99-Pr/Sf-

Instruction sheet **554 61 ff**

X-ray apparatus P equipment program

This unit is designed as a horizontal counter-tube goniometer, which includes a swivel measurement arm as well as a sample holder arranged in its rotating axis. In order to observe the Bragg reflection, the rotation angle of the measurement arm and the sample holder are linked at a ratio of 2:1. The measurement arm is equipped with a slide magazine. This permits the simple positioning of the measurement accessories as well as the sample materials mounted in the slide frame into the ray path.

The X-ray apparatus not only makes measurement with photographic methods possible but also measurements using a Geiger-Müller counter tube (559 05). The film material (554 892, 554 894) can be exposed and developed by daylight due to the fact that the films are packed individually in light-proof material. A timer switch with maximum 2 hour switching time not only permits comfortable setting and longer exposure times, but also prevents the uncontrolled continuous operation of the device.

Experiment examples

- Verification of X-ray radiation via:
  luminescent screen, ionisation chamber, Geiger-Müller counter tube, film blackening
- Inverse square law
- Linear absorption coefficients
- Dosimetry and radiation shielding
- Diffraction of X-rays:
  Bragg's reflection, Laue methods, Debye and Scherrer methods, Duane and Hunt's displacement law (*h*-determination)
- Moseley's law

⚠ 1 Radiation shielding

The device is to be safeguarded against tampering by unauthorized persons.

In order to conduct the experiments all of the respectively required equipment is to be gathered in the experimenting area. Switch-on of the high voltage and thus the actual putting into operation of the apparatus is only possible when the shroud cover is closed. For this very same reason the body of the apparatus is also secured with a single-way screw to prevent opening. Thus experimenters are shielded from the X-ray radiation, permitting non-hazardous experimenting.
The maximum operating conditions $U = 30$ kV and $I = 100$ µA can not be exceeded. The local dose rate at 0.1 m distance from the contact surface amounts to less than 7.5 mSv/h.

The effectiveness of the radiation protection mechanisms must be checked by the radiation protection officer each time prior to putting the apparatus into operation as specified in Section 4.1.

⚠ 2 Safety instructions

Should the high-voltage control lamp ⑰ light up, although the shroud cover is not properly closed but stuck in the middle position, the apparatus must be switched off immediately.

The X-ray apparatus P must be checked for damage incurred during transport immediately after unpacking. If, in spite of the protective packing material, damage is found on a delivered device, this unit may not be put into operation and Leybold Didactic must be notified immediately.

Set the device to the correct mains voltage before putting it into operation using the selection switch ㉓ (preset to 230 V AC at delivery).

The radiation protection mechanisms are to be inspected by the radiation protection officer prior to operating the device each and every time in accordance with Section 4.1. If any deficiencies are discovered, the X-ray apparatus may not be put into operation and the device must be returned to Leybold Didactic for repair.

If the cathode heating of the tube does not operate but the high voltage is still switched on, then high voltages may still be applied to the tube for as long as six hours later due to high capacitances. Therefore, in the case of a defective cathode, one may only make contact with high-voltage carrying components six hours subsequently at the earliest.

3 Equipment description, scope of supply, technical specifications (see Fig. 1)

3.1 Equipment description of the X-ray apparatus P (554 61/2)

① X-ray tube (554 62), already inserted and adjusted, if necessary, readjustment is possible via 2 screws (1.1), (1.2) (accessible at edge of housing after removing rubber caps)

② Potassium lead glass for the shielding against scattered radiation, fastened with screws (2.1), which are integrated in a safety circuit

③ Lead collimator, with fixed connection to the lead glass dome ②,
Diameter of the beam outlet opening 5 mm

④ Sample holder to accommodate monocrystals as well as glass rods, e.g for the adjustment of the beam path, Rotation angle Θ relative to beam axis can be read off the scale (4.1).

⑤ Knurled platen, is used to fasten the carrier plate for a 2:1 coupling ratio of measurement arm and sample holder.

⑥ Swivel measurement arm, designed as slide magazine, for the mounting e.g. of window counter tube, ionisation chamber as well as materials in slide format, with snap-on clips for adjustment and attachment, reference axis with respect to centre adjustment, left edge of the magazine. Angle 2 Θ with respect to beam axis can be read off scale (6.1), Precision setting via thumb wheel ⑦,
Distance from the cathode spot of the X-ray tube for Θ = 0° can be read off scale (6.2).

⑦ Thumb wheel for precision setting of the measurement arm ⑥, with angular scale ± 4°

⑧ Jack socket for the measurement of the emission current, Adapter cable included in scope of supply

⑨ Mains switch, mains voltage indicator with white control lamp ⑯

⑩ Timer, continuously adjustable up to a max. 2 h; switches off the unit after procedure has been completed

⑪ Pushbutton for switching the high voltage on; High voltage indicator with red control lamp ⑰

⑫ Screw-type potentiometer to set the emission current of the tube

⑬ Dumbbell-shaped slit for locking in the shroud cover with locking bung ⑳

⑭ 4-mm sockets e.g. for attaching the Debye Scherrer motor

⑮ High voltage selection switch for setting to U = 20 kV or U = 30 kV

⑯ Mains voltage control lamp (white)

⑰ High voltage control lamp (red)

⑱ Leadthroughs e.g. for high-voltage supply cable or hose for the ionisation chamber

⑲ Shrouding cover made of plastic, integrated into the safety system, switch-on of the high voltage only possible when the shrouding cover is closed and clamped

⑳ Locking bung for the secure sealing off of the experimenting field; integrated into the safety system in conjunction with ⑬

㉑ Aluminium-lead shielding (with radiation warning sign) for the shielding against the radiation beam removed by the collimator; Disassembly is not permitted

Underneath the apparatus:

㉒ Fuse holder for high voltage

㉓ Voltage selection switch for 110-120V/210-220 V/230-240 V

㉔ Fuse holder for mains voltage

3.2 Scope of supply for the X-ray apparatus P as well as accessories

554 61 ***X-ray apparatus P:***
1 Basic apparatus
1 Built-in and pre-adjusted X-ray tube (554 62), Tube replacement only permitted at Leybold Didactic (see Section 6.8)
1 Adapter cable with jack plug for the measurement of the emission current
2 Safety fuses T 1/250, (698 15)
1 Monograph:
"X-ray physics" in student experiments (554 612)"
6 Snap-on clips
1 Instruction sheet
1 Quality approved certificate

554 62 ***X-ray tube***
Exchange is only permitted at Leybold Didactic (see Section 6.8)

554 63 ***Counter tube holder:***
1 Stirrup-shaped counter tube holder with thumb screw
1 Highly-pliable coaxial cable with plug and socket

554 64 ***Ionisation chamber:***
1 Cylindrical chamber
1 Chamber cover with rod-shaped electrode
1 Chamber cover with evacuation connection
1 Chamber cover with large aperture
3 Toroidal sealing rings
3 Cable connectors

