

## Fluorescence of a luminous screen due to x-rays

### Objects of the experiment

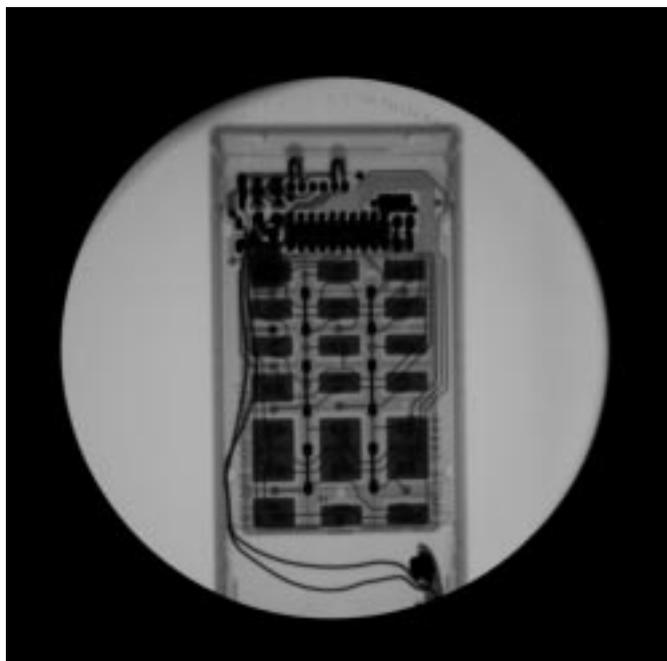
- Detecting x-rays by observing the fluorescence of a luminous screen.
- Transillumination of objects with different absorption characteristics.
- Investigating the dependence of brightness and contrast of the luminous screen on the emission current and tube high voltage.

### Principles

Very soon after *W. C. Röntgen's* discovery of x-rays in 1895, researchers were quick to apply the fact that x-rays can be “observed” on a luminous screen in medical examinations. At that time, the most common type of luminous screen was barium-platinum-cyanide, which fluoresces bright green; today, yellow-green zinc-cadmium-sulfide is used almost exclusively. The fluorescent substance is applied to lead glass, which protects the observer from the harmful effects of x-rays.

Fluorescence is a luminous phenomenon that occurs in certain materials when these are exposed to light, x-ray or particle radiation. The energy of the incident radiation is used to excite or ionize the atoms and molecules; when these return to the ground state, a portion of this energy is released in the form of visible light. The transitions are extremely rapid ( $< 10^{-5}$  s), so that fluorescence can only be observed during irradiation (in contrast to phosphorescence).

The ability of x-rays to pass through opaque materials and bodies make them particularly useful in diagnostic applications. Depending on the composition of the irradiated object, the radiation is attenuated to a greater or lesser extent. That is why the images on the luminous screen reveal details of the internal structure of objects. In this experiment, this fact is demonstrated using a simple object, e.g. a pocket calculator, which has parts made of materials with different absorption properties. This experiment investigates the effect of the emission current  $I$  of the x-ray tube on the brightness and the effect of the tube high voltage  $U$  on the contrast of the luminous screen.



Luminous-screen image of a pocket calculator

**Apparatus**

1 X-ray apparatus . . . . .	554 811
or	
1 X-ray apparatus . . . . .	554 812

*Additionally required:*

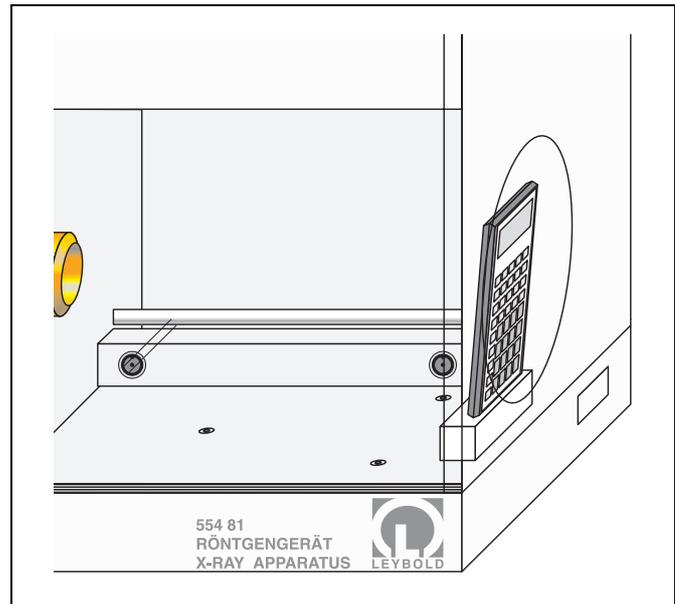
1 Object for transillumination, e.g. pocket calculator with plastic housing

Any flat, opaque object with an internal structure and made primarily of plastic and metal parts is suitable.

