



Boston Piezo-Optics, Inc.

**"GREATER X"**

**A Visible Orientation Reference**

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## GREATER X - A VISIBLE ORIENTATION REFERENCE

Most components currently manufactured from crystal quartz are cut from manmade, hydrothermally grown cultured quartz.

Although all crystal quartz has 3 main axis (X, Y and Z) cultured quartz only grows in the X and Z directions. There is no commercially viable method at this time which produces Y axis growth.

In the Z axis direction cultured quartz grows equally on both Z surfaces of the seed.

In the X axis direction cultured quartz grows asymmetrically. It grows approximately 1 1/2 times faster in one X direction than the other.

We are thankful for this difference in growth rate which produces this asymmetry because this is the feature which makes Crystal Quartz Piezo Electric and Birefringent.

AND - IN CULTURED QUARTZ THIS ASYMMETRIC GROWTH RATE YIELDS A READILY RECOGNIZABLE VISUAL REFERENCE.

For many years the direction of faster growth was called the plus X direction and the direction of slower growth was called the minus X direction.

Several years ago it was decided to change the sign of these two directions with plus X becoming minus X and minus X becoming plus X.

The AT cut of quartz, easily the single most used crystal quartz element, became a minus 35°15' rotated Y cut where-as it was, for about 50 years, a plus 35°15' rotated Y cut.

The ST cut, the most popular Surface Acoustic Wave orientation, originated as a plus 42°15' cut and is currently called a minus 42°15' cut.

The purpose of this dissertation is not to take issue with the original system or the changes, either current or proposed. It is only to call attention to this irrefutable X axis asymmetry which can be used to help identify an appropriate starting point from which non-standard orientations can be cut from quartz crystals regardless of the label put on the X axis.

Currently some confusion results from the sign change. Some are not aware of the change, some do not know how important the difference can be and many persist in using the sign system with which they are familiar.

Some of the quartz growing companies label the direction of fastest X growth "GREATER X" and it's opposite end "LESSER X".

Those of us who fabricate custom-made crystal quartz components for a clientele ranging from undergraduate students to engineering managers of large corporations frequently encounter a communications gap.

We propose this approach as one vehicle to improve orientation specification.

For X, Y, Z and single rotated cuts the "GREATER X" asymmetry can be employed as follows:

- A. Assume a position facing the sawing machine. (Machine spindle running left-to right as in accompanying photographs.)
- B. Specify which surface of the quartz crystal is to rest on the saw table.
- C. Specify which axis of the quartz crystal runs left-to-right.
- D. Position the quartz crystal to your right of the saw blade.
- E. Specify an angle of rotation either clockwise or counter clockwise if required.

It is hoped that these comments and the accompanying photographs will contribute to a better utilization of a visual, reproducible starting point from which any single or double rotation of quartz can be defined regardless of which plus/minus system is in use.

- Photo A The crystal is resting on its "GREATER X" surface. This photo illustrates the difference in growth rate of the two X directions and the extent of faceting in the "GREATER X" direction.
- Photo B The crystal is resting on its "LESSER X" surface. The photo is a 3/4 view of the crystal. The metal clip which held one end of the seed in the autoclave is visible.
- Photo C This is a view of the "LESSER X" surface (still marked "minus X") which shows the size in this growth direction. The crystal is resting on a Z surface.
- Photo D The crystal is resting on its "LESSER X" surface. The Y axis runs left-to-right. The saw would cut Y slices.
- Photos E&F The crystal is resting on a Z surface. The "LESSER X" surface is close to the saw blade. The saw would cut X slices from the "LESSER X" portion of the crystal.
- As the crystal is traverssed to the left the saw would cut one or more X slices which would contain some seed.
- After traversing past the seed the saw would be cutting X slices from the "GREATER X" portion of the crystal.
- Every X slice regardless of where cut, has a plus X and a minus X surface.
- Photo F shows the seed clip.
- Photo G The crystal is resting on its "LESSER X" surface. The Z axis is left-to-right. The saw would cut Z slices.
- Photos H&I The crystal is resting on its "GREATER X" surface. The saw would cut Z slices.

The quartz crystal in these photos weighs 13.69 pounds.

The seed dimensions are;

Y Axis	13.50	inches
X Axis	Approximately .200	inches
Z Axis	Approximately .080	inches

Its as grown dimensions are;

Y Axis	13.50	inches
X Axis	3.28	inches
Z Axis	4.38	inches

Z growth in both directions from the seed is 2.19". Z growth is equal in both directions.

