INTRODUCTION

In the course of the project to digitalize the estate of the famous historian of law Friedrich Carl von Savigny (1779–1861), preserved in the university library of Marburg, and afterwards to restore those of its items which are endangered by ink corrosion, some contemporary copies, of original documents that had been lost, were discovered. These copies, therefore, were to be preserved as primary documents. It was for this reason that we decided to take a closer look at historical copying processes, in particular the use of a mechanical copying press, which was the process used for the Savigny documents.

Such copies were made directly from their respective template, based on the use of offset they were duplicates of the original. The original was written or sketched with copying ink. For the copies very thin, unsized paper was pressed onto the original so that some of the copying ink penetrated it, allowing the script to be read or the design to be inspected in the right orientation from the back. Copy press copies have existed since 1780. They reached their height at the beginning of the 19th century and were sporadically used until the 1950s.

FIRST ATTEMPTS AT COPYING

The simplest and oldest method of reproducing documents was to make handwritten copies1, 2. Early methods of producing several identical copies using a three-dimensional pattern for stamping or rubbing, as used in Mesopotamian3 and Chinese antiquity, pertain more to the pre-history of printing than to the history of copying.

The history of copying, in the true sense, began with the Polish scholar Samuel Harlib, who lived in London during the middle of the 17th century. Freshly writ-
ten letters were covered with another sheet of paper that was carefully pressed onto the original thus producing an exact copy of the written text. However, those copies gave the script in reverse and without practice they had to be read using a mirror. It was James Watt, inventor of the steam engine, who developed the method of Samuel Harlib further and in 1780 his invention, the letter copying process, also called the colouring transfer method, was patented. Together with Matthew Boulton and the chemist James Keir, James Watt founded “James Watt & Company”, which put the “Watt’s copying press” on the market. It was sold predominantly in Rouen (France).

In the course of the industrial and commercial revolution that characterizes the first half of the 19th century its use increased and expanded to private correspondence, banks, the Governments of several European countries and the US, British and American law courts and also to transportation, i.e. such copies were accepted as tickets on trains or steam boats. They had the status of legal evidence as long as they were manufactured perfectly. By the end of the 19th century the letter copying process was omnipresent, at least in the developed countries and was used up to the 1950’s.

The production of various copying presses, of moist and dry processes, was supposed to make copying easier, adapting it to individual requirements. For safekeeping the very thin, fragile copying papers were often glued into books. However, after the introduction of copying books in the middle of the 19th century this way of filing became obsolete, since the copies were copied directly into these books. For orientation there was an index in the front section of the book and the sheets within the book were numbered which provided a better overview.

Despite the technical development of copying processes, copying clerks were employed until the end of the 19th century, on one hand because the equipment for technical copying was expensive and, on the other, because there was a certain distrust in the thin, weak copies produced by mechanical means. It was also suspected that the copying process could be used for forgery.

**PRODUCTION OF HISTORICAL COPIES**

For the preparation of historical copies a machine and special paper were needed, together with specific copying ink and writing equipment. James Watt’s invention comprised not only the press, but also the formula for a specific copying ink. Additionally, he discovered a method of pre-conditioning the copy paper. The whole process was as follows.
The Copying Press Process

Fig. 1 (taken from Ref. 4): a: Original with copying ink; b: original and copy during the copying process; c: copy with writing visible on the back; d: face of the copy.

The text was first written using a modified iron-gall ink, which due to its chemical composition, stayed wet for at least 24 hours. The copying paper was moistened evenly and put onto the writing (Fig.1). A sheet of adhesive paper (oiled or waxed paper) was placed either side of the two sheets in order to prevent the moisture from evaporating, and the four-part sandwich was put in the copying press for about 30 seconds. Due to the pressure, the copying ink of the original penetrated the thin copying paper, and thus the writing could be read in its original configuration when the copying paper was turned over and examined from the back. In order to dry the copy it was often pressed again.

Copying paper

To be used as copy paper the product had to meet the following criteria.

- Water absorption capacity
  Copying paper had to absorb just enough moisture so that the finest ink lines of the copying ink could be transferred. Another function of the water was to swell the gum arabic contained in the copying ink and thus causing the release of its coloured component. Generally, the ink had to be both absorbed quickly and to be able to penetrate the paper to the verso without spreading sideways thus producing blurred lines.

