United States Patent

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[33] **Australia**
[31] **57,569**

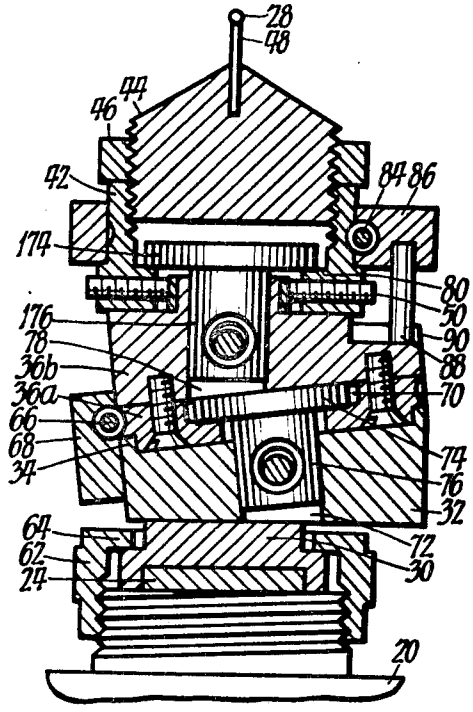
[54] **DEVICE FOR ORIENTING AXES OF BODIES FOR INSPECTION**
19 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **356/31,** 250/51.5, 356/244
[51] **Int. Cl.** **G01n 21/04**
[50] **Field of Search** 356/30, 31, 150, 172, 244; 350/90; 250/51.5

[56] **References Cited**
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ABSTRACT: A goniometer head for orienting a crystal so that a plane associated therewith is normal to a predetermined directional axis comprising a support rotatable about an axis transverse to the directional axis so that the latter lies in the surface of an imaginary cone generated about the transverse axis, and a mounting for the crystal carried by the support and rotatable relative thereto about an adjustment axis which passes through the apex of the cone to cause a crystal axis normal to the plane to lie in the surface of the cone so that if the normal axis is not in the directional axis when it has been adjusted to lie in the surface of the cone the support member can be rotated about the transverse axis to move the normal axis around the cone until it lies in said directional axis.



