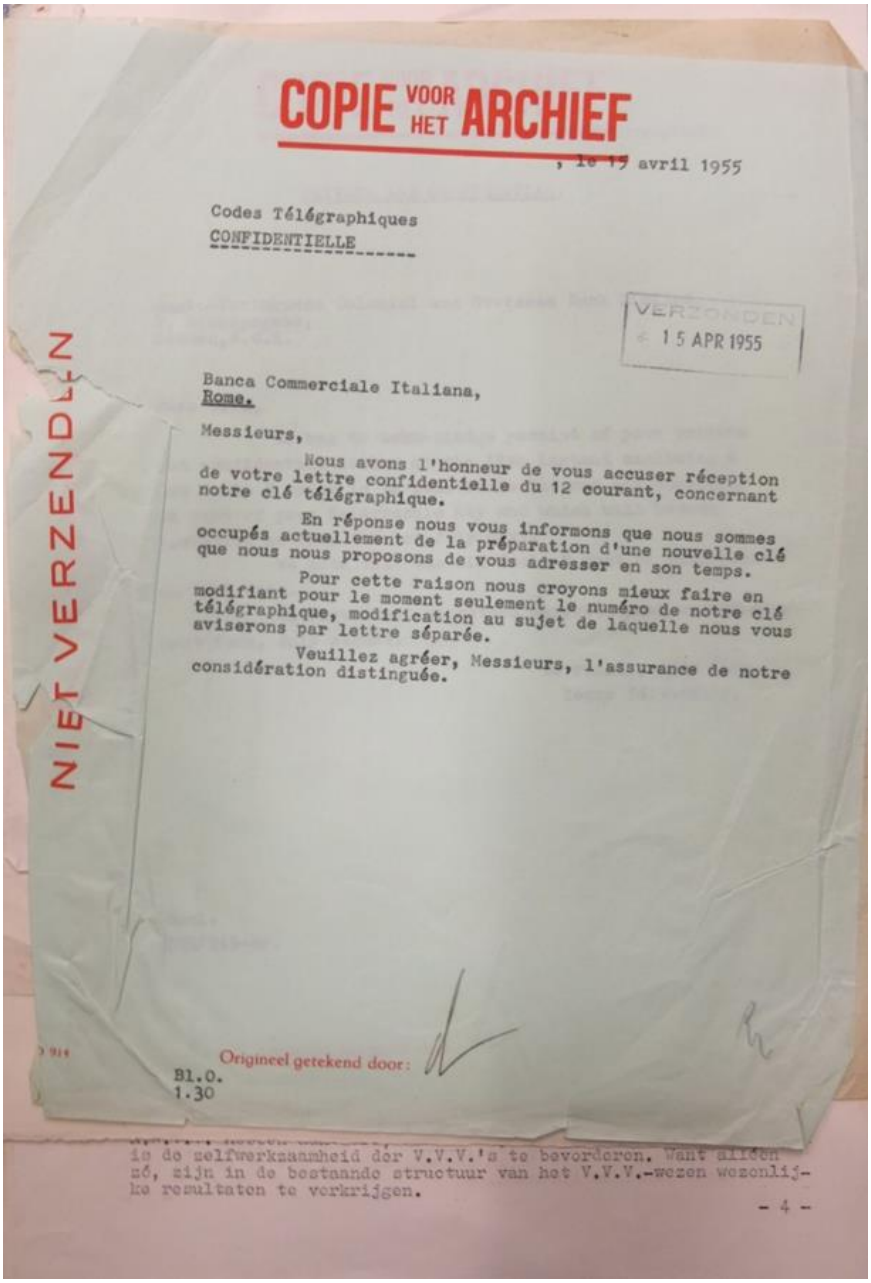
A survey of the material deterioration of office copies

research report



Janien Kemp

Autumn 2018

Research report

A survey of the material deterioration of office copies

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This research was carried out within the Metamorfoze Research programme

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Image front page: Toegang 735, Firma Hope & Co, Inventarisnummer 65A. Stadsarchief Amsterdam

Summary

This research into the deterioration of office copies is an exploratory investigative study carried out in the city archives of Amsterdam. The aim of this survey is to find out if the current conservation policy of the Amsterdam City Archives meets with office copies requirements.
The first part of the research concerns questions such as, 'What are office copies?' How were they made, and what different techniques were used in the Netherlands? How often do copies occur in Amsterdam's archives and is this quantity substantial? The second part deals with the deterioration of office copies. To this end, the paper and ink composition of copies of diverse common techniques were analysed and the fight fading fastness of the inks was tested. In order to answer the question of the relevancy of research into on the deterioration of office copies, sampling was carried out in addition to the cause of damage. The third part presents conclusions and conservation recommendations to prevent damage through use and depot storage. Literature study shows that office copies were used worldwide. Almost half of the inventory numbers of the Amsterdam archives contain office copies. Five copying technics where most popular. Office copy paper is machine made, wood pulp paper. Therefore the copies are less strong than handmade paper made from rags. Documents piled up in loose stacks are most vulnerable for damage by use. The blue/violet inks are very light sensitive. One of the five copying technics, the diazo/Océ, contains residues of chemicals use in the making process. These residues can harm the surrounding objects. The diazo technic is also used in architectural drawings. More research must be done to find out if the conservation methods used in preserving architectural drawings also applicable to this office copying technic.

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Foreword

In the 1990s, I began my career as a conservator in the archival world. It was the era of the Delta Plan for Cultural Conservation.[1] The National Coordination Point for Conservation Policy (CNC)[2] was established, which conducted research into the preservation of paper heritage in Dutch archives and libraries. Various findings invited further research. The quality of paper of the mid-nineteenth century proved to be poor[3]. The book, *The Office Copying Revolution*, by Ian Batterham of the National Archives of Australia[4], intrigued me. The era of the office copy revolution falls in the period of poor quality documents. Could there be a link between these factors?

My own experiences played a role in this research. As an object management expert, I am struck by the enormous variety of document types in the 19th and 20th century archives. The stacks of loose items in boxes often look untidy and damaged. The documents are typed but the inks have different colours, and sometimes the texts are thin and faded. What is going on here? Is this a fading of the inks, or are these letters the original result of the making process? And how did these creases and tears occur? Is the strength of the paper so poor? Is the packaging inadequate? Are these forms of damage due to an inherent process that also continues in the depot in the right packaging with the right relative humidity and temperature?

In 2015, my project application, 'Survey of material deterioration of office copies between 1800 - 1950' was accepted by Metamorfoze Research. Metamorfoze is a national programme for the preservation of paper heritage and is brought under the Koninklijke Bibliotheek [National Library of the Netherlands]. The programme is an initiative of the Ministry of Education, Culture and Science.

