UD 124
Universal Rotary Stage

Operating manual

Knowledge of this manual is required for the operation of the instrument. Please therefore familiarize yourself with its contents and pay special regard to the sections dealing with the safe handling of the instrument.

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Contents

1 Notes

ACHTUNG!

Operation!
The instrument may be operated by trained personnel only who must be familiar with the possible dangers involved in microscopy and the relevant field of application.

ACHTUNG!

Dust!
Dust and dirt can impair the performance of the instrument. Therefore, protect the instrument against these interferences as far as possible. Always use the dust cover if you do not intend to use the microscope for longer periods of time.

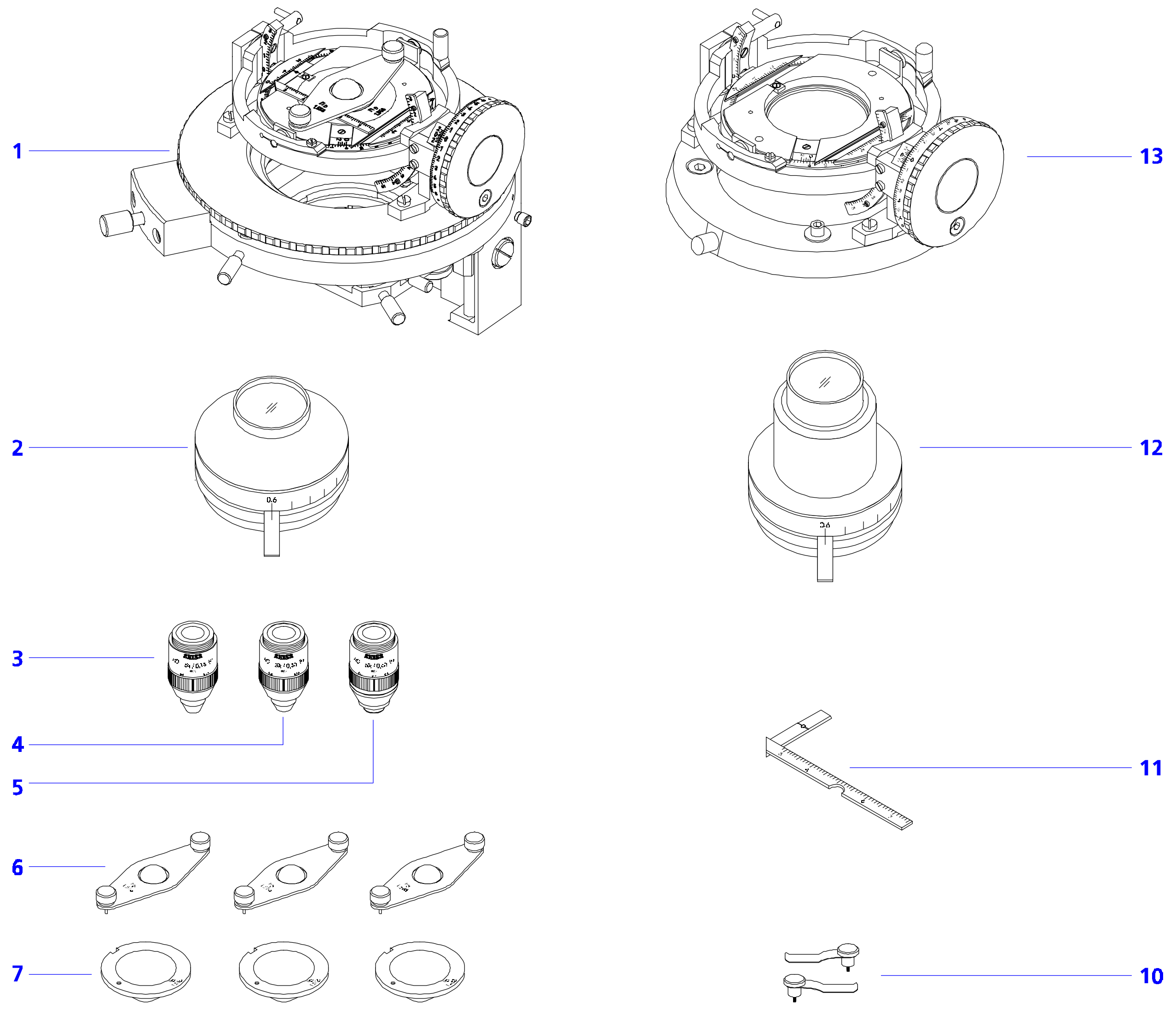
ACHTUNG!

Use of toxic immersion agents!
If the toxic α-bromonaphthalene is used as an immersion agent, make sure to avoid all skin contact with this substance to elimi-nate the possibilty of health risks. Wear protective goggles and gloves, if necessary..

ACHTUNG!

Damage to microscope parts!
To eliminate collisions between the objec-tives and parts of the universal rotary stage during work, the 4-position objective nose-piece of the **Axiolab Pol** must be equipped with no more than 2 objectives, with a free nosepiece eye between each objective. The 6-position nosepiece of the **Axioplan Pol** may accommodate 3 objectives (always separated by a free eye). Use caps to close nosepiece eyes not in use.