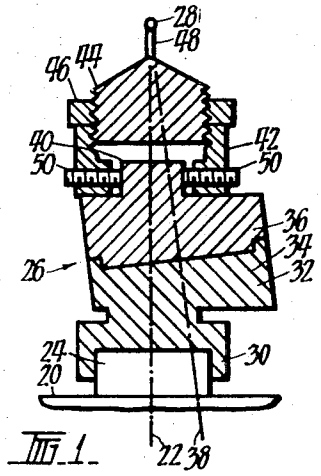


Fig. 1

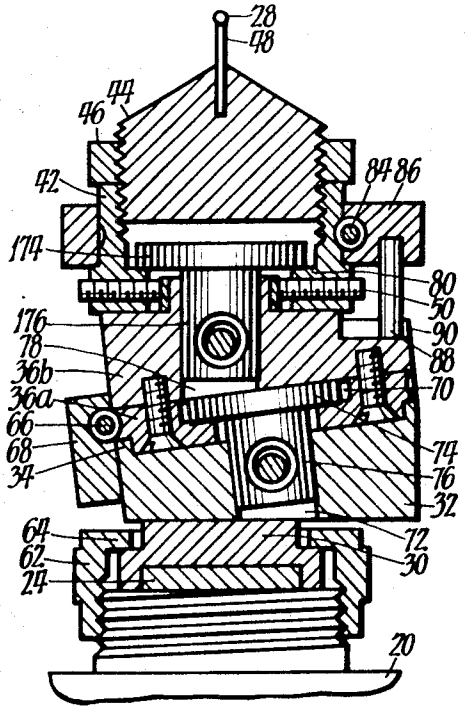


Fig. 2

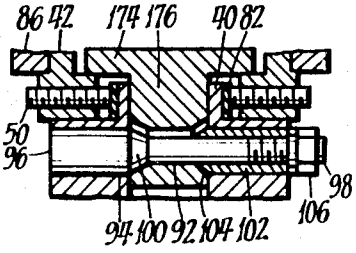


Fig. 3

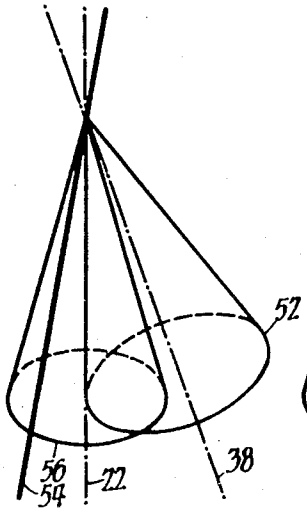


Fig. 4

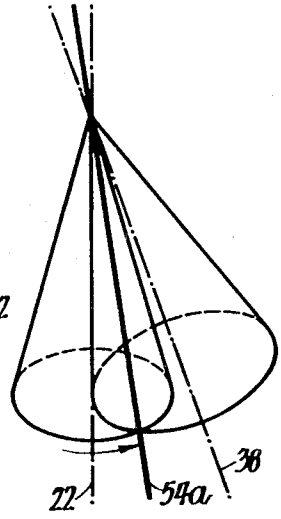


Fig. 5

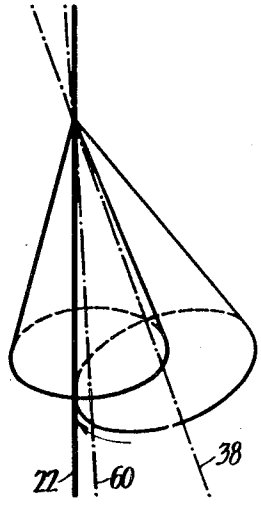


Fig. 6

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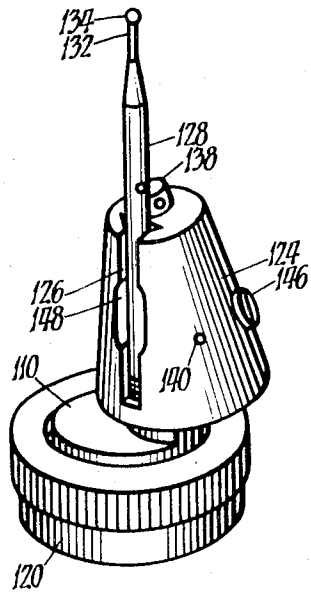