The office copy research was carried out in collaboration with various colleagues. The first team consisted of Gabriëlle Beentjes, Anna Bülow, Claire Phan Tan Luu and myself. Donna Plugge, masters student of Archive Sciences at the University of Amsterdam, also contributed to this research. Sophie van de Water joined as a permanent team member. Experts in the field of paper and inks were consulted, including Han Neevel, Henk Porck and Bas van Velzen. Ian Batterham has also made a great contribution to this research. I sincerely thank all these people!

Dr. Enrico Pigorsch at the Papiertechnik Stiftung in Heidenau, Germany, performed chemical analyses. Willen Bosveld and Merijn Heijnen at the Amsterdam Research & Statistics Department set up, supervised and analysed the sampling. Many thanks to them as well!

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[1] (1990), Kiezen voor kwaliteit. Beleidsnota over de toegankelijkheid en het behoud van het museale erfgoed. 's-Gravenhage, Ministerie van Welzijn, Volksgezondheid en Cultuur. (Tweede kamer, vergaderjaar 1990 - 1991, 21 973, nr 1-2)

[2] (1996), Papierconservering in Nederland. Een overzicht van de ontwikkelingen in de periode 1980-1995, Den Haag, CNC Coördinatiepunt Nationaal Conserveringsbeleid.

[3] Grijn, E. van de, Kardinaal, A., and Porck, H., (1996), The 1845 paper crisis in the Netherlands. An historical-technical study into the Dutch paper market, and into the nature and extent of the inferior quality of mid-19th century paper. In. IPH Congress Book (Vol. 11). Marburg, Germany: International Association of Paper Historians, 153-163.

[4] Batterham, I., (2008), The Office Copying Revolution: History, Identification and Preservation. National Archives of Australia.

More and more colleagues have become aware of the subject over the past year. People have become interested, and the importance of recognising specific problems has become increasingly clear. Office copies are so diverse that many interesting and important questions remain open that hopefully will be answered one day. Many of my colleagues (impossible to name them all) were always prepared to answer all kinds of questions and give me office copies for this research. My warm thanks to you all.

Janien Kemp

Amsterdam, December 2018

1. Formulation of objective and questions

The aim of this research is to examine if the current conservation policy of the Amsterdam City Archives meets with office copies requirements for long term conservation.

This research answers four questions:

Which mechanically manufactured office copies were used in Amsterdam?

How stable are their papers and inks?

Can they be preserved with the same conservation measures as for other documents, or is special treatment required?

Are the conservation methods used in preserving architectural drawings also applicable to some sorts of office copies?

2. Introduction

1.1 The history of office copies.

Texts were copied as early as in the Middle Ages. Up until the 19th century, this was done by copying the text by hand. Batterham defines office copies as:
"A document copying processes used in commercial and government offices to produce single copies, or small runs of copies, from an existing original, from a prepared stencil or master, from an electronic data file, from a microform, or through the use of movable type. In other words, in-house copying is the scope, rather than large-scale copying by printing companies." (Batterham, 2008)
The above definition is used in this research.

The City Archives of Amsterdam currently manages more than 53 kilometres of documents, dating from the early Middle Ages to the beginning of the twenty-first century. These records are kept for eternity under the rules of the Archive Act and the Archive Regulations. The oldest items have a parchment carrier and are often inscribed with iron-gall ink. The oldest piece is the Tol Charter of Floris V from 1275. In the 15th century, with the introduction of handmade rag paper in the Netherlands, the use of parchment disappeared, but the use of iron-gall ink continued.

The material for rag paper was old clothing and other sorts of worn textile. The nineteenth century is characterized by the industrial revolution and the mechanization of all kinds of processes. People switched from paper mills, where the paper was handmade, to paper factories. This saw a change in the raw material. Rags were gradually replaced by wood. The preparation of the wood fibres into paper pulp could be done mechanically and chemically. Mechanical pulp contains residues such as lignin which has a negative influence on the quality of the consequential paper. The chemical pulping of wood fibres is done with the application of special chemicals. For the machine production of paper, new sizes were developed that were better suited for use in machines. The mechanisation of the office through the use of office machines was also introduced. Many new processes for making office copies followed in rapid succession. The introduction of the personal computer at the end of the twentieth century saw the beginning of the digitisation of office copies.

Written communication expanded enormously from the 19th century onwards[5]. The Commercial Code of 1838 obliged every business owner to keep a kind of diary about the ups and downs of their business. They were also obliged to keep received letters and a pressed letter book of sent letters, and to draw up an annual inventory and balance sheet. Account books and pressed letter books were deemed as legal evidence[6].

Making and keeping copies in the archives of businesses, trading companies, banks, and government institutions was thus made obligatory by law. These archives are now held by Dutch archive repositories. An example from the archive of the company Hope & Co (access 735, inventory number 65A) contains documents with the stamps 'copy for the archive', or 'copy'.

[5] Ophem, M.V., & Duyvendak, M.G.J., (1984) Mechanisatie op kantoren tussen 1870 – 1930, Jaarboek voor de geschiedenis van bedrijf en techniek, 1, 276 – 287.
[6] Ketelaar, F.C.J., (2000), Context Interpretatiekaders in de archivistiek. Besturen door registratuur, 1870 – 1940. Stichting Archiefpublicaties. Den Haag.

Several Dutch publications provide insight into the history of the office from the end of the nineteenth century. The book, Techniek in Nederland[7], describes the rise of the information society, and how technology made its entry into the Dutch office from the nineteenth century onwards. The rise of modern administration, the scaling-up of companies, and the use of machines go hand in hand. The introduction of the typewriter in 1880 is a popular topic, and had a great impact on document reproduction. The book, Reproductie- en druktechniek voor kantoorgebruik [Reproduction and printing techniques for office use] (1958) [8], from the Netherlands Institute for Efficiency, gives an overview of the most common techniques used in the first half of the twentieth century.

Every new developed copying technique had its own apparatus, papers and inks. The first mechanical office copying technique, the pressed letter book, came into use in 1780 and remained so until 1958. With these, outgoing letters were copied using a copy press. From around 1850, there were four different office copying techniques in use: the pressed letter book, carbon, stencil and hectograph. After the introduction of the typewriter at the end of the 19th century, all these techniques were used to make typed documents.

Later in the 20th century, another popular technique based on the photographic diazo technique came into use. Océ van der Grinten of Venlo was a Dutch company that marketed a variant of this process[9]. This technique was in use from 1930 to 1970. These Océ copies are also to be found in the Amsterdam archives. The photocopying technique, still used today, came into use from 1960. Nowadays there is still a 'copier' in every office space. With this device we make paper photocopies of paper documents, we can print digital files on paper, and we can make paper documents digital by scanning them. One can speak of the current time as being a hybrid era between analogue and digital.

1.2 Types of damage

In the conservation literature, there is a differentiation between chemical and mechanical damage[10].

