Chapter VII

Radiography

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1. INTRODUCTION*

X-rays were discovered by the physicist Wilhelm Conrad Röntgen on November 8, 1895. In the electromagnetic spectrum, X-rays are situated between 1.000 Å and 0.1 Å. X-rays are invisible. They travel in a straight line and pass through matter according to the nature of that matter and the energy developed. By reason of their ionizing character, they free electrons of the material through which they pass[1].

X-ray examinations have numerous applications in the medical and industrial fields. Tests of their application to the study of works of art were carried out promptly. Yet, no systematic assembling of data took place prior to 1938, date of two important publications (Burroughs, Wolters)[2]. Even though no study entirely devoted to the use of X-rays was published since that time, the application of X-rays developed considerably[3]. This development is practically parallel to its use in medicine and industry. New discoveries in these fields also benefited its application in the study of art works. Several of these improvements are directly applicable to the present sector of study.

2. PROCEDURES

2.1. *Sources*

X-rays[4] are produced by a vacuum glass tube made up of an anode (positive electrode) and a cathode (negative electrode). When the cathode filament is excited by a current it emits electrons. An electric volt is

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produced. The electrons are attracted to the anode and form a current that a focusing cup concentrates into a beam. The X-rays are produced by the rapid bombardment of a beam of electrons on the anti-cathode. The penetrating power of the X-rays is a function of their energy, this being inversely proportional to the wavelength. Hard rays and soft rays can be distinguished by their short or long wavelenghts. In the study of paintings, soft rays with a tube voltage of 20 to 60 KV are normally adopted. It is also possible to use very soft rays with a voltage less than 20 KV.

2.2. *Support*

The traditional radiographic film is made up of cellulose triacetate. Nowadays, polyester is used. An emulsion coating can be found on both sides of the film. These emulsion layers are placed on a substratum which facilitates adhesion to the support. A protective layer of gelatin covers them. In order to study works of art several types of industrial radio films of varying graniness, sensitivity and contrast are utilized. These films can be used in a darkroom or in daylight if they are properly packaged. They are available pre-cut in standard sizes or in long rolls several meters long. The use of large size films drastically reduces the manipulations and gives an homogeneous image of the painting[5]. Color sensitive film can be used in certain cases.

Paper can also be used as a support. Excellent results have been obtained this way (Voute and von Imhoff, 1972) by using an intensifying screen[6]. In very special cases when no running water is available for the treatment of negatives, there exists a paper support that requires the use of a cassette whith a fluorescent screen. The results are considered 'not exceptional'. With long term conservation in mind, the papers must undergo further washing and fixing. The question of aging and alteration of radiographs[7] as well as their conservation has been examined (Hollanders-Favart and Van Schoute, 1981). A particular aspect of the reduction of radiographs has been studied by White (1975).

2.3. *Taking the radiograph*

The object to be X-rayed is exposed to a beam of rays that strike the film which is situated directly beyond the object and in close contact with it. In the case of film of standard format, the object is placed at a distance ranging from ± 0.80 to 1.20 m from the source of the rays. When using large-format film, it is necessary to cover the entire surface to be filmed by increasing the distance bearing in mind the law of squared distances which states 'the intensity of the radiation by unit of the film surface is the inverse proportion squared of the distance film-lens'.

Various elements of the operating techniques will not be examined here. For example, it is necessary to consider the action of diffused rays that reduce the clarity of the image while weakening the contrast. These diffused rays originate in the object itself and from objects nearby that partially reflect rays that strike them. It is possible to use intensifying screens (fluorescent or lead) which increase the photographic effect. In the cases that we are concerned with, this utilization is rare but lead intensifying screens can improve the rendering of details and are likely to diminish the exposure time. Similarly, the use of filters is limited in cases where a stronger radiation is desired, a situation that normally does not exist in the radiography of paintings.

3. Particular procedures

Due to certain conditions concerning the nature of the object to be examined, such as paintings on opaque supports, reinforcement elements, such as cradling or when the support is painted on both sides, the traditional procedures of filming can be replaced by several improvements. These applications come into play the moment the film is taken, or afterwards. Notable among these interventions is the logetronic treatment of the film and the separation of the radiographic images by computer. Among the other advanced techniques, there is stratiradiography, stereoradiography, radiography by electron emission or by reflection, autoradiography, neutron activitation radiography, color radiography and xeroradiography.

It is important to mention the scanner which is widely used in the field of medicine. It acts on sections or slices of the object to be examined. An X-ray source and one or two detectors are submitted to a series of displacements and rotations related to the section chosen, and registers, for each point scrutinized, its power of absorption. The different values of amounts measured are transmitted to a computer which after calculations reconstructs the image of the section on a screen. This image can appear in black and white or in simulated colors, be photographed or still be translated into numbers. The results are recorded. This machine, therefore, gives valuable information in the qualitative and quantitative area.

Today, test applications in the history of art have revealed particularly interesting results for three-dimensional objects (D. Hollanders-Favart and R. Van Schoute, 1978). This area will not be covered in this study[9].

3.1. *Logetronic radiography*

In the case of parqueted panels, a system of masks can be used, like placing Lucite n° 41 in the intervals of the cradle, to modify the exposure of the various areas (Bridgman and Keck, 1961). This method is time-consuming

Fig. 1. After Dieric Bouts, Jesus in the House of Simon, *2nd half 15th century. Brugge, Sint-Janshospitaal (Neg. Lab. Art., U.C.L.).*

and often produces unsatisfactory results[10]. Using a photographic wire on the cathode tube[11] can considerably improve the image (Craig, Delbourgo, 1958 ; Loose, 1964 ; Van Schoute, 1970). A luminous beam emitted by a tube of cathode rays strikes the radiographic negative. An automatic procedure regulates the mask in terms of the negative and permits the restitution of details that an ordinary development would omit. A balanced, improved image with good definition is obtained with logetronic radiography. The logetronic technique can be used alone or together with stratiradiography.