X growth is asymmetrical as can be seen in all the photos. This is a normal result of the hydrothermal growth process and is not the result of any attempts to influence the result. Total X growth is 3.28".

Growth in the direction of the large flat face currently called "LESSER X", formerly known as "minus X" and currently to be thought of as "plus X" is approximately 1.312 inches.

Growth in the opposite X direction is approximately 1.5 times greater. This direction leads to much more faceting. This direction was formerly the "plus X" but is currently to be known as "minus X".

No grinding, lapping or polishing has been done to the quartz crystal. It is as-grown.

The photos clearly show that Z growth is equal in both Z directions and that X growth is 1.5X greater in one X direction versus the other regardless of the sign assigned.

Total Z growth always exceeds total X growth.

No growth occurs in the Y directions.

The ratios used in this document pertain to quartz crystals usually referred to as "right hand Y bars".

The Diamond saw blade is .065" thick.

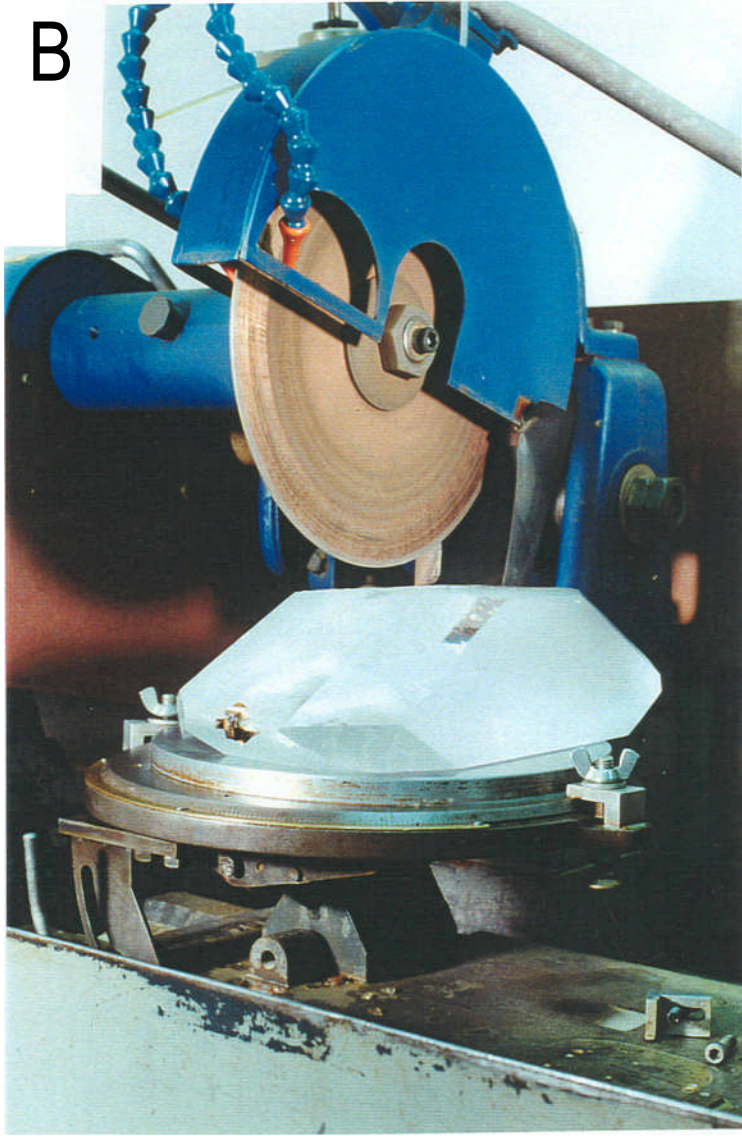
The Diamond saw blade is 10 inches in diameter.

The rotary table on which the quartz crystal is positioned is 12 inches in diameter.

