Radiographic survey

X-rays allow for imaging details beneath the surface and examining their condition, including any possible degradation. Radiography is a non-destructive imaging technique that is used not only to image the layers of materials, internal parts of objects (condition and structure of the bookbinding) but also to detect inhomogeneities, defects, cavities, etc. that cannot be detected by other means without destroying the book. This visible information will then make it easier for restorers or conservators to decide what steps will or will not be necessary to save the book or how to take care of the book.

Principle of the Lamp and Detector

The measuring apparatus can be arranged in different ways, depending on the purpose. The usual arrangement is that the object to be examined is illuminated with ionising radiation and the detector is used to take an image showing the areas that absorb more or less radiation than the surroundings. The X-ray chamber at the National Library of the Czech Republic is arranged in this manner. It uses a sensitive electronic flat panel as a detector to transmit a digital image. The flat-panel detector represents a major technological achievement when compared to the film previously used. A live preview leads to a significant reduction in exposure time and provides a digital image directly stored on the computer. This makes the work much easier and faster, especially if test images have to be taken first to find the optimum exposure time, voltage and power.

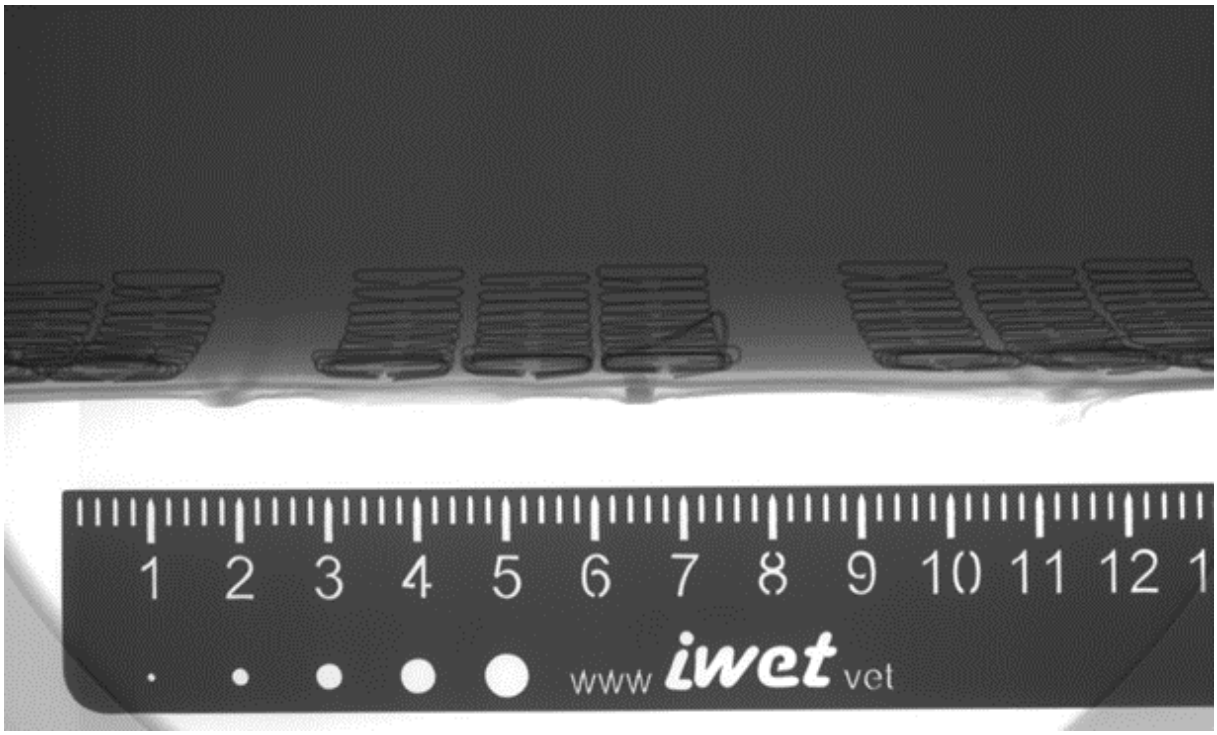
The greyscale of the acquired image represents a higher or a lower level of X-ray absorption in a given part of the object. The darker shades in the positive image correspond to the materials absorbing more radiation (with a higher proton number, esp. metals), while the lighter areas represent the material absorbing less radiation (paper, textiles, leather, etc.). Another factor determining the total amount of radiation absorbed (and therefore the shade of grey in the image) is the thickness of the material being irradiated. Last but not least, the level of grey depends on the equipment settings when taking the image.

Typical materials for books are paper, textiles, wood, leather, parchment and, to a lesser extent, metal; but plastics or bone are used as well. Due to the different physical properties of these materials, different instrument settings are required to achieve optimal images of the bookbinding's components made from these materials, their structures and possible defects. This, in particular, includes appropriate settings of electric current and voltage of the X-ray tube, the distance of the X-ray tube from the detector and the distance of the scanned object from the detector. It is also essential to choose the optimal position of the book (or, for obtaining more complex information, several successive positions of the same book) and a suitable structure that holds the book at the desired position and distance from the detector, including suitable materials for this structure (especially non-absorbent materials).