3.2. *Separation of the radiologic images by computer*

When two paintings are superimposed on the same support, their X-rays are often difficult to interpret, whether the density of the paint layers is similar or very different. The importance of reading each radiographic image separately cannot be overemphasized. Such a result was obtained (Druzik, Glackin, Lynn and Quiros) in the case of a painting on panel by an anonymous Netherlandish artist representing the *Descent from the Cross* inspired by the Rubens composition preserved in the Antwerp Cathedral. This work covers another painting from which it is separated only by a sheet of paper. The technique of electron emission radiography provides an X-ray image of the visible composition. After eliminating the highly visible wood grain structure, one proceeds with the subtracting of the two images in order to isolate them so that the underlying composition can be seen and identified[12].

3.3. *Stratiradiography*

As early as 1935, A. Vermehren noted the importance of eliminating foreign elements in the radiographic image of the paint layer. In order to do this, he created an apparatus in which the displacement in an arc of a circle by the X-ray source gave a clear image only in one plane of the object being examined. He improved this process[13] by adopting a double movement, pendular for the X-ray source and rotating for the painting (Vermehren, 1952).

In 1938, B. Marconi[14] developed a technique of rotary radiography produced by allowing the X-ray apparatus to describe a complete circumference during the exposure time. The ray is 50 cm ; the object to be X-rayed is at a distance of one meter. The machine is tilted in such a way that the focal spot strikes the center of the film. The image formed is of the layer most directly in contact with the film. The other layers are practically invisible (Marconi).

Two other processes were proposed and tested by Murray Pease[15]. In the first experiment, the painting and the film remained stationary while the X-ray source describes an arc. In the second case, considered the more practical one, the panel and the film are uncovered around the arc within the X-ray beam. In the two instances, like other procedures based on the same principle, the sensitive film must adhere as much as possible to the layer to be X-rayed (Murray Pease, 1946).

A decisive step was taken in 1961 when Loose[16] developed stratiradiography. The importance of this technique lies in the fact that it eliminates the need to handle the painting and the emitting tube can be manœuvred with great ease. The exposure time is cut into four shots of the same length taken from distances of 45° in such a way to sweep the surface of the painting in its entirety (Loose, 1964).

In spite of a great deal of interest in this last technique, the most satisfying[17] results are obtained when stratiradiography and logetronic radiography are used for the same case.

3.4. *Stereoradiography*

Applying the principles of stereoradiography to X-ray, Loose (1960) showed the usefulness, in certain cases, of rendering an image with a three-dimensional appearance. For example, for wings of altarpieces painted on the front and the reverse side[18]. The process is simple and can be obtained both by sufficient shifting of the X-ray source as well as moving the object. At the same time, Kozlowski (1960) praised the system of microstereoradiography[19]. The limits of these procedures[20] are apparent when it is necessary to use a special viewer or a film in two colors, visible only with special glasses as in the case of stereoscopic macrophotography (Loose, 1961). In any case, the applications of stereoradiography are justified especially when three-dimensional objects have a high relief such as sculpture, furniture or musical instruments.

3.5. *Electron emission radiography*

The method[21] was developed in 1958 (Bridgman, Keck and Sherwood). It requires a voltage tube of at least 150 to 250 KV, an important filtering of X-ray beams and the placement of the painting and a sensitive plate (note that this should be free of its protective envelope and placed underneath and not on top as in other methods) in a vacuum cassette to obtain a good adhesion between the two elements. The electron emission caused by the action of the X-rays on the metallic pigments of the painting produces an image that reveals the condition of the paint layer without interference from the support.

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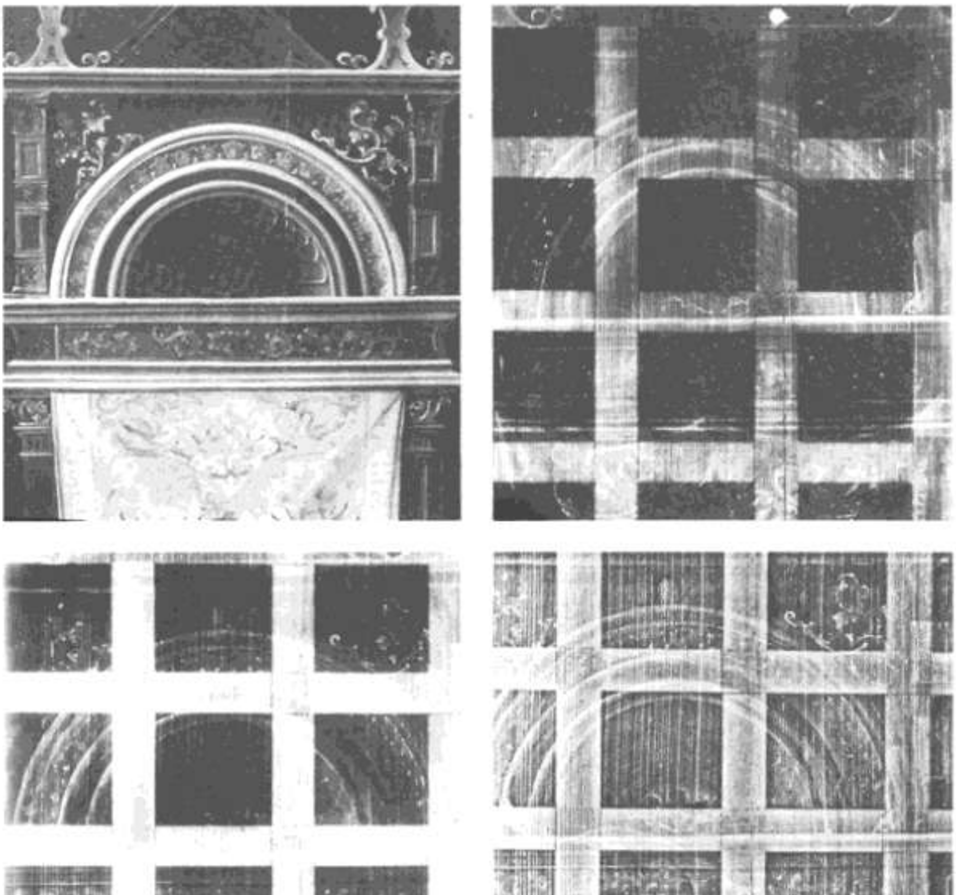
Fig. 2. After Dieric Bouts, Jesus in the House of Simon, *2nd half 15th century.*
a. Brugge, Sint-Janshospitaal, detail. (Neg. Lab. Art., U.C.L.)
b. Detail : radiography 35Kv, 4 ma, 90 sec., 80 cm (Neg. Lab. Art., U.C.L.)
c. Radiography 35Kv, 4 ma, 45 sec., 80 cm (Neg. Lab. Art., U.C.L.)
d. Logetronised radiography (Radiology service of Professor Baert, Sint-Rafaëlskliniek, Katholieke Universiteit, Leuven) (Neg. Lab. Art., U.C.L.).