Chemical damage

Yellowing of paper is sometimes called browning. This discolouration can be even, and spread over the entire sheet of paper, but can also occur only along the edges. Yellowing can also occur locally in the form of stains as a result for example of, mould or other contamination through use. The appearance of brown spots is named foxing. Yellowing can also be caused by the transfer of coloured matter from adjacent papers in a book, stack, or from packaging materials. Another well-known

[7] Schot, J. W., Lintsen, H. W., Rip, A., & Albert de la Bruheze, A. A., (1998), Techniek in Nederland in de twintigste eeuw. Deel 1, Techniek in ontwikkeling, waterstaat, kantoor en informatietechnologie, Walburg Pers

[8] Schippers, M. E. & Commissie ter Bestudering van het Rationele Gebruik van Reproductie- en Vermenigvuldigingsmachines, (1958), Reproductie- en druktechniek voor kantoorgebruik: Bureaugrafische werkwijzen ten behoeve van administraties, bibliotheken en archieven. 's-Gravenhage: Nederlands Instituut voor Efficiency, Werkgroep Administratieve Arbeid.

[9] (2007), Océ, Innovation by Nature 1877-2007. Océ, Venlo.

[10] Most, P. van der, Defize, P., Havermans, J., (2010),Archives Damage Atlas: A tool for assessing damage, Metamorfoze, Den Haag.

cause of yellowing is alum-rosin sizing[11]. Even discolouration and yellowing along edges is a sign of paper instability. For example, browning in paper is caused by lignin (a by-product of wood fibres), and an alkali from a filler or additive[12]. By measuring the pH, it can be investigated whether the yellowing is an indication of decay. A low pH means acidification of the paper. An acidic environment catalyses the breakdown of cellulose chains and weakens the paper[13].

Pale ink may indicate that the ink has faded and is unstable. Unstable inks fade more quickly under the influence of light, temperature, and relative humidity in the air. Violet-coloured inks, also referred to as aniline inks, contain the dye methyl violet, which is known to be very sensitive to light and water[14].

Mechanical damage

Tears in papers can vary from 1 millimetre to many centimetres. Small tears at the edges are common. Tears occur on edges when a page protrudes from a stack. This can be due to bumps during transport, or handling. How rapidly a tear occurs also depends on the quality and strength of the paper. Tears form faster when a paper is aged, and the cellulose chains are shortened. The thickness of paper also affects its vulnerability to tearing. An 80 gram copy paper is thicker and stronger than a carbon copy paper that has a grammage per m^2 between 30 and 45.

Folds are a major form of damage because folding paper causes tears. An historical fold is a one made during the formation of the archive. For instance, A3-size drawings that are folded down to A4-size to fit in a file, and letters folded in envelopes.

1.3 Conservation of office copies

Rag paper and iron-gall ink are materials that have proven their stability over the centuries. If such objects are stored in a secure, well-acclimatised space, they remain unaffected for a very long time. The greatest risk is inherent deterioration. The inherent deterioration of iron-gall ink, so-called ink corrosion[15], has been well researched[16] and conservation measures have been developed and established[17]. However, this research concerns paper made from wood, as became common during the industrial revolution.

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[11] Thurn, J., (2003), History, Chemistry, and Long-Term Effects of Alum-Rosin Size in Paper, The Cochineal, USA Texas.

[12] Grijn, E. van der, Kardinaal, A., (2003), Technical ontwikkelingen in de Nederlandse paper production in de eerste helft van de 19th century. Een bijdrage tot de discussie over paper quality en – deterioration, Amsterdam.

[13] Holik, H. (2006), Handbook of Paper and Board. WILEY-VCH Verlag GmbH & Co. KGaA, Wernheim, Germany.

[14] Tristan, P. de, (1997), The Analysis and Conservation of Aniline-Dyed Nineteenth-Century Japanese Prints.

[15] https://www.nrc.nl/nieuws/2009/03/10/inktvraat-en-scheuren-11695216-a962446

[16] Reissland, B., (1999), Ink Corrosion – Aqueous and Non-Aqueous Treatment of Paper Objects- State of the Art, Conservator, vol.20.

[17] Neevel, J.G., (2002), (Im)possibilities of the Phytate Treatment of Ink Corrosion. In: Mosk, J.A. and Tennant N.H., Contributions to Conservation, Research in Conservation at the Netherlands Institute for Cultural Heritage, James & James.

In 1999, the book, 'Before photocopying: the art & history of mechanical copying, 1780 - 1938: a book in two parts'[18] appeared, describing the technique and history of office copying techniques up to the photomechanical processes. In 2008, the National Archives of Australia published the book, The Office Copying Revolution. History, identification and preservation, by Ian Batterham, senior researcher at the National Archives of Australia, which describes 34 different copying techniques found in the archives there. He clearly describes the history of each process, the materials used and the manufacturers. The identification of copies is also described. Finally, the causes of damage for concern are described and the reasons why. Much attention is paid to identification with an enclosed identification map as an aid. The properties and components of papers and inks are set out, based on manufacturers' data and patents. However, the causes of decay are only briefly and generally discussed.

In 2014, Ford and Batterham published the article, Accelerated Light-Fading of Some Historic Office Copy Documents[19]. It reports on research into the light stability of papers and inks. This research shows that more knowledge about the causes of decay is desirable. At present, office copies are kept under the same conditions as other papers in an archive. At exhibitions, the pieces are exhibited in acclimatised spaces with reduced lighting. The latter is important because many pieces are light sensitive. The Blue Wool Standard is considered to be the guiding standard in this case. In the ISO classes of the Blue Wool Standard[20], the Delta E determines the degree of sensitivity and the classification. The Blue Wool classification ranges from ISO 1 to ISO 8. Most archive materials in the Netherlands are highly sensitive to light and fall under ISO class 1-3.

To date, the extent of use of office copies and the number of copies kept in archives is unknown. The relevance of specific conservation measures has not been indicated. Does a particular sort of copy occur rarely or in great quantities? Quantitative research could provide a verdict.

So far, few relevant publications of research into the conservation and / or material composition and deterioration of different sorts of office copies have appeared. In-depth investigations into the causes of deterioration of the first mechanical copy form, the pressed letter book, have been carried out and published. In 2001, Rachel-Ray Cleveland[21] gave an historical overview of the copy inks used in the copybook process. Ubbink and Partridge[22] describe conservation treatments for pressed letter books in their 2003 article. An article from 2011 describes conservation measures for the Letterpress Copying Books of the Baird Collection in the Smithsonian Institute[23].

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[18] Rhodes, B., Streeter, W.W., (1999), Before photocopying: the art & history of mechanical copying, 1780 – 1938: a book in two parts. New Castle, DeE: Oak Knoll Press.

[19] Ford, B., Batterham, I., (2014), Accelerated Light-Fading of Some Historic Office Copy Documents. Sydney: The 8th AICCM Book, Paper and Photographic Materials Symposium.