2 System overview



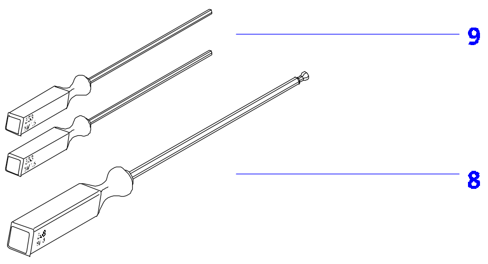


Fig. 1 System overview

1 UD 124 universal rotary stage for **Axiolab Pol**
2 UD condenser 0.6 pol für **Axiolab Pol**
3 Achromat objective 5x/0.10 Pol segment
4 Achromat objective 20x/0.30 Pol segment
5 Achromat objective 50x/0.60 Pol segment for conoscopy
6 Upper segments n_D = 1.516; 1.556; 1.648
7 Lower segments n_D = 1.516; 1.556; 1.648
8 Ball head screw driver SW 3
9 Pin wrench SW 1.5
10 Stage clamps
11 Schmidt ruler
12 UD condenser for **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol**, **Axiophot 2 Pol**
13 UD 124 universal rotary stage for **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol**, **Axiophot 2 Pol**

3 Application

The three-axis universal rotary stage (FigFig. 1/**1**) is mounted on the rotary stage of the polarization microscope of the **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol** und **Axiophot 2 Pol** microscopes. For the **Axiolab Pol,** the universal rotary stage is equipped with a special stage carrier (Fig. 1/**13**) and mounted directly on the stand in place of the rotary stage. Observation and measurement is generally possible in the orthoscopic and the conoscopic mode. Linearly polarized and circularly polarized light can be used. With the help of one rotary and two tilting axes (stage 1), the three-axis universal rotary stage is suitable for aligning a crystal, which normally is birefringent, in any defined direction relative to the optical axis of the microscope.
The major fields of application of the universal rotary stage can be classified into three categories:

Crystal diagnosis

- ❑ Determining the optical character
- ❑ Determining the absolute birefringence
- ❑ Determining the grinding thickness
- ❑ Measuring position and dimension of indicatrix
- ❑ Measuring the optical shaft angle
- ❑ Measurement of morphological reference planes, such as cleavage faces, composition surfaces of twins or the periphery of idiomorphous unit crystals
- ❑ Determining the pleochroism

Determining the chemical composition of mixed crystals

- ❑ Examination of plagioclases
- ❑ Analysis of alkali feldspas
- ❑ Analysis of pyroxenes and amphiboles

Structural analysis

- ❑ Analysis of the structural arrangement of optically monaxial crystals, e.g. quartz in quartzite or calcite in marble
- ❑ Analysis of the structural arrangement of biaxial crystals, e.g. muscovite in gneiss.

The most customary and also the clearest definition of the axes of a universal rotary stage is the one introduced by Berek in 1924, in which the axis numbers increase from the inside toward the outside. The inside rotary axis, for example, is numbered A_1, the inside tilt axis A_2. The rotary axes are provided with odd, the tilt axes with even numbers.

Reinhard [10] and Sarantschina [12] have introduced different definitions. The axial designations of Sarantschina are based on the inventor of the universal rotary stage, E. S. von Fedorow. With the three-axis universal rotary stage the A_3 axis has not been developed. This, however, is no drawback, because three axes are absolutely adequate for aligning any orientation in the sample relative to the optical axis of the microscope. In addition, the possibility of operational errors is reduced. Given the option, old hands will therefore normally give preference to a three-axis universal rotary stage over the four-axis one.

Axial definition:

Berek	Reinhard	Sarantschina	Universal rotary stage component
A_1	N = Normal axis	N = Normal axis	Inside rotary axis
A_2	H = Horizont axis	H = Auxiliary axis	Inside tilt axis
A_3	A = Auxiliary axis	M = Mobile axis	Outside rotary axis
A_4	K = Control axis	I = Immobile axis	Outside tilt axis
A_5	M = Microscope axis	A = Optical microscope axis = Rotary axis of microscope stage	Rotary axis of microscope stage = Optical microscope axis

