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[54] **METHOD AND APPARATUS FOR SLICING CRYSTALS**

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[52] **U.S. Cl.** .... **125/23 R;** 51/235; 83/152; 83/870; 269/21

[58] **Field of Search** .... 83/870, 152, 27; 51/235, 283; 125/13 R, 23 R; 269/21

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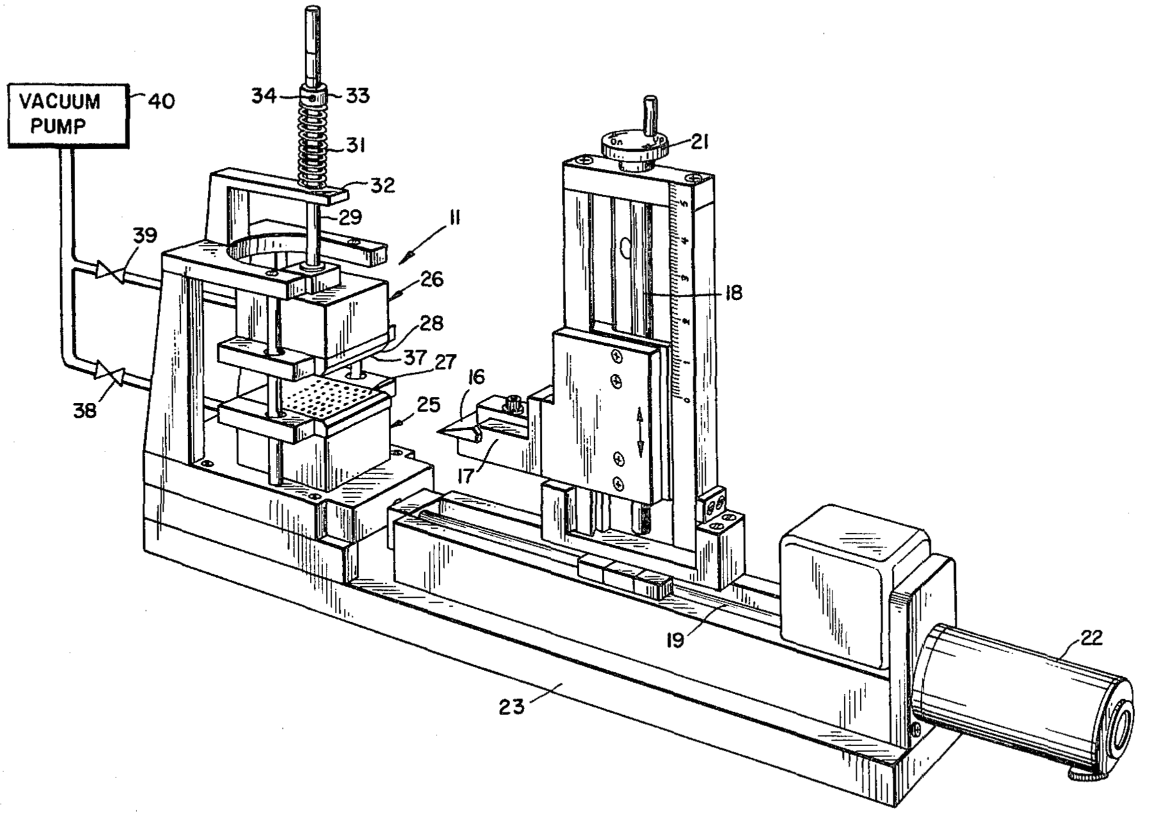
[57] **ABSTRACT**

A crystal is sliced in a plane parallel to flat, opposed parallel end faces of the crystal. The end faces of the crystal are gripped by a pair of opposed, perforated platens of a pair of vacuum chambers, one of which is translatable relative to the other. A blade cuts the crystal through the desired plane. A spring biases one of the vacuum chambers away from the other vacuum chamber while both of the faces are gripped by the vacuum chambers and the blade is cleaving the crystal. Thereby, a sliced portion of the crystal gripped by one of the vacuum chambers is pulled away from the remainder of the crystal gripped by the second vacuum chamber when the crystal has been cleaved by the blade through the plane.

