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A crystal manipulator has been designed for the study of metal surfaces at low temperatures by low energy electron diffraction (LEED). The outstanding features of this particular design are: the manipulator is easily constructed by modifying the commercially available Varian model;* the crystal can be rotated 360 degrees and translated both horizontally and vertically, heated, and cooled to liquid nitrogen temperature. Complete (360°) rotation makes other measurements in conjunction with LEED, i.e., mass spectroscopy, ellipsometry, etc., and the ion bombardment of the metal surface possible. In addition, the fluorescent screen in the diffraction chamber is more than 85% visible, and this allows for photographing of the diffraction features. Such a manipulator is extremely useful for the study of the physical adsorption of gases and phase transitions on metal surfaces at low temperatures. Low temperature manipulators[1,2] have been used to study the surfaces of graphite and for the epitaxial studies of metallic films on ionic crystals. However, single crystal metal surfaces at low temperatures have yet to be investigated by LEED. It is particularly advantageous to study metals such as lead, tin and silver at low temperatures. These metals have high Debye-Waller factors which greatly reduce the intensity of the diffracted spots at higher temperatures.

The low temperature crystal manipulator is shown in Fig. 1. Stainless steel tubing (.125 in. o.d. and .015 in. wall) is formed around the main

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* Model 954-5031. Varian Incorporated, Palo Alto, Calif.

support rod which is connected to an oxygen free copper block (.875 in. × .500 in. × 1.062 in.). The copper block should be plated if there is any danger of copper diffusion into the metal single crystal under investigation. The stainless steel tubing is rigidly mounted by silver brazing to the crystal manipulator flange and to two hollow support rods connected to the copper block (Fig. 2). Thirteen turns on the inner coil and ten on the outer gives excellent flexability and complete (360°) rotation through the spring action of the stainless steel coil. The liquid nitrogen which is introduced by pressure into the stainless steel tubing via the inlet opening on the flange cools as it flows through a cavity in the copper block (Fig. 2). A self pressurized liquid nitrogen level controller designed by J. Harvey of the Lawrence Radiation Laboratory, Berkeley is used to automatically stop the flow of liquid nitrogen when the temperature sensitive probe of this device reaches liquid nitrogen temperature. This probe is inserted into the outlet on the flange.

The single crystal is held in mechanical contact with the copper block by means of stainless steel washers and quickly cools by conduction to within a few degrees of liquid nitrogen (77.5°K). The crystal's temperature is measured by a chromel-alumel thermocouple attached to the copper block and calibrated in liquid nitrogen. The crystal can also be heated by a small alumina enclosed tungsten resistance furnace (Fig. 2) to approximately 500°C. Both the thermocouple and heating leads are electrically insulated by alumina beads. The heating element is placed within the copper block for greater heat conduction and to raise the temperature of the crystal above that of liquid nitrogen when needed.