a b c d

A radiography is not an objective document, but rather depends on various conditions such as the characteristics of the emitting tube, the kilovoltage, the exposure-time and miliamperage, the characteristics of the film and the development. In the case of this painting, the cradle on the reverse increases locally the densities. In 2c the radiography is the result of a 45 sec exposure time, while in 2b the exposure time reaches 90 sec. In the first case (c), the areas not covered by the cradle are clearly legible, while in the second case (b) the areas covered by the cradle are best legible.
A treatment of the film after development, the so-called logetronisation, uniformises the values as to make the radiography perfectly legible in its complete surface.

Fig. 3. P.P. Rubens, Triptych of the Descent from the cross *(1612-1614). Antwerp, cathedral ; central panel, detail in ordinary light (Copyright A.C.L.).*

This method can be applied to wood, canvas, copper[22] (Bridgman, Michaels, Sherwood, 1965) or paper supports[23] (Pollack, Bridgman, Splettstosser, 1955, Bridgman, 1965). In the last case, the X-rays react on a lead sheet. A uniform yield of electrons results and the paper absorbs a part of it. The image on the film is produced by the electrons that penetrate the paper.

3.6. *Autoradiography*

Neutron beams emitted by an atomic pile can result in the radiography of the object[24]. The different coefficients of absorption of neutrons in comparison to X-rays can cause different results from those obtained by traditional X-rays (Barton, 1965). The application to oil paintings, using a

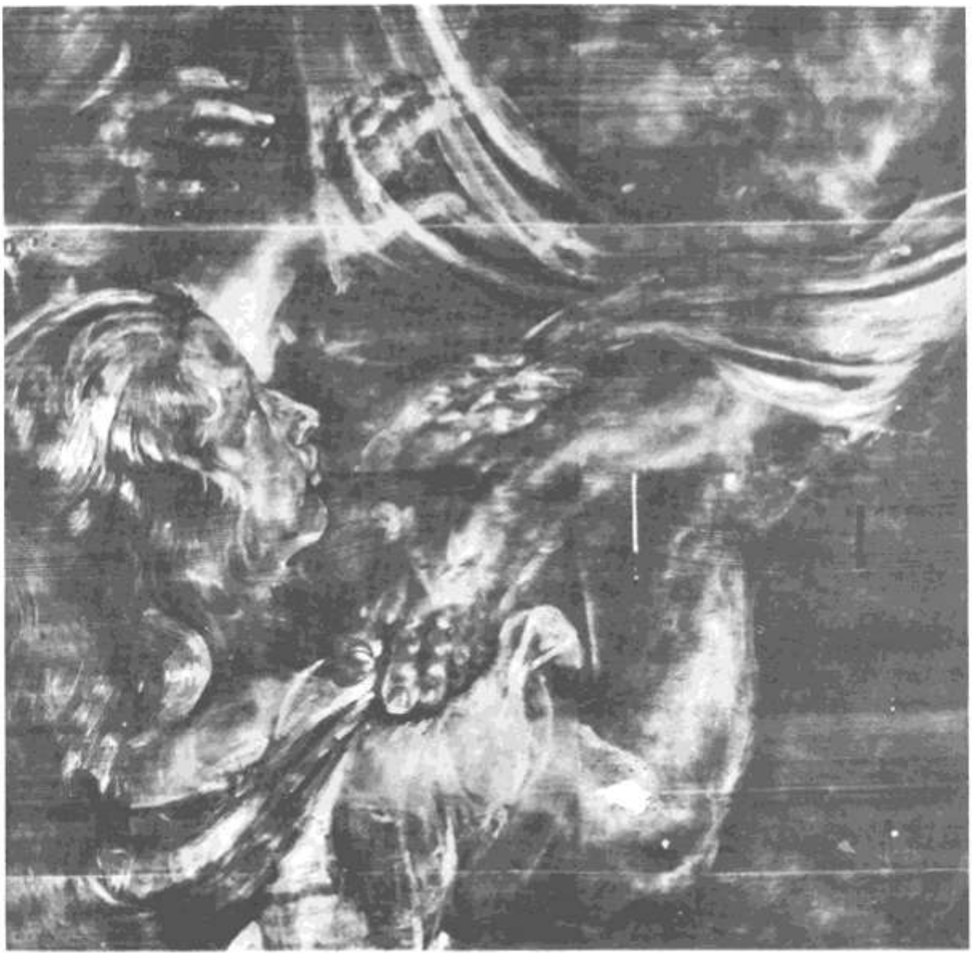


Fig. 4. P.P. Rubens, Triptych of the Descent from the cross *(1612-1614). Antwerp, Cathedral ; radiography 35 Kv, 4 ma, 45 sec., 80 cm (Copyright A.C.L.). Radiography of a detail of Rubens'* Descent from the Cross *(Antwerp, Cathedral) reveals a change in composition in the left arm of a Holy Women. This change in composition is due to the Master himself, and was done shortly after completion of the painting. Indeed an ancient copy (London, Courtauld Institution) was executed according to the first stage. (P. Coremans et al.,* La Descente de croix *de Rubens. Étude préalable au traitement,* in *Bulletin de l'Institut royal du patrimoine artistique, IV, 1962, p. 6-187, pl. 12-13). Rubens' fast working habits with large brushstrokes is well illustrated by the radiography. Large streaks in rather strong densities correspond to a coating layer on the reverse.*

very moderate[25] radioactivity, has made evident the possible identification of a certain number of pigments and their distribution in painting (Sayre and Lechtman, 1968). This procedure is described in detail[26] by Cotter (1981) and applied to miniatures by the 'Spanish forger' and works in the style of the

