Method and apparatus for writing or etching narrow linewidth patterns on insulating materials (with Rodney T. Hodgson, Jackson E. Stanland).
- 1995 Method and apparatus for detecting low loss electrons in a scanning electron microscope (sole inventor)
- 2004 Method for SEM measurement of topological features (with Lynne M. Gignac, Jonathan L. Rullan, Conal E. Murray)

Awards and Honors

Figure 8. Left: At M&M 1992 after being awarded MSA's Distinguished Scientist award in Physical Sciences, with Fritiof Sjöstrand, awardee for Biological Sciences on the left and James Hillier in the center. Right: At M&M1994 with Dennis McMullan at their joint symposium that year.

- 1980 President of Micobeam Analysis Society.
- 1987 Presidential Science Award of the Micobeam Analysis Society (now Microanalysis Society).
- 1992 Microscopy Society of America's Distinguished Scientist Award in Physical Sciences.
- 1994 IEEE Morris E. Leeds Award "For contributions to the application of scanning electron microscopy in dimensional, electrical, and magnetic measurements."
- 2009 Fellow of the Microscopy Society of America.
- 2012 Sir Charles Oatley Prize.

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