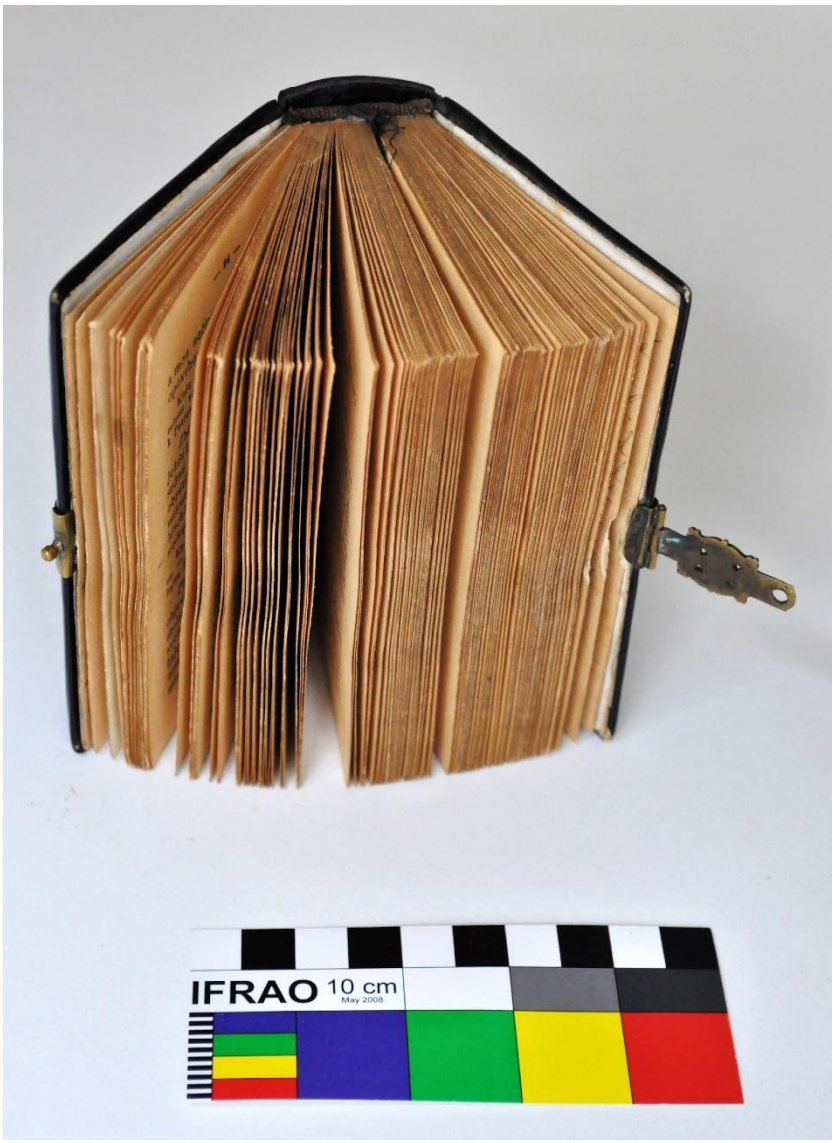
Cabinet with X-ray system

Examples of X-ray systems used

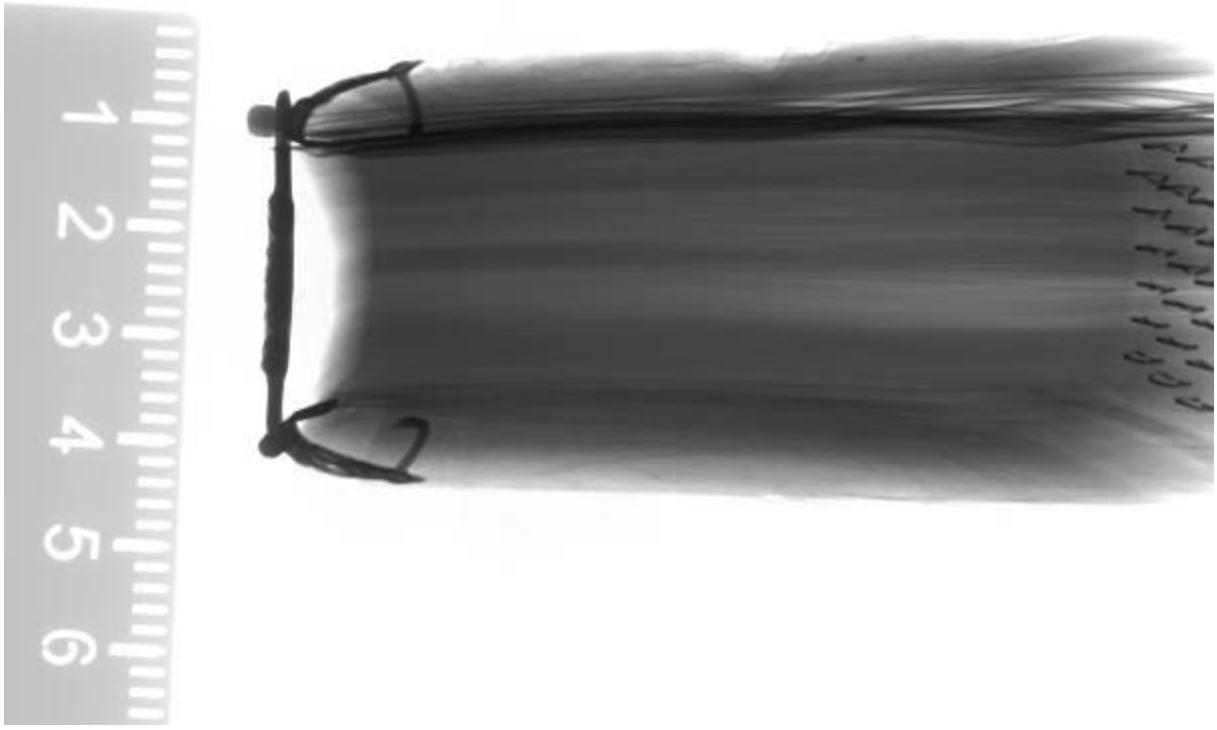
A detail of the spine of the book *Grundrisz zur Geschichte der deutschen Dichten*



A detail of the spine of the book *Grundrisz zur Geschichte der deutschen Dichten*. False bands of a book that is bound with metal staples.



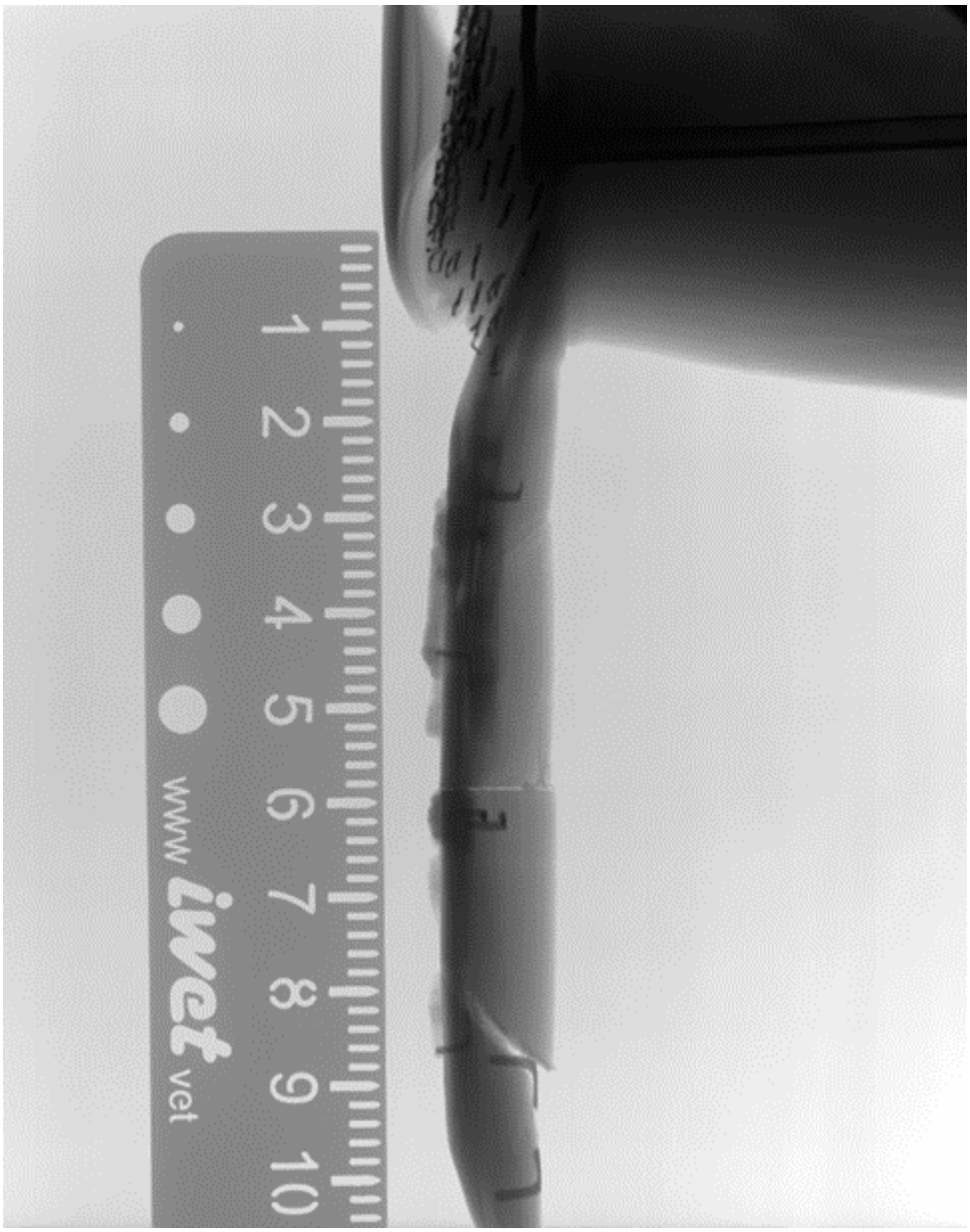
The book *Maria královna nebeská*, a view of the opened book.