3 Claims, 4 Drawing Figures



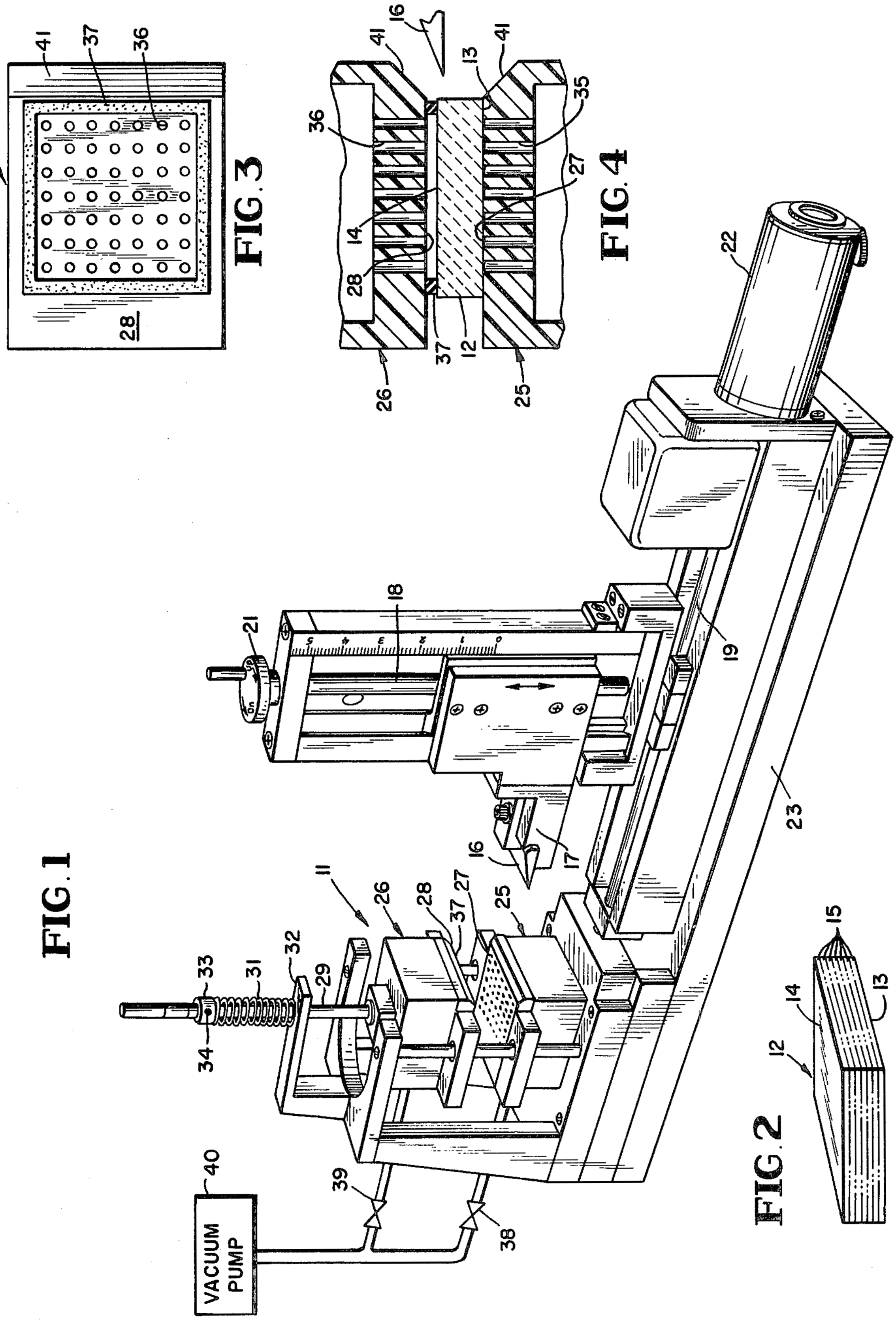

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FIG. 3
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FIG. 4
FIG. 1
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FIG. 2

METHOD AND APPARATUS FOR SLICING CRYSTALS

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BRIEF SUMMARY OF THE INVENTION

The present invention relates generally to an apparatus for slicing a crystal, and more particularly, to such an apparatus wherein flat, opposed parallel end faces of the crystal are gripped and urged apart while the crystal is being cut through a plane parallel to the end faces.