Table 1

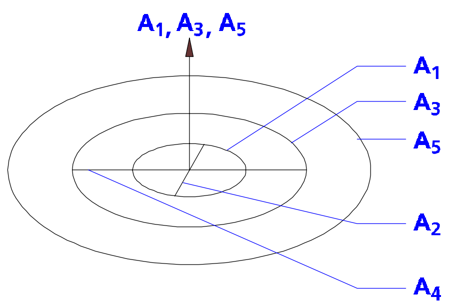


Fig. 2 **Axial definition of universal rotary stage**

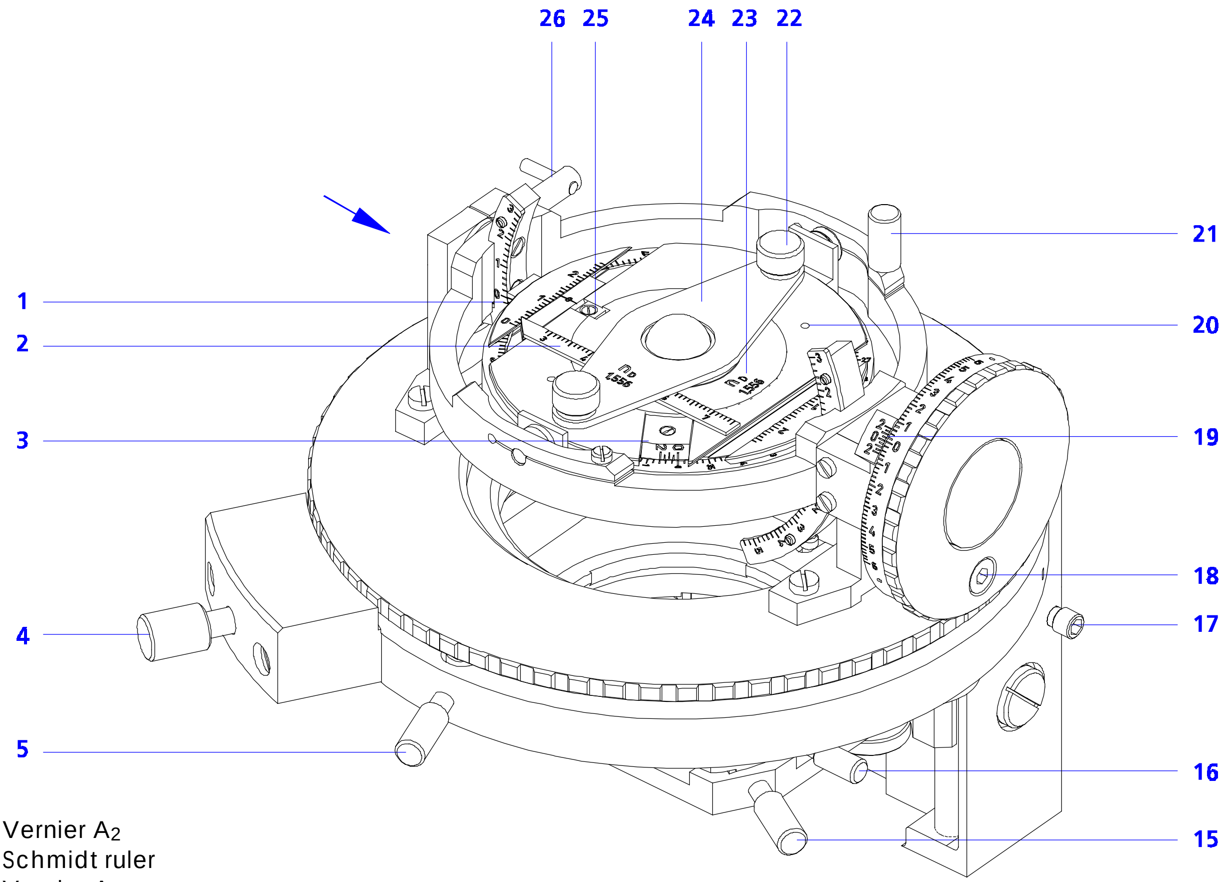
4 Instructions for use

4.1 Adaptation of universal rotary stage

Axiolab Pol	Axioplan Pol, Axioplan 2 Pol, Axiophot Pol, Axiophot 2 Pol
❑ Remove rotary stage in accordance with microscope manual.	❑ Center the rotary stage to the microscope in accordance with the manual, take out the reducing plate.
❑ Remove objectives.	❑ Remove the Pol objective and Pol condenser.
❑ Adjust the coarse drive to its upper limit stop. ❑ Insert the 0.6 Pol UD condenser (Fig. 1/**2**) in the condenser carrier of the universal rotary stage. For this purpose, lower the condenser drive (Fig. 3/**8**) as far as it will go and insert the UD condenser (Fig. 1/**2**) in the dovetail guide of the condenser carrier. Make sure the condenser is correctly seated and clamp it (Fig. 3/**16**). Then raise the condenser drive again (Fig. 3/**8**).	❑ Move the stage carrier to its top stop, raise the stage and lower the condenser carrier as far as it will go. ❑ Insert the 0.6 Pol UD condenser.(Fig. 1/**12**) (**Note!** Place the condenser in an almost vertical position, slide it into the dovetail and clamp it, (see microscope manual. If necessary, remove the rotary stage from the stand, insert and clamp the condenser and replace the rotary stage). Then slighly move up the condenser drive.
❑ Mount the universal rotary stage on the stand so that the retaining pin (Fig. 3/**7**) is in contact with the dovetail guide of the microscope and clamp it (Fig. 3/**17**). The stage is now automatically centered to the optical axis of the microscope; lower the condenser carrier as far as it will go.	❑ Lower the stage carrier by about 15 mm and clamp it. (See microscope manual.) ❑ Place the UD 124 universal rotary stage on the microscope stage (Fig. 4/**7**) and use the ball-head screwdriver (Fig. 1/**8**) (or a 90° offset Allen key) to tighten the two mounting screws (Fig. 4/**4** and **10**).
❑ Set the tilt positions about the axes A_2 and A_4 to 0° click stops (Fig. 3/**1** and. Fig. 3/**19**), switch to the click stops (Fig. 3/**13** and. Fig. 3/**14**), set the graduated circle of the A_1 axis to the 0°-mark (Fig. 3/**3**) and clamp all tilt movements (Fig. 3/**21** and **26**).	❑ Set the tilt positions about the axes A_2 and A_4 to 0° click stops (Fig. 4/**1** and. Fig. 4/**15**), switch to the click stops (Fig. 4/**13** and. Fig. 4/**14** set the graduated circle of the A_1 axis to the 0°-mark (Fig. 4/**3**) and clamp all tilt movements (Fig. 4/**17** and **22**)
❑ Screw the UD Achromat Pol objectives (Fig. 1/**3**, **4**, **5**) into the nosepiece, always leaving one nosepiece eye between each objective vacant. (It is recommended to use two objectives). Use dust caps to close the vacant nosepiece eyes.	❑ Adjust the vertical condenser stop so that the condenser will not hit the stage (see manual). ❑ Check whether the spacer ring H“0“M 27 on W 0.8 (4549109) has been screwed into the fixed (not centerable) nosepiece eye. (Screw in if necessary.) Screw the UD Achromat 20x/0.30 Pol in this nose-piece eye, screw in the other objectives so that one eye is left vacant between each of them. Use dust caps to close the vacant nosepiece eyes.