554 65 ***Debye Scherrer camera:***
1 Cylindrical camera
1 Camera cover
1 Sample holder with key type drill chuck
1 Rectangular film envelope on camera floor

554 66 ***Basic accessories*:***
24 components for basic experiments with the X-ray apparatus P
1 Storage tray with pre-moulded inserts with space for crystallography (554 67) and radiography accessories (554 68)

554 67 ***Crystallography accessories*:***
16 components for more advanced investigations in the area of crystallography

554 68 ***Radiography accessories*:***
16 components for more advanced investigations in the area of X-rays

554 69 ***Motor drive***,
Suitable for the Debye Scherrer camera (554 65) for structural analysis according to Bragg's method
1 Allen key for mounting the conical gear wheel

554 892 ***Film pack 2:***
20 Sheets of film 38 mm · 35 mm packaged in light-proof plastic covers
1 Bottle of X-ray developer
1 Bottle of X-ray fixative
1 Syringe
1 Hollow needle

554 894 ***Film pack 4:***
12 Sheets of film 150 mm · 12 mm in light-proof plastic covers
for Debye Scherrer camera
identical to film pack 2 with the exception of film format

* Further details on the individual components contained in the accessory sets can be found in the following tables

Scope of supply of the basic accessories as well as the crystallography and radiography accessory sets (554 66/67/68)

Code-no.	Object (number)	554 66	554 67	554 68
562.007	Maltese cross			x
008	Magnets (2)			x
009	Plate electrodes (2)	x		
012	Phantom			x
013	Film cassette, single	x		
014	Al-foils, graded			x
015	Slit diaphragm, 1mm	x		
016	Slit diaphragm, 3 mm	x		
017	Al-absorber 0.1 mm			x
018	Al-absorber 0.25 mm			x
019	Al-absorber 0.5 mm			x
020	Al-absorber 1.0 mm			x
021	Al-absorber 2.0 mm			x

Code no.	Object (number)	554 66	554 67	554 68
562.028	Lead shield, 0.5 mm			x
029	Plastic shield			x
031	Film cassette with small shield	x		
033	Pin-hole diaphragm, 9.5 mm	x		
563.005	LiF-monocrystal	x		
564.001	Scattering foil magazine with wire trigger	x		
002	Fe filter		x	
003	V filter		x	
004	Ni filter	x		
005	Mn filter		x	
006	Cu filter	x		
007	Cr filter		x	
008	Co filter	x		
009	Zn filter	x		
567.004	Glass miniature rods	x		
567.005	MgO powder		x	
008	Assembly clips (5)	x		
582.001	Slit, collimator, 1 mm	x		
002	Collimator, 1 mm dia.	x		
003	Luminescent screen	x		
004	NaCl monocrystal	x		
005	Auxiliary magazine	x		
006	Small pin-hold diaphragm			x
007	Mini-monochrystal, LiF (2)	x		
008	LiF powder	x		
583.001	KCI monocrystal		x	
002	RbCl monocrystal		x	
003	Auxiliary disk		x	
584.002	Painting test			x
003	Porosity			x
004	Tears			x
005	Porous weld seam			x
006	Lead mask	x		
585.001	NaF powder		x	
002	SiC powder		x	
003	Nb wires, 15 mm (3)		x	
004	NH_4Cl powder		x	
005	Al wires, 15 mm (3)		x	
006	Polyethylene threads		x	
007	Slide frames with glass		x	
008	Al powder		x	
009	Acetate glue	x		
586.003	Wires for small sample tubes (10)	x		

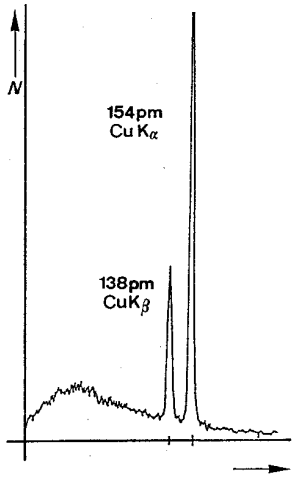
3.3 Technical specifications

X-ray apparatus P (554 61) and X-ray tube (554 62)

Anode material:	Cu
Characteristic radiation:	$\lambda(K\alpha(Cu)) = 154$ pm $\lambda(K\beta(Cu)) = 138$ pm
Local dose rate at 0.1 m distance from contact surface:	< 7.5 µSv/h
Anode voltage:	$U = 20$ kV or $U = 30$ kV
Emission current:	can be set between $I_A = 0$ µ A and approximately $I_A = 80$ µA
Cathode heater:	$U_{max} = 4$ V, $I = 1$ A
Cathode spot:	5 mm · 1 mm
Window in tube:	Borosilicate glass
Lead collimator:	Diameter 5 mm
Divergence of the beam:	better than 10°
Measurement accuracy of the doubled Bragg angle 2 Θ :	5 angular minutes
Mains connection:	110-120 V/210-220 V/ 230-240 V adjustable 50 Hz/60 Hz AC voltage
Power consumption:	P = 100 VA
Dimensions:	Height 25 cm Diameter 37 cm
Weight:	9 kg

Mono-crystals (from 554 66/67)

Mono-crystals:	Interplanar spacing d:
LiF	201 pm
NaCl	282 pm
KCl	315 pm
RbCl	329 pm



Bragg reflection at LiF crystal

Ionisation chamber (554 64)

Cylindrical interior:	Length 83 mm Diameter 25 mm
Electrode:	rod-shaped, length 74 mm
Operating voltage:	$U \leq 2$ kV
Ionisation current:	$I \approx 10$ pA

Debye Scherrer camera (554 65)

Internal diameter:	51 mm
Sample diameter:	$d \leq 1$ mm

Motor drive (554 69)

Mains connection:	110 V up to 220 V, 50 Hz
Power consumption:	3 VA

4 Operation

4.1 Checking the mechanisms designed for radiation protection (see Fig. 1)

Make sure that the safety circuit is functioning properly each and every time before putting the X-ray apparatus P into operation. In order to reliably test the circuit logic, it is important to follow the test steps listed below in strict sequence in the manner of a flow chart. In addition to the visual check, the following process serves to test the various safety elements, which only enable X-ray radiation to be generated when the housing is sealed shut. If there should be any deficiency during a test step, the apparatus is to be disconnected from the mains immediately. Should it prove impossible to eliminate these deficiencies using the procedures found in Section 6, this device must be returned to Leybold Didactic for repair.