Detail of the method of attaching the metal clasp to the book cover *Maria královna nebeská*. The picture also shows the metal staples used to bind the book.

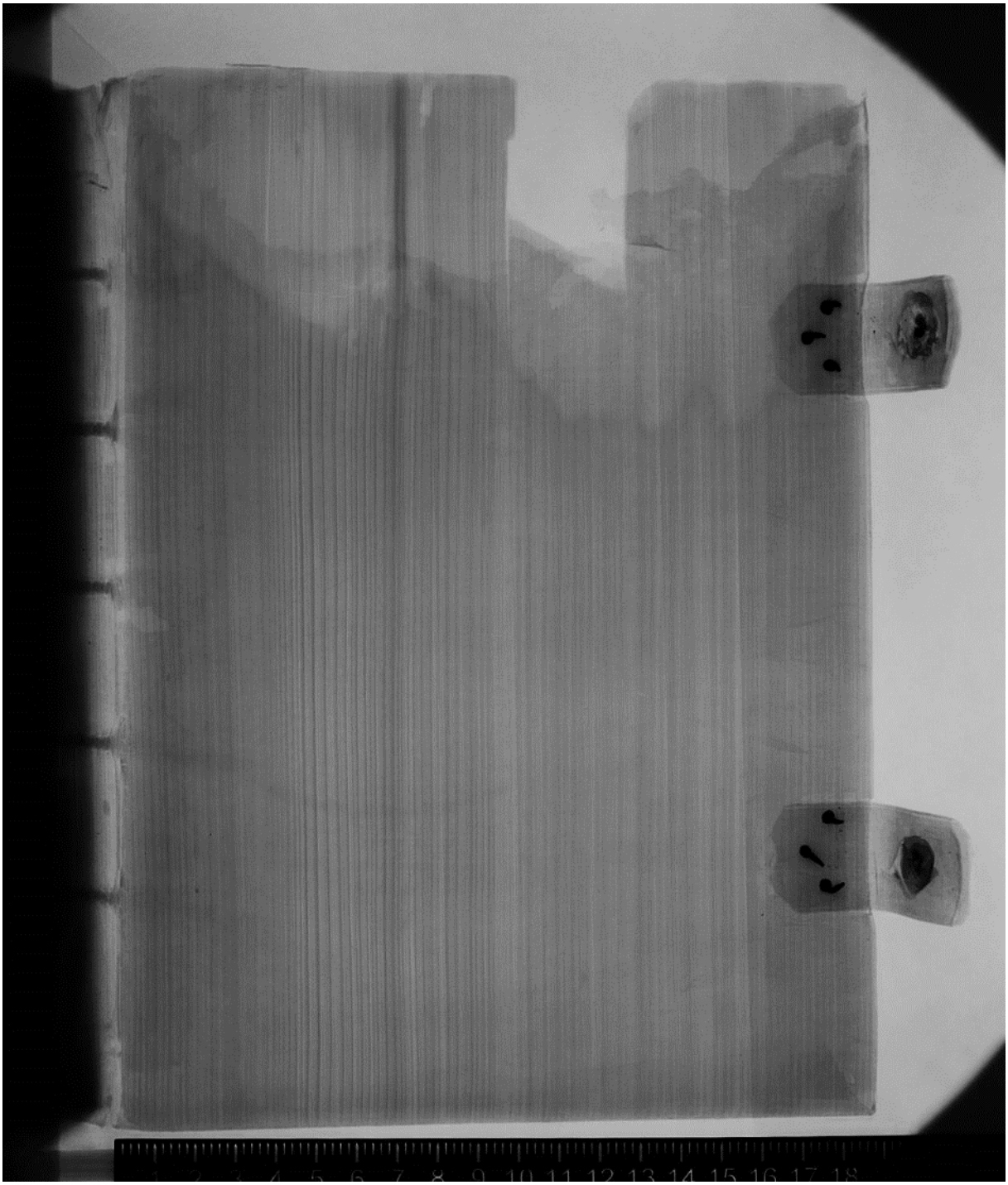
The book *Posvátní zvukové*, a view of the front cover.

The opened book *Posvátní zvukové*. The image shows the attachment of bone appliqués to the book cover, as well as the structure of plates made of bone, glue and metal clips.