Table 2

4 Instructions for use



1 Vernier A_2
2 Schmidt ruler
3 Vernier A_1
4 Clamping screw A_5
5 Click stop mechanism A_5
6 Pins for vertical adjustment of lower segment (4x)
7 Arresting pin universal rotary stage
8 Control for condenser height adjustment
9 Vertical condenser stop
10 Centering screw for condenser
11 Dovetail for condenser
12 Aperture diaphragm
13 Condenser
14 Click stop mechanism A_2
15 Centering screw for condenser
16 Clamping screw for condenser
17 Clamping screw for univ. rotary stage
18 Click stop mechanism A_4
19 Vernier A_4
20 Threaded bore for stage clamp
21 Clamping mechanism A_2
22 Screw for upper segment
23 Lower segment
24 Upper segment
25 Annular bearing
26 Clamping device A_4

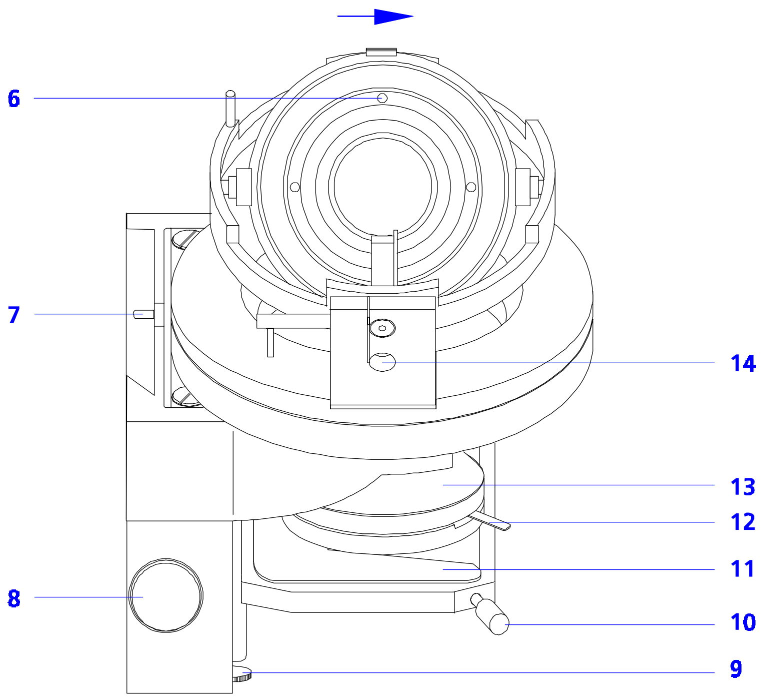
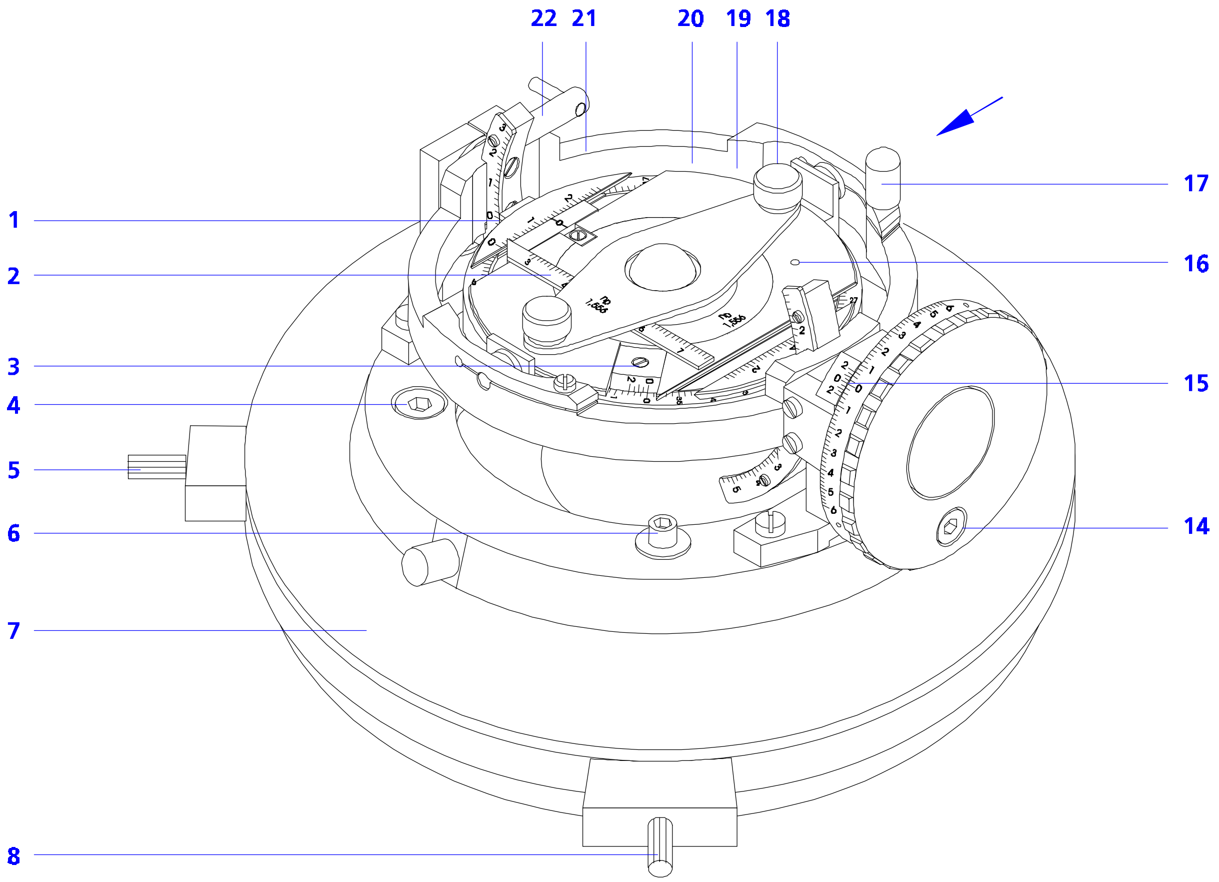
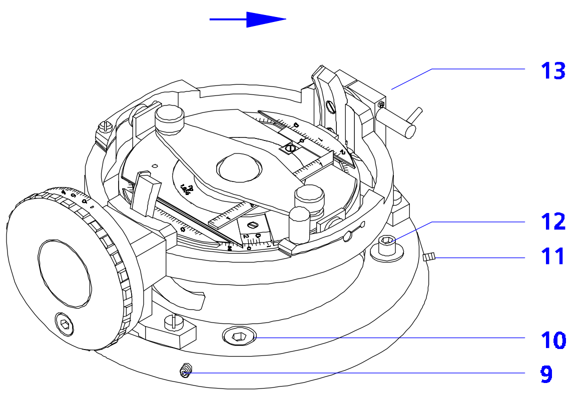


Fig. 3 **Universal rotary stage for Axiolab Pol**

4 Instructions for use





1 Vernier A_2
2 Schmidt ruler
3 Vernier A_1
4 Screw for mounting univ. rotary stage
5 Click stop mechanism A_5
6 Clamping screw for stage centering
7 Rotary stage of microscope
8 Clamping screw A_5
9 Adjusting screw for stage centration
10 Mounting screw for univ. rotary stage
11 Adjusting screw for stage centration
12 Clamping screw for stage centration
13 Click stop mechanism A_2
14 Click stop mechanism A_4
15 Vernier A_4
16 Threaded bore for stage clamp