- Visually check that the shrouding cover ⑲ has not been damaged
- Check that the radiation warning sign with shielding plate is fitted securely
- Visually check that the locking bung ⑳ has not been damaged, see Fig. 1
- Check that the lead glass dome ② with lead collimator ③ have not been damaged and are firmly secured
  For this open the shrouding cover ⑲; this is only possible in the direction toward the measurement arm ⑥
- Check the mains control lamp ⑯
  For this close the shrouding cover ⑲, connect the apparatus to the mains, set the timer switch ⑩ to the preset time, switch the mains switch ⑨ on. The mains control lamp should light up (see Section 6.1 for fault possibilities). The high-voltage control lamp ⑰ may not light up.
- Check that the timer switch is running
  For this switch mains on, preselect time.
- Test the relay of the timer switch ⑩
  For this set the time to 0. The mains control lamp ⑯ must go off resp. not light up when the mains switch ⑨ is switched on.
- Test the high-voltage control lamp ⑰
  This is done with the shrouding cover ⑲ closed and locked (insert locking bung ⑳ into one end of the dumbbell-shaped slit ⑬, then push the entire shroud with locking bung into the middle position). Set the timer switch ⑩ to the preselected time, switch on the mains ⑨. The high voltage lamp ⑰ should not light up yet. Switch on the high voltage with pushbutton ⑪. The control lamp ⑰ must light up (see Section 6.3 for possible faults)
- Testing the switching functions of the safety elements in the shrouding cover hinge
  For this push the shrouding cover ⑲ to the side with the high voltage switched on, but without opening it (the locking bung ⑳ thus remains in one end of the dumbbell-shaped slit ⑬). This should cause the high-voltage (high-voltage control lamp ⑰) to switch off.

If all of the above steps have been carried out with positive results, then the safety test has been carried out successfully and the apparatus may be used. However, should any deficiency arise, this unit must not be put into operation. Repairs may only be undertaken at Leybold Didactic.

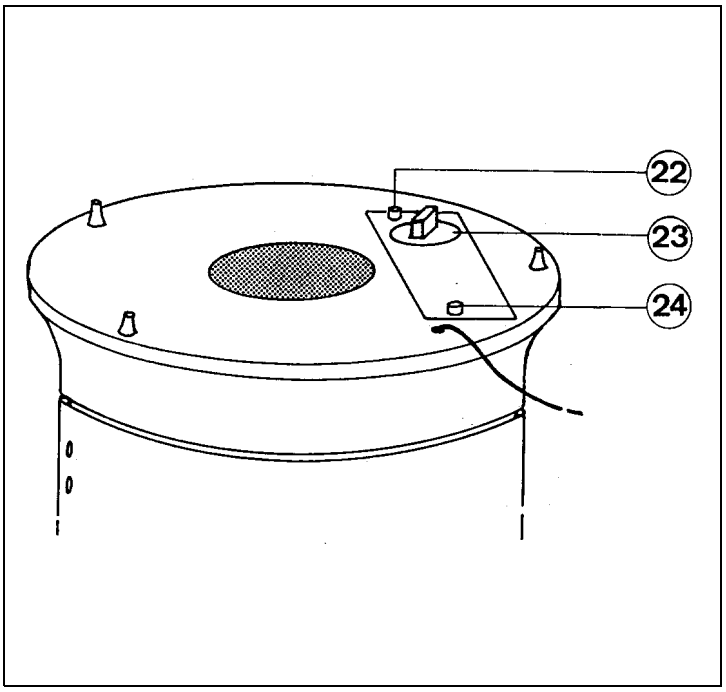


Fig. 1.3

① X-ray tube
(1.1), (1.2) Adjustment screws for ①
② Lead glass dome
(2.1) Locking screws for ②
③ Lead collimator
④ Sample holder
(4.1) Angle scale for ④
⑤ Knurled platen
⑥ Swivel measurement arm
(6.1) Angle scale for ⑥
(6.2) Distance scale for cathode spot
⑦ Thumb wheel
⑧ Jack socket for emission current measurement
⑨ Mains switch
⑩ Timer
⑪ Pushbutton for high voltage
⑫ Screw-type potentiometer from emission current setting
⑬ Dumbbell-shaped slit for ⑳
⑭ 4-mm socket
⑮ High voltage selection switch
⑯ Mains control lamp (white)
⑰ High voltage control lamp (red)
⑱ Inlet feeds
⑲ Shrouding cover
⑳ Locking bung for ⑬
a) current model
b) older model
㉑ Aluminium lead shield
㉒ Safety switch for high voltage
㉓ Voltage selection switch
㉔ Fuse holder for mains voltage