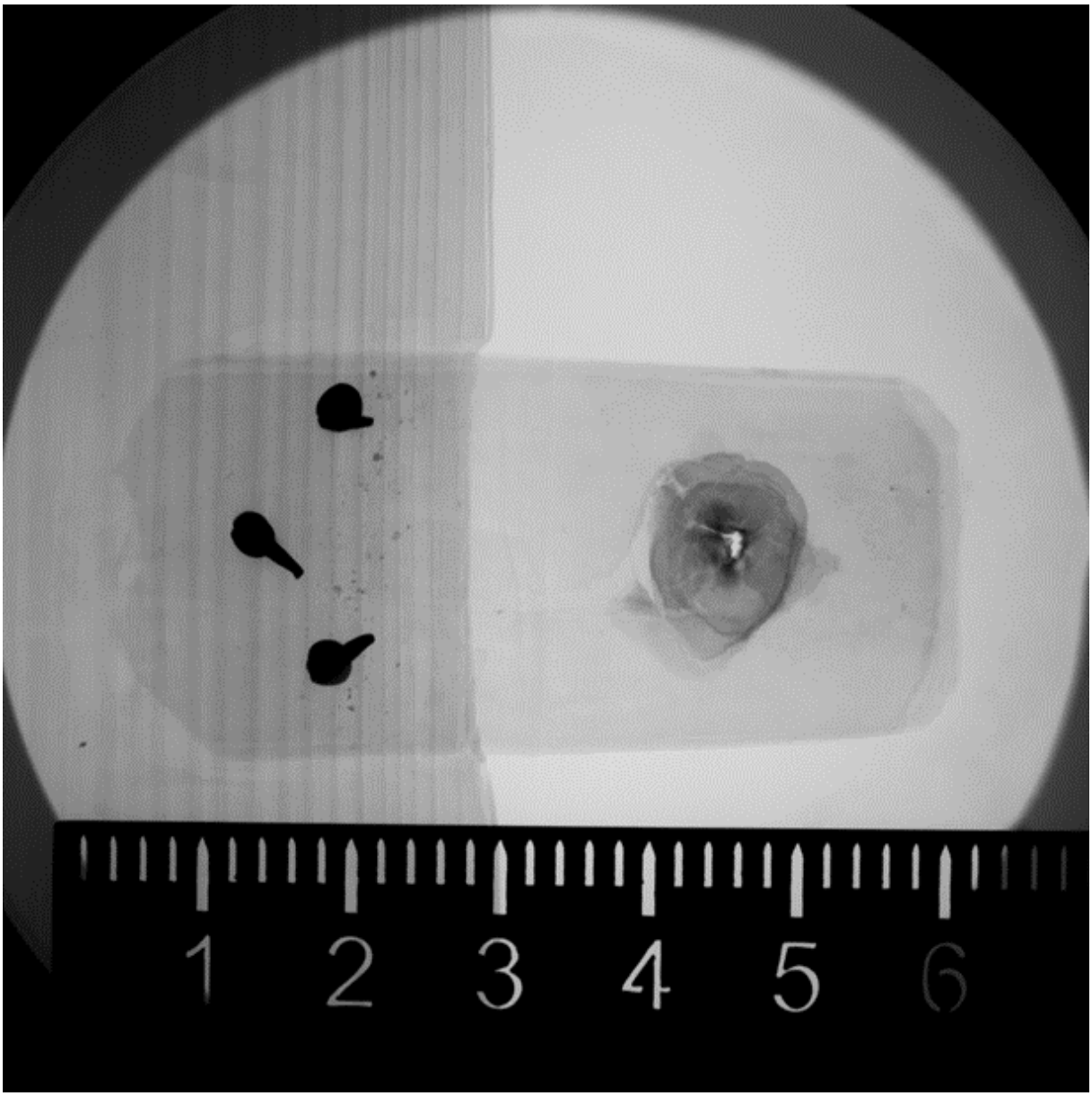


A detail of the method of bone appliqués attached to the cover of the book *Posvátní zvukové*. The picture shows the attachment of the bone appliqués to the book cover with metal elements.

The book *Animadversiones in regulas et usum critices*, a view of the back cover

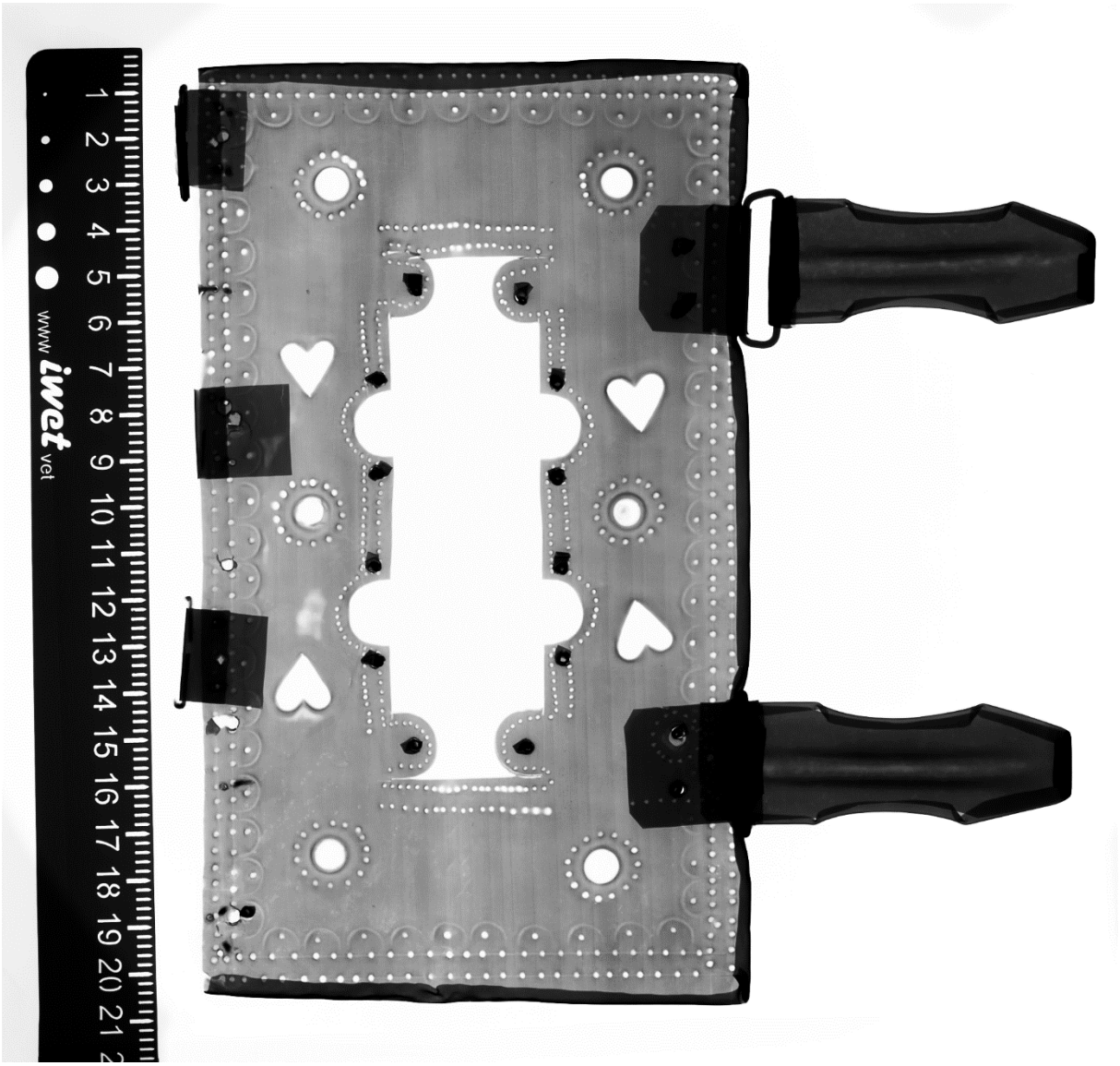


The back cover of the book *Animadversiones in regulas et usum critices*. The image shows damage to the cover in the form of cracks in the wooden cover and its missing parts – see the top of the image, as well as damage caused by insects. It is obvious that a part of the book covering is missing; parts of the fittings embedded inside the case and book bands are visible, as well.