Previously, relatively soft, KAP (potassium acid phthalate) and RAP (rubidium acid phthalate) crystals, as utilized in connection with X-ray spectrometers, have been cleaved by hand using a wire or sharp blade. When the crystals are cleaved by a wire they have a tendency to be scratched and it is often difficult to obtain crystals having uniform thickness. When the crystals are cut by sharp blades, such as razor blades, it is impossible to obtain very thin crystals, i.e., crystals having thicknesses on the order of 5 mils, a frequent requirement of KAP and RAP, soft crystals utilized in X-ray spectrometers. Both of the prior art, manual techniques were found to be slow and have a poor yield. While numerous machines have been developed to cut crystals and other objects in a precise manner, none apparently has been developed to precisely cut soft crystals, such as KAP and RAP crystals to thicknesses of 5 mils. A further problem is dealing with cleavable soft crystals, such as the RAP and KAP crystals, is that they are extremely fragile as they are formed of delicate materials. In consequence, handling these crystals by hand, particularly to cleave them to 5 mils, is extremely difficult and there is a high risk of such handling and cleaving leading to irreparable crystal damage.

In accordance with the present invention, a new and improved aparatus for cutting crystals, particularly soft RAP and KAP crystals, to thicknesses on the order of0.005 inches, includes bringing a blade into contact with an edge of the crystal, between a pair of opposed parallel faces of the crystal, while the opposed faces are being gripped and urged apart. Thereby, a sliced portion of the crystal is pulled away from the remainder of the crystal as the crystal is being cleaved by the blade through a plane where it is desired to make a slice. In a preferred embodiment, the flat, opposed, parallel end faces are gripped by first and second opposed, perforated plates of a pair of vacuum chambers. The use of a vacuum to grip the opposite faces of the crystal is particularly advantageous because of the delicate nature of the crystal and the very thin slices which are obtained from it. In addition, the vacuum facilitates release of the crystal slices and enables the force applied to the opposite faces of the crystal to be easily controlled, to prevent possible breakage of the crystal at points other than the desired cleavage plane.

The first plate is translatable relative to the second plate, with a spring urging the first plate away from the second plate while the plates grip the end faces. A holder for the crystal cutting blade is positioned to enable the crystal to be cut by the blade through each of the several planes. The holder position is variable so the cutting plane can be adjusted relative to the end faces to enable the crystal to be sliced through each of a plurality of desired planes. The blade intersection with the side of the crystal is precisely controlled, to within one mil, by connecting the blade holder to a pair of orthogonally mounted lead screws that respectively control the cutting plane of the blade and the blade position relative to the side of the crystal.

A further feature of the invention is that the perforated area of the translatable plate is bordered by a resilient cushion, formed, for example, of neoprene rubber. The cushion protects the crystal from damage when the opposed faces of the crystal are simultaneously gripped, and enables irregularities on the crystal face to be compensated, whereby there is increased suction and more uniform pull by the vacuum on the two faces of the crystal.

It is, accordingly, an object of the present invention to provide a new and improved apparatus for cutting crystals in a precise manner.

Another object of the invention is to provide a crystal cutting apparatus which enables crystals to be cut precisely to a thickness of 5 mils.

A further object of the invention is to provide a crystal cutting apparatus wherein crystals of uniform thickness are easily obtained, at relatively high speed and with high yield.

Another object of the invention is to provide a crystal cutting apparatus wherein the crystal is cut without scratches.

An additional object of the invention is to provide a crystal cutting apparatus wherein opposite, parallel end faces of the crystal are gripped and urged away from each other while the crystal is being cleaved by a cutting blade.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective, overall view of a preferred embodiment of the apparatus of the invention;

FIG. **2** is a perspective view of a crystal adapted to the cut by the apparatus of FIG. **1**;

FIG. **3** is a top plan view of a plate included in a vacuum chamber for holding the crystal in situ, particularly showing a rubber cushion in contact with the crystal; and

FIG. **4** is a side view in cross section, FIG. **1** specifically showing the crystal, a pair of plates for holding opposed faces of the crystal in situ, and a blade for cleaving the crystal in a plane between the faces gripped by the vacuum plates.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to FIG. **1** of the drawing wherein there is illustrated a station **11** for gripping a relatively soft mother crystal **12**, such as a, KAP, or RAP crystal, having the shape of right parallelepiped, as illustrated in FIG. **2**. Crystal **12** includes a pair of opposed, parallel faces **13** and **14** and is to be cleaved in a plurality of planes **15** parallel to faces **13** and **14**. Crystal **12** is cleaved so that a plurality of very thin crystal slices, each typically having a thickness on the order of 5 mils, are formed.

