Cat 23

Code 1
Pages 08
CR-76630
HC $3.00
MF .65

# LOW TEMPERATURE ELECTRON MICROSCOPY WITH HIGH FIELD SUPERCONDUCTING LENSES

Paper to be presented at the Sixth International
Congress for Electron Microscopy
Kyoto, Japan
August 27 - September 4, 1966

H. Fernandez-Moran

Department of Biophysics
University of Chicago
Chicago, Illinois U.S.A.



Following our first successful electron microscopy experiments with high field superconducting lenses operating at liquid helium temperature (1a), a comprehensive research program is being pursued with different types of cryo-electron microscopes concentrating on 2 approaches:

1. Cryo-electron microscope optical bench system (Fig. 1) using high field superconducting niobium-zirconium solenoid lenses in liquid helium Dewars, operating at 4 to 32 kG without pole pieces, and with modified objective, and objective-projector pole pieces. An additional current vernier control circuit for the superconducting objective solenoid is used in conjunction with a 25 A regulated power supply to permit adjustable current changes of $10^{-9}$ for achieving reproducible "superfine" focusing, orders of magnitude better than conventional systems. This device, specially developed for our lenses by D. Kasun and associates of Westinghouse Cryogenics Div., consists of a low field two-winding superconducting toroid with its secondary connected in series with the main solenoid. Energizing the toroid primary changes the total flux linkage in the solenoid circuit, altering the persistent current value, and results in an incremental change of field in the main solenoid. After optimum focusing adjustment is achieved, transfer of toroid primary to persistent mode places the entire system in a lossless, completely stable condition. Improved point cathode sources and highly stabilized 50 kV accelerating potential were used, taking special precautions to minimize mechanical, magnetic and electrical field perturbations. Once correct focus of test specimens at electron optical magnifications of 200x-20,000x is attained, the superconducting solenoid system is switched into persistent current mode. The high quality images (50-100 Å resolution) thus maintained without any external lens current source are of an unprecedented

degree of stability, permitting exposures of up to several minutes with low intensity illumination for direct photographic recording on high resolution films. The same area can be continuously recorded at 5-15 minute intervals over a 10-hour period under carefully controlled conditions without detectable image changes, demonstrating typical long-term superstability (Fig. 2a, b). Combination of this unique stability of superconducting lenses with coherent microbeam illumination appears promising for practical realization of Gabor's wavefront-reconstruction microscopy.

2. Special superconducting objective lens in liquid helium cryostat which may be used as integral part of cryo-electron microscopes or replace the objective lens in modified high resolution commercial electron microscopes. The superconducting objective lens in a special Dewar (Figs. 3, 4), designed and built to our specifications by Westinghouse Co., comprises a main Nb-Zr coil (27,220 ampere-turns) with vernier coil, superconducting stigmators, persistent current switches and improved current control devices. Specimens are mounted on microstages of special design maintained at 4.2$^{\circ}$K together with pole pieces of different types, including short focal length, single field condenser-objective pole pieces of iron or dysprosium, and trapped-flux $Nb_3Sn$ lenses. Our microscope (Fig. 3) mounted on a 10-ton vibration isolated base, features extensive magnetic shielding, ultrahigh vacuum ion pump system, improved field and T-F emission source, image intensifier and photographic recording. It is primarily designed for high resolution electron microscopy of biological specimens, examined preferably in the frozen hydrated state under ideal low-temperature conditions of minimized specimen contamination, radiation damage and thermal noise.

The valuable collaboration of A. Peuron, D. Kasun, F. Lins of Westinghouse Cryogenics Div., in key aspects of this work, the technical assistance of L. Ouwerkerk, R. Vicario, H. Krebs and discussions with Dr. K. Yada are gratefully acknowledged. This work was supported by National Institutes of Health Grant GM-13243, U. S. Atomic Energy Commission Contract AT(11-1)-1344, National Aeronautics and Space Administration Grant NsG 441-63 and the L. Block Fund of the University of Chicago.