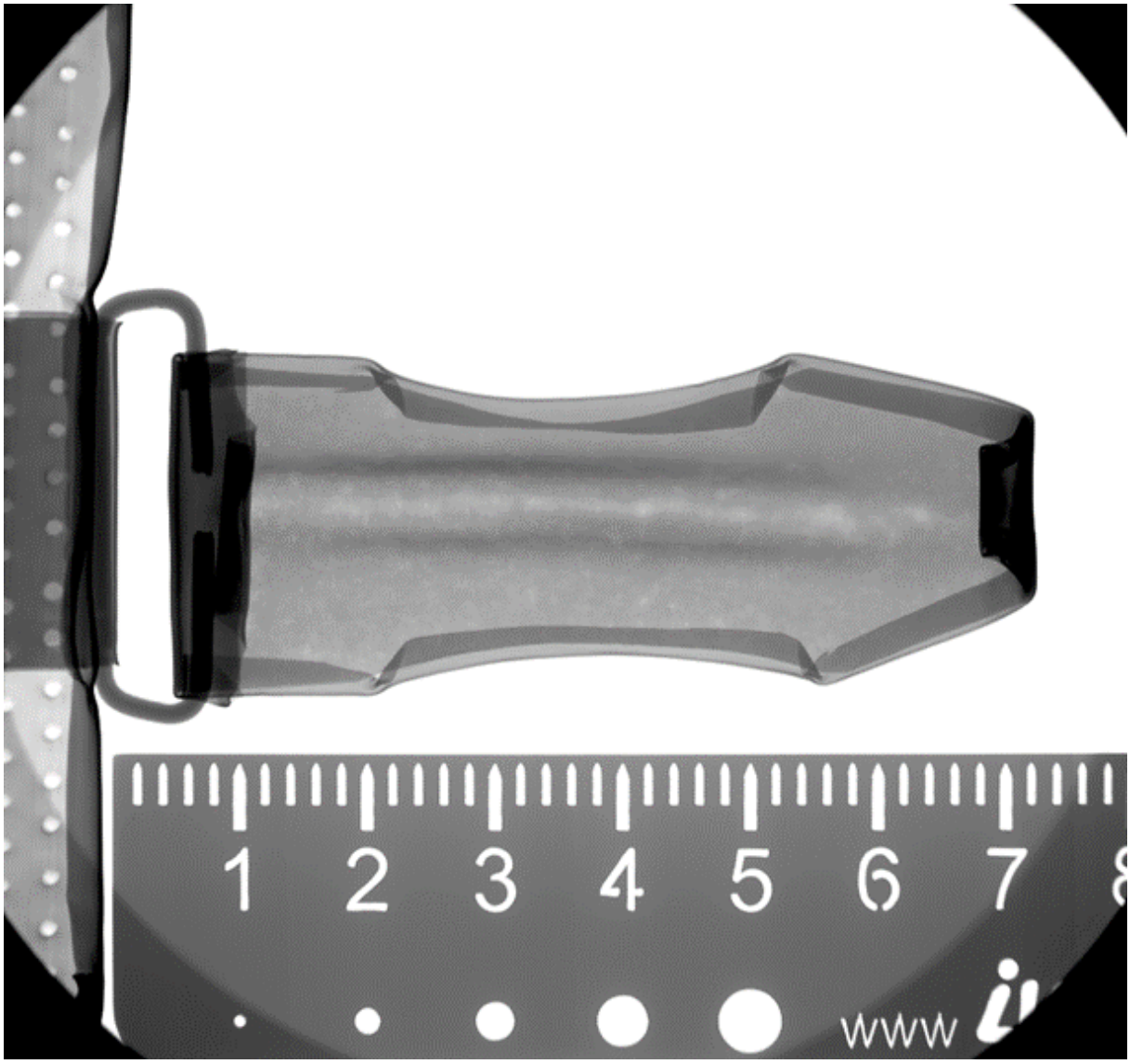


A part of the closure of the book *Animadversiones in regulas et usum critices*. The image shows the attachment of the tape to the cover using metal nails, as well as corrosion products of the metal in the tape that have penetrated onto its surface and into its structure from a missing metal component.