FIG. 7

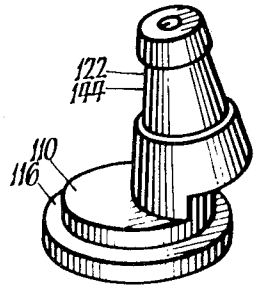


FIG. 11

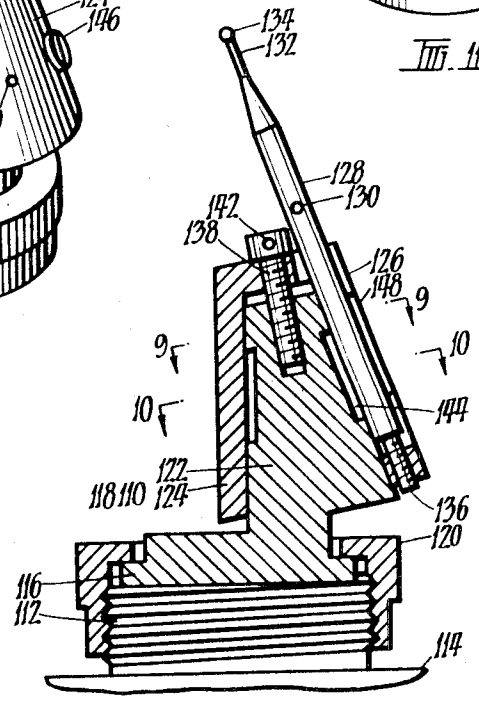


FIG. 8

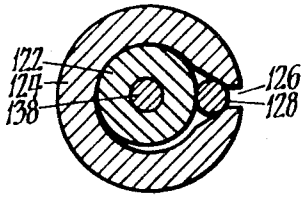


FIG. 9

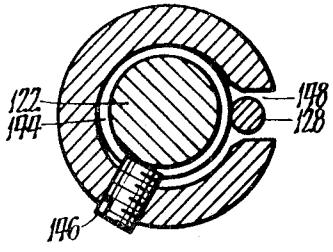


FIG. 10

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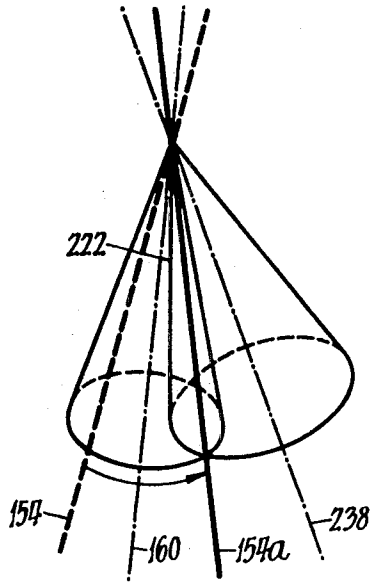


FIG. 12.

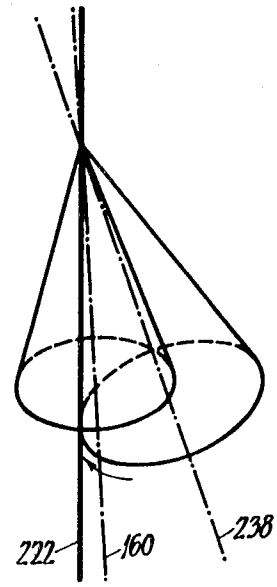


FIG. 13.

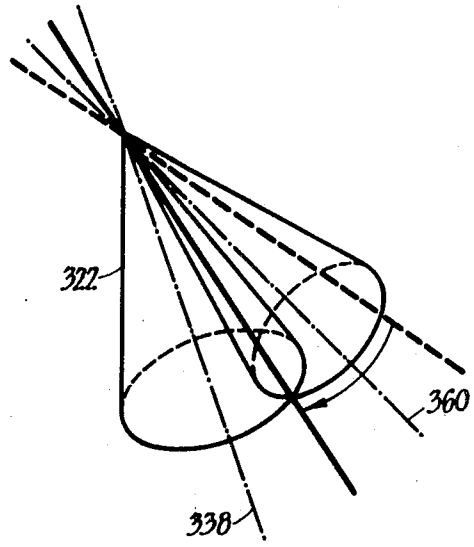


FIG. 14.

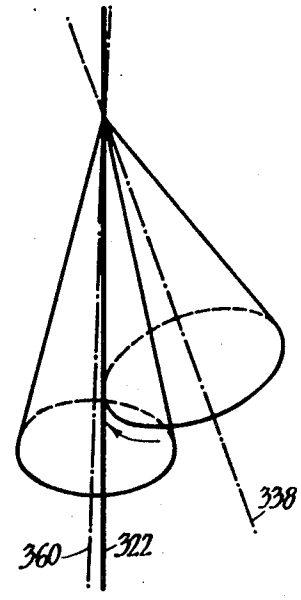


FIG. 15.

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DEVICE FOR ORIENTING AXES OF BODIES FOR INSPECTION

The present invention relates to devices for orienting bodies. The invention is intended particularly, but not exclusively, for use in the construction of goniometer heads, such as are used for the initial orientation of crystal axes in say X-ray diffractometers.

The known types of goniometer head are described in a paper written by D. A. Davies and A. McL. Mathieson of the Chemical Physics Division of the Commonwealth Scientific and Industrial Research Organization and published in Vol. 18, Part 5 of the Acta Crystallographica, 1965. As discussed in that paper, there are two basic concepts for the design of a goniometer head. The first concept has been in use for approximately 35 years and involves adjustment of the crystal axis by rotating it about two axes at right angles to each other and to the preferred axis. Goniometer heads designed in accordance with this concept include a pair of physical arcs generated about respective adjustment axes.

The second concept, which was developed by the authors of the paper referred to, permitted the omission of one of the physical arcs, and substituted therefor a full circle adjustment about an axis which passed through the axis of the remaining arc. By rotating the crystal axis about the axis of the full circle adjustment, the crystal axis could be made to define a cone, at one location in which it would be in parallelism with the goniometer axis when viewed in one direction. The crystal axis would then probably be skew to the goniometer axis when viewed from a direction at right angles to the first, but the arcuate adjustment which remained on this head construction permitted swinging of the crystal axis to bring it into parallelism when viewed from the second direction also.