- Thin texture
  Copying paper had to be very thin so that the ink lines could penetrate it allowing it so that legible copy of the original writing could be inspected from the back.
• Mechanical and wet strength

Even if extremely thin, the paper had to have enough mechanical and wet strength to get through both the strain of the copying process and the stress of being handled during use. This was obtained by heavily beating the fibres during the paper making process. From heavily beaten pulp a thin transparent paper of relatively high tear resistance can be made7.

Copying paper was produced from different fibres. Mainly a blend with 70% cotton fibres was used together with a small proportion of mineral clay, which assists the copying process. Cotton was cheap and did not require bleaching. Technical literature also mentions flax, silk, ramie, hemp and Gampi. This latter has a very fine and lustrous quality, which can be utilised in the manufacture of transparent paper with high wet strength8. Pure Gampi paper from Japan was sometimes sold as “silk paper” due to its smooth and glossy surface. Ramie has an excellent tear resistance in wet conditions9. Hemp pulp, too, consists of very thin fibres and can be used for thin paper of high mechanical strength; such copying paper was used for business documents. Jute and chemical pulp were not suitable for the lengthy fibrillation process required for copying paper and were used only for low quality and cheap products. Flax and silk were not found in the examples analysed in the course of the research reported here.

The paper was made by hand. The advantage of such a product, besides having greater stability and elasticity, was that it expanded evenly in both directions, which prevented irregularities in the designs during the copying process. Even at the time the letter copying press was being used, copying paper was being impregnated with different substances in order to adjust the paper’s characteristics. One of these additions was tannin. “Watt’s copying ink” contained less tannin than regular iron-gall ink, i.e. not enough to convert all iron sulphate to the coloured ink complex. The surplus sulphate was transferred to the copying paper and the tannin provided by impregnation could convert it into the coloured complex.

An impregnation with tannin (gallic acid) was not really necessary for the copying process. It did, however, enhance the formation of coloured ink compounds thus making the copying process more effective. Using tannin impregnated paper the copy had to be made within 24 hours. The iron(II)-gallate complex reacted with the oxygen of the air and formed coloured blue-black and water-insoluble iron(III)-gallate complexes7,10. After 24 hours this process would have advanced too far, i.e. all the ink substance would have become insoluble and untransferable.

Further additives were glycerol (used since the 1850s), magnesium chloride (MgCl₂), sugar and honey. Their function was to make the copying paper more
flexible and to keep it. kept it in damp condition for a longer time. Further hu-
midification briefly before the copying process was rendered unnecessary The
paper could be stored in a moist condition and used when required.

“Watt’s Impregnation Solution” for copying paper contained pulverized calcined
oyster shells which, chemically reacting with water, was converted to calcium
hydroxide. Thus Watt had unknowingly inserted an alkaline reserve into the pa-
per, which minimised the risk of damage caused by acidic inks and generally pro-
vided a chemically stable paper. Moreover, as observed later, i.e. in the course of
research into ink corrosion, alkaline substances support the generation of insol-
uble ink complexes thus making the writing on the copy more legible. Borax was
also used as an alkaline substance for copying paper.

Other additives were gum arabic and gelatine. It was believed that these
would act as adhesives and enhance the transfer of the ink.

Potassium chromate \( (K_2CrO_4) \) or dichromate \( (K_2Cr_2O_7) \) were not used until
1857; they were supposed to make the writing as well as the copy more durable.
Aluminium acetate had been used since 1863 as a fixing agent for coloured inks.

Due to the numerous substances that were used to impregnate the copying
paper, their durability is often difficult to evaluate, since every method of im-
pregnation will show different characteristics of deterioration.

**Copying inks**

Dobrusskin\(^1\) divides the copying inks into three main groups:

- Iron-gall copying inks,
- iron-gall copying inks with the addition of coloured substances: logwood iron-
gall copying ink, alizarin copying ink, etc.,
- pure colouring inks: logwood copying ink, black, red and blue colouring copy-
ing ink, etc.

This article focuses on copying inks based on iron-gall ink. Generally, such ink
is an aqueous dispersion of an insoluble coloured substance: the black iron(III)-
gallate complex. It is made by mixing green vitriol \( \text{iron(II)-sulphate} \) with tan-
ingen agents such as gallnut extract. Further additives are gum arabic, functioning
as a protective colloid and binding agent, and wine or vinegar, which prevent the
premature precipitation and sedimentation of the iron-gall ink complex.