[20] ISO. ISO 105-B08:1995: (1995) Textiles - test for colour fastness - Part B08. Quality control of blue wool reference materials 1 to 7. International Organisation for Standardization, Geneva, Switzerland.

[21] Cleveland, R., (2001), Selected 18th, 19th and 20th century iron gall ink formulations developed in England, France Germany and the United States, for use with the Copy Press process. In: Iron Gall Ink Meeting, 4-5 September 2000, Post prints, University of Northumbria, Newcastle.

[22] Ubbink, K. and Partrige, R., (2003), Preserving Letterpress Copying Books, Canadian Association for Conservation of Cultural Property 28: 38-45.

[23] Antoine, B., Mecklenburg, M., Speakman, R., Wachowiak, M., (2011), The Conservation of Letterpress Copying Books: A study of the Baird Collection. USA: The Book and Paper Group Annual 30.

Much has been published about the conservation needs of architectural drawings. Various publications give good advice on the conservation measures to be taken[24]. There is an overlap with architectural drawings and office copies. The diazo process and synthetic aniline inks are used for both architectural drawings and office copies. Price states that these inks may have alkaline sensitivity[25]. This would mean that they should be kept in neutral packaging. Diazo architectural drawings continue to emit ammonia gas and should therefore be packed separately from other architectural drawings and documents (Price, 2010).

Publications from the Coördinatiepunt Nationale Conservering (CNC) indicate that the paper quality in the period 1840 -1950 was poor[26]. Can a cause be found for the large-scale deterioration of paper documents from this period? The article, 'The 1845 paper crisis in the Netherlands. A historical-technical study into the Dutch paper market, and into the nature and extent of the inferior quality of mid-19th century paper'[27], provides insight into the poor quality of papers from 1800 to 1950. Original records support the facts in this article. In 1845, following a letter about the poor quality of Dutch paper, the Minister of Finance, van Hall, initiated an investigation into the quality of Dutch paper. The article describes the rapid decline in the number of paper mills between 1800 and 1850 and the rise of the first paper factories in the Netherlands.
Both the high quality handmade rag paper and the poor quality mechanical wood-containing paper were in circulation in the second half of the 19th century. Various office copies techniques were produced in the same period. Can we discover whether there is a link between paper quality and copying technique?

In the Nederlands Archievenblad of 1951, M.W. Jurriaanse, archivist at the Ministry of Foreign Affairs, wrote an appeal for help in the article, The impending destruction of our modern archives [28]. Quote: "The carbon-copy paper is far below the minimum quality of paper, moreover carbon fades so much that it is unreadable after about 10 years. In the modern departmental administration, the Retocé process, or photocopying with R. Foil or transparent, is widely used. These photocopies go to the files unwashed, so that all chemicals remain in them. Tests have shown that such a photocopy, hung in the light, is white in three months, or rather an even yellow. In the department where I work about 3000 of these photocopies are made per day (…). Stencil prints have a shelf life of no longer than about 10 years. The ever-deeper penetration of mechanisation threatens our culture (…..)." Jurriaanse concludes her appeal for help with the words, "The auto-destruction has taken on gigantic forms". This cry for help was not scientifically substantiated and has never been further investigated.

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[24] Kissel, E., Vigeau, E., (1999), Architectural Photoreproductions: A Manual for Identification and Care. Oak Knoll Press. New York.

[25] Price, L.O., (2010), Line, Shade and Shadow. The Fabrication and Preservation of Architectural Drawings, Oak Knoll Press. USA New Castle, p. 276.

[26] Hol, R., Voogt. L., (1991), Bedreigd papierbezit in beeld, Coördinatiepunt Nationaal Conserveringsbeleid, CNC-Publicatie 2, Den Haag.

[27] E. van de Grijn, A. Kardinaal and H. Porck. (1996),The 1845 paper crisis in the Netherlands. A historical-technical study into the Dutch paper market, and into the nature and extent of the inferior quality of mid-19th century paper. In: IPH Congress Book (Vol. 11). Marburg, Germany: International Association of Paper Historians, 153-163.

[28] Jurriaanse M.W., (1952), De dreigende ondergang van onze moderne archieven, Nederlands Archievenblad, jaargang 56, Koninklijke Vereniging van Archivarissen Nederland.

The loss of information of the Civil Registry records is another cry for help. The Amsterdam Civil Registry records from the 1980s to the 2000s could contain acts that have been affected by ink damage, and therefore run the risk of becoming illegible. This particular problem was investigated in 2007[29]. Three factors had played a major role in the damage process: the ink, the paper and the climatic storage conditions.

Literature research performed by D. Plugge, Archive Sciences student at the University of Amsterdam, revealed that in the period from 1800 to 1950, roughly five different processes were used to produce office copies in the Netherlands[30].

1.4 The pressed letter book (1780-1958)

The pressed letter book was used between 1780 and 1958, but decreased rapidly after 1920. The copy method is a transfer method based on water solubility/water sensitivity. This method could be performed as a loose-leaf copy, or as a bound copy in a pressed letter book. The method has existed for almost 200 years. Thus there are many known variations and patents of this method. The changes were not so much to speed up the process, but to improve ease of use. The pressed letter book consists of thin semi-transparent sheets of blank paper bound in a simple binding. All sent letters were copied and stored in it. The copy was printed directly from the original. The original letter was written with water-sensitive dye, and/or with a water-sensitive binder, and/or slow-drying ink on a paper that did not absorb moisture too quickly. Copies could be made within 24 hours after making, but letters copied within a few hours were of better quality. (See Appendix 1)

1.5 Carbon (1850-1990)

This copying method is based on impact or pressure. Carbon paper consists of a sheet of paper coated on one or both sides with binder, pigment and/or dye. By applying pressure to the carbon paper, this layer releases ink and makes a print. This can be either a mirror image or an exact image, depending on the purpose of the copy. The original and copy are made simultaneously. The carbon paper is placed between two sheets of blank paper. The top sheet is for the original and the bottom sheet for the copy. The carbon paper lies with the ink side against the face of the paper to become the copy. The original is typed and the copy is made behind it simultaneously. With one original, 10 readable copies could be made at the same time. It was a cheap way to make a copy directly from the original.

The first form of carbon paper was patented in 1806 and was invented to quickly and easily duplicate handwritten letters. Carbon paper was not immediately popular. To make a copy, some pressure is required and this was not possible with pen and ink. An original could only be made with pencil, graphite marker or metal scriber, but, after the invention of the typewriter, the development and production of carbon paper increased rapidly. Carbon paper could also be part of other copying methods. Carbon paper was also used for the hectograph and the pressed letter book. (See Appendix 2)

[29] Water van de, S., (2007), Inktmigratie: Afstudeeronderzoek naar de inktmigratieschade in aktes van de burgerlijke stand, Amsterdam, Instituut Collectie Nederland.
[30] Plugge, D., (2017), Onderzoeksverslag: Waar zijn de kantoorkopieën? Amsterdam: Universiteit van Amsterdam, Archiefwetenschap.