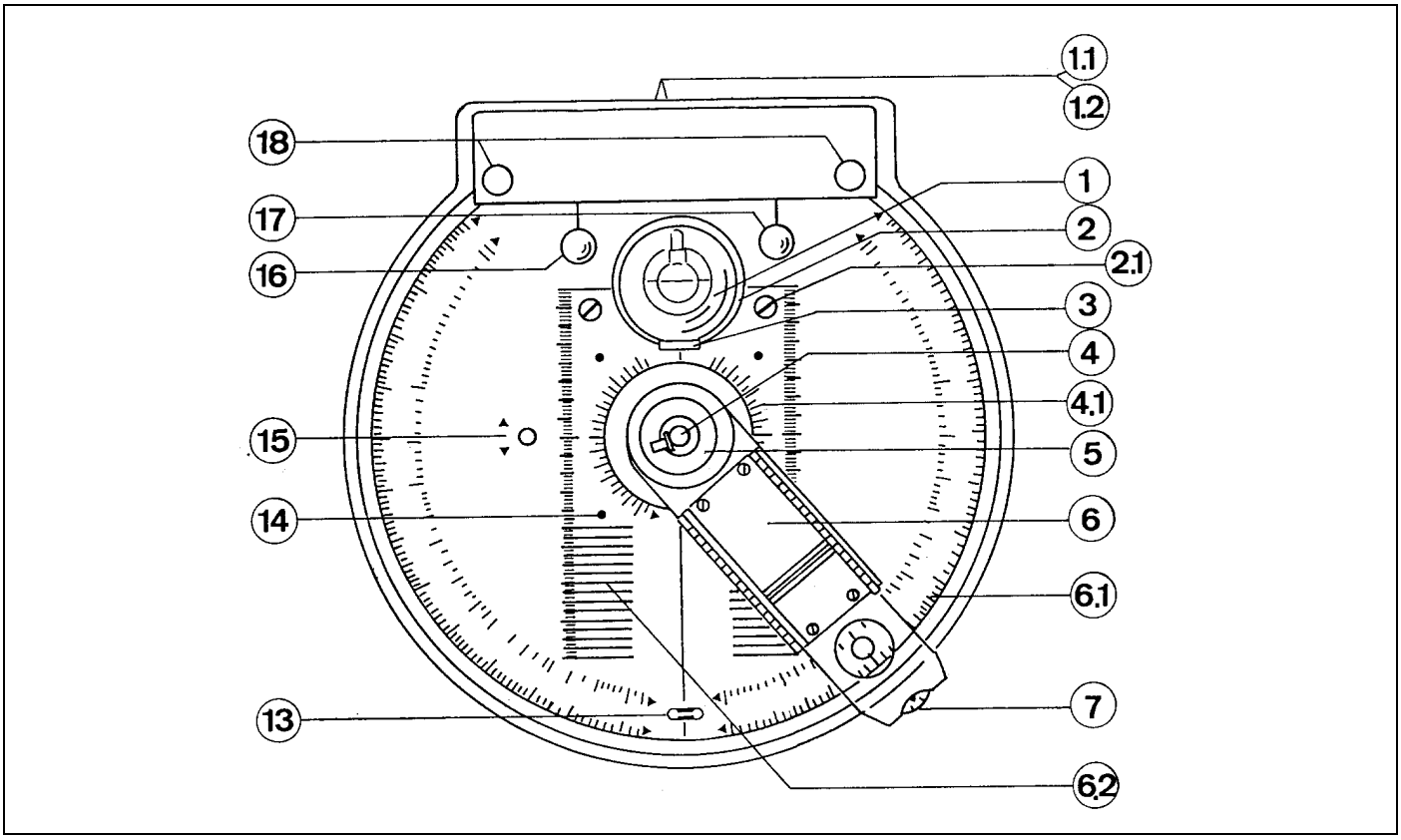

1.1
1.2
18
17
16
15
14
13
1
2
2.1
3
4
4.1
5
6
6.1
7
6.2

Fig. 1.1

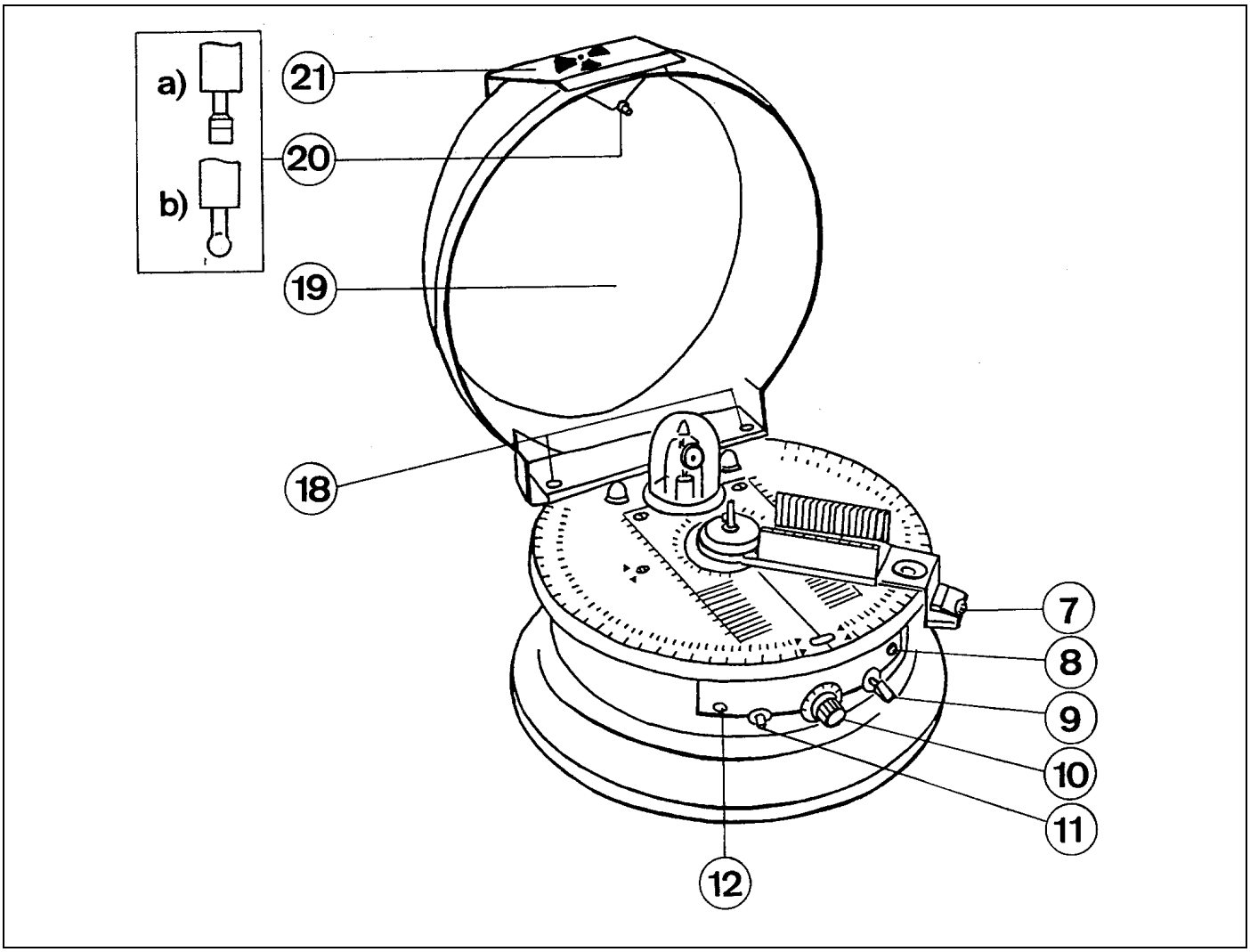

a)
b)
21
20
19
18
7
8
9
10
11
12

Fig. 1.2

4.2 Putting the X-ray apparatus P into operation

4.2.1 Closing and locking the shrouding cover

In order to close the shrouding cover ⑲ insert the locking bung ⑳ into the end of the dumbbell-shaped slit ⑬. In the case of measurement arm positions $2\,\Theta > 20°$ this may only be possible on the side, where the measurement arm ⑥ is located.

Then push the shrouding cover ⑲ with the locking bung ⑳ sideways into the middle position. Once the cover catches the locking bung now lock the cover against any direct opening. Consequently, the safety elements in the dumbbell-shaped slit ⑬ as well as the cover hinge permit high-voltage to be switched on.

When the cover is to be opened proceed as follows: push the cover sideways (take note of the measurement arm ⑥) and open the shrouding cover.

4.2.2 Switching the apparatus on

The apparatus is equipped with a timer switch ⑩, which switches the device off (at no current) after the preselected time elapses. Only after the preselected time has been set, can the device be switched on using the switch ⑨.

The mains control lamp ⑯ and the cathode heater light up.

4.2.3 Switching on the high voltage

After switching on the unit first select the desired high voltage U = 20 kV/30 kV using the slide switch ⑮. Close the shrouding cover and lock it into the centre position. Then operate the high voltage pushbutton ⑪:
The high voltage control lamp ⑰ lights up, signalling that X-ray radiation is being generated. Set the emission current as specified in Section 4.2.4.

Verification of X-ray radiation can now be carried out using a luminescent screen, Fig. 2.1, an ionisation chamber Fig. 2.2, the Geiger-Müller counter tube Fig. 2.3 or by measuring the emission current. Switch-off of the high voltage is carried out by pushing sideways on the shrouding cover ⑲.