The aqueous solution of iron(II)-sulphate forms an uncoloured or only slightly
coloured water soluble iron(II)-gallate complex: the so called ink body. When
brought onto paper or parchment during writing a coloured, water-insoluble
iron(III)-gallate-complex is created by oxidation\(^2\).
Additives as used for “Watt’s Impregnation Solution” were also mixed to copying ink: sugar, glycerol, honey; also syrup, i.e. a concentrated sugar beet juice, and molasses, a kind of syrup that remains if sugar is crystallised out of sugar cane or sugar beet juice were employed. Their function was as described above, to make the ink hygrosopic causing it to remain wet for a certain period after application, promoting the adhesion of the original to the copy. The sugar-containing substances generated a thin film on the surface of the ink, which delayed the process of oxidation; copying became possible for a period of up to 24 hours. Altogether, three to five copies could be made from an original.

As already reported, Watt’s ink contained less tannin than regular iron-gall inks and not enough to completely convert the iron(II)-sulphate to the ink complex. In order to complete the complex formation “Watt’s Impregnation Solution” was necessary.

Preservatives such as alum, clove or alcohol were added in order to prevent mould formation. Coloured substances, such as aniline dyes, made the script visible whilst writing. During the formation of the dark black iron(III)-gallate complex these dyestuffs became invisible. A high content of aniline dyes with strong colour intensity allowed more copies to be made from the original.

Writing instruments

Like other inks, copying inks were used with either a quill or with a steel pen. Quills were made from the large stiff feathers of a bird’s wing or tail: geese, swans, turkeys, pheasants or crows. In 1780 the first steel pens were manufactured by Samuel Harrison in Birmingham (England). Their mechanical production began in 1845; the company Gillott in Birmingham produced 80 million pens annually. Since 1843 at the latest, metal pens were also produced in Germany. They soon totally replaced the older instrument.

The Copying Press

It was Matthew Boulton, partner of James Watt, who developed the copying press; it was a so-called roller press. Later this type of press was replaced by another, the screw press, which became the standard copying press up to the beginning of the 20th century. The presses had to provide an even pressure. Usually they were made of iron; their heavy base plate was covered with smooth vulcanised natural rubber to provide a soft, even contact surface. For the first copy light pressure was sufficient, for additional copies the pressure had to be increased.
The Copying Press Process

Fig. 2: Copy made in the copy press (Marburg University Library, Savigny Ms.925/1105), left: side that had been pressed onto the original; right: back side showing the script in the right orientation.

Fig. 3: Details of Fig. 2 (line 13).

slightly step by step: allowing just enough ink to transfer from the original to the copy paper necessary for a legible copy.

IDENTIFYING CHARACTERISTICS FOR COPYING PRESS COPIES

It is often not easy to identify copying press copies. Both the paper and the script must be inspected for several characteristics:

- Paper
  - very thin, light, slightly sized or unsized paper (Fig. 2, because the ink must penetrate the paper during the copying.

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Appearance of script

The writing is clearly legible on both sides of the sheet. Yet, the ink on the front appears darker and more dense than it appears on the other, where the writing is legible in the right orientation (Fig. 3).

The ink lines are quite dark with lighter, blurred borders caused by the unsized paper absorbing the ink and causing it to disassociate in several phases. The capillary forces of the paper web caused the substances dissolved in the ink to migrate through the pre-moistened paper and, during drying, to some extent into the surrounding paper (Fig. 4 left). The blurred feathered edges outside the actual ink lines are caused by a liquid phase that may contain iron(II)-ions, sulphuric acid, iron(II)-sulphate gallic acid and other water-soluble substances. The actual ink lines also contain the oxidised ink complex. Feathered or discoloured edges do not (or only to a lesser extent) occur with regular iron-gall ink on sized writing paper (Fig. 4 right). Within the same document heavily blurred edges as well as clearly visible ink lines can be found. They are caused by an uneven impregnation or moistening of the paper.

Within one document heavily blurred edges as well as clearly visible ink lines can be found. They occur due to an irregular impregnation or moistening of the paper before the copying process.

Quite typical are areas of incomplete writing, as they were found occasionally (Fig. 5). They appear to be the result of insufficient impregnation or moistening of the copying paper. The copy is incomplete along the paper edges, which dried too quickly and thus did not provide enough moisture for the copying ink transfer.
In contrast to recent publications, as for example the research of Staatsarchiv Bern¹⁷, ink damage could be observed with the Savigny copies. Both tears and outbreaks are to be found within the ink lines.