1.6 Stencil (1871-1980)

The mimeograph copying method is a stencil method and has existed in several forms all of which are based on the same principle. The 'base document' (the stencil) is a porous/open sheet of paper or textile through which the ink is printed. This copying method is similar to screen printing and is classified under stencil printing in printing techniques. The method was widely used between 1871 - 1950 by businesses, then used in schools, clubs and associations until the mid 1980s. The stencil has a great variety of printing processes.

The method developed due to the rapid mechanisation of the business world. The first stencil device was manual and appears very similar to a screen print frame, with its mesh and inked roller. Soon machines were developed where mechanical stencil copies could be made at high speed. Business demand for a faster and higher copying rate not only sparked development of the device, but also of the paper, ink and the way in which the 'master document' was produced. A new stencil was patented nearly every year. (See Appendix 3)

1.7 Hectograph and spirit duplication (1878-1975)

Hectograph is an ink transfer method in which a copy of the original is made directly. The method is based on transferring ink while the original remains intact. This method uses the water solubility of the inks that are transferred. With a hectograph, an indirect copy is made by which the ink is transferred to a master copy that is then copied. The manual hectograph was further developed into mechanical fluid hectograph so that more and faster copies could be made. This liquid duplicator was much more common in offices than the manual method.

Spirit duplication makes a direct copy. The paper is moistened with solvents, causing the ink of the master to adhere to the paper of the copy. The hectograph was used for copying documents, but also for architectural drawings. The liquid hectograph was developed to make office and administration copies faster and on a larger scale. (See Appendix 4)

1.8 Diazo/Océ (1930-1970)

Diazo is a copying method based on light sensitivity. The diazo copying method was initially used for duplicating architectural drawings, but after 1930 it was also used for copying documents. The diazo copy is based on a light-sensitive diazonium bond with which a positive print is made. The result is a white background with dark lines. Several processes have been developed for this copying method: the dry-copy system and semi-dry copying system are the two best known.

There are two components in this process. A photosensitive chemical, diazonium salt, and an azo dye known as the coupler. Azo dye is a colourless chemical substance that forms colour in combination with the diazonium salt. These two chemicals are mixed in water in various proportions. The paper is impregnated on one side with this mixture, and then dried in the dark. This diazo paper was commercially available, but had to be kept sealed from light. The original document is produced on a transparent or semi-transparent surface. With this master, copies can be made under the influence of UV light.

The diazo process was patented, so other companies were forced to circumvent it. That is how Van der Grinten came up with its own diazo paper called Primulin paper. This paper contained additives to prevent the paper from yellowing. In 1927, Van der Grinten introduced a new variant to the market: Primulin o.c. paper, where o.c. stands for 'ohne components' [without dye components]. It was

a semi-dry process. As a result, it was no longer necessary to develop with ammonia, and this method was better suited for making multiple copies than the dry-copy system. In 1930, the paper was so popular that it ultimately became the name of the entire company: Océ. The semi-dry copy system was used in the Netherlands more than the diazo dry-copy system. (See Appendix 5)

3. Design and implementation of the research

3.1 Sampling

In order to answer the question of the relevancy of research into on the deterioration of office copies, sampling was carried out. In addition to the cause of damage, extent is an important factor in setting conservation priorities. The Research & Statistics Department carried out the sample. All inventory numbers of the inventoried archives were used. The time period of these archives covers 1275 - 2018. The inventory numbers of the library, print & drawing collections, the photographical collections and audio-visual material are excluded, because these are separate collections and physically totally different to the standard archive documents. The archive collection has almost 925,000 different inventory numbers.

A random sample of 350 numbers was drawn from these inventory numbers. When the sample was taken, it was not stratified by depot, but it later emerged that the sample was divided almost equally over all depots. Based on this data, a statement can be made about the presence of office copies in the entire archive. In scientific social research, 95% reliability is often pursued: it can then be said with 95% certainty that the value found is valid for the entire population, taking into account margins of error in relation to the found value. The larger the sample is, the smaller the error margins will usually be, while a higher desired reliability level with a sample of the same size will lead to higher error margins.

The 350 ID numbers from the sample were assessed on the following points:

Sample form

ID number	
Access number	
Inventory number	
Location	depot/rack/cupboard/shelf
packaging unit	SL SS HS PM XGD SB<60 SB<50 SB<40 LB<27 [31]
number of inventory numbers in units	
inventory number thickness	Cm
copy / original	original copy
bound / loose	loose bound
various sizes in stack	yes no
Year	
document type	
copying technique	pressed letter book carbon stencil hecto diazo
written / typed	written typed
ink colour	brown black blue violet grey
paper type	rags machine carbon copy
yellowed paper	yes no
tears	yes no
Creases	yes no
Comments	

[31] SL = standard horizontal box
SS = standard standing box
HS = high box
PM = print box M
XGD = print box G or X
SB< 60 = vertical book <60cm
SB<50 = vertical book <50
SB<40 = vertical book <40 cm
LB<27 = horizontal book <27 cm (thickness)

3.2 Identification of copies

The Omega project has been in progress at the Municipal Archives of Amsterdam since 2015. The archive has approximately 11 kilometres of non - inventoried archives. For this project, about 15 staff are inventorying archives on a daily basis, and the documents to be described are selected on the basis of substantive criteria. Not all offered archival material is kept. Only one copy of duplicate documents needs to be retained. For this reason, many double copies have ended up in the paper waste bins. From this collection of double copies, approximately 1.5 metres of office copies were collected, aiming for the greatest possible diversity between 1800 and 2000.

3.3 Training of research staff

Although the researchers are trained in conservation techniques, identifying the different types of office copies requires a certain specialisation. Thirty-seven frequently occurring different materials and inks were selected by visual identification from the 1.5 metres of double office copies. The technique used was determined using the book by Ian Batterham. The objects were then sent to Ian Batterham in Australia, who carried out the final assessment. This way, we learned how to reliably classify office copies.

3.4 Sampling

The 1.5 metres of double office copies were sorted according to the 5 techniques defined by Plugge, plus another group. The pressed letter book does not appear in this selection because these books are never double and therefore never discarded. Within the four groups, a chronological selection was made and selected based on the same technique and a different external appearance. For example, a different colour of ink or type of paper. From the copybook, 4 samples of unused pages were taken.

The pressed letter book K1 - K4	(sample period 1880 - 1918)
Carbon C1 - C91	(sample period 1917 - 1984)
Stencil S1 - S42	(sample period 1919 - 1980)
Spirit duplication H1 - H40	(sample period 1916 - 1970)
Diazo D1 - D19	(sample period 1946 - 1969)

The samples vary in number and period, and there are several reasons for this. Carbon paper and stencils were widely used over a relatively long period. They were therefore amply present. The (liquid) hectograph was also used over a long period, but less often, and therefore occurred less in the double collection. The diazo technique has been in use for a short time in the Netherlands, and is therefore rare. The pressed letter book was mainly used prior to World War I, while other methods arose later (result of this literature research). This was also the case for the 1.5 metres; no papers from pre -1916 were found.