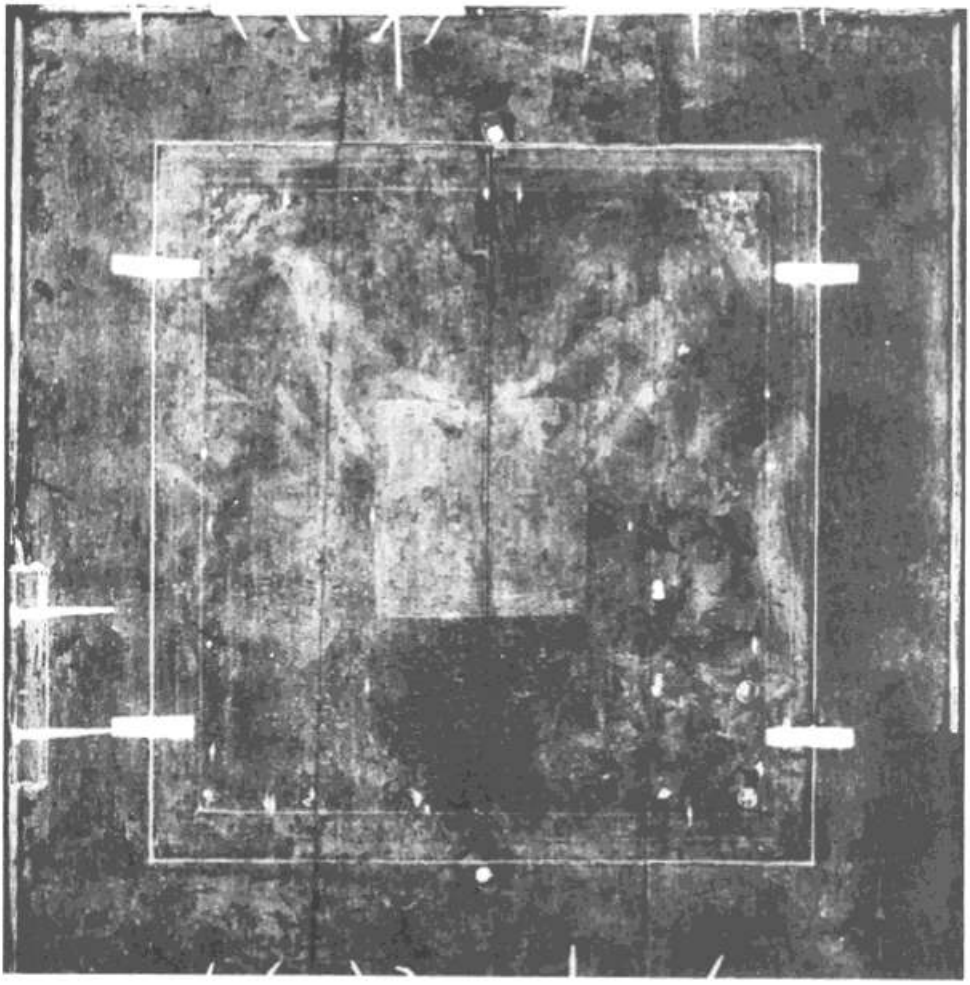


Fig. 5. Flemish. anonymous, Triptych with Annunciation, *ca. 1400. Tongeren, Onze-Lieve-Vrouwkerk. Triptych closed ; radiography 35 Kv, 4 ma, 45 sec., 80 cm (Neg. Lab. Art., U.C.L.). (See photograph p. 22, Fig. 6).*

Characteristics of the support appear clearly on the radiography : joints, dowels hinges, locks, non original metallic reinforcements, and pieces of wood repairing the old support, either glued on (right) or nailed (left).

In pre- or para-eyckien paintings, radiographies reveal a strong general density in the painted areas with little or no contrast due to absence of modeling.

Besides numerous lacks, the angels wearing the Veil on the central panel are visible on the radiography of the closed triptych, whereas the Anunciation, lighter in execution, is nearly invisible.