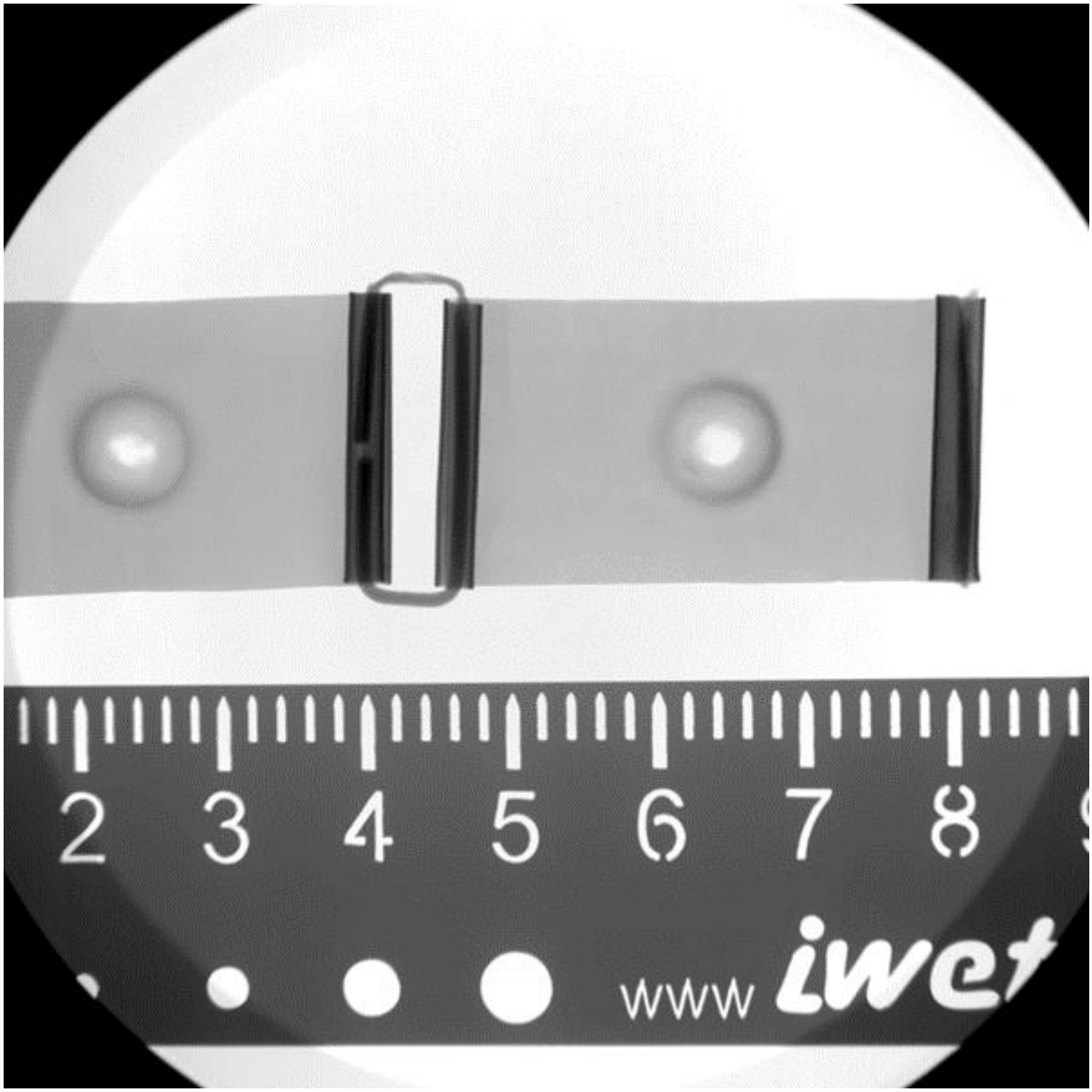
The book *Nebeklíč*



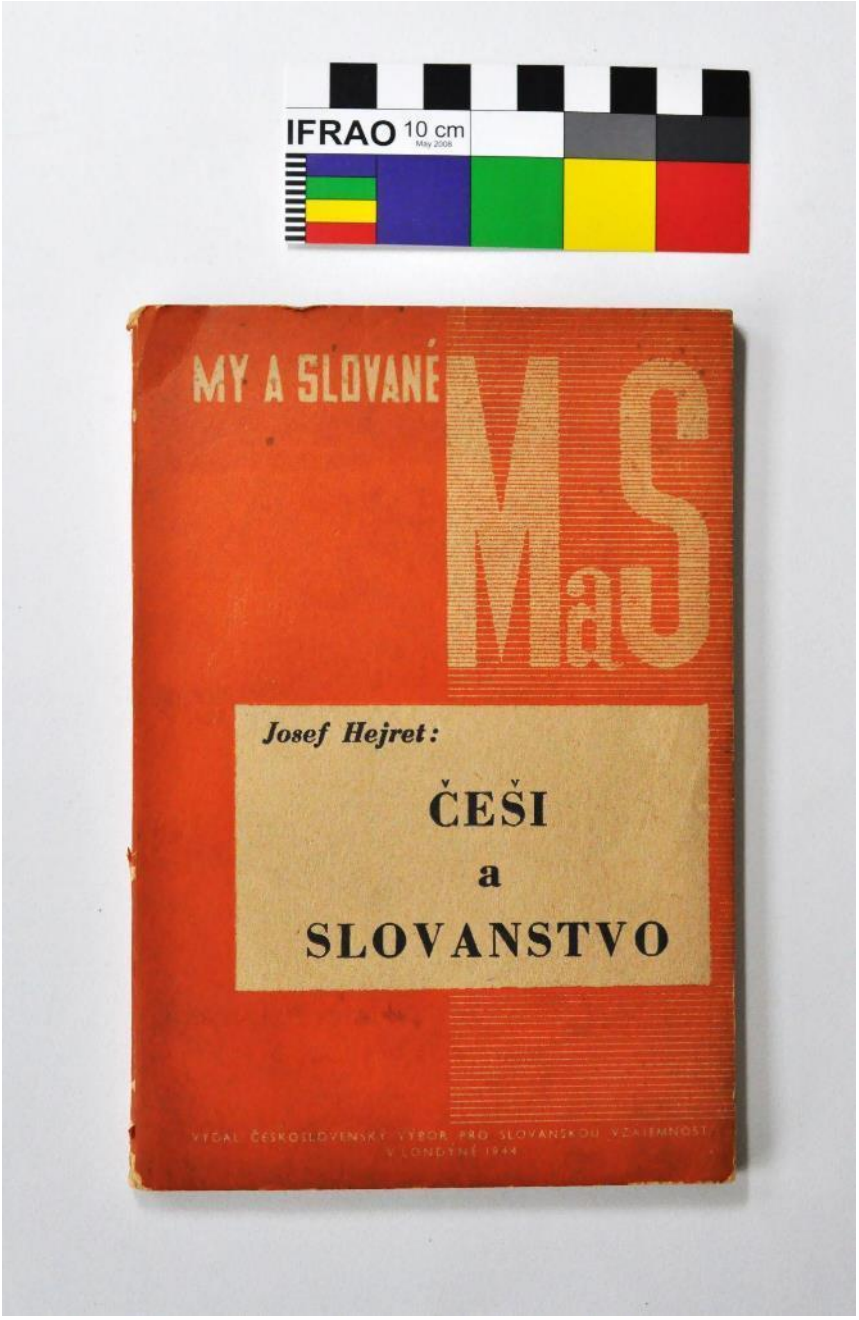
The back cover of the book *Nebeklíč*. The relief plate covering the book cover and the points of its attachment to the book cover are clearly visible in the image.



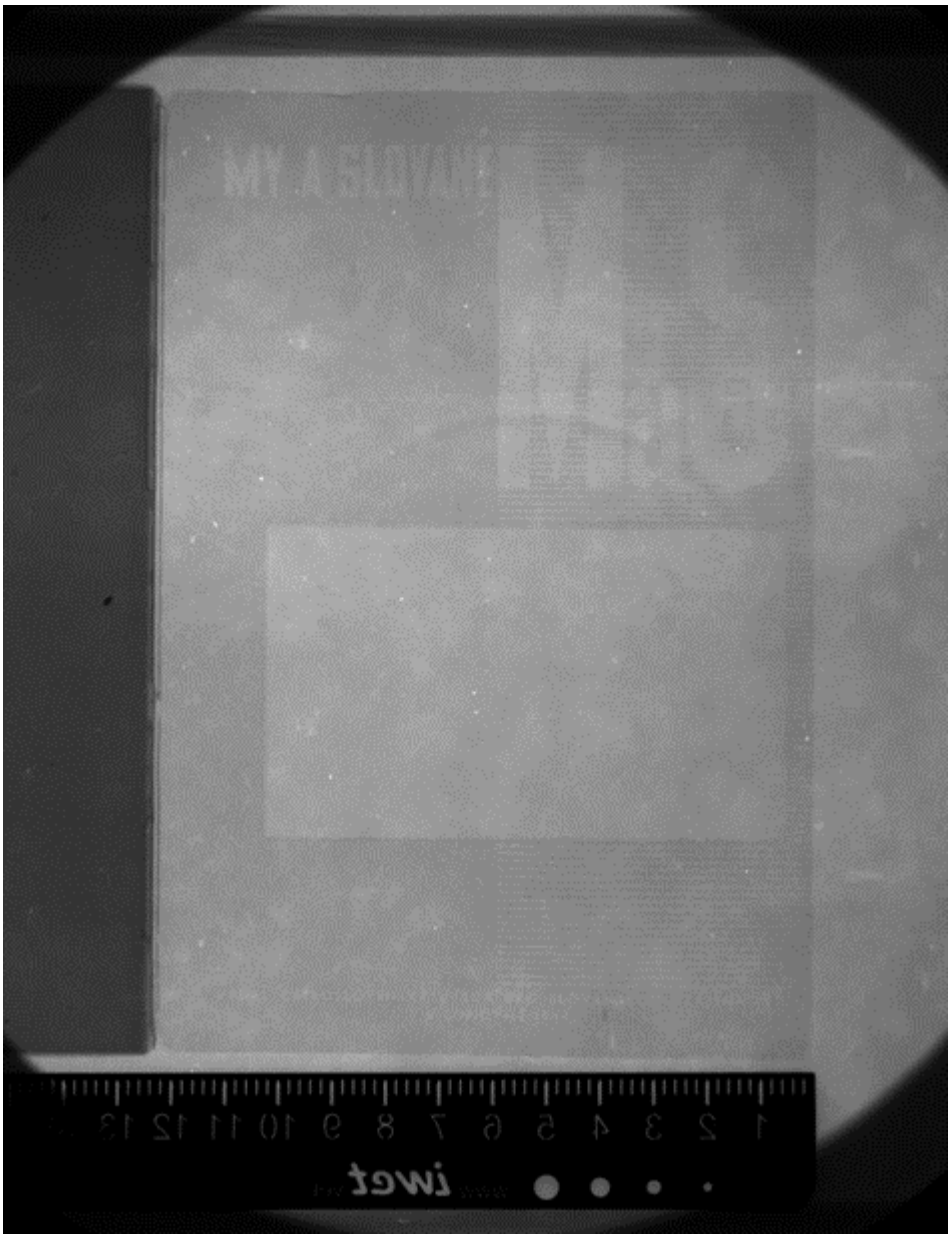
A detail of the ironwork of the book *Nebeklíč*. The buckle closure has a core made from material 3 mm thick; its face is covered with a thin metal sheet that also covers the book cover. A thin metal sheet folded over the core is clearly visible in the image. We can also see that the metal element connecting the clasp to the book cover does not show signs of significant corrosion damage.