3.5 Sampling of the selected samples

Chemical analysis and light fading are costly and time-consuming processes. From the selected 196 samples, 23 were selected for further analysis. This included one from the beginning of a technique's use, one from the end, and some from the middle period.

The following 23 samples were selected:

Pressed letter book: K1, K4
Carbon: C2, C29, C48, C64, C73, C86
Stencil: S3, S12, S21, S25, S28, S37
Spirit duplication: H1, H6, H13, H22, H31
Diazo/Océ: D2, D6, D12, D17

Copying process	Pressed letter book (1780-1958)	sample K1	sample K4
	Number	K1	K4
	Year	1880	1918

Copying Process	Carbon (1850-1990)	sample C2	sample C29	sample C48	sample C64	sample C73	sample C86
	Number	C2	C29	C48	C64	C73	C86
	Year	1920	1945	1953	1958	1963	1979

Copying Process	Stencil (1871-1990)	sample S3	sample S12	sample S21	sample S25	sample S28	sample S37
	Number	S3	S12	S21	S25	S28	S37
	Year	1924	1936	1945	1949	1954	1965

Copying Process	Spirit duplication (1878-1975)	sample H1	sample H6	sample H13	sample H22	sample H31
	Number	H1	H6	H13	H22	H31
	Year	1916	1930	1939	1953	1963

Copying process	Diazo /Océ (1930-1970)	sample D2	sample D6	sample D12	sample D17
	Number	D2	D6	D12	D17
	Year	1946	1955	1962	1967

3.6 Chemical analysis

In order to analyse the composition of the papers, a fibre analysis was performed on the 23 samples by the Papiertechnik Stiftung laboratory in Heidenau, Germany. The surface pH of all samples was also measured. The following methods were used.

The IR spectra of each paper sample are presented and interpreted. Detailed information on the attribution of IR bands to specific components is given only once. The spectroscopic analysis of the papers allows one to: detect mechanical pulp (lignin), determine if the paper contains mainly rag

fibres, or chemical pulp fibres (wood cellulose). If the paper contains only chemical pulp fibres (wood cellulose), then in most cases it is possible to say if the cellulose comes mainly from soft or hard wood. The top side is always the side with the sample name on it.
Raman measurements were performed to determine ink and paper colorant pigments and also to get additional or more detailed information on the chemical composition of the papers.
NIR measurements were used for the non-destructive quantification of the contents of the clay and talc fillers. A quantification of the filler barium sulphate is not possible with NIR.

IR measurements

Infrared (IR) spectroscopy measurements were performed with a Tensor 27 FT-IR spectrometer (Bruker) with an ATR (Attenuated Total Reflection) accessory.
Three IR spectra were acquired on each paper side to calculate the corresponding average spectra.
Note: The penetration depth of IR light is between 2 to 4 µm in ATR measurement, i.e. the latter analyses only the outermost layer of the sample surface.

Raman measurements

Raman measurements were performed with a WITec alpha 300M+ Raman microscope using a 532 nm laser with a power of 5 mW at the sample.
The Raman imaging measurements were done on the cross-sections of thin paper strips (about 1 mm), which were taken from the paper edges that had been already used for sample extractions.
The Raman images were measured with a step size of 1 µm. The chemical substances detected in the images were visualised by colour coding.

NIR measurements

Near Infrared (NIR) measurements were performed with a FT-NIR spectrometer MPA (Bruker).
The NIR spectra were used for the quantification of the filler contents in the papers by applying an in-house developed calibration model. The standard error of prediction (SEP) of the calibration models for the quantification of clay and talc are +/- 1 %.

pH value of the surface

The samples were stored, handled and measured under standard climatic conditions at 23°C. A measuring device WTW pH 538 together with a SenTixSur electrode was used for the testing.
The mean value was calculated from 5 single measurements per sample. The surface pH was measured after 2 min.

A second chemical analysis of the papers was conducted under the guidance of Bas van Velzen according to his method. This research was done to put the newly developed method into practice, and to collect additional data such as fibre length. A fibre sample was teased apart with a needle under a magnification of 50-200 on a bi-ocular microscope and under polarization filters. The fibre samples were then placed on a bed of 50:50 water/glycerine. Examining the structure with this method can easily identify the type of fibre. Mineral fillers can also be identified with this method. In this way, the following substances can be identified:[32]

Rag: flax, hemp, cotton, cotton linters, jute, bast fibre, presence of wool fibres
Wood: coniferous, deciduous (eucalyptus)
Grasses: esparto, straw
Leaf fibres: abaca
Mineral fillers: barium sulphate (barite, blanc fixe), calcium carbonate (ground), calcium carbonate (precipitated), kaolin, smalt, titanium oxide, starch used as filler

3.7 Light fading

The Dutch Cultural Heritage Agency (RCE) tested the inks of the different samples for their sensitivity to light. Delta E determines the degree of sensitivity and the classification in the ISO classes of the Bluewool Standard. The Bluewool classification is from ISO 1 to ISO 8.[33]
Paul Whitmore introduced the idea of micro fading in 1999. RCE has made a number of changes to the equipment he originally used:[34]
Spectrophotometer: Avantes AvaSpec 2048
Xenon light source: Newport Type no.71702, 75 Watt
Fibre optics: exposure via 2 long Avantes FC-UV 400 micron diameter fibre optics; sensor fibre: Avantes FC-UV 200 micron diameter fibre optics
UV and IR radiations are blocked by means of an Optics Balzers CALFLEX C heat-protection filter. This blocks everything above 750 nm and below 380 nm. Additionally, by means of an Ocean Optics filter holder (FHS In-Line Filter Holder), a neutral grey filter was positioned to weaken the light directed at the spectrophotometer, so that the detector was not overloaded.

[32] Velzen van, S.T.J., (2018), The universe between felt and wire: A new look into the typology of Western made paper, University of Amsterdam.
[33] ICN informatie, (2005), Het beperken van lichtschade aan museale objecten: Lichtlijnen. Amsterdam, Instituut Collectie Nederland.
[34] Whitmore, P.M., Pan, X. & Bailie, C., (1999), Predicting the fading of objects: identification of fugitive colorants through direct non-destructive lightfastness measurements, Journal of the American Institute for Cultural Heritage, 38, 395-409.

4. Results

The discussion of the results is based on the four questions forming the research.

4.1 Research question 1

Which mechanically manufactured office copies were used in Amsterdam in the 19th and 20th centuries?

Literature research has shown that various office-copying techniques were used side by side. The most commonly used are described in the table below.

Overview of characteristics of the most popular office copying techniques in the Netherlands.