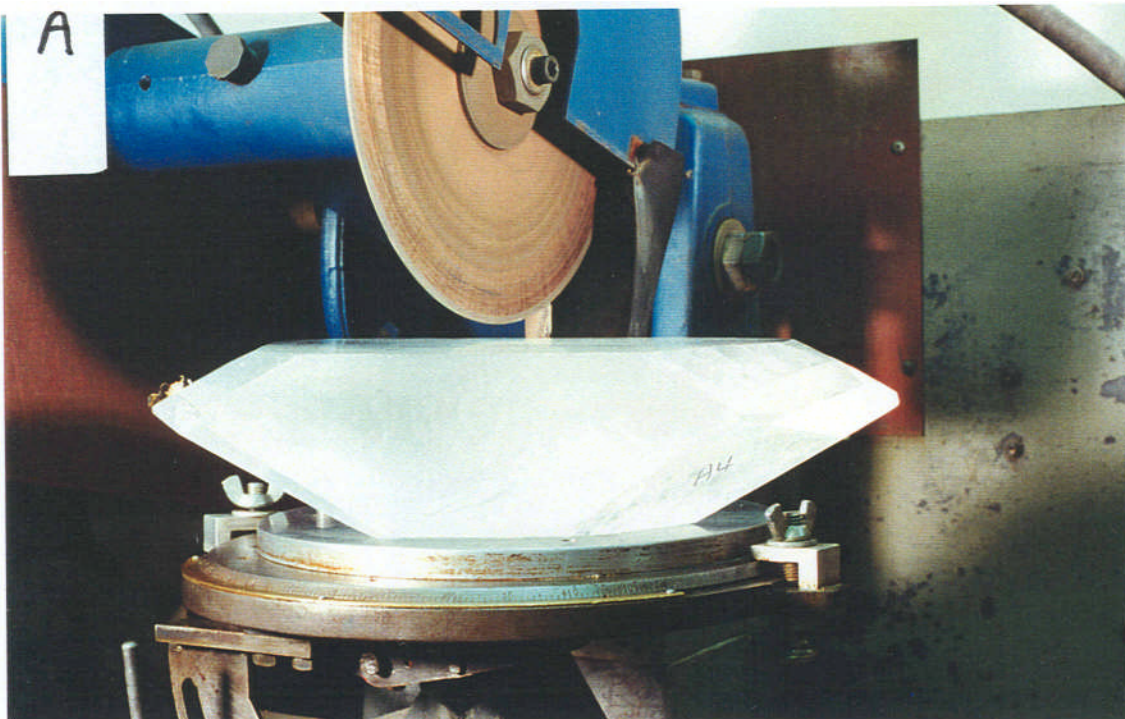
NOTE: No work was done to saw or grind a large Y face because this could render this large crystal less usefull but if the crystal was to rest on a Y surface, Z or X slices could be cut depending on which axis was specified as the left-right direction.

November 95'