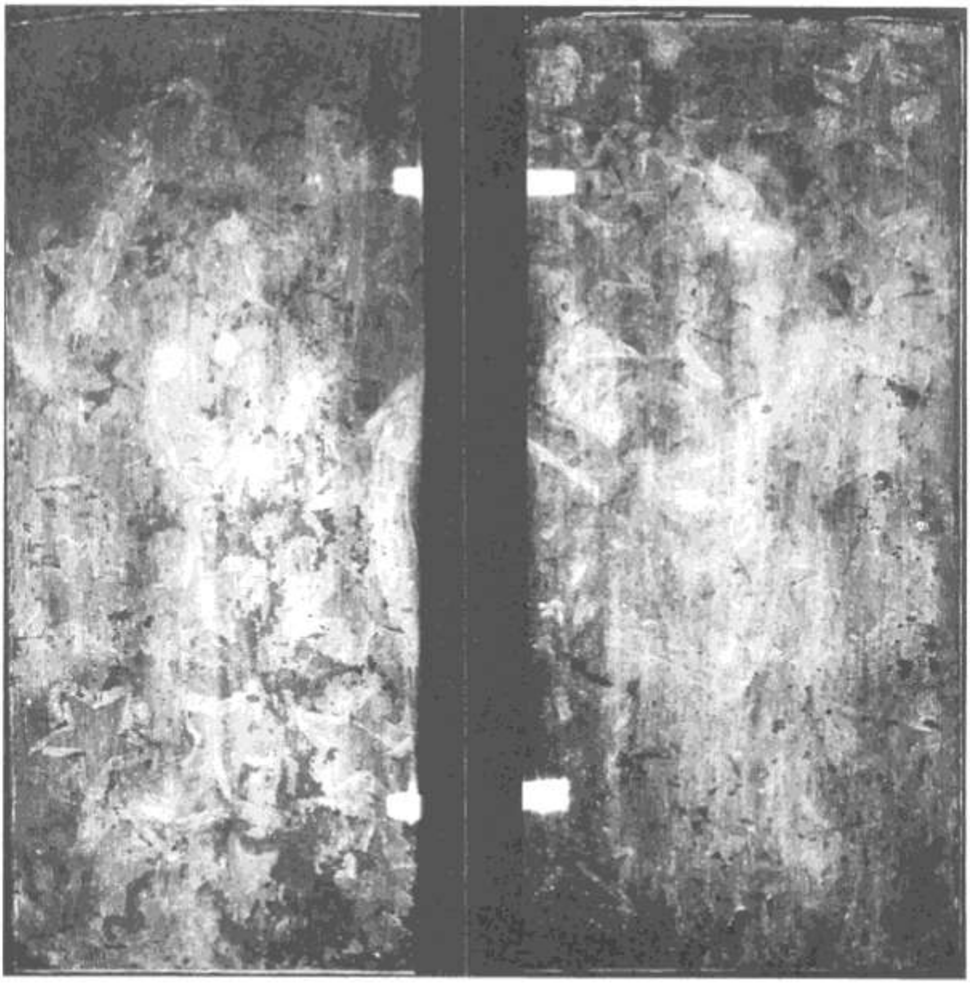


Fig. 6. Flemish Anonymous, Triptych with Annunciation, *ca 1400, Tongeren, Onze-Lieve-Vrouwkerk, wings : radiography 35 Kv, 4 ma, 45 sec., 80 cm (Neg. Lab. Art., U.C.L.).* *(See photograph p. 22, Fig. 6).*

The radiographies of the wings solely allow to read their paint layers of front and reverse. The stars decorating the reverse appear in their somewhat rough execution. On the left wing one can see the angel and the dove, and on the right wing, the Virgin with, in the upper corner, God the Father. The numerous lacunae in the paint layers appear as dark areas on the radiography.

15th century (R.A. Blakelock). The standard work dealing with this question is devoted to works of the 17th century in the Metropolitan Museum of New York[27], particularly paintings by Rembrandt, Van Dyck and Vermeer (Meyers, Wynn Ainsworth, Brealey, Cotter, Haverkamp-Begemann, Sayre and van Zelst, 1982).

3.7. *Color radiography*

Inspired by the color technique used in the field of medicine (Lietaert-Parmentier, Pirard-Schoutteten, Van Schoute, 1972), three types of possible applications to the history of art were shown[28]. Simulated color radiography produces an image of high contrast in comparison to the original black and white radiography which showed a rather weak contrast. Direct radiography in several colors uses a color sensitive film ; the insertion of yellow, cyan or magenta filters during the development helps to distinguish the results obtained. Sometimes, details are brought to light ; other times, areas of strong density. The best results have been obtained with monochromatic blue radiography with a very fine grain and with a large latitude of exposure. The improvement of the image is evident. New indications appear in the areas of no contrast in black and white radiography. Areas of low density reveal unexpected nuances. Areas heavily charged with lead white that have a homogeneous appearance when conventional methods are used, present differences providing more complete information about the real condition of the densities. In most cases, the use of yellow filters by reading results in a deepening of the image.

3.8. *Xero-radiography*

Xero-radiography uses the usual methods of filming with X-rays[29]. The traditional film is replaced by a support covered with selenium, developed dry by a photo-electric process and immediately transferable to a paper support (Boag 1973). The overall blue color yields an image full of information. The use of xero-radiography in the field of medicine and particularly for mammography. To our knowledge, it has not been the subject to a study in the field of art history. Research is currently underway at the Bayerisches Nationalmuseum in Munich. The initial results are promising.

4. Applications

4.1. *Brief survey*

It is not possible to envisage charting the entire history of the application of X-rays to the study of paintings in such a limited space. Only a few points will be uncovered. Shortly after Röntgen's discovery and particularly after the Second World War, radiography was adopted in museums in Germany, France, Great Britain and the United States. There are only a few publications dedicated to these studies even though numerous studies were carried out.

An important study, undertaken[30] by Bauer and Rinnebach (1931) determined the advantages and the limits of the utilization of radiography and warned for possible falsifications.

Technical Studies in the Field of the Fine Arts published from 1932 to 1942 made a considerable contribution towards defining the methods and applications of X-rays[31].

In the year 1938 two important books were published : Alan Burroughs, *Art Criticism from a Laboratory*, and Ch. Wolters, *Die Bedeutung der Gemäldedurchleuchtung mit Röntgenstrahlen für die Kunstgeschichte*. Since 1925, Burroughs[32] has been using radiography for art works at the Fogg Museum at Harvard University. Although he does not neglect the other laboratory methods, he mainly uses X-ray techniques. He demonstrates the usefulness of this method in the discovery of fakes and copies. He estimates that a number of the problems in art history, notably in Flemish painting