A part of the spine fittings of the book *Nebeklíč*. The image shows a part of the metal fittings in the book spine. The metal link connecting the sheets shows clearly visible corrosion damage and significant thinning of the base material.

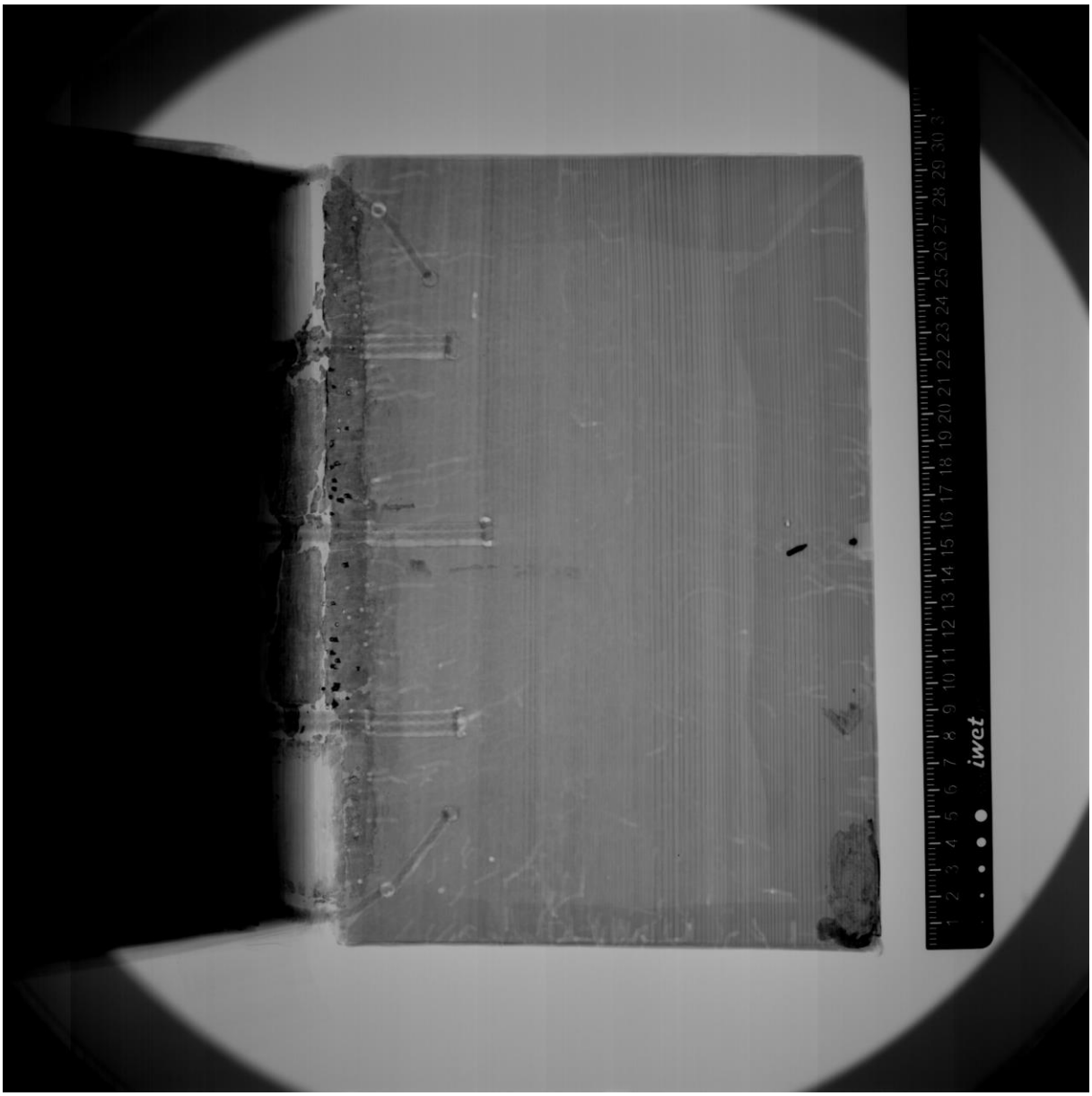


The book *Češi a slovanstvo* by Josef Hejret, a view of the front cover.



The front cover of the book *Češi a slovanstvo* by Josef Hejret. The orange colour on the cover of this book is interesting. This colour has a visible shielding property for X-rays, so the print on the cover is clearly visible in the image. Analysis with a portable XRF analyser showed an increased lead content.