## ACKNOWLEDGMENTS

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## REFERENCES

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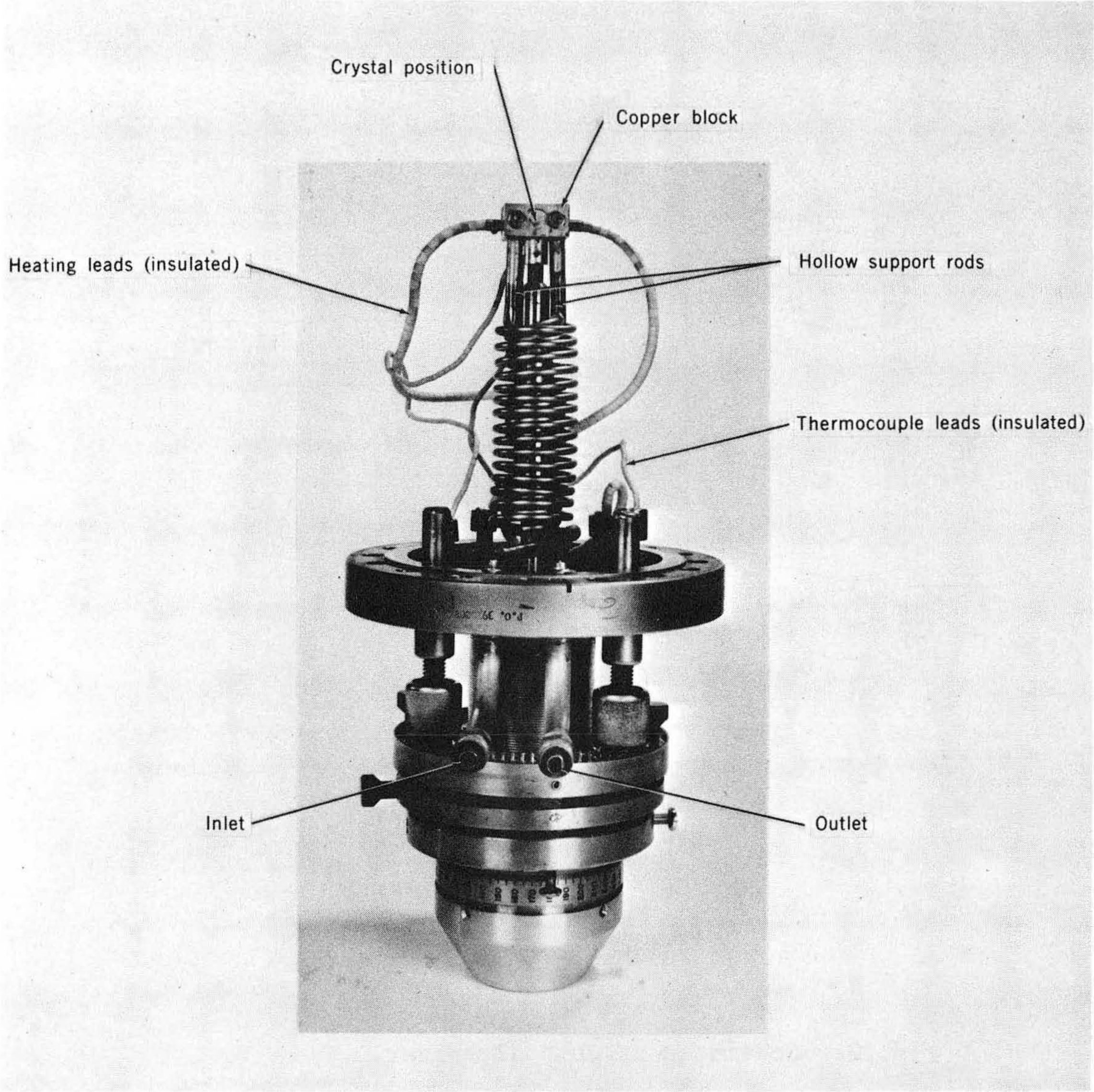

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Fig. 1 Low temperature crystal manipulator.

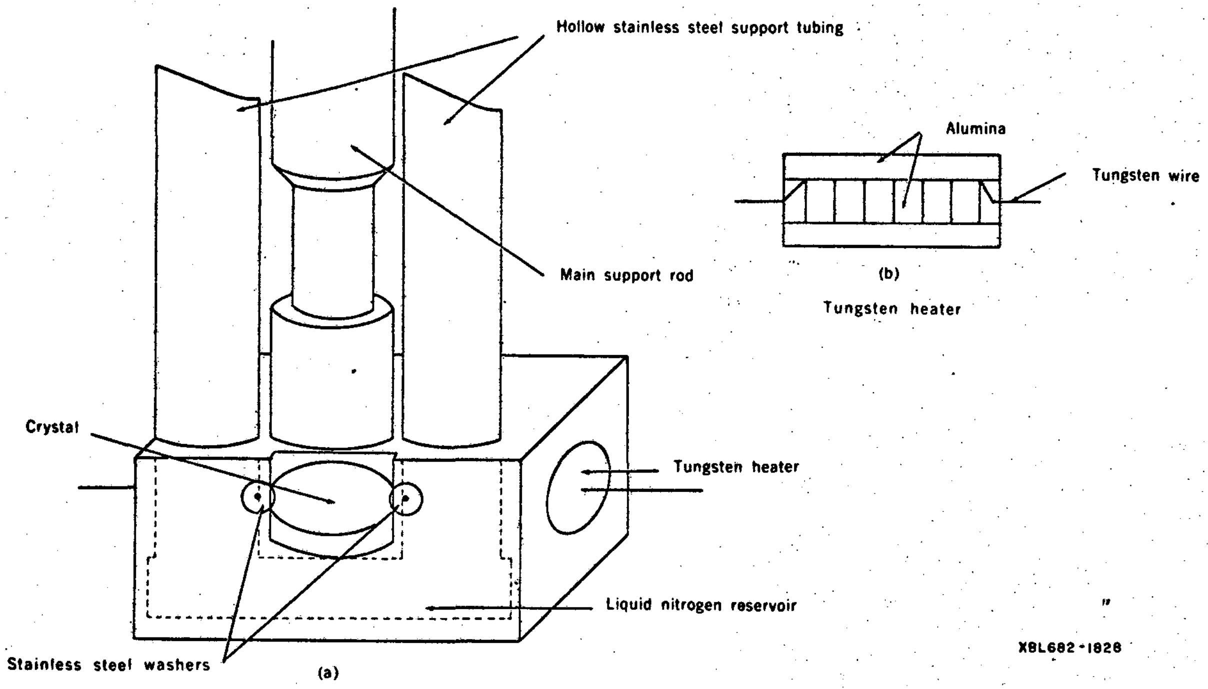

Fig. 2 Schematic of crystal holder.