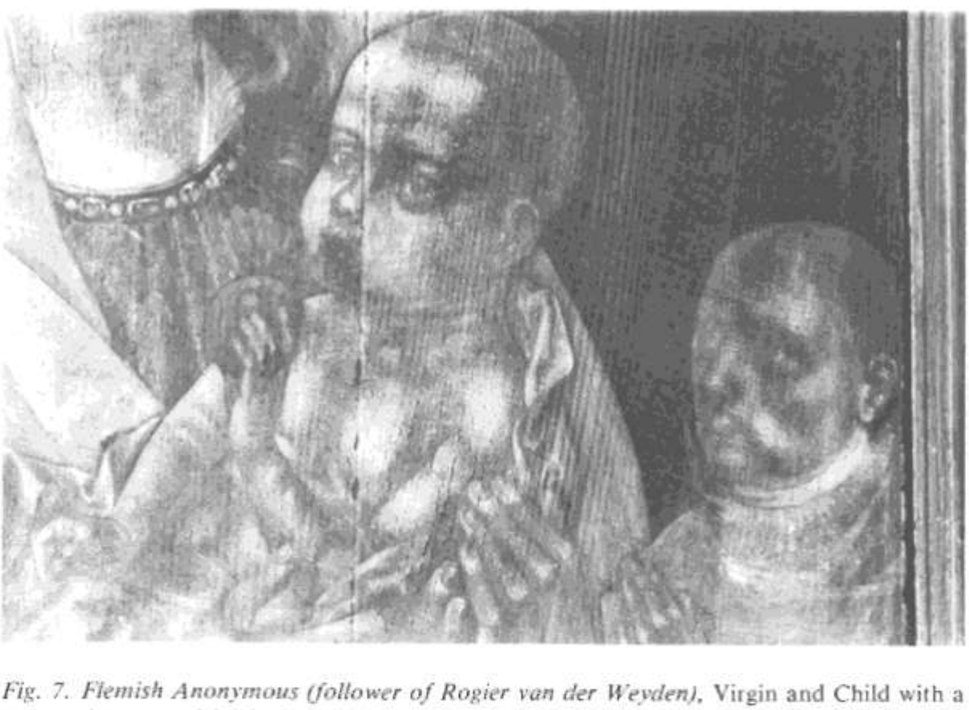


Fig. 7. Flemish Anonymous (follower of Rogier van der Weyden), Virgin and Child with a donor *(2nd half of the 15th century). Tongeren, Stedelijk Museum, radiography 35 Kv, 4 ma, 45 sec., 80 cm (Neg. Lab. Art., U.C.L.). (See photograph p. 23, Fig. 7). In opposition to the painters of the 14th century, the masters of the 15th century achieved a better modelling, resulting — on the radiography — in contrasts between areas of low and high densities.*

could be solved with these techniques especially the problem of the van Eyck brothers and Campin-Flémalle-Weyden for which he proposes several solutions. In his study, Wolters[33] examines several paintings in Berlin, Vienna, Frankfurt and Kassel. He deals primarily with Flemish and German primitives. It is worth noting that this study is presented like a manual concerned with all aspects of X-raying paintings in a theoretical and practical way depending on the physical and technological conditions of the works to be examined. Wolters' publication can be considered a reference source in the field of the Fine Arts and nearly thirty years later it has not been replaced. Among works exclusively devoted to radiography it is important to mention the recent publication devoted to the application of X-rays to art history in general : *X-rays in Art. Physics - Technique - Applications* (Gilardoni, Ascani Orsini, Taccani, 1977). A large portion of this extremely well-documented publication is devoted to the study of paintings. For the first time, as far as we know, it proposes an atlas on the application of X-rays by L. Mucchi[34].

Immediately after World War II, the *Laboratoire central des Musées de Belgique* which in 1957 became l'*Institut royal du patrimoine artistique*, undertook an important project. Under the guidance of its director Paul Coremans aided by a team of notable specialists, a series of studies were carried out on the occasion of a conservation treatment that was a major breakthrough in understanding Flemish painting techniques of the 15th century[35]. The studies included *The Mystical Lamb* by van Eyck (1953), *The Justice of Othon* (1958) by Dirk Bouts, *The Carrying of the Cross* by Hieronymus Bosch (1959) and *The Descent from the Cross* by P.P. Rubens (1962-1963).

The most important characteristic of these studies is the fact that they brought together specialists from various disciplines to solve the diverse problems — first of all, the questions of conservation and restoration along with all the physical and chemical methods of the laboratory with X-rays playing just a minor role among the other means of investigation.

The *Corpus de la peinture dans les Anciens Pays-Bas méridionaux*, edited by the 'Centre national de recherches, Primitifs flamands' (Brussels) led to the publication of several X-rays of Flemish works from the 15th century[36]. It is important to note that initially and for several years only X-rays that revealed special information related to a painting were published. During the Sixties it was accepted that for every ancient painting the publication of an X-ray was useful, independently of any particular information it revealed concerning the painting.

In 1967 the Central Museum of Utrecht published[37] sixty X-rays of antique paintings of the Netherlands (Houtzager, Meier-Siem, Stark, Smedt). The documents are explained and an effort towards a certain systematization

Fig. 8. Flemish Anonymous, Holy Sacrament of Miracle *(2nd half 16th century — 18th century ?) Kuringen, Herckenrode abbey (Neg. Lab. Art., U.C.L.).* *(See photograph p. 24, Fig. 8).*

In interpreting a radiography, one should always take into account the characteristics of the document as well as those of the painting.

This radiography reflects a heavily damaged painting consisting of two superimposed compositions. In the original 16th century composition the Christ in the centre was sustained by two angels on a pinkish-red background. The now visible composition is an 18th century overpainting of poor quality. The abundance of lacunae in the paint layers as well as the fact that the overpainting is much thicker than the delicate 16th century painting makes it difficult to gain information about the underlaying composition.

of the commentaries was realized. The work is prefaced with a useful commentary on theory of the application of X-rays to the study of paintings. This is an uncommon publication. Generally radiographs are mentioned as one among other methods.

Along the same line of ideas, L. Mucchi came out with a catalogue for an important exhibition, *I Leonardeschi ai Raggi X*. About 100 paintings are studied with the publication of radiographs accompanied by a commentary[38].

On the occasion of exhibitions, X-rays of paintings were presented, in some cases with comments. These exhibitions can contribute significantly not only to the laboratory methods but also to the study of painting techniques and the question of conservation and restoration of a work of art. It's virtually impossible to give an exhaustive list of these scientific exhibitions but we will mention some that seem significant to us.

For example, *Les dossiers du département des peintures* since 1971 in the Louvre Museum in Paris. Nearly thirty exhibitions in which a documentary aspect dominates contributed considerably to a better understanding of the museum's rich collection of antique paintings as well as of the technology and the conservation of these works[39].

In 1975 the city of Louvain organized an important exhibit on *Thierry Bouts et son temps* (Dirk Bouts and his Time). A special section, illustrated by works on view, showed the usefulness of laboratory methods, especially radiography, in the understanding of paintings. In addition to the catalogue, which contained a section of technological aspects of the works, results of the scientific investigations undertaken during the exhibition were published one year later in *Arca Lovaniensis*[40].

In 1979, the province of Limburg presented a double exhibition : one part, *Gemälde im Licht der Naturwissenschaft* loaned by the Herzog-Anton Ulrich Museum of Braunschweig (K. Nicolaus) and the other, an original exhibit of works belonging to the patrimony of the province, *Regards sur l'art. Examen des peintures par les méthodes des sciences naturelles (A Look at Art. Examination of Paintings by Natural Science Methods)*[41]. It presents works in their true condition in order to carry out thorough examinations and sensitize the public to the problems of conservation and restoration. Next to other documents, X-rays of the entire surface of the works exhibited were presented using methods developed by Van De Voorde[42].