17 Clamping mechanism A_2
18 Screw for upper segment
19 Lower segment
20 Upper segment
21 Annular bearing
22 Clamping mechanism A_4

Fig. 4 Universal rotary stage for Axioplan Pol

4.2 Preparation of universal rotary stage

4.2.1 Positioning the sample

- Select the suitable segment pair (Fig. 1/**6** and **7**), The refractive indices of the sample and the segment pair should be almost identical. For quartz or feldspa crystals, for example, the segment pair featuring the refractive index n_D = 1,556 should be selected, for pyroxen or amphibol crystals the one with the refractive index n_D = 1,648.
- Insert the larger, lower segment (Fig. 1/**7**) into the annular bearing (Fig. 3/**25**) to fit the groove. Apply immersion fluid, e.g. glycerin, to the flat segment surface.
- Position the sample and put one drop of immersion fluid on it.
- Center the upper segment (Fig. 1/**6**) parallel to the sample so that the screws (Fig. 3/**22**) touch the threaded bores in question. Lightly tighten the screws so that the immersion fluid is evenly distributed and shows no bubbles.
- Align the objective on the nosepiece with the rotary axis A_5 according to the microscope manual. (For the **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol** and **Axiophot 2 Pol** microscopes, check the center-ing of the microscope stage and re-center it, if necessary.)