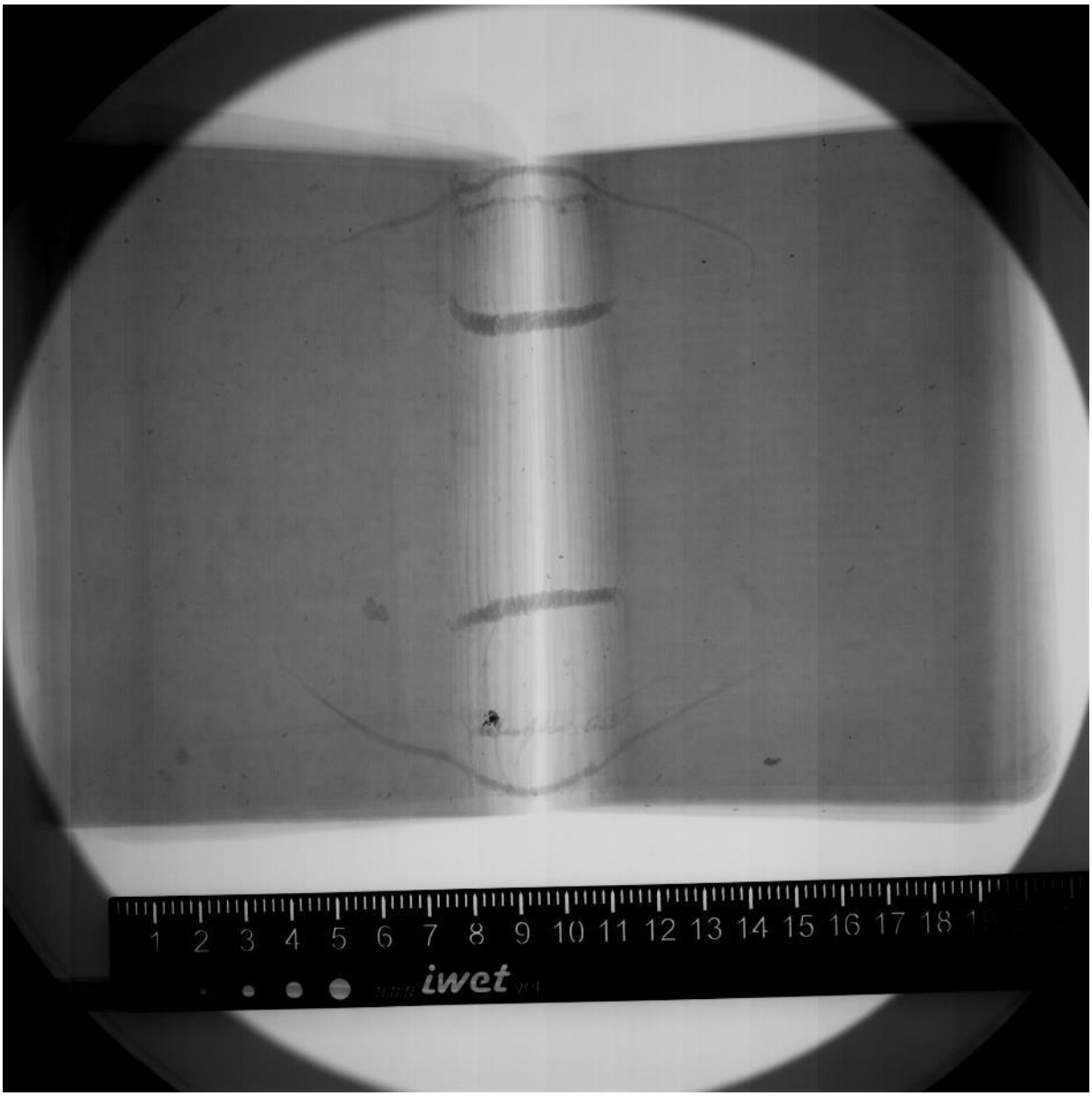
A book from the historical collections of the National Library (shelf mark XXIII D 136), front cover



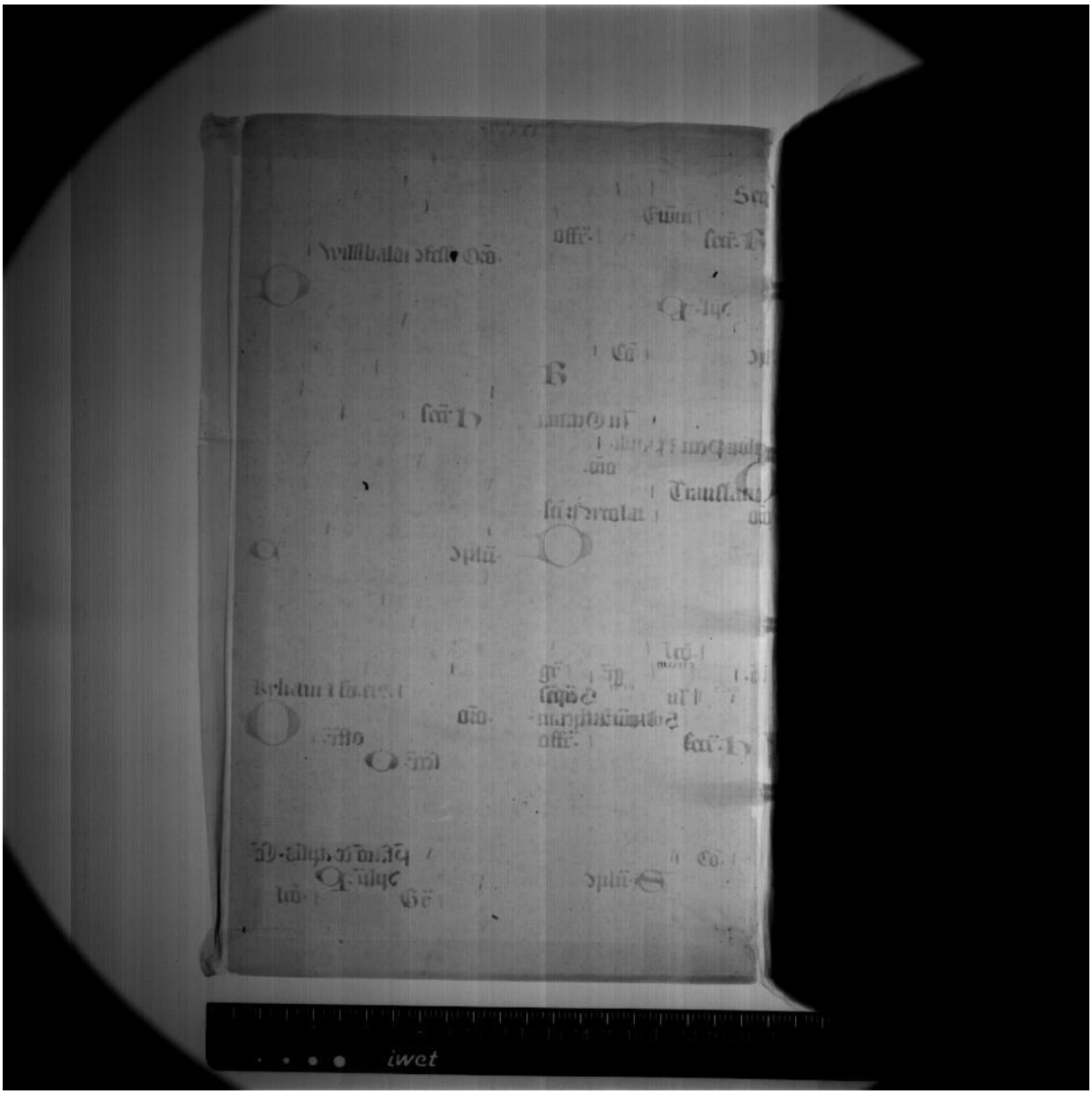
Front cover of a book from the historical collections of the National Library (shelf mark XXIII D 136). The book cover shown in the picture is heavily damaged by insects. The cover is made of wood and has a thickness of about 10 mm. It is also possible to see the termination of bands, residual attachment of the fittings which have been removed, overpainting of a part of the cover (lower right corner of the image) with paint containing apparently an admixture of heavy metal, damage to the book covering in the spine area and unexplained particles in the spine area shielding the X-rays.

Ghirard Imbert´s book *I reali di Francia : ne'qvali si contiene la Generatione de gl'Imperatori*, 1629, a view of the front cover.

Ghirard Imbert´s book *I reali di Francia : ne'qvali si contiene la Generatione de gl'Imperatori*, 1629, a view of the spine.



The opened Ghirard Imbert book *I reali di Francia : ne'qvali si contiene la Generatione de gl'Imperatori*, 1629. The image clearly shows intact bookbindings and inhomogeneities in the book cover.



Front cover of a book from the historical collections of the National Library (shelf mark 15 A 45/T.2).). The image shows a manuscript on parchment that was secondarily used as a book covering. The visible writing is only in red with a higher content of heavy elements (probably vermilion).