B

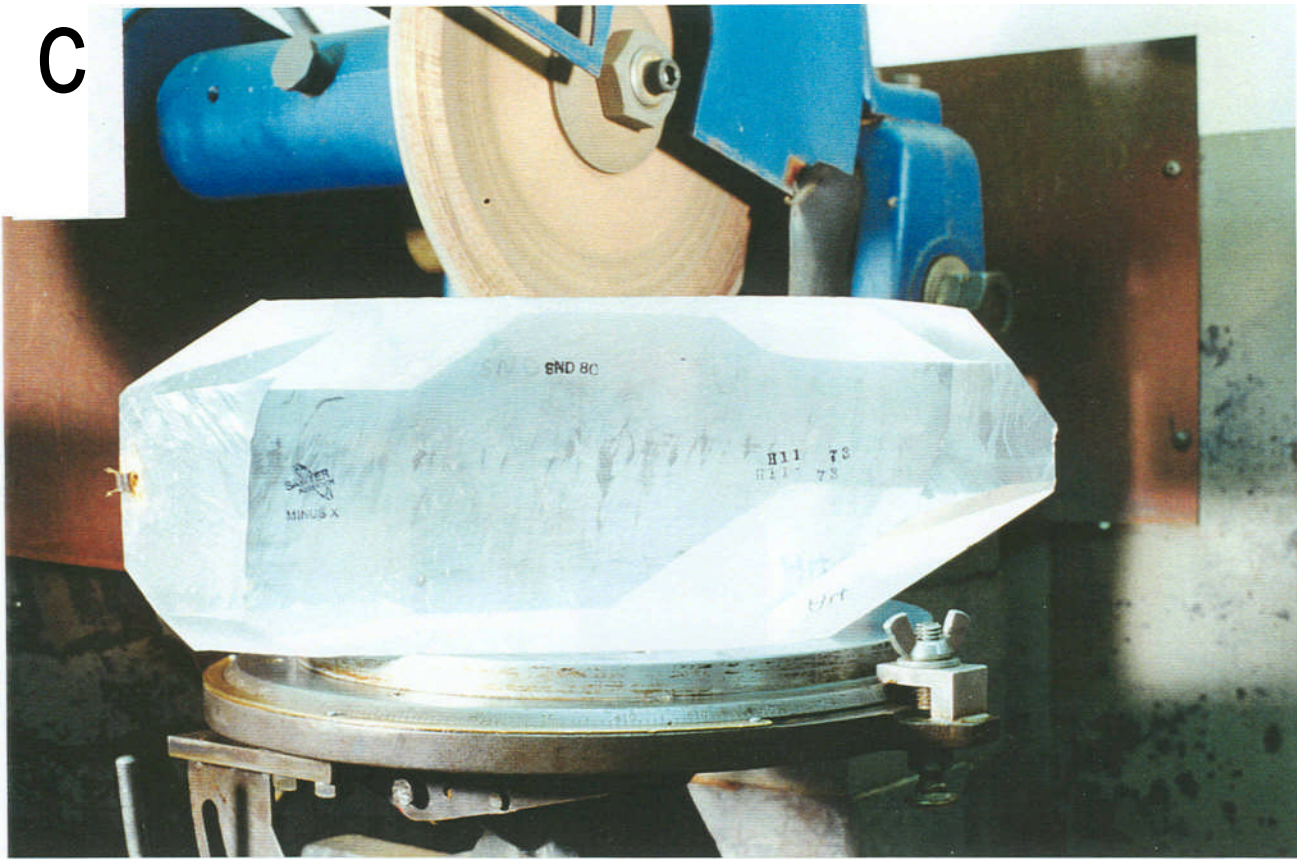


A





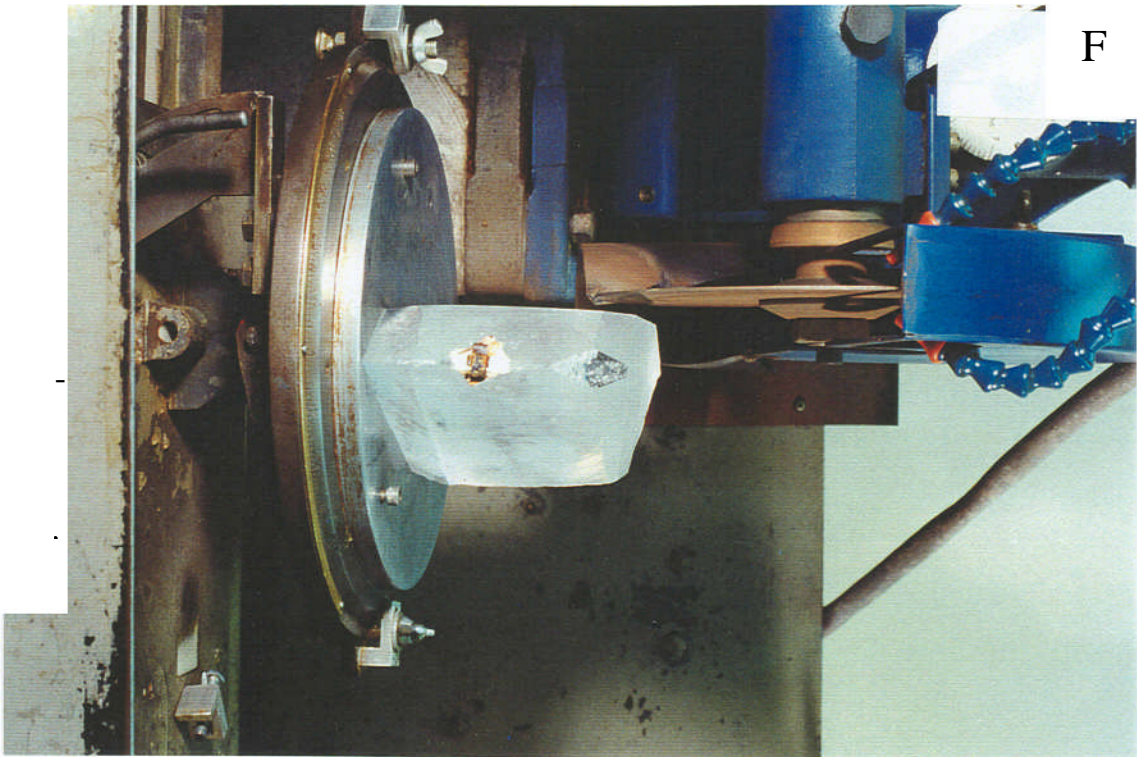