Recently three very prestigious exhibitions in Paris, Geneva and Florence brought to light the most recent developments in the application of X-rays along side other techniques for the study of works of art[43].

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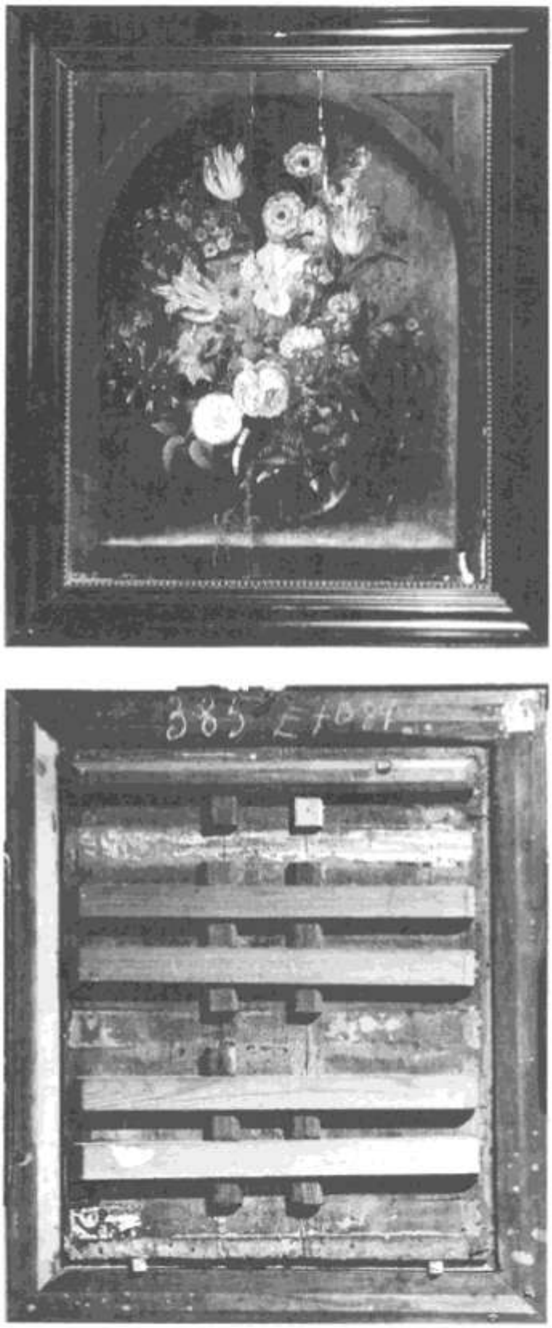

Fig. 9. Anonymous, (20th century ?), Flowers, *Private collection ; front and reverse (Neg. Lab. Art., U.C.L.).*

In 1969, on the occasion of the first triennial reunion of the ICOM Committee for Conservation, R.J. Gettens estimated that at the time there existed some 100,000 X-rays of art objects. In the face of such a quantity, the need to establish inventories was felt. A study was undertaken by S. Rees Jones and the results presented in Madrid in 1972[44]. Concurrently, a proposal to create a center dedicated to radiography in the field of fine arts was developed by White[45]. The first results of this initiative were presented by White and Baer in Zagreb in 1978[46].

4.2. *Painting technology*

X-rays give indications of the different layers which make up a painting in so far as they measure the atomic weight of each element. The higher the atomic weight of a substance the less permeable it is to X-ray penetration. The white pigment used in antique paintings is usually lead white which has a high atomic weight. The radiographic image is distinguishable more in the zones where a large quantity of lead white is adjacent to areas where there are small quantities of it.

Therefore, it is possible to determine the characteristics of the artist's brushstrokes, the manner in which the pictorial material has been applied to the support, and to a certain point it is possible to identify the hand, workshop, period or place when and where the work was executed. Mainly on account of the observation of specific zones it is often easy to accurately draw up a detailed chronology of the execution ; the placement of the figures with regard to the background, the realization of certain details like the hands or the feet in relation to the rest.

The observation of the network of craquelure at times difficult to discern using other methods, becomes easy ; the distinction is easy between networks of age cracks and premature cracking.

Pentimenti or reworked areas as well as superimposed areas in the composition, become visible and help to understand the creative process.

The radiographic image can define a technique practiced mainly by the Old Masters of easel paintings, that is, making an incision in the ground to define elements of the composition such as the contours of figures, folds in garments, design of a floor or basic lines of an architectural decor. In fact, the color is deposited in the grooves traced and produces in these areas an overabundance of material that is visible in the form of fine white lines.

Radiography also allows an analysis of the support to the extent that X-rays can penetrate it. For example, in the case of wood supports, frequently adopted in the earliest paintings, one could detect the type, quality and number of wood elements, the system of joints and the original type of reinforcement. In the case of a canvas support, its texture, which may be hidden by the addition of various things on the back or by a relining, becomes visible.