Technique	Period	Method	Ink	Papers	Additives
Letter pressed book	1780-1958	Pressed letter book with press	Iron-gall ink and aniline ink	In the form of a book. Thin, semi-transparent paper with high wet strength.	In paper for fixing inks: acid mordants. For making paper and ink hygroscopic: sugar, honey, glycerine, hygroscopic salt
Carbon	1850-1990	Impact transfer technique using carbon paper	Black: pigments; carbon black, lampblack Blue-purple aniline ink. Combinations of both.	Carbon copy paper 30 - 45 grams, or tissue paper. Also in different colours.	Ink binders: oil, wax, paraffin.
Stencil	1871-1990	Stencil technique using the base document: the stencil is made using a machine copy.	Generally carbon black pigment in oil. In early recipes; aniline ink in glycerine.	Slightly porous, fibrous and open in structure; highly absorbent for oil-based inks.	Additives in inks: linseed oil diluted with white spirit, resin, resin-based soap, and solvents
Spirit Duplication	1878-1975	Ink transfer technique using a master copy of gelatine, or a methylated spirit master using a hectograph machine.	Based on aniline dye, and is water soluble.	Low absorbency due to alum-rosin or gelatine sizing.	Ink binder: water, alcohol, glycerine. Duplicator fluids: mixtures of solvents; isopropanol, methanol. Or 10% trichlorofluoromethane and 90% of a mixture of 50% methyl alcohol, 40% ethyl alcohol, 5% water and 5% ethylene glycol mono-ethyl ether. Optical brighteners in paper.
Diazo/océ	1930-1970	Technique based on light sensitivity. The base document is (semi) transparent. The copies are made with a machine using UV light.	Azo dyes with diazonium salt. Océ = D/NL: Ohne Componenten kleurstof = ENG: without dye components	Océ Primulin paper is yellow on one side, and made light-sensitive with diazonium salt.	Diazo: ammonia developer. Océ: developer fluid Yellow dye Substances to prevent yellowing.

4.2 Research question 2

How stable are the papers and inks of the most popular office copying techniques?

Extensive literature research in public sources provided no information about the composition of the papers for the various copying techniques, except for the occasional remark that the paper should be smooth, or have an open structure.

Results of chemical analysis and general information

The results of the chemical analyses of the samples by the Papiertechnische Stiftung laboratory and the results from Van Velzen are presented in tables per copying technique. General information was also compiled per sample. This general information consists of the year, size, colour, paper thickness, presence of a watermark, presence of lignin, surface pH and folding resistance.

Copy book

The copy book has thin paper and is always bound. The papers are not or barely sized.
Iron-gall ink is used on papers for typewriter use. Iron-gall ink is water sensitive and can lead to ink corrosion. Halos often become visible around the letters at an early stage.

Copying process	Pressed Letter (1780-1958)	Sample K1	Sample K4
General information	Number	K1	K4
	Year	1880	1918
Description	Size		
	Color recto	white/beige	white
	Paper thickness	0,21 mm	0,21 mm
	Surface recto		
	Surface verso		
	Watermark	none	none
Fiber analysis BvV	Fiber type	flax	coniferous/deciduous CP
	Fibrillation	high	Normal
	Fiber length	predominantly short	predominantly long
	Fiber size distribution		even
	Sizing		
	Filler	kaolin low	
	Look-through of the paper	hollander or refiner beaten	hollander or refiner beaten
Paper composition PTS	Fiber	rag	rag, cell-S
	Filler	clay <1	
	Sizing		
	Additives	traces of calcium oxalate	

Ink	Ink pigment		
Decay	Lignine (MP)		
	Fold endurance	>20	>20
	Surface pH	4,6	6,2

Cell-S soft wood cellulose (pine, spruce etc)

Cell-H hard wood cellulose (birch, poplar etc.)

MP mechanical pulp

CP chemical pulp

SW Softwood (coniferous wood)

HW Hardwood (deciduous wood)

Carbon

Carbon copies are often made on thin carbon-copy paper. They can have different colours such as pink, yellow and blue. Carbon copies were made on various papers of various sizes. The fibres are chemically pulped from wood and the filler is clay. The ink of the first sample is blue, and that of the other samples is black.

Copying process	**Carbon copies(1850-1990)**	**Sample C2**	**Sample C29**	**Sample C48**	**Sample C64**	**Sample C73**	**Sample C86**
General informati-on	Number	C2	C29	C48	C64	C73	C86
	Year	1920	1945	1953	1958	1963	1979
Description	Copy size	331 x 196 mm	299 x 229 mm	293 x 206 mm	294 x 207 mm	29,3 x 20,6	29,7 x 21
	Color recto	beige	blue	yellow/white	beige	blue	yellow
	Paper thick-ness	0,23 mm	0,23 mm	0,22 mm	0,25 mm	0,22 mm	0,25 mm
	Surface recto						
	Surface verso						
	Watermark	none	none	none	yes	none	none
Fiber analysis BvV	Fiber type	coniferous CP	coniferous CP/straw	coniferous CP	coniferous CP	coni-ferous/decidu ous CP	coni-ferous/deciduo us CP
	Fibrillation		low	normal	low	normal	
	Fiber length					long	short and predominantly long
	Fiber size distribution		normal / even	normal	normal	normal	
	Sizing						
	Filler		none			kaolin low	low

	Look-through of the paper	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten
Paper composition PTS	Fiber	cell-S	MP cell	MP cell	cell-S	cell-S	cell-H
	Filler	clay <1	clay 2 %	clay 6 %	clay 1%	clay 3%	clay 7%
	Sizing	Rosin	?	?	rosin	rosin	rosin ?
	Additives	long chain carbohydrate on two surfaces	prusian bleu			acid blue	benzimidazolone type PY 151
Ink	Ink pigment	methyl violet					
Decay	Lignine (MP)		MP	MP			
	Surface pH	4,5	4,8	5,2	5,2	5,1	7
	Fold endurance	>20	>20	>20	>20	>20	>20

Stencil

Stencil papers are relatively thick, have diverse sizes and a rough surface. A number of samples are strongly yellowed and consist of mechanically-pulped wood fibres. Clay is used as filler. The ink is black except for one sample.