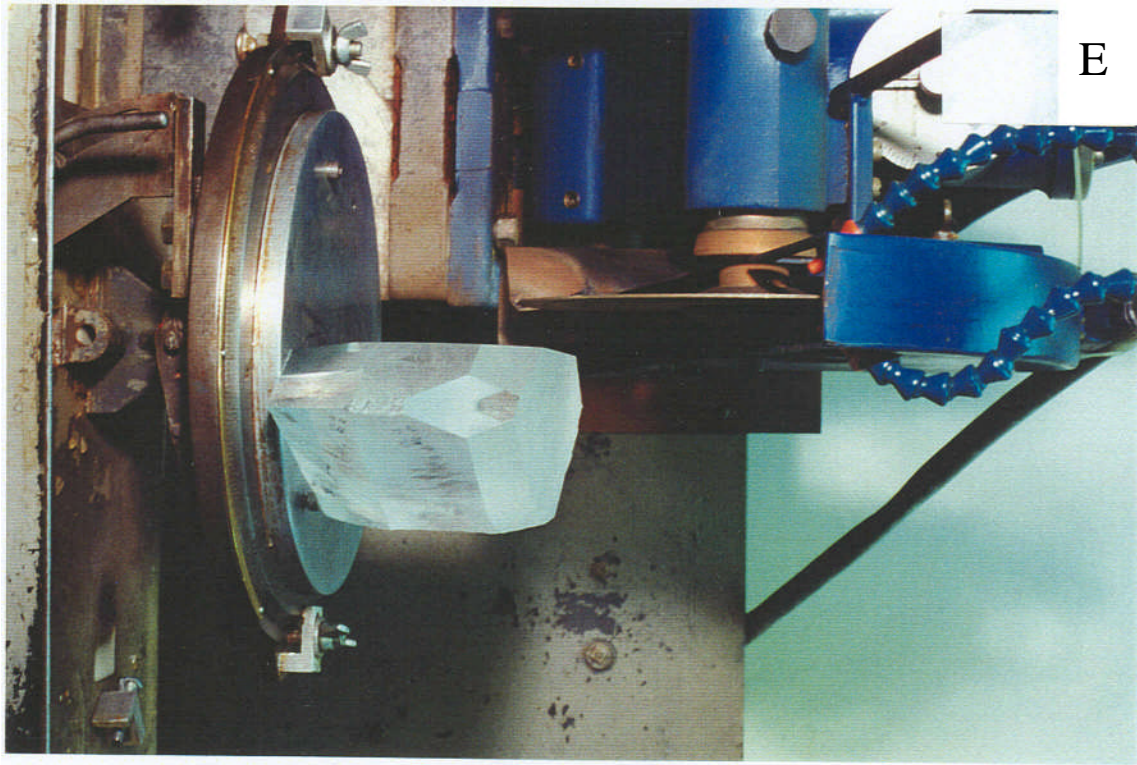
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