The paper referred to above specifies the advantages of the substitution of the full circle adjustment of the second concept for the arcuate adjustment of the first concept, and in particular refers to difficulties involved in accurate manufacture of physical arcs, and stability problems involved in their use. A full circle adjustment, which can be supported by relatively robust bearings, is to be preferred.

According to the present invention there is provided a device for orienting a body such that a plane associated therewith is normal to a predetermined directional axis, comprising a support member rotatable about an axis transverse to the directional axis such that the latter lies in the surface of an imaginary cone generated about the transverse axis, and means for mounting the body on the support member so as to permit rotation therewith about said transverse axis and to permit relative adjustment between the body and the support member to cause an axis of the body normal to said plane to lie in the surface of said cone, whereby if the normal axis is not in the directional axis when it has been adjusted to lie in the surface of the cone the support member can be rotated about the transverse axis to move the normal axis around the cone until it lies in said directional axis.

The means for mounting the body may comprise a second support member carried by the first support member in a manner permitting relative rotation of the support members about an adjustment axis which preferably intersects the apex of said imaginary cone. Preferably the adjustment axis is arranged to be located coaxial with directional axis.

According to a feature of the invention, the device is arranged for use as a goniometer head.

By way of example, two embodiments of the invention, each designed as a goniometer head, will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic section of a first goniometer head in accordance with the invention,

FIG. 2 is a section of a practical form of the head diagrammatically illustrated in Figure 1,

FIG. 3 is a section taken at right angles to the section shown in Figure 1 and illustrating a detail of the head shown in the preceding Figure,

FIGS. 4 to 6 are diagrams for use in explanation of the operation of the head shown in Figures 1 to 3,

FIG. 7 is a perspective view of a second goniometer head in accordance with the invention,

FIG. 8 is a vertical section of the head shown in Figure 7,

FIGS. 9 and 10 are sections on the lines 9—9 and 10—10 respectively in Figure 8,

FIG. 11 is a perspective view of part of the head shown in Figures 7 to 10,

FIGS. 12 and 13 are diagrams for use in explanation of one mode of operation of the head shown in Figures 7 to 11, and

FIGS. 14 and 15 are diagrams for use in explanation of an alternative mode of operation of that head.

In Figure 1, reference numeral 20 indicates a portion of an X-ray diffractometer having a preferred axis 22, which is illustrated as upright but may be in any desired disposition. The diffractometer has a cylindrical stud 24 coaxial with axis 22, and the goniometer head 26 is mounted on stud 24. In use, head 26 carries a crystal 28. For purposes of X-ray crystallography a particular plane in the crystal must be adjusted to lie perpendicular to axis 22. This disposition of the plane is obtained by adjusting an axis of the crystal normal to the plane to lie parallel to axis 22, and this normal axis referred to in the description of the drawings as "the crystal axis."

Head 26 comprises a mounting base made up of two generally cylindrical portions 30 and 32, lower portion 30 being arranged to seat on stud 24 so that the axis of seat portion 30 coincides with axis 22. For convenience, the axis of seat portion 30 will be treated in the following description as the same as the axis 22, but it will be understood that the construction of the head is referred to the axis of the seat portion and not to some "external" axis. Portion 32 is eccentric with respect to portion 30 and has a rim 34 the uppermost surface of which lies in a plane disposed at an angle of 83° to axis 22.

Mounted on the base is a generally cylindrical platform 36 which has an edge rebate to receive rim 34 so that the platform rests on the rim. Platform 36 is rotatable on the rim and relative to the base about an axis 38 which is normal to the plane of the uppermost surface of rim 34. Axis 38 is therefore transverse to axis 22 and intersects that axis at an angle of 7°. The upper surface of platform 36 is generally normal to axis 22 and has a cylindrical boss 40 which is coaxial with the axis 22.

Platform 36 supports a hollow turret comprising an annular portion 42 which is internally screw threaded at its upper end and an externally screw-threaded block 44 which is received in the annular portion and is releasably lockable relative thereto by means of a locking nut 46. Block 44 carries a filament 48 which in use of the head carries the crystal 28. Annular portion 42 surrounds boss 40 and in use the crystal can be "centred" on the axis of boss 40 by lateral adjustment effected by means of two pairs of grub screws 50 which project through annular portion 42 to engage the boss. The pairs of screws are arranged at right angles to each other, one pair only being seen in Figure 1. The screw threading of block 44 into annular portion 42 permits adjustment of the crystal longitudinally of the axis of the boss. Crystal 28 can therefore be adjusted so that the crystal axis passes through the intersection of axes 22 and 38, but at an arbitrary disposition relative thereto.