**Setup**

- Remove the collimator from the experiment chamber, as well as the goniometer or any other assemblies.
- Remove the protective cover of the luminous screen.

Fig. 1 Experiment setup for demonstrating fluorescence of a luminous screen due to x-ray radiation

**Safety notes**

The x-ray apparatus fulfills all regulations governing an x-ray apparatus and fully protected device for instructional use and is type approved for school use in Germany (NW 807/97 Rö).

The built-in protection and screening measures reduce the local dose rate outside of the x-ray apparatus to less than  $1 \mu\text{Sv/h}$ , a value which is on the order of magnitude of the natural background radiation.

- Before putting the x-ray apparatus into operation inspect it for damage and to make sure that the high voltage is shut off when the sliding doors are opened (see Instruction Sheet for x-ray apparatus).
- Keep the x-ray apparatus secure from access by unauthorized persons.

Do not allow the anode of the x-ray tube Mo to overheat.

- When switching on the x-ray apparatus, check to make sure that the ventilator in the tube chamber is turning.

**Carrying out the experiment**

*Note:*

*Carry out the experiments in a darkened room.*

**a) Brightness of the luminous screen:**

- Close the lead glass sliding door, set the tube high voltage  $U = 35 \text{ kV}$  and switch on the apparatus with the hv on/off key.
- Increase the emission current  $I$  continuously from 0 to 1.00 mA and observe the brightness of the luminous screen.

**b) Varying the emission current  $I$ :**

- Place the transillumination object, e.g. pocket calculator, in the experiment chamber as close as possible in front of the luminous screen.
- Set the emission current  $I = 1.00 \text{ mA}$ , the tube high voltage  $U = 35 \text{ kV}$  and switch on the unit with the hv on/off key.
- Reduce the emission current  $I$  in steps and observe the change on the luminous screen.

**c) Varying the tube high voltage  $U$ :**

- Set the emission current  $I = 1.00 \text{ mA}$ .
- Reduce the tube high voltage in steps and observe the change on the luminous screen.