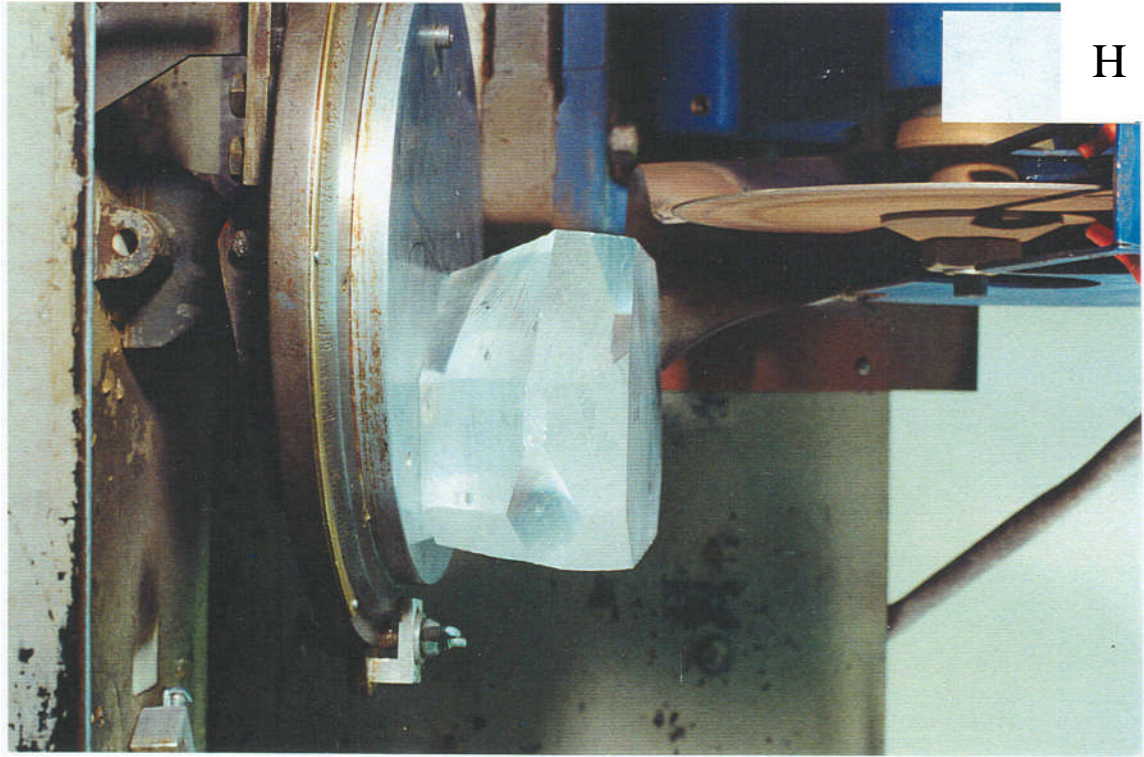
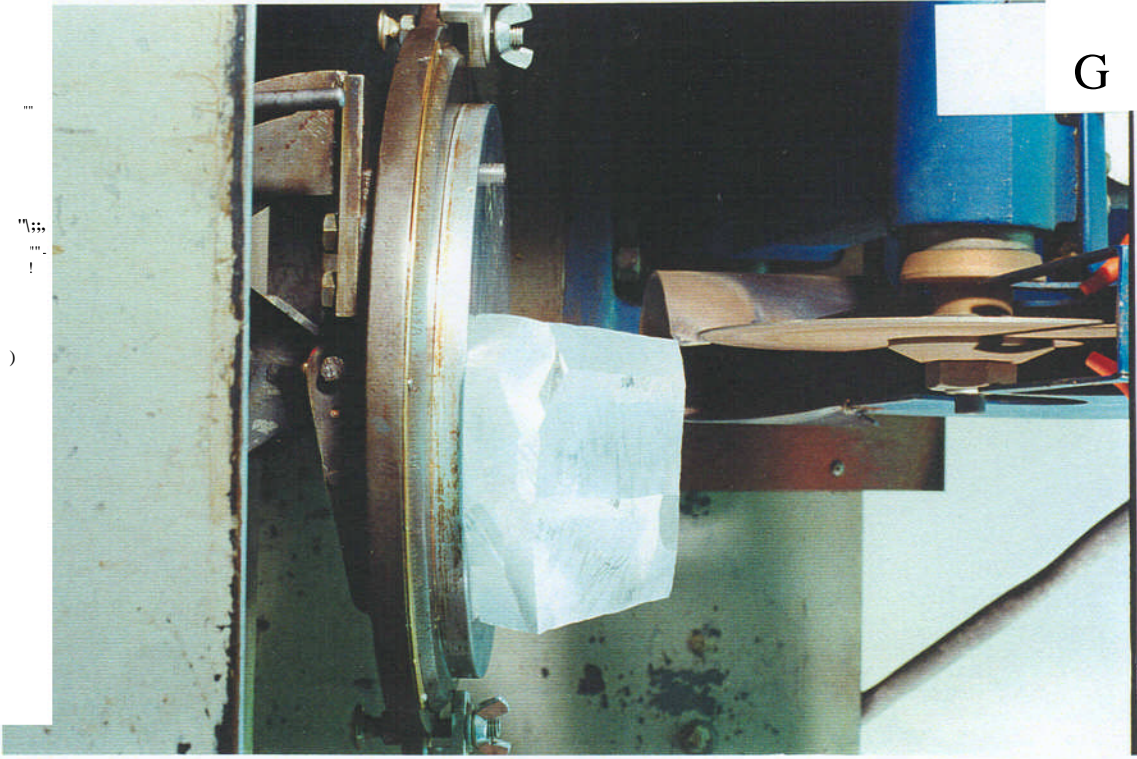
D