In describing operation of the head, reference will be made to Figures 4 to 6 which represent diagrammatically various axes referred to in the description of Figure 1. For convenience in illustration, the angle between axes 22 and 38 has been considerably exaggerated.

It will be seen from Figure 4 that if a line extending along axis 22 is rotated about axis 38 it generates a cone which will be referred to as the "main cone" and which has a section indicated at 52. The crystal axis is indicated by a heavy black line in an arbitrary initial position 54. Rotation of the crystal axis around axis 22 therefore generates another cone which will be referred to as the "adjustment conte" and which has a section indicated at 56. Provided the crystal axis is within 14° of axis 22, the adjustment cone will intersect the main cone. Hence, the crystal axis can be rotated about axis 22 as indicated by the arrow in Figure 5 to a position 54*a* at which it

lies in the surface of the main cone. If rotation of the crystal axis about axis 22 is then terminated, and the whole system is rotated about axis 38 as indicated by the arrow in Figure 6, it can be seen that the crystal axis will move around the main cone until it adopts a disposition coaxial with axis 22. The adjustment axis, represented by the axis of boss 40, about which the crystal was first rotated, and which coincided with axis 22 when the crystal axis was in positions 54 and 54*a*, will move to the position indicated at 60 during the rotation about axis 38.

Referring back to Figure 1, rotation of the crystal axis about the axis 22 is effected by rotation of the turret relative to platform 36. When the crystal axis has been rotated to position 54*a*, the turret is clamped relative to the platform 36, and the platform is rotated on base portion 32 about axis 38. This has the effect of moving the crystal axis around the main cone from position 54*a* to a position coincident with the axis 22.

In practice, the exact adjustment of the crystal axis from its initial position to position 54*a* will not be known, and an estimate will have to be made. Coincidence of the crystal axis with axis 22 would be attained by successive approximations each involving the adjustment sequence referred to above.

FIGS. 2 and 3 illustrate in greater detail the construction and mounting of the goniometer head shown in FIG. 1. As seen in FIG. 2, portions 30 and 32 of the base are formed separately, and are connected together in the assembled head. Seat portion 30 is clamped onto the stud 24 by means of a suitable nut 62 having an inturned lip 64 to engage a shoulder on seat portion 30. The nut cooperates with a screw-threaded block on which stud 24 is formed.

Platform 36 is formed in two portions 36*a* and 36*b*, the lower portion 36*a* cooperating with the base portion 32. Lower portion 36*a* is provided with a peripheral worm ring to cooperate with a worm screw 66 mounted in a reaction block 68 which in turn is mounted on base portion 32. The upper surface of portion 36*a* has a central shallow recess 70, and a passage extends from recess 70 through the portion 36*a* in alignment with a passage 72 in base portion 32 coaxial with axis 38. A clamping member comprising a circular plate 74 and an integral cylindrical shank 76 is located with the plate in recess 70 and the shank extending into the passage 72. The operation of the clamping of the clamping member will be described hereinafter.

The upper portion 36*b* of the platform is provided with a passage 78 coaxial with axis 22 and extending through stud 40. A second clamping member identical with the first is located with its shank 176 in passage 78 and its plate 174 engaging an internal shoulder 80 on the annular portion 42 of the turret. Stud 40 is provided with a plastics sheath 82 which is abutted by the inner ends of grub screws 50 and slides smoothly on the underlying portion of the stud. The exterior of annular portion 42 is provided with a peripheral worm ring which cooperates with a worm screw 84. The latter acts against a reaction ring 86 which rests on an external shoulder on the annular portion. The ring is retained in a fixed angular disposition relative to platform portion 36*b* by means of a pin 88 which is secured in ring 86 and engages the sidewalls of a groove 90 in portion 36*b*, the pin moving along the groove as the turret is adjusted radially of stud 40 by grub screws 50.

The operation of both clamping members can conveniently be described by reference to the one which clamps the turret by cooperation with platform portion 36*b*, it being understood that the other clamping member clamps the platform by cooperation with base portion 32. The arrangement for clamping the turret is shown in FIG. 3.