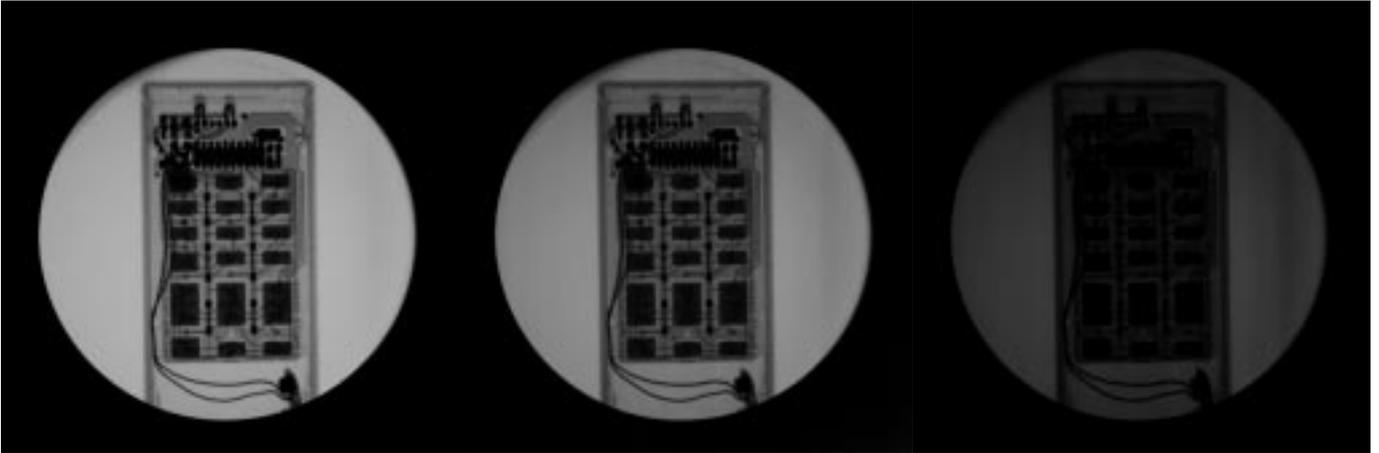


Fig. 2 Luminous-screen image of a pocket calculator (photographed using a digital camera) at maximum tube high voltages and different emission currents.  $I = 1.0 \text{ mA}$ ,  $I = 0.7 \text{ mA}$  and  $I = 0.4 \text{ mA}$

### Measuring example

#### a) Brightness of the luminous screen:

The luminous screen becomes brighter as the emission current rises.

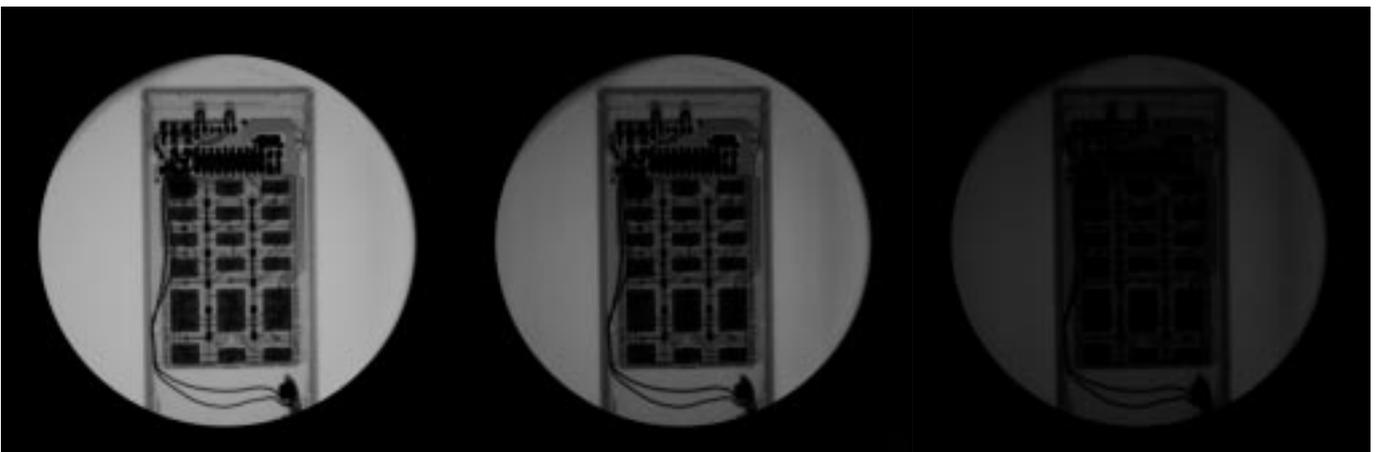
#### b) Varying the emission current $I$ :

Fig. 2 shows the relationship between the luminous screen and the emission current  $I$ .

#### c) Varying the tube high voltage $U$ :

Fig. 3 shows the relationship between the luminous screen and the tube high voltage  $U$ .

Fig. 3 Luminous-screen image of a pocket calculator (photographed using a digital camera) at maximum emission currents and different tube high voltages.  $U = 35 \text{ kV}$ ,  $U = 31 \text{ kV}$  and  $U = 27 \text{ kV}$



### Evaluation

When no object is in the beam path, the luminous screen fluoresces more brightly as the emission current rises, because the intensity of the x-radiation increases.

The brightness of the luminous screen is reduced behind the transilluminated object, because the object attenuates the x-rays. Objects that are thicker or have greater attenuation characteristics show up on the luminous screen as darker features. However, the brightness of the image as a whole increases with the emission current.

An increase in the tube high voltage generally results in greater image contrast, as the x-rays are harder (a greater proportion of high-energy x-rays). At the same time, the brightness increases, because the intensity of the x-rays also increases (see P6.3.3.2).

### Results

The luminous screen shows a relatively sharp image of the internal structure of the transilluminated object. This explains the great importance of x-rays in diagnostic medicine and non-destructive materials testing.