The apparatus for cleaving crystal **12** through planes **15** includes microtome or blade **16** that is carried by a blade holder **17**. Blade holder **17** is adapted to be vertically and horizontally translated by vertical and horizontal lead screws **18** and **19**. Lead screw **18** is manually controlled by handle **21** so that the positon of the cutting edge of microtome **16** can be controlled very precisely, preferably to within one mil. Blade **16** and holder **17** are horizontally translated into a side wall of crystal **12**, between faces **13** and **14**, by driving the holder with lead screw **19**, that is driven by motor **22**. The entire mechanism including gripper **11**, lead screws **18** and **19**, holder **17**, and motor **22**, is stably mounted on a base plate **23**.

Gripping station **11** includes lower and upper vacuum chambers **25** and **26** respectively having perforated, flat-faced platens **27** and **28** that respectively mate with and grip lower and upper faces **13** and **14** of crystal **12**. Vacuum chamber **25** is fixedly mounted on base **23**, while vacuum chamber **26** is vertically translatable relative to chamber **25**, by virtue of the connection between chamber **26** and vertically extending rod **29**. Rod **29** is biased upwardly by tension spring **31**, so that chamber **26** and platen **28** have a tendency to be biased away from chamber **25** and platen **27**. Opposite ends of tension spring **31** are connected to bracket **32**, through which shaft **29** extends, and collar **33**, the vertical position of which can be adjusted by set screw **34**. Adjusting the vertical position of collar **33** changes the tension on spring **31** and therefore the force with which platen **28** has a tendency to pull face **14** of crystal **12** away from the remainder of the crystal when the crystal is cleaved by microtome **16**.

As illustrated in FIGS. **3** and **4**, platens **27** and **28** respectively include a matrix of relatively small diameter, vertical bores **35** and **36** that draw a vacuum on faces **13** and **14** of crystal **12**. In one preferred embodiment, bores **35** and **36** are formed on ¼-inch centers by using a number **65** drill bit on platens **27** and **28**. Surrounding the matrix of bores **36** is a border formed of a resilient, air impervious strip **37**, preferably formed of neoprene rubber. The bottom face of strip **37** engages the top face **14** of crystal **12** so that the crystal does not bear directly against platen **28**. The resilient, air confining strip **37** enables crystals having non-uniform top faces to be handled by the machine of the present invention without scratching the top surface, and enables any non-uniformity introduced on the top surface, during the cutting operations, to be compensated. Cushioning strip **37** also prevents chipping or cracking of crystal **12** because face **14** cannot contact platen **28**, while enabling an increased force to be applied against face **14**, resulting in a uniform pull on the face. The areas of the matrices in platens **27** and **28**, as well as border **37**, relative to the areas of faces **13** and **14**, are such that all of the bores **35** are covered by bottom face **13** and all of bores **36** are in a chamber formed by the inner edge of strip **37** and top face **14** of crystal **12**. A suitable vacuum, of a few pounds per square inch, is applied to faces **13** and **14** through bores **35** and **36**, by virtue of chambers **25** and **26** being evacuated by vacuum pump **40**. Chambers **25** and **26** are selectively connected to vacuum pump **40** and the atmosphere through valves **38** and **39**, respectively. To enable microtome **16** to easily cleave crystal **12** in planes **15** and to reach the side of the crystal without any problems, chambers **25** and **26** include beveled faces **41** in proximity to the opposing faces of platens **27** and **28**.

Crystal **12** is cut or cleved along planes **15** by the following procedures. Initially, valves **38** and **39** are adjusted so chambers **25** and **26** are connected to the atmosphere and crystal **12** is placed so that bottom face **13** thereof lies on platen **27**, with one side wall of the crystal even with beveled edge **41** of chamber **25**. If any bores **35** are not covered by face **13**, it is necessary to cover the ends of the bores so that vacuum integrity is maintained. Similarly, if there are any bores **36** in platen **28** which are not within a vacuum chamber between upper face **14** of crystal **12** and the lower face of platen **28**, these bores must be covered. When crystal **12** has been placed in the desired position on platen **27**, valve **38** is adjusted so chamber **25** is evacuated by pump **40** and the crystal is held firmly in situ.

Holder **17** is horizontally translated by motor **22** and lead screw **19** so blade **16** is almost in contact with a side of crystal **12**. The height of microtome **16** is then adjusted, by turning handle **21** so that lead screw **18** drives holder **17** vertically until the microtome edge is at the top face **14** of crystal **12**. Of course, blade **16** was previously placed in holder **17** so that the edge of the blade is parallel to crystal cleaveage planes **15**. A reading from a micrometer (not shown), associated with the lead screw **18** is recorded to indicate the starting height of microtome blade **16**. After the height of blade **16** has been adjusted so that the blade edge is aligned with face **14**, holder **17** is horizontally translated away from crystal **12** in response to motor **22** driving lead screw **19**. Then, handle **21** is rotated so that the edge of blade **16** is lowered to the plane where the desired cleavage is to be made; typically, this is a distance of 5 mils.