Shank 176 has a transverse circular-section bore 92 which is flared at both ends. Portion 36*b* has a circular-section passage 94 which is generally aligned with bore 92 but is slightly eccentric with respect thereto, so that the axis of bore 92 is above the axis of passage 94. A rod extends through passage 94 and bore 92 and comprises two cylindrical portions 96, 98 joined by a flared portion 100 which fits into one flared end of bore 92. Rod portion 96 is encircled by a coaxial sheath 102 having a frustoconical portion 104 which engages the other flared end of bore 92. Rod portion 96 projects from passage 94, the projecting end being screw threaded to receive a nut 106 which can be used to force sheath 102 along passage 94 towards rod portion 98.

In the unclamped position, due to the eccentricity of passage 94 and bore 92, the flared portions 100 and 104 engage the lower sides of the flared ends of the bore 92. As nut 106 and sheath 102 are moved inwardly of the passage, however, the wedging action of the rod and sheath on the flared ends of bore 92 draws shank 176 downwardly until the bore is coaxial with the rod. This draws plate 174 directly downwards to clamp annular portion 42 against the platform portion 36*b*. The clamping effect is obtained without rotational movement of the plate 174 which might upset the setting of the instrument.

It will be understood that the angle between directional axis 22 and transverse axis 38 may take any value provided the directional axis lies in a cone generated about the transverse axis. Use of a small angle reduces the bulk of the head adjacent the crystal and hence the portion of the crystal obscured by the head. Also a reduction of the angle between the transverse axis and the directional axis increases the fineness of the adjustment of the crystal axis after it has been located in the main cone—the smaller the cone angle associated with full rotation of the platform 36, the greater being the fineness of adjustment. Against this must be offset the increased difficulty in adjusting the crystal axis to lie in the smaller cone.

FIGS. 7 to 11 illustrate an alternative form of goniometer head in which the bulk of the instrument near the crystal has been considerably reduced in relation to the embodiment shown in the preceding FIGS. In this second embodiment, the mounting base comprises a circular, stepped block 110 having a flat surface arranged to rest on a corresponding surface on a screw-threaded stud 112 provided on the diffractometer which is indicated at 114. In use, shoulder 116 on the stepped block is engaged by an in-turned lip 118 on a nut 120 which is similar to the nut 62 shown in FIG. 2. In the second embodiment however, until nut 120 is tightened, block 110 is adjustable laterally of stud 112 within limits determined by the internal diameters of nut 120 and lip 118. As will become clear from the following description, this lateral adjustability of block 110 replaces the translational adjustability permitted by the mounting of the turret in the preceding embodiment.

Block 110 is formed integral with an upstanding portion 122 which is generally conical and arranged so that its longitudinal axis intersects the axis of block 110 at an angle of approximately 10°. In terms of a comparison with the preceding embodiment, therefore, the axis of the block 110 in the second embodiment represents the axis of the seat portion 30 in the first embodiment, while the longitudinal axis of upstanding portion 122 in the second embodiment represents the axis 38 of the first embodiment.

Mounted upon upstanding portion 122 is a hollow, frustocone 124, the portion 122 being received in the hollow interior of frustocone 124. The latter has a longitudinal peripheral slot 126 which communicates with the upper face of frustocone 124 but does not extend to the lower face thereof. The walls defining the slot are internally relieved to form a clawlike arrangement (FIG. 9) which in use holds a rod 128 against upstanding portion 122 while leaving the rod free enough to permit it to be rotated by means of a tommy bar inserted in opening 130 (FIG. 8). Rod 128 carries a filament 132 which in use carries the crystal 134. The second embodiment uses an adjustment cone and a main cone in essentially the same way as the first embodiment. In the second embodiment, the adjustment axis is represented by the longitudinal axis of rod 128, and the crystal axis is adjusted to lie in the main cone by rotating the rod by the tommy bar as described above. Rotation of the crystal axis about the main cone is effected by rotating frustocone 124 about the axis of upstanding portion 122. The diagrams of FIGS. 4 to 6 therefore apply equally to the second embodiment, assuming that the axis of block 110 has been aligned with the preferred axis of the dif-

fractometer, and the axis of rod **128** is initially aligned with the axis of block **110**. Centering of the crystal can be effected in the second embodiment by moving it along the adjustment axis, and an adjustment screw **136** (FIG. 8) is provided to enable this to be effected. Rod **128** rests at its lower end on screw **136** and can be moved along the slot **126** by the screw.