Fig. 2 Examples of experiment assemblies using the magazine of the measuring arm

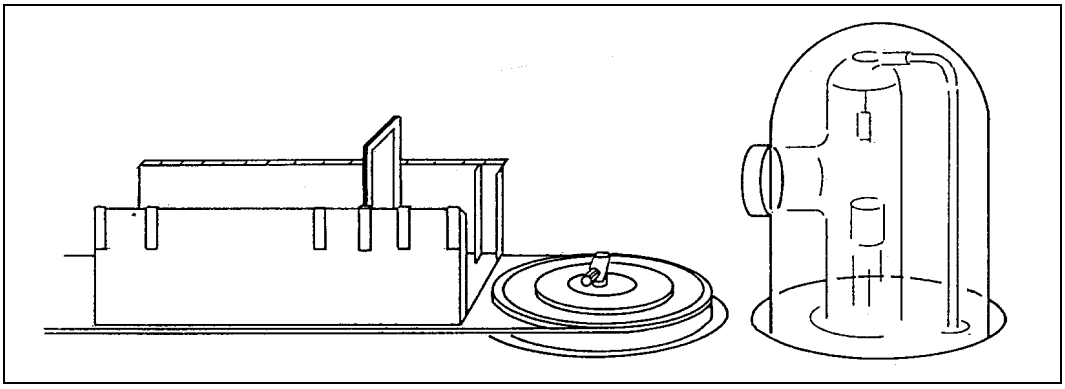


Fig. 2.1 Luminescent screen

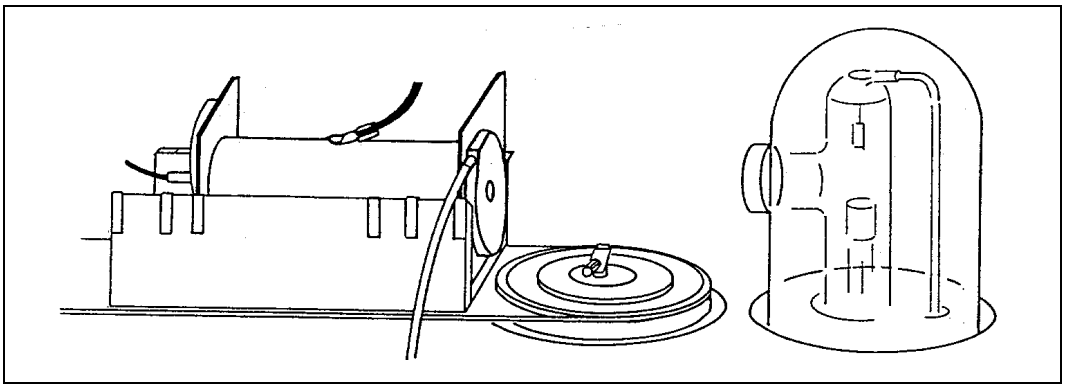


Fig. 2.2 Ionisation chamber

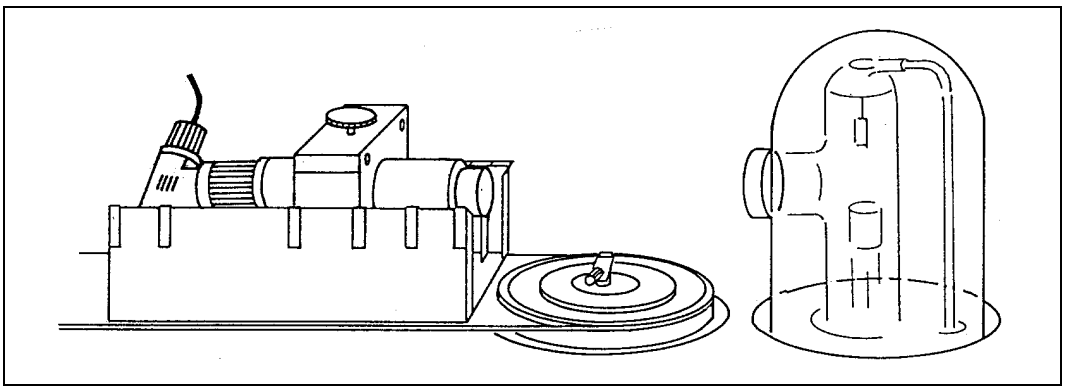


Fig. 2.3 Geiger-Müller counter tube

4.2.4 Setting and measurement of the emission current

First connect the jack ⑧ to a micoammeter via the adapter cable. Then set the desired emission current at the screw-type potentiometer ⑫ using a screwdriver.

4.2.5 Specimen holder

The monocrystals (NaCl, LiF, ...) can be fixed on the specimen holder ④ using the clamp ⓑ, see Fig. 3.1. In this way the monocrystal, along with the clamp ⓑ, is pressed against the fixed part of the specimen holder ⓓ) thus defining the angle adjustment of the crystal, see Fig. 3.2.

The clamp ⓑ complete with support ⓒ can be removed by unscrewing the screw ⓐ.
The angle Θ between specimen holder and beam axis is read off the scale (4.1).

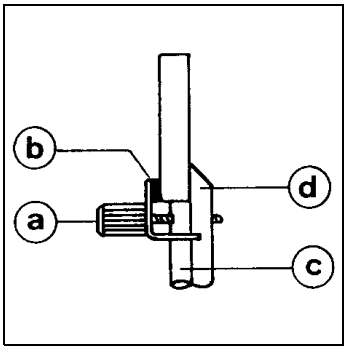


Fig. 3.1 Crystal placed in specimen holder

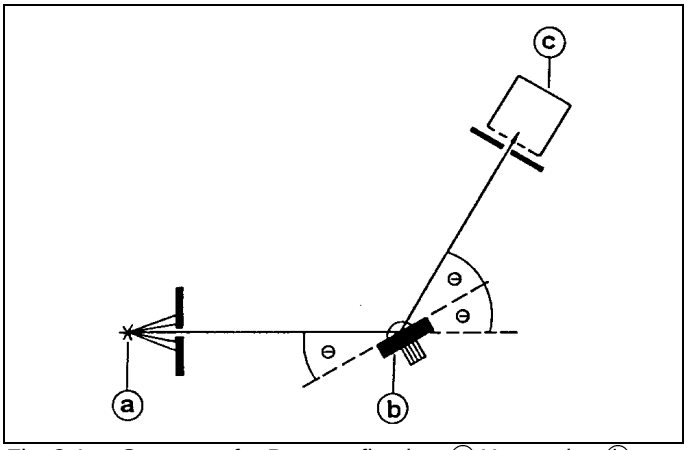


Fig. 3.1 Geometry for Bragg reflection; ⓐ X-ray tube, ⓑ monocrystal, ⓒ counter tube

4.2.6 Measuring arm

The slide magazine of the measuring arm ⑥ has 18 plug-in sockets, in which experiment accessories or demonstration devices can be inserted and adjusted using the snap-on clips, see eg. Fig.2. The angle 2 Θ between measuring arm and beam axis is read off from scale 6.1. Exact angle measurements are possible using the scale of the thumb wheel ⑦. Here, the measuring arm should first be set to the next whole angle 2 Θ. The thumb wheel can then be set to 0 against the spring tension while holding the measuring arm fixed. The measuring arm can subsequently be adjusted by ± 4° on the thumb wheel.
The relative angle can now be read off exactly to around 5 arc minutes on the thumb wheel scale.