Then, upper vacuum chamber **26** is lowered so that cushioned strip **37** abuts against top face **14** of crystal **12**. The position of collar **33** is adjusted so that tension spring **31** exerts a desired force on chamber **26**. Typically, for a crystal having a top face with rectangular dimensions of 1 inch by 2 inches, 600 to 800 grams of force are exerted by tension spring **31** on shaft **29** and chamber **26**. Smaller crystals require a smaller lifting force while larger ones require a greater force. Excessive force exerted by spring **31** on shaft **29** and chamber **26** causes crystal **12** to be improperly cleaved along a cleavage plane that is not necessarily parallel to faces **13** and **14**. After the force applied by spring **31** to chamber **26** has been properly adjusted, valve **39** is adjusted to connect pump **40** to the chamber **26** while the top face **14** of crystal **12** is being engaged by cushioned border **37**. Top and bottom faces **13** and **14** of crystal **12** are at this time respectively gripped by vacuum platens **27** and **28**. With crystal **12** gripped by vacuum platens **27** and **28** and the edge of microtome blade **16** vertically positioned for the desired thickness of the crystal to be cleaved, motor **22** is activated so that lead screw **19** advances holder **17** and microtome **16** toward crystal **12** at a slow speed that is regulated with conventional velocity feedback control apparatus.

In response to the edge of blade **16** contacting the wall of crystal **12** between faces **13** and **14**, cleavage of the crystal occurs through a cleavage plane **15** that is parallel to faces **13** and **14**. When cleavage occurs, the force exerted by spring **31** on rod **29** and chamber **26** causes the cleaved slice to be suddenly pulled away from the remainder of crystal **12**, which remains in situ on platen **27**. The cleaved crystal attached to platen **28** remains attached to platen **28** until the vacuum on chamber **26** is removed by adjusting valve **39** so that the chamber is connected to the atomosphere. When the vacuum on chamber **26** is released, the cleved crystal drops from platen **28** and is collected either manually or automatically.

The next wafer from crystal **12** is obtained in a similar way, by lowering chamber **26** so that platen **28** engages the newly formed planar top face of crystal **12**. The newly formed top face of crystal **12** is again gripped by platen **28** by activating valve **39** so that vacuum pump **40** is connected to chamber **26**. Then, blade **16** is lowered to the next desired cleavage plane, by turning handle **21** and reading the micrometer for lead screw **18**. Microtome blade **16** and blade holder **17** are then advanced again by activating motor **22** so that it drives lead screw **19** and the crystal holder. The operation is continued as desired until the mother crystal has been sliced into the desired number of cleaved crystal slices having the desired thickness.

While there has been described and illustrated one specific embodiment of the invention, it will be clear that variations in the details of the embodiment specifically illustrated and described may be made without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. Apparatus for slicing a soft crystal in a plane parallel to first and second flat opposed parallel end faces of said soft crystal comprising vacuum chamber means including a stationary platen having perforations therein for gripping said first flat end face of said soft crystal with vacuum, a moveable platen having perforations therein for gripping said second flat end face of said soft crystal with vacuum, said moveable platen being moveable substantially perpendicular to said plane, and spring means coupled to said moveable platen and applying a continuous force thereto substantially perpendicular to said plane and away from said stationary platen for applying stress forces to said soft crystal; a cleaving blade selectively moveable substantially perpendicular to and parallel to said plane; means for holding said cleaving blade at a position to enable said soft crystal to be cut by said cleaving blade through said plane; means for adjusting the position of said holding means so the cutting plane of said cleaving blade can be adjusted relative to the end faces; and means for driving said holding means so said cleaving blade is driven into contact with a side of said soft crystal in said cutting plane where said cleaving blade has been adjusted.

2. The apparatus of claim **1** wherein said moveable platen includes a resilient, air impervious strip bordering said perforations against which said first end face bears.

3. The apparatus of claim **1** wherein said stationary and moveable platens include beveled faces adjacent said perforations in proximity to said first and second end faces of said soft crystal for ease in moving said cleaving blade into contact with said soft crystal.

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