## REFERENCES

1. H. Fernandez-Moran: (a) Proc. Natl. Acad. Sci., 53, 445, (1965).
H. Fernandez-Moran: (b) Science, 148, 665, (1965).

Low Temperature Electron Microscopy with High Field Superconducting Lenses

H.Fernandez-Moran,Dept.Biophysics, University of Chicago

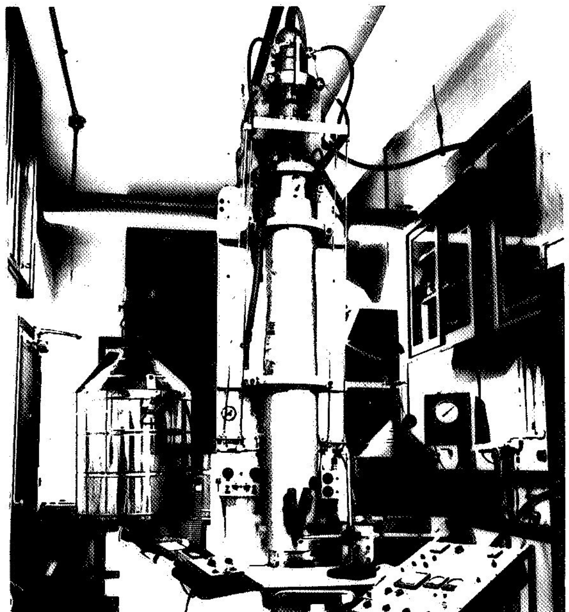


Fig.1.Cryo-electron microscope comprising liquid helium Dewar with high field NbZr superconducting solenoid objective-projector lenses, superconducting circuitry and power supply controls;50 kV gun with point cathode;essential magnetic shielding and accessory cryogenic equipment.

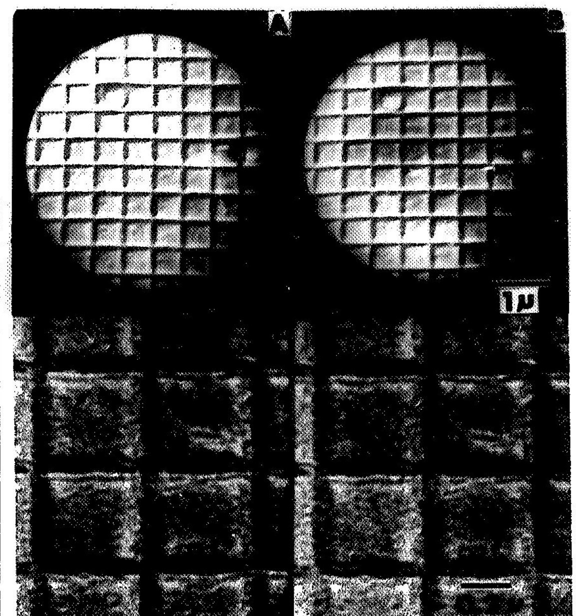



Fig.2. Electron micrographs of 2160 lines/mm diffraction cross-grating replica recorded at 50kV, 10,000 x electr.opt.(top);20,000x (below)with supercond.lens in persistent current mode continuously over 10hour period.Unaltered images of first(a)and final(b)series demonstrate unique long-term stability.

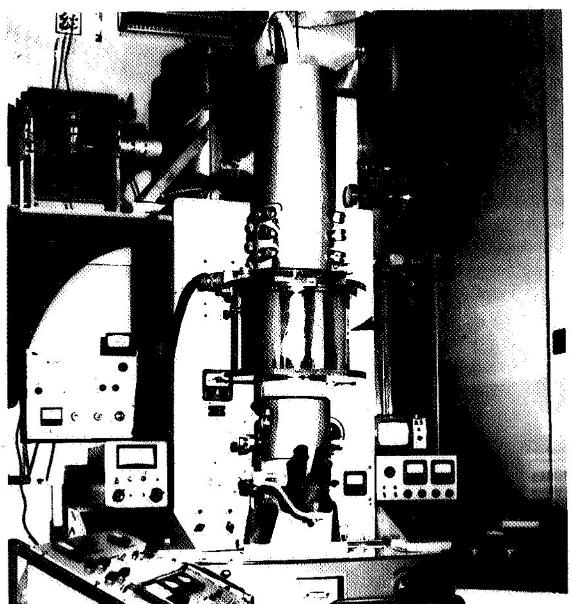
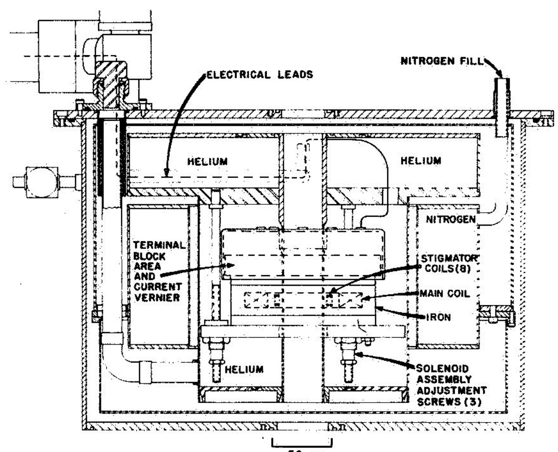


Fig.3.Special high resolution electron microscope(modified HU-11B) with superconducting objective lens assembly,power supply and controls, ultrahigh vacuum ion pump(Ultek) system,extensive magnetic shielding, image intensifier.Mounted on 10 ton vibration isolated base.




SUPERCONDUCTING OBJECTIVE LENS AND LIQUID HELIUM COLD STACE ASSEMBLY FOR CRYO-ELECTRON MICROSCOPE

Fig.4. Sketch of special superconducting objective lens in liquid helium Dewar(Westinghouse Cryogenic Div.)comprising:iron-encased Nb-Zr main coil with superconducting stigmators,vernier control circuitry,and central cryostat space for specimen microstage and pole pieces.