4.2.7 Angle coupling 2 : 1

In order to record the Bragg spectrum it is necessary to rotate the measuring arm ⑥ by the double angle 2 Θ and the specimen holder ④ simultaneously by the angle Θ. To carry out this coupling, which has the ratio 2 : 1, pull out the platen ⑤. To do this, set the goniometer, specimen holder and measuring arm to exactly Θ = 0°, then pull the platen tight. The specimen holder now also moves through half the angle when the measuring arm moves.

5 Operating instructions for accessories

5.1 Inserting the collimators (from 554 66)

To reduce the beam divergence, attach one of the collimators [582.001/2] directly to the collimator ③ of the lead glass dome.

5.2 Inserting slits and other experiment objects with slide format into the measuring arm

Each experiment object is to be inserted into the corresponding groove of the measuring arm and secured flush with the left side using the snap-on clip, see Fig. 2.1.

5.3 Ionization chamber (554 64)

Assemble the ionization chamber as shown in Fig. 4. The ionizing effect of X-rays is demonstrated at normal pressure using the chamber lid with large opening ⓐ, at reduced pressure (principle of the Geiger-Müller counter tube) using the lid with vacuum connection ⓑ. The voltage supply and, if necessary, the pump line can be fed out of the experiment zone through the leadthrough ⑱. Here, it is necessary to use the delivered plugs to modify the experiment cable. The chamber is then inserted into the measuring arm using the snap-on clips (Fig. 2.2).

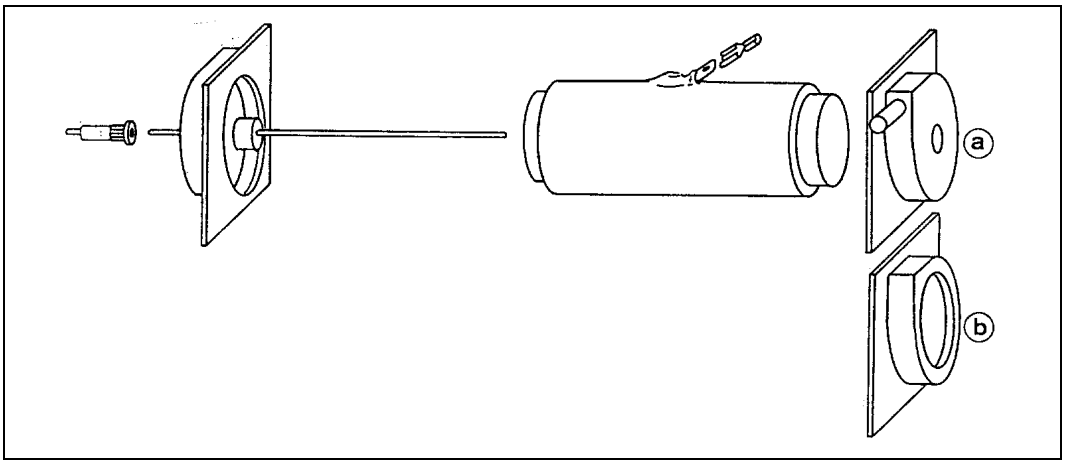


Fig. 4 Assembly of the ionization chamber
a) for reduced pressure
b) for normal air pressure

5.4 Counter tube

Use the snap-on clip to insert the counter tube (from 554 63) in the slide magazine at the desired position in the measuring arm. Slide the counter tube (559 05) into the holder and fix using the knurled screw, see Fig. 2.3. Connect the flexible counter tube cable (from 554 63).
Make sure that the shrouding cover can be closed: if necessary shift the counter tube.

5.5 Scattering foil magazine (from 554 66)

The scattering foil magazine contains 8 different metal foils which can be rotated into the radiation beam one after the other using the remote release. The element symbol of each foil also appears in a window on the rear of the magazine.

After removing the clamp, attach the magazine [564.001] with the semi-circular depression to the specimen holder, see Fig. 5. Screw on the remote release and activate it to ensure that it functions properly. Lead the remote release out under the shrouding cover and close the cover.

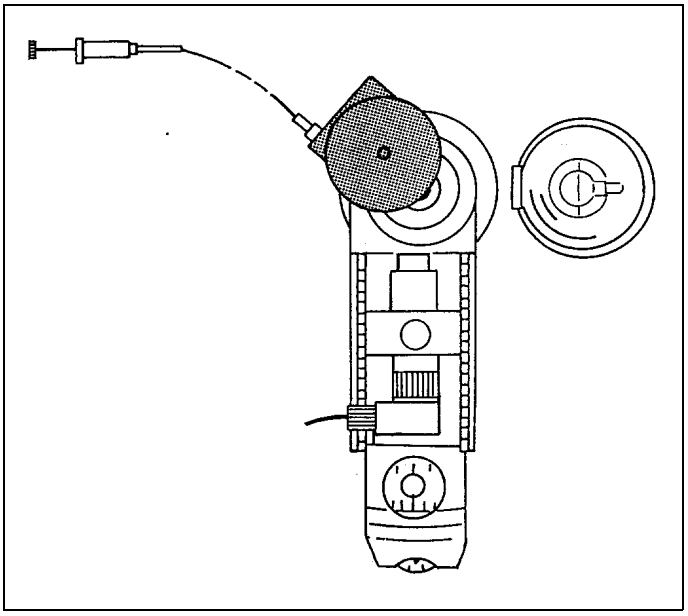


Fig. 5 Scattering foil magazine

5.6 Debye Scherrer camera and motor drive (554 65/69)

The Debye Scherrer camera (554 65), Fig. 6, consists of three parts: the base ⓐ and cover ⓑ, which together make up a light-proof housing, and a clamp holder ⓒ with a chuck for clamping the specimen. The conical gear wheel is required for the motor drive (554 69) of the Debye Scherrer camera. This makes, for example, rotating crystal recordings possible.

First remove the clamp from the specimen holder, rotate the measuring arm to $2\,\Theta = 90°$, and set the specimen arm to $\Theta = 90°$, so that the flat side of the holder is facing X-ray tube. Attach the 1-mm collimator to the lead glass dome collimator, and try to insert the bottom section ⓐ of the Debye Scherrer camera (Fig. 6.1) between the lead glass dome and the specimen holder, (Fig. 6.2). Should it prove impossible to position the camera between the dome and the specimen holder so that there is no play, use the screw on the base of the camera, Fig. 6.1, to carry out the necessary adjustments.

Remove the cover of the X-ray film (150 mm·12 mm) from film packet 4 (554 894) in the darkroom and load the film into the camera. Hereby it is important to insert the film tight against the interior cylinder wall. For rotating crystal recordings also place a film (38 mm · 35 mm) from film packet 2 (554 892), also without cover, tight against the bottom interior side of the camera. Close the camera lid ⓑ and then carefully insert clamp holder ⓒ with the clamped specimen.