Frustocone **124** has an opening **140** to receive the tommy bar by means of which its angular position relative to portion **122** can be adjusted.

Clamping of frustocone **124** in a desired position relative to upstanding portion **122** can be effected by clamping screw **138** the head of which is provided with opening **142** so that it can be operated by the tommy bar. The screw passes through an unthreaded opening in the frustocone to cooperate with a screw-threaded opening in upstanding portion **122**. The claw arrangement of the slot walls holds rod **128** with enough friction to make clamping of this part unnecessary.

To minimize the effect of errors in machining the upstanding portion **122**, frustocone **124** and rod **128** are arranged to make "five point" contact with that portion. Portion **122** is therefore provided with a central recess **144** so that the rod only contacts the portion above and below the recess. Frustocone **124** has a grub screw **146** arranged to project into its interior to engage portion **122** within recess **144**. Grub screw **146** is angularly spaced approximately 120° form rod **128**, and between them they draw frustocone **124** into contact with portion **122** at a position approximately 120° from rod **128** and screw **146**. Frustocone **124** will of course contact portion **122** only above and below the recess. The five "contact points" are just sufficient to define a cone which runs on the conical guide provided by portion **122**.

As seen in FIGS. **7** and **8**, the central portion of slot **126** is also cut away at **148** to reduce the effect of machining errors in forming the slot.

In the description of the operation of the embodiments described above, it has been assumed that the adjustment axis, about which the crystal axis is rotated to place it in the main cone, is initially aligned with the directional axis on which the crystal axis is to be aligned. This is not essential however, and FIGS. **12** and **13** illustrate the geometry of a system in which the adjustment axis does not even lie in the main cone. These diagrams are similar to FIGS. **4** to **6**, but FIG. **12** corresponds with both FIGS. **4** and **5** of the previous diagrams. The initial disposition of the crystal axis is indicated in FIG. **12** by the heavy dotted line at position **154**. The directional axis on which the crystal axis is to be aligned is indicated by line **222** on the cone generated about transverse axis **238**. The initial position of the adjustment axis is indicated at **160**; it intersects the apex of the main cone but does not lie in that cone. If the crystal axis is rotated about axis **160**, it will sweep out an adjustment cone which will intersect the main cone. It will be seen, however, that this arrangement reduces the chance of intersection of the two cones for a given angle between the crystal axis and adjustment axis. Provided the angles are within certain limits, however, the crystal axis can be rotated to a position **154***a* in which it lies in the main cone. As before, it can then be rotated about the main cone to a position coincident with line **222** (FIG. **13**).

The disadvantage of the reduced chance of intersection of the two cones can be removed by arranging the adjustment axis in the main cone, while still spacing it from the preferred direction. However, this still involves a disadvantage in that extra rotation of the crystal axis about the main cone is required to bring it to the preferred direction.

Consideration of FIGs. **7** and **8** shows that the second embodiment can be operated in a mode in which the adjustment axis does not lie initially in the preferred direction. FIG. **7** shows the head arranged for normal operation, while Fig. **8** shows the head with frustocone **124** rotated through an angle of 180° on portion **122** relative to its normal disposition. The geometry of this arrangement is illustrated in FIGS. **14** and **15** in which the transverse axis (the axis of portion **122**) is indicated at **338** and the adjustment axis (the axis of rod **128**) is indicated at **360**. The crystal axis can be rotated about axis **360** from an initial position indicated by the heavy-dotted line, to a position indicated in heavy solid line in FIG. **14** in which it lies in the main cone generated about axis **338** and including the preferred direction indicated at **322**. As seen from a comparison of FIGS. **14** and **15**, a considerable rotation of frustocone **124** is now required to bring the crystal axis round to lie in the preferred direction, and for this reason the normal mode of operation is preferable. Further consideration will show that it is not essential that the adjustment axis passes through the apex of the main cone, but the device is considerably simpler to operate and is more flexible if this intersection is arranged.