4.2.2 Imaging the sample

- Sharply image the sample and use the condenser to illuminate it (as specified in the microscope manual). Sharply image the narrowed luminous field diaphragm together with the sample, center and open it until the field of view is visible.

4.2.3 Centering the universal rotary stage to the microscope axis

- The universal rotary stage of the **Axiolab Pol** has already been centered by the manufacturer.
- With the polarization microscopes **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol** and **Axiophot 2 Pol** the universal rotary stage must be centered relative to the rotary axis of the microscope stage.
- Arrest the microscope stage (Fig. 4/**8**). Rotate the sample through axis A_1. Use the adjusting screws (Fig. 4/**9** and **11**) and pin key (Fig. 1/**9**) to align the rotary axis of the universal rotary stage relative to the rotary axis of the microscope stage in accordance with the crosslines visible in the eyepieces, tighten the clamping screws (Fig. 4/**6** und **12**) with the ball-head screwdriver (Fig. 1/**12**) (This secures the centering).

4.2.4 Vertical adjustment of sample

- Loosen the clamps of axis A_4 (Fig. 3/**26**) and observe the sample as it is tilting. If the sample moves in the direction of rotation, it is located too high. If it moves opposite to the direction of rotation, it is located too low.
  If the specimen remains unchanged when it is tilted about axis A_4, it is at the correct height. In this case the intersections of the universal rotary stage axes, the center point of the sphere and the focus are located in this point, which is intersected by the surface of the sample.
- If the sample is too high, use the pins (Fig. 3/**6**) to turn the threaded ring **counter-clockwise** as seen from below. When the correct height has been reached, lightly tighten the screws (Fig. 3/**22**).
- If the sample is too low, loosen screws (Fig. 3/**22**) and turn the threaded ring (Fig. 3/**6**) **clockwise** as seen from below. When the correct height has been reached, lightly tighten the screw (Fig. 3/**22**), if necessary.

4.2.5 Aligning the A_2 and A_4 axes to the eyepiece crosslines

- Tilt the universal rotary stage about the A_4 and A_2 axes while observing the direction in which a dust particle below or above the object plane is moving.
- When the stage is tilted about the A_4 axis, the particle must move parallel to the vertical line of the eyepiece crosslines. It it fails to do so, disengage the stage click stop mechanism and perform the necessary alignment by rotating the stage through the A_5 axis..
- Activate the stage click stop mechanism.
- When the stage is tilted about the A_2 axis, the particle must move parallel to the horizontal (left-right), when tilted about the A_4 axis, parallel to the vertical eyepiece crossline (top-bottom). This is the standard setting.

4.3 Application examples

4.3.1 Orthoscopic work in linearly polarized light

Example 1: Measuring the angle 2 V of the optical axis of a biaxial crystal

- •• Center the selected grain in the crosslines.
- •• Switch in the 5x/0.13 objective (standard use).
- •• Adjust the iris diaphragms of the 20x/0.30 and 50x/0.60 objectives and the aperture diaphragm of the condenser (Fig. 3/**12**) to increase the contrast of the **Axiolab Pol** (same procedure for **Axioplan**-microscopes).
- •• Rotate through the A_1 axis to dark position.
- •• Tilt about A_4 axis (max. possible angle). Normally this will result in brightening up.
- •• Tilt about the A_2 axis to dark position.
- •• Tilt about the A_4 axis in opposite direction until it brightens up.
- •• Rotate through the A_1 axis to extinction.
- •• If the grain remains dark when the stage is tilted about the A_4 axis, the plane of the optical axis lies parallel to the microscope's symmetry plane (if not, repeat the previously described steps).
- •• Clamp the A_2 axis (Fig. 3/**21**).
- •• For **Axioplan** microscopes, release the clamping device of the microscope stage (Fig. 4/**5**) and rotate the universal rotary stage by 45° through the A_5 axis up to the next click stop.
- •• Use the graduated circle and the vernier (Fig. 3/**19**). to measure the optical axes (dark position when tilted about the A_4 axis).
- •• If only one of the axes of a biaxial crystal lies between the tilting range A_4, the angle of the optical axes must be determined using the Wulff network (Fig. 5).

4.3.2 Conoscopic work in linearly polarized light

The advantage of the conoscopic over the orthoscopic method is that the axial directions of monaxial or biaxial crystals can be identified directly in the interference image. For this purpose, a high-aperture (e.g. 50x/0.60) LD (long distance) objective and a Bertrand lens permitting observation of the rear focal plane of the objective are required.

Example 2: Measuring the angle 2 V of the optical axis of a biaxial crystal (conoscopically)

- •• Proceed as described in **example 1** (steps 1 to 10).
- •• Switch in the 50x/0.60 objective.
- •• Switch in the Bertrand lens (focus **Axioplan** microscopes).
- •• Use the graduated circle and the vernier (Fig. 3/**19**) to measure the optical axis by tilting about A_4. The axial directions can be identified from the curved, dark , hyperbola branches. The exit point of the crystal's optical axis lies in the vertex of the hyperbola.

Note: If only one optical axis is located within the tilting range about A_4, proceed as described in **example 1**.