Place the camera on the specimen holder as shown in Fig. 6.2. If necessary also insert the motor drive (554 69): to do this insert its plug into socket B, (see Fig. 6.3). Make sure that the conical gear wheel runs smoothly: if necessary change the position of the motor conical gear wheel on the axis using the supplied allen key.

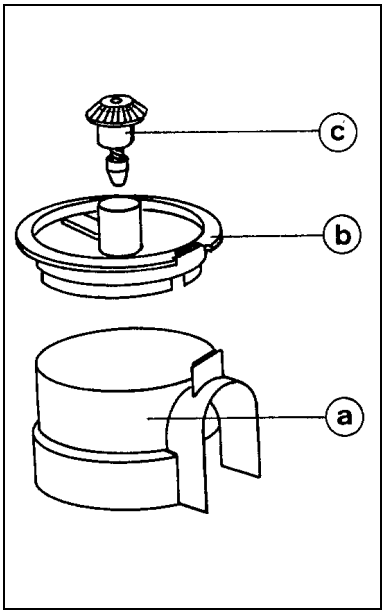


Fig. 6.1 Debye Scherrer camera

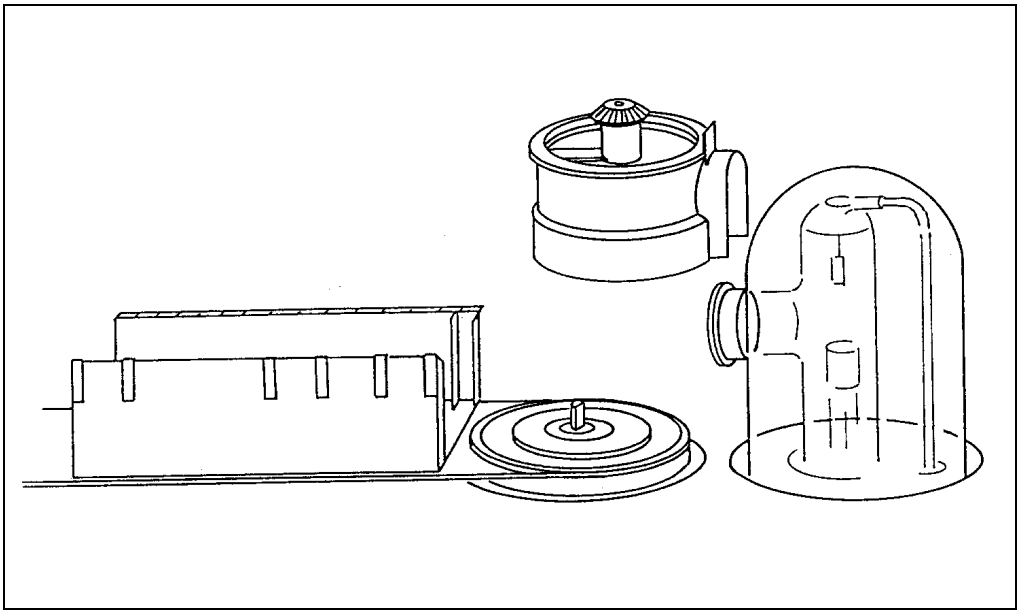


Fig. 6.2 Insertion system of the Debye Scherrer camera

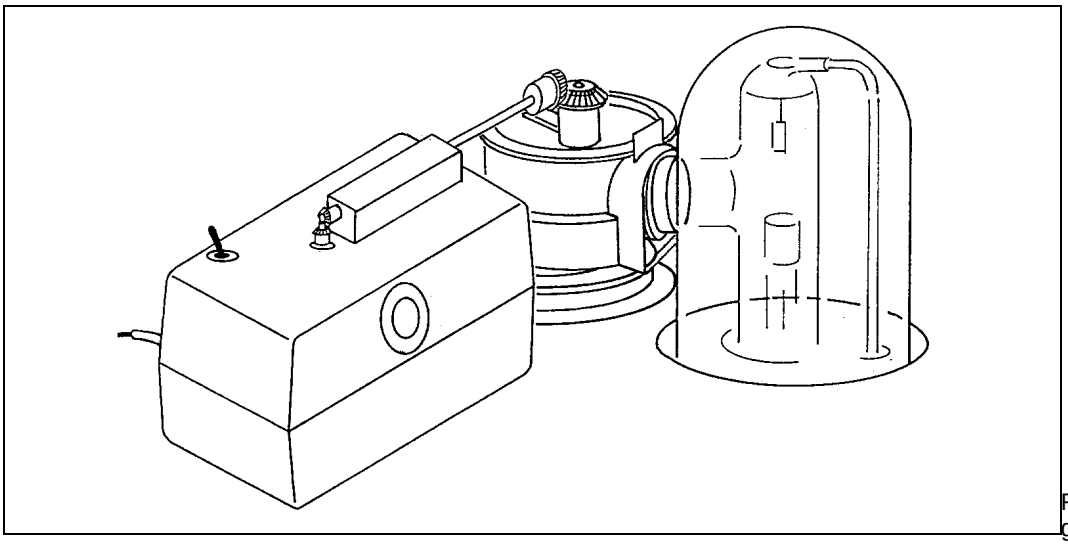


Fig. 6.3 Debye Scherrer arrangement with motor drive

5.7 X-ray films

The highly-sensitive X-ray film (from 554 892/894), which is coated on both sides, is sealed in a thin black PVC cover and has two light-proof openings for the injection of chemicals. After having been exposed to beta, gamma or X-rays the film is quickly developed in daylight by injecting the chemicals into the PVC covers one after the other. The process need only around 6 minutes. Afterwards the film can be cut out of its cover - already developed and fixed.

Light can not directly impinge on the film through the openings. However, the film can be clouded through the PVC cover if it is subjected to direct sunlight or illuminated over a period of time by a fluorescent lamp.

The sealing of the film in a PVC cover sometimes results in pressure marks at the edges.

Working with the film in the darkroom can result in scratches and bends. Some edges may become strongly blackened after development. Sometimes curved images appear in the middle of the film.

Both these phenomena are the result of blackening caused by pressing and demonstrate the need for care when handling the film.

Developing and fixing

Quantities of chemicals:
Film packet 2: developer 2.5 ml, fixative 3.5 ml
Film packet 4: developer 3.5 ml, fixative 5 ml
Developing time: 1.5 minutes
Fixing time: 4 minutes

Filling up with the liquids

The photochemicals are injected into the PVC covers using a syringe and a hollow needle. To make this possible, the hollow needle must be inserted into one of the two openings near to the written imprint.

The piston should be pulled up to the 1 ml mark before the liquid is drawn into the syringe so that an amount of air is present above the liquid level. This ensures that the entire volume of liquid is expelled from the syringe into the film cover.

Liquid movement

To ensure that the photochemicals properly cover the films on both sides, the film cover should be gently massaged between thumb and forefinger and the fluid uniformly distributed over both sides during the developing and fixing stages.