I claim:

1. A device for orienting a body such that a plane associated therewith is normal to a predetermined directional axis, comprising a support member rotatable about an axis transverse to the directional axis such that the latter lies in the surface of an imaginary cone generated about the transverse axis, and means for mounting the body on the support member so as to permit rotation therewith about said transverse axis and to permit relative adjustment between the body and the support member to cause an axis of the body normal to said plane to lie in the surface of said cone, whereby if the normal axis is not in the directional axis when it has been adjusted to lie in the surface of the cone the support member can be rotated abut the transverse axis to move the normal axis around the cone until it lies in said directional axis.

2. A device as claimed in claim **1** and comprising mounting means upon which the support member is mounted and which defines the directional axis, the mounting means being arranged for mounting on a structure with the directional axis extending in a preferred direction relative to the structure.

3. A device as claimed in claim **2** wherein the mounting means is provided with a track and the support member is provided with track engaging means which cooperate with the track to locate the support member laterally of said transverse axis.

4. A device as claimed in claim **2** wherein the mounting means is provided with a track and the support member is provided with track engaging means which cooperate with the track to locate the support member laterally of said transverse axis, the track on the mounting means and the track engaging means on the support member being provided on a male portion on one of said parts and a female portion on the other, the female portion being adapted to receive the male portion.

5. A device as claimed in claim **4** wherein the track is provided on a generally conical surface.

6. A device as claimed in claim **2** comprising means to hold the support member in a desired angular position relative to said transverse axis by releasably securing it to the mounting means.

7. A device as claimed in claim **1** wherein the means for mounting the body comprises a carrier member mounted on the support member in a manner permitting relative rotation of said members about an adjustment axis.

8. A device as claimed in claim **1** wherein the means for mounting the body comprises a carrier member mounted on the support member in a manner permitting relative rotation of said members about an adjustment axis and comprising mounting means upon which the support member is mounted and which defines the directional axis, the mounting means being arranged for mounting on a structure with the directional axis extending in a preferred direction relative to the structure.

9. A device as claimed in claim **8** wherein the adjustment axis can be arranged coaxial with the directional axis.

10. A device as claimed in claim **8** wherein adjustment means is provided to permit adjustment of the position of a body carried by said carrier member relative to the support member and longitudinally of the adjustment axis.

11. A device as claimed in claim **8** wherein the arrangement is such as to permit adjustment of the position of a body car-

ried by the carrier member laterally relative to the adjustment axis.

12. A device as claimed in claim 8 wherein the support member is provided with a guide and the carrier member is provided with guide engaging means cooperable with said guide to locate the carrier member laterally of the adjustment axis.

13. A device as claimed in claim 12 wherein the guide on the support member and the guide engaging means on the carrier member are provided on a plug portion on one of said parts and a socket portion on the other of said parts, the socket portion being adapted to receive the plug portion.

14. A device as claimed in claim 8 wherein means is provided to secure the two members in a desired relative angular position about said adjustment axis by releasably securing them together.

15. A device as claimed in claim 1 and arranged for use as a goniometer head.

16. A goniometer head for orienting a crystal so that a plane associated therewith is normal to a predetermined directional axis comprising a support member, mounting means upon which the support member is mounted and which defines the directional axis, the mounting means being arranged for mounting on a structure with the directional axis extending in a preferred direction relative to the structure, the support member being rotatable relative to the mounting means about an axis transverse to the directional axis such that the latter lies in the surface of an imaginary cone generated about the transverse axis, a carrier member arranged to carry the crystal and mounted on the support member so as to permit rotation therewith about said transverse axis and rotation relative thereto about an adjustment axis such that relative thereto about an adjustment axis such that relative rotation of said members about said adjustment axis can be used to cause an axis of the crystal normal to said plane to lie in the surface of said imaginary cone, whereby if the normal axis is not the directional axis when it has been adjusted to lie in the surface of the cone, the support member can be rotated about the transverse axis to move the normal axis around the cone until it lies in said directional axis.

17. A goniometer as claimed in claim 16 wherein the arrangement is such as to permit adjustment of the position of a crystal carried by the carrier member laterally relative to the adjustment axis.

18. A goniometer head as claimed in claim 16 wherein adjustment means is provided to permit adjustment of the position of a crystal carried by said carrier member relative to the support member and longitudinally of the adjustment axis.

19. A goniometer head as claimed in claim 16 wherein the adjustment axis can be arranged coaxial with the directional axis.