4.3.3 Working in circularly polarized light.

•• The **Axiolab Pol**, **Axioplan 2 Pol** and **Axiophot 2 Pol** microscopes permit the universal rotary stage to be used also for work in circularly polarized light. For this, the circular polarizer D consisting of a polarizer and two λ/4 plates must be used. The polarizer and one of the λ/4 plates is used in the place of the standard polarizer. The second λ/4 plate is inserted in the compensator mount. Before doing so, adjust the polarizer and the analyzer so that they are at a 90° angle to each other. Align the upper λ/4 plate to the lower one until dark position is reached without adjusting the objective. Circularly polarized light can be used in conjunction with the universal rotary stage to precisely measure the angle of the optical axes 2 V in birefringent, optically biaxial crystals, for example. If you wish to work in linearly polarized light, remove the two λ/4 plates from the beam path.

Note: For details on the use of circularly polarized light, please refer to Zschach [15].

Example 3: Measuring the angle 2 V of the optical axis of a biaxial crystal in circularly polarized light

- Proceed as described in **example 2** (steps 1 to 10).
- Switch in the 50x/0.60 objective.
- Switch in the Bertrand lens (focus **Axioplan** microscopes).
- Use the graduated circle and the vernier (Fig. 3/**19**) to measure the optical axis by tilting about A_4. The axial directions can be identified by the two circular, dark zones with the exit point of the optical axes in their centers .

Note: If only one optical axis is located within the tilting range about A_4, proceed as described in **example 1**.

5 Modules

5.1 Universal rotary stage

5.1.1 Sample

The sample is inserted between glass segments (Fig. 1/**6** and **7**) and connected with them by the immersion fluid. The sample surface must be in the center of the sphere. The thickness of the object carrier should therefore be 0.9 to 1.1 mm, that of the cover glass 0.16 to 0.18 mm, and that of the sample 0.03 mm. If the thickness of the object carrier and the object differs, the segments and the sample can be vertically adjusted.

5.1.2 Schmidt ruler

The Schmidt ruler (Fig. 1/**11**) is used for structural analyses. The short leg (Fig. 3/**2**) is inserted in one of the trapezoidal guideways. The position of the sample can be secured using the stage clamps (Fig. 1/**10**) which must be screwed into the threaded bores (Fig. 3/**20**).

5.1.3 Segments

The segments are supplied in pairs. Each pair consists of an upper segment (Fig. 1/**6**) with a radius of 6.24 mm and a lower segment (Fig. 1/**7**) with a radius of 14.01 mm.
The stage is equipped with three segment groups featuring different refractive indices. Segments with the refractive index n_D = 1.516 can be used, for example, to measure the cleavage direction in fluorite.
Segments with the refractive index n_D = 1.556 are suitable for examining quartz and feldspa crystals.
Segments with the refractive index n_D = 1.648 are intended for the measurement of higher-refracting minerals such as pyroxenes and amphiboles, for example. In this case, a higher-refracting contact fluid is also recommended such as α-bromonaphthalene, for example.

5.2 Objectives

Examinations using the universal rotary stage can only be performed with the newly computed Achromat objectives which are screwed into the objective nosepiece direct, without any adapter. The engraved magnification and aperture figures apply when used in conjunction with the segment pair n_D = 1.556.

If the objective is combined with a segment pair featuring another refractive index, the magnification figure and the numerical aperture change by the factor K:

$$K = \frac{x}{1{,}556}$$

with x being the refractive index 1.516 or 1.648 (depending on the segment pair used).

In orthoscopic observation, the contrast is increased by closing the iris diaphragm with which all objectives are equipped. The condenser stop should be narrowed down simultaneously..

Use the Achromat 50x/0.60 objective for conoscopic observations, opening the iris diaphragm of the objective and the aperture stop of the condenser.

Achromat objectives with segment n_D = 1.556:

Magnification / Aperture		Working distance in mm		Cat.No
with segment	without segment	with segment to segment surface	without segment to sample surface	
5x/0.13	3.2x/0.08	2.8	9.0	442001
5x/0.30	12.8x/0.19	4.4	10.6	442003
50x/0.60	32x/0.38	2.3	8.5	442005

Table 3

5 Modules

5.3 Condensers

For the **Axioplan Pol**, **Axioplan 2 Pol**, **Axiophot Pol** and **Axiophot 2 Pol** microscopes, the UD 0.6 Pol condenser , Cat.No. 445460, is used. It is suitable for orthoscopic and conoscopic examinations. When working orthoscopically, the condenser aperture should be stopped down. For conoscopic work the condenser aperture must be fully open.
With the LD 0.6 Pol condenser , Cat.No. 445311, a condenser of identical optical performance is available for the **Axiolab Pol**. The above information also applies to this condenser.

5.4 Wulff network

Evaluation of the results obtained with the universal rotary stage is made easier by using the Wulff network (Fig. 5, page 15). It consists of the stereographic projection of meridians and latitudes onto a horizontally oriented plane.

If the measurement of the axis angle of optically biaxial crystals, for example, reveals one of the axial directions to lie outside of the tilting range of the A_4 axis, the stereographic projection can be used to determine the second axial direction and thus the axis angle 2 V of the crystal under examination.