**CONSERVATION ASPECTS**

In the same way as other paper objects, copying press copies require constant storage conditions: 18°C and approximately 50% RH. Low humidity is important because glycerol or other hygroscopic products as they are present in the copies easily absorb moisture. Because of its alkaline reserve (see p. 93) the paper is chemically stable. Historical copies based on iron-gall ink are more susceptible to the migration of soluble ink compounds and to ink corrosion because the paper can absorb water more easily because of its lack of sizing. As for biological decay, the sugar contained in the copying ink provides an ideal medium for the growth of micro-organisms.

Frequent handling of such objects should be avoided, because every turning can result in damage especially in the inked area. Exhibition should be minimised since all substances that might have been used for impregnation may be sensitive to light. If exhibited, the objects must be presented at low light levels (max. 50 lux), and RH must be kept constant. In general, copying press copies should be stored
in the dark. In order to avoid further damage they should be stored in acid-free envelopes and kept away from objects containing acid.

Bartelt and Färber describe a mounting method for such fragile documents when their handling cannot be avoided. However, for historical copies that have been classified as stage four according to the damage scale by Reißland and Hofenk de Graaff, this method can only be applied after the paper has been stabilised. Direct use should be limited by providing a microfilm or a digital copy.

CONCLUSION

Copying press copies often cannot be distinguished from other historical documents at first glance. Identifying them and treating them appropriately, as described above, will help to avoid damage.

The Savigny copies, on which the report given here is based, show ink corrosion. They were submitted to analyses: pH-value micro extraction measurement, Time of flight-secondary ion mass spectroscopy (ToF-SIMS) and SynchrotronX-ray absorption spectroscopy (XAFS). Such tests can help to gain deeper insight into the chemical mechanisms of the damage and develop a concept for conservation treatment. The results and the restoration of some press copy from Friedrich Carl von Savigny’s estate that has been damaged by ink corrosion will be presented in the second part of this report.

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SUMMARIES

The Copying Press Process: History and Technology. Part 1

Copies of documents have been made on copy presses since 1780. For the process, documents were written with special copying ink and pressed whilst moist onto very thin and usually smooth,
unsized paper that would accept the ink. Due to their composition the inks are sensitive to water and sometimes exhibit damage within the ink lines. The history and manufacture of copies is especially significant with regard to conservation and storage of these documents. Conservation interventions can have severe consequences if the documents have not been clearly identified as copy press copies in advance of treatment. In order to assist the conservator the identification characteristics of historical copies are represented in this paper.

Les procédés de reproduction : histoire et technologie. 1ère partie

Des copies historiques ont été établies depuis 1780 pour la plupart des cas à l’aide d’encres spéciales de copiage sur des feuilles très minces de papier gras. En raison de leur composition ces encres sont sensibles à l’eau et présentent partiellement sur les surfaces écrites des détériorations qui ressemblent à des taches de rouille. La fabrication et l’histoire de copies historiques revêt du point de vue de la restauration et de la conservation de ces documents une grande importance. La restauration de telles copies historiques peut cependant avoir des conséquences graves lorsque la technique de copiage utilisée pour ce document n’a pu être identifiée au préalable de façon univoque. Afin de procurer une assistance au regard du restaurateur non averti des caractéristiques d’identification des copies historiques ont été élaborées et sont exposées dans cet article.

Die Kopierverfahren: Geschichte und Technologie. Teil 1


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Sonja Titus, Dipl. Rest
Regina Schneller, Dipl. Rest.
Dr. Gerhard Banik, Professor
Staatliche Akademie der Bildenden Künste Stuttgart
Studiengang Konservierung und Restaurierung von Graphik, Archiv- und Bibliotheksgut, Höhenstraße 16,
D-70736 Fellbach, Germany
Tel. +49-711-664638-11
Fax +49-711-586453
sekretariat@sabk.de
homepage: www.sabk.de
The Copying Press Process

Enke Huhsmann, Dipl. Rest.
Ulrike Hähner, Dipl. Rest.
Universitätsbibliothek Marburg
P.O.B. 920
D-35008 Marburg, Germany
Tel. +49-6421-2825178
Fax. +49-6421-2826506,
huhsmann@ub.uni-marburg.de
haehner@ub.uni-marburg.de
homepage: www.ub.uni-marburg.de/allg/aktiv/tinte.html