The fixative is injected at the end of the developing process without previously removing the developer.

Removing the film

At the end of the fixing process a corner of the film cover is cut off and the photochemical liquid pressed out. The bottom edge of the PVC cover is then cut off. By gripping it at a corner, the film can be pulled out. Before observation, the film should be washed for a few seconds under running water. If the film is to be stored, it should be fixed for a further 10 minutes (here normal fixative with or without setting agent can be used) and then washed for 30 minutes under running water.

Storing the chemicals

While the fixer is relatively stable, the developer is sometimes corrupted by the air above the liquid surface. If a partly full bottle of developer is to be stored for a period of time, it is recommended that the developer be poured into a smaller bottle. This should ensure the long-term quality of the developer.

Brown coloring indicates that the developer is decomposing.

Notes

When carrying out transparent recordings, the distance to the film object should be a minimum and the distance between film and X-ray source a maximum.

The X-ray films are also blackened by the $\beta-$ and γ rays which are emitted by standard school radioactive specimens.

The pattern of the PVC cover can become visible on the developed films if the radiation contains a high component of soft X-ray radiation.

Important

After having opened the developer bottle and before closing it again, press the liquid surface right up to the upper edge of the bottle opening by pressing the bottle together. This is to ensure that the amount of air enclosed above the liquid is minimal.
A light yellow coloring does not mean that the developer has deteriorated.

6 Help in the case of faults

Make sure that the mains plug is removed before replacing lamps or fuses!

6.1 Mains control lamp ⑯ does not work, even though the mains connection has been checked:

Possible causes	Remedy
Timer switch to 0	Set pre-selection time
Faulty mains fuse	Screw the fuse holder ㉔ out of the housing base, insert new fuse which has been checked for the correct value (T,1/250; 698 15), and screw in
Faulty high-voltage fuse	Screw the fuse holder ㉒ out of the housing base, insert new fuse which has been checked for the correct value (T,1/250; 698 15), and screw in
Faulty display lamp	Unscrew the plastic cover from the lamp, unscrew lamp, insert new one (12 V,0.1 A; 505 09), (best using a short piece of plastic tubing), replace cover
Other causes	Device must be checked by Leybold Didactic

6.2 Cathode heating does not glow, even though mains control ⑯ lights up

Possible causes	Remedy
Faulty cathode	Must be repaired by Leybold Didactic (cf. Section 6.8)
Faulty heating circuit	Must be repaired by Leybold Didactic

6.3 High-voltage control lamp ⑰ does not work, even though mains control ⑯ lights up

Possible causes	Remedy
Safety circuit	Check the circuit in accordance with Section 4.1 i.e. make sure that the lead glass dome has been locked, the cover properly closed and clamped
Faulty display lamp	Unscrew the plastic cover from the lamp, unscrew lamp, insert new one (12 V,0.1 A; 505 09), (best using a short piece of plastic tubing), replace cover
Other causes	Can only be repaired by Leybold Didactic

6.4 High voltage crackles directly after switch-on

Possible causes	Remedy
Moisture underneath lead glass dome	Allow the cathode heating to glow for a few minutes with the high voltage switched off. The glass dome heats up and dries out. Switch high voltage on again

6.5 Cathode briefly lights up brightly when the high voltage is switched off

This is not a fault: serves to discharge the high-voltage capacitors.

6.6 X-rays cannot be determined, even though the high voltage is switched on.

Possible causes	Remedy
Cathode does not glow	corresponds to case 6.2, must be repaired by Leybold Didactic (cf. Section 6.8) Danger! Even after switch-off, high voltage remains present at the tube for several hours.
Emission current to small	Setting see Section 4.2.4
No emission current	Repair of the high-voltage supply or tube replacement cf. Section 6.8) by Leybold Didactic
Collimators or similar in beam path	Check experimental assembly
X-ray tube completely out of adjustment	See Section 6.7

6.7 Adjusting the X-ray tube

The tube has been carefully adjusted by the manufacturer. Further adjustment is normally not necessary. Since, however, the tube can come out of adjustment as a result of transportation, a method of checking the adjustment and if necessary readjustment is described below. First of all, insert the counter tube in grooves 17 and 20, see also Section 5.4, and Fig. 2.3.

To adjust the height of the tube, rotate the counter tube to the 0°- position, insert the 1-mm slit [562.015] horizontally in groove 13, mount the collimator, 1 mm Ø [582.002] directly on the lead glass dome.

Switch on the device, switch on the high voltage at 20 kV.

Preselect the emission current so that the counter tube counts approx. 200-400 pulses/s (it is possible that this value cannot be achieved when the tube is completely out of adjustment).

Now remove the bottom rubber stopper on the back of the device. Adjust the tube height using the screw which has become accessible 1.2, (Fig.1) by setting to the maximum count rate.

Replace the rubber stopper. Do not carry out the lateral adjustment until this has been completed.

For lateral adjustment, open the device, insert the 1-mm collimator slit [582.001] on the lead glass dome and now adjust vertically in groove 30 just as for the 1-mm slit screen [562.015].

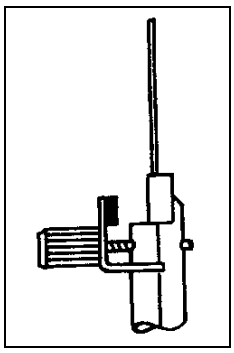


Fig. 7

Remove clamp from specimen holder, use mounting clip [567.008] and insert glass rod [567.004] see Fig.7.

Switch on mains, aim for the tube through the two slits. The glass rod should be at the center of the cathode reflex on the anode.
If this is not the case, the dome can be rotated through a small angle after the clamping screw (2.1), (Fig. 1) has been loosened. Remove mounting clip [567.008] and glass rod [567.004].

For fine adjustment, insert LiF monocrystal (marked blue) into the specimen holder. Set measuring arm and specimen holder to 0, carry out 2:1 angle coupling, see Section 4.2.7.

Now set the measuring arm to the angle $2\Theta = 45°$, whereby the side of the goniometer is to be selected so that the incident and reflected beam both lie on the tapered side of the specimen holder (defined crystal rotating point, see also Fig. 3.2).

Set the high voltage to 30 kV.

Close shrouding cover and switch on high voltage.

Determine the Cu-K_α reflex (literature value $2\Theta = 44°56'$ for LiF). The measured value should agree with that from literature to within $\Delta\Theta = 30'$.

If this is not the case, check the coupling once more for $\Theta = 2\Theta = 0°$, then determine the reflex again. If the measured value still lies outside the tolerance limits:

a) Set measuring arm to the average value of the measured and literature value. Remove the top rubber stopper from the back of the housing. The tube can be tilted using screw 1.1. Maximize the counting rate by tilting the tube.
b) Now once again determine the reflex maximum with the measuring arm. If it still does not lie within the tolerance limits, repeat a)
   Carry out alternative adjustments until the literature value and measured value agree to within $\Delta\Theta = 30'$.