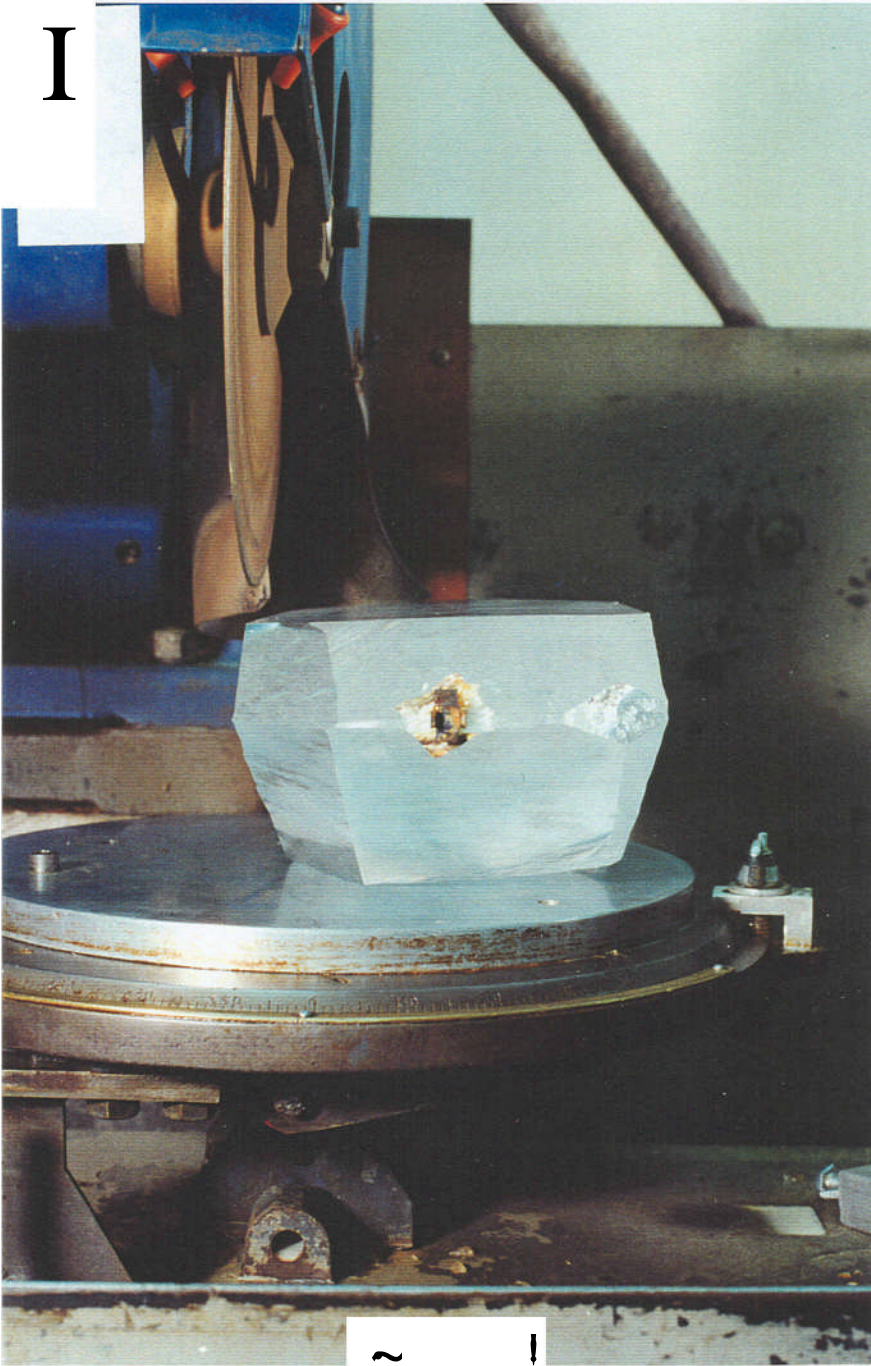








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