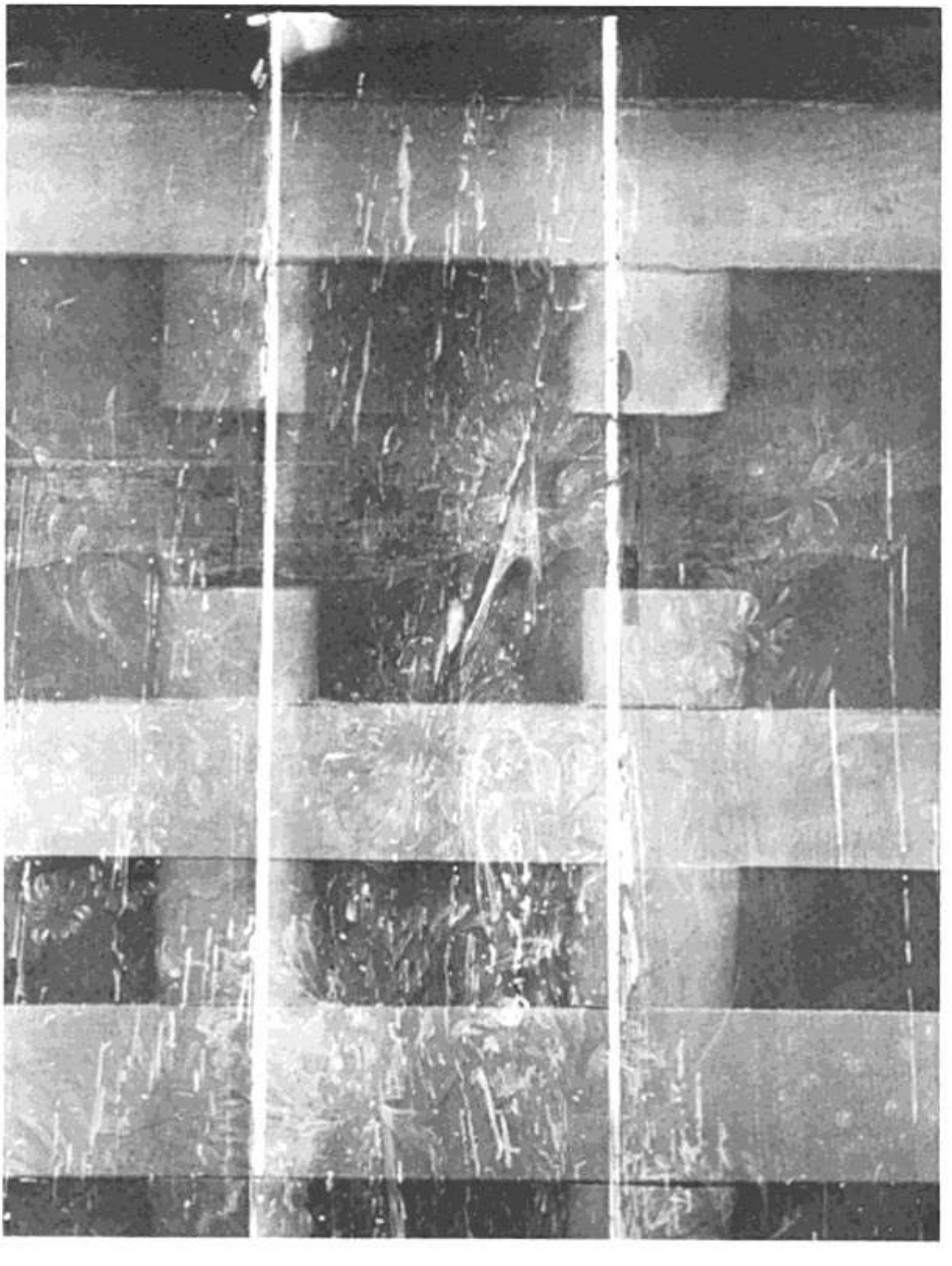

Fig. 10. Anonymous, (20th century ?), Flowers, *Private collection, detail : radiography 35 Kv, 4 ma, 45 sec., 80 cm (Neg. Lab. Art., U.C.L.).*
Executed according to the style of Old Masters, this painting was attributed to a flemish painter of the 17th century. Densities as seen on the radiography are fully compatible with those of ancient paintings. However, the use of soft wood, worm eaten before priming, does not correspond to flemish working habits, but rather points out to the recent character of the painting.

4.3. *Conservation and restoration*

Radiography also indicates a great number of transformations or deterioration that can affect the painting (with the exception of the varnish).

The modifications in a wood support appear — for example, attack by microorganisms with open tunnels or holes, the types of reinforcement that are not original, such as nails, the replacement of a damaged original portion. For a canvas support tears, patches, sometimes relinings can be observed.

A painting transferred from wood to canvas, besides its characteristic network of age cracks, often reveals with this method exactly where the original joints of the support were placed.

Changes in the paint layer also become evident ; filled or empty lacunae, sometimes repainted or overpainted areas. What is particularly important in the area of restoration is determining with precision the extent of later additions in relation to original areas.

Before any intervention, it is now possible to carry out a precise examination of the condition of a damaged painting in such a way as to put forth a diagnosis and prescribe, with a complete understanding, the most appropriate treatment.

5. NOTES

1. About the use of radiography in the field of paintings see the general bibliography. Only specialized bibliography will be mentioned here.
2. A. BURROUGHS, *Art criticism from a Laboratory*, Boston, 1938 ; Ch. WOLTERS, *Die Bedeutung der Gemäldedurchleuchtung mit Röntgenstrahlen für die Kunstgeschichte dargestellt an Beispielen aus der niederländischen und deutschen Malerei des 15. und 16. Jahrhunderts (Veröffentlichungen zur Kunstgeschichte, 3)*, Frankfurt-am-Main, 1938.
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6. Résumé

Les rayons X sont utilisés dans le domaine médical et industriel depuis leur découverte en 1895 par Röntgen. Ils furent peu à peu appliqués à l'étude des œuvres d'art. On peut considérer qu'avec la parution en 1938 des ouvrages de Wolters et Burroughs, leur usage augmente.

Avec le temps des procédés particuliers ont été mis au point comme la stratiradiographie, la stéréoradiographie, la radiographie par émission d'électrons ou par réflexion, l'autoradiographie ou radiographie par activation de neutrons, la radiographie en couleurs, la xéroradiographie. Ces procédés ont pour but de résoudre des cas où la radiographie traditionnelle serait inopérante ou, dans le cas spécifique de l'autoradiographie, de donner des informations nouvelles. Après 1938, l'utilisation de la radiographie devient plus fréquente, mais il ne faut pas perdre de vue que la plupart du temps, les documents sont réalisés à l'occasion de la restauration d'œuvres de peinture ; la radiographie n'occupe qu'une place à côté d'autres méthodes d'examen des œuvres.

L'image radiographique donne des indications sur l'état de conservation de l'œuvre, les caractéristiques du support, l'état de la couche picturale, les usures, les différents types de craquelures, les lacunes, les surpeints. Le document radiographique est également utile pour l'histoire de l'art. Il permet de déterminer les transformations apportées par l'artiste à l'œuvre d'art. Il informe sur l'exécution de l'œuvre au stade de la couleur, les caractéristiques de la touche, la chronologie de l'exécution.