6 Maintenance

For general information on care and maintenance, please refer to the operating instructions G 42-311, B 40-016 and B 40-042.

Kindly also observe the following::

- The universal rotary stage is a precision instrument and must therefore be protected against mechanical damage to ensure that settings and adjustments are not lost.
- Treat the segments with care (risk of scratching).
- Glycerin is recommended as an immersion agent due to it being water soluble.
- Always clean the universal rotary stage immediately on completion of your work. For this, loosen the knurled screws of the upper segment and lift it out of the center part of the universal rotary stage together with the sample and the lower segment.
- Carefully separate these components sideways and rinse off the immersion fluid with clean water, or dab it off using wet cotton wool. Distilled water is recommended for glycerin and light gasolin for immersion oil. Use an optical cleaning cloth or leather for the actual cleaning process.
- The mechanical parts are cleaned in the same way.
- **Caution!** The annular groove for the lower segment and the guideway for the Schmidt rulers must be cleaned very thoroughly due to the high-precision fit to eliminate the possibility of functional defects.
- The smoothness of the vertical objective adjustment must be checked at regular intervals.
- On completion of your work, store the universal rotary stage and all accessories in the storage container supplied.

7 Literature

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8 Wulff network for stereografic projections

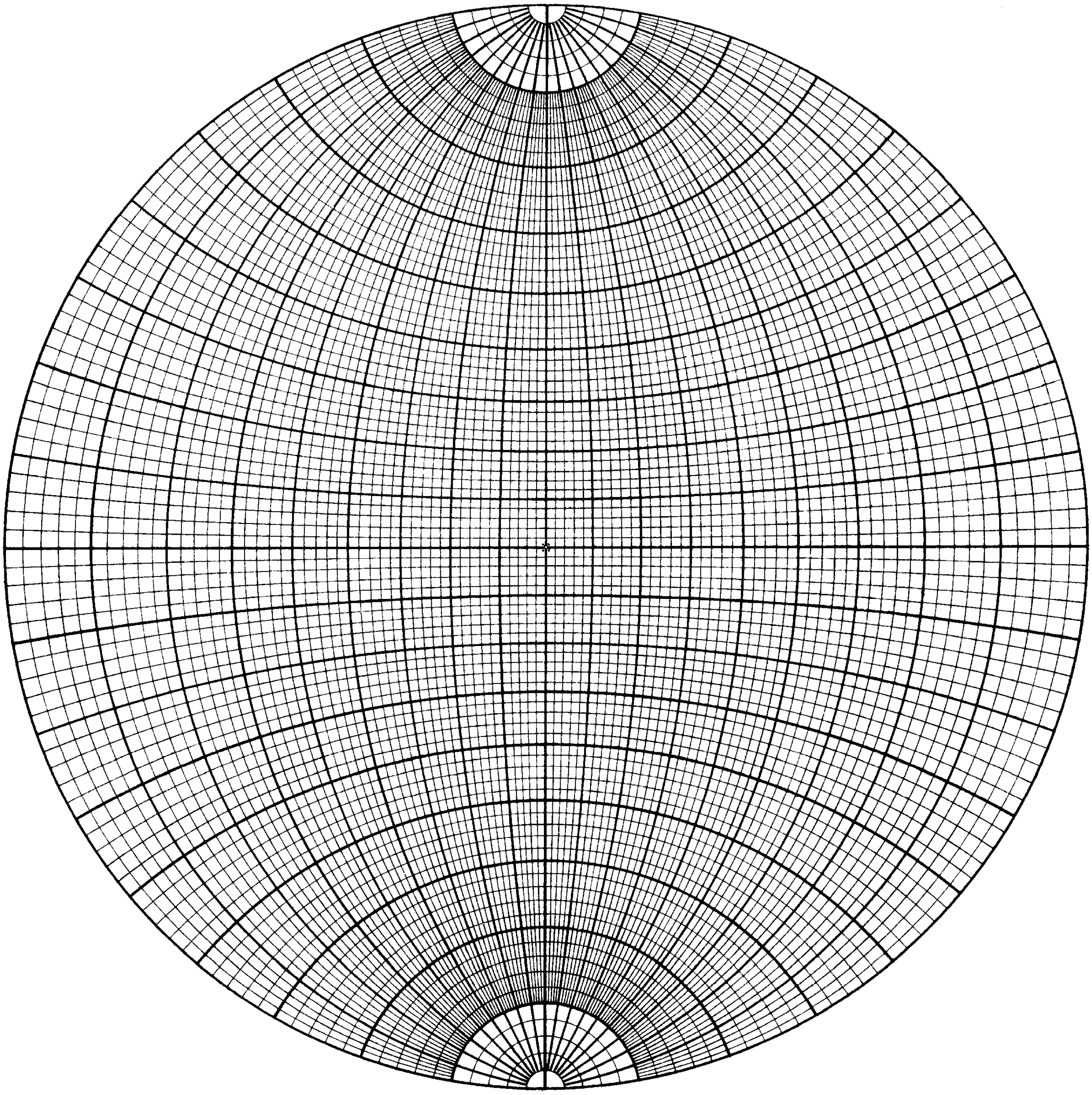

Fig. 5 **Wulff network**