Copying process	**Stencil (1871-1990)**	**Sample S3**	**Sample S12**	**Sample S21**	**Sample S25**	**Sample S28**	**Sample S37**
General information	Number	S3	S12	S21	S25	S28	S37
	Year	1924	1936	1945	1949	1954	1965
Description	Copy size	343 x 216 mm	270 x 209 mm	294 x 208 mm	330 x 216 mm	297 x 210 mm	294 x 206 mm
	Color recto	beige	beige	yellow/brown	yellow/brown	yellow/brown	beige
	Paper thickness (mm)	0,32 mm	0,27 mm	0,32 mm	0,28 mm	0,31 mm	0,31 mm
	Surface recto		open structure	open structure	open structure	very open structure	open structure
	Surface verso		open structure	open structure	open structure	very open structure	less open structure
	Watermark	none	D. Gestedner's 23	none	none	none	none
Fiber analysis BvV	Fiber type	coniferous CP/esparto	coniferous CP/esparto	coniferous MP/conferous CP	coniferous MP / conferous CP	coniferous MP/ conferous deciduous CP	deciduous CP
	Fibrillation	low		low	low		
	Fiber length		predominantly short	predominantly short	predominantly short	predominantly long	predominantly long

	Fiber (size) distribution		even	wild and cloudy	wild and cloudy	normal	even
	Sizing	starch (uncooked granules)					
	Filler	kaolin	kaolin low			kaolin medium	barium sulfate
	Look-through of the paper	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten
Paper composition PTS	Fiber	cell-S	cell-S	MP	MP	cell	cell-H
	Filler	clay 5%	clay 13%	clay <1	clay <1	clay 16%	clay 7%
	Sizing	rosin	rosin				rosin
	Additives						
Ink	Ink pigment						
Decay	Lignine (MP)			yes	yes	yes	
	Surface pH	5,1	4,5	4,1	4	4,4	4,5
	Fold endurance	>20	>20	>20	>20	>20	>20

Spirit duplication

The papers have various sizes, a smooth surface and are made of wood fibre. The mechanically-pulped papers are yellowed. These papers are sized with alum-rosin and contain a relatively high amount of clay. The ink is coloured blue/violet, and the dye is methyl violet.

Copying process	**Spirit duplication (1878-1975)**	**Sample H1**	**Sample H6**	**Sample H13**	**Sample H22**	**Sample H31**
General information	Number	H1	H6	H13	H22	H31
	Year	1916	1930	1939	1953	1963
Description	Copy size	330x 203 mm	288 x 207 mm	297 x 210 mm	294 x 207 mm	294 x 207 mm
	Color recto	beige	beige	yellow/brown	yellow/brown	beige
	Paper thickness	0,26 mm	0,27 mm	0,25 mm	0,28 mm	0,28mm
	Surface recto		smooth	smooth	smooth	smooth
	Surface verso		smooth	smooth	smooth	smooth
	Watermerk	none	none	none	none	none
Fiber analysis BvV	Fiber type	coniferous deciduous CP	coniferous CP/straw	coniferous CP/straw	coniferous MP / deciduous CP	coniferous MP/ coniferous deciduous CP

	Fibrillation	normal	low	low		
	Fiber length	predominantly long	predominantly short	predominantly short	predominantly long	predominantly long
	Fiber size distribution		even		wild and cloudy	wild and cloudy
	Sizing		alum-rosin	alum-rosin	alum rosin	alum-rosin
	Filler	kaolin	kaolin (medi-um/high)	kaolin (medi-um/high)		kaolin low
	Look-through of the paper	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten
Paper com-position PTS	Fiber	rag / cell-S	cell-S	MP , cell	MP, cell	MP, cell
	Filler	talc 7%	clay 11%	clay 12%	clay 20%	clay 24%
	Sizing	rosin	rosin	?	?	?
	Additives	traces of gelatin all over both paper sides				
Ink	Ink pigment		methyl violet	methyl violet	methyl violet	
Decay	Lignine (MP)			Yes	Yes	Yes
	Surface pH	4,4	4,2	3,9	3,9	4,4
	Fold endurance	>20	>20	20 half through	>20	>20

Diazo/Océ

Almost all papers have the same sizes and thickness. There is a colour difference between the recto and verso sides of the documents. The paper is smooth, sized with alum-rosin with clay as filler. Ethyl-vinyl acetate was found on the top surface of the papers. The documents have a characteristic odour of sulphur. The ink is an azo dye.

Copying Pro-cess	**Diazotype / Océ (1930-1970)**	**Sample D2**	**Sample D6**	**Sample D12**	**Sample D17**
General infor-mation	Number	D2	D6	D12	D17
	Year	1946	1955	1962	1967
Description	Copy size	298 x 213 mm	296 x 210 mm	297 x 212 mm	297 x 212 mm
	Color recto	yellow/brown	yellow/brown with pink	yellow/brown with pink	yellow/brown with pink
	Color verso	beige	yellow/brown with pink	beige	beige
	Paper thickness	0,27 mm	0,28 mm	0,27 mm	0,28 mm
	Surface recto	smooth	open structure	smooth	smooth
	Surface verso	smooth	open structure	smooth	smooth
	Watermark	none	none	none	none

Fiber analysis BvV	Fiber type	coniferous CP	coniferous deci-duous CP	coniferous deci-duous CP	coniferous deci-duous CP
	Fibrillation	normal			low
	Fiber length	predominantly long	long	long	short
	Fiber size distri-bution	even	normal	normal	normal
	Sizing				
	Filler	kaolin low	kaolin low		
	Look-through of the paper	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten	hollander or refiner beaten
Paper composi-tion PTS	Fiber	cell-S	cell-H, MP	cell-S	cell-H
	Filler		clay 5%	clay 1% / talc 3%	
	Sizing	rosin	rosin	rosin	rosin
	Additives	traces of gelatin all over both paper sides	ethyl-vinyl acetate on topside	ethyl-vinyl acetate on topside	ethyl-vinyl acetate on topside
Ink	Ink pigment				
Decay	Lignine (MP)		yes		
	Surface pH	5,2	7	4,8	4,7
	Fold endurance	>20	>20	>20	>20

Average acidity and thickness per copying technique.

Average acidity (surface pH) and paper thickness
In order to compare the different techniques, it is convenient to calculate the averages of the acidity and thickness of the paper samples.

Copy book pH: 5.4.	Thickness: 0.21mm
Carbon paper pH: 5.3.	Thickness: 0.23 mm
Stencil pH: 4.4.	Thickness: 0.30 mm
Spirit duplication pH: 4.2.	Thickness 0.27 mm
Diazo/Océ pH: 5.4.	Thickness 0.28 mm

Results of light fading

The inks of the carbon copies of samples C2 and C64 were tested. Of the stencil samples, S3 letters 'a' and 'z' and S37 were measured by spectrophotometric analysation. Testing of the hectograph inks showed that thin ink fades faster than thick ink under the influence of light. The fading rate is the same over time, but because the volume of thick ink is greater, it remains visible longer. This is illustrated in the table below. See for example the letter 'v' of H1 compared to the digit '4' of sample H1. The light sensitivity of the inks of the diazo samples D6 and D17 was also tested. The inks of samples C2, H1, H22 are aniline inks containing methyl violet dye. These inks are very light-sensitive and fall under the Blue Wool Standard (BWS) class 1. The thickness of these aniline inks sometimes results in a BWS class 2. The black inks of the carbon paper and stencil samples contain the light resistant pigments of carbon or lamp black, and thus fall under BWS class 3. The inks of the diazo samples fall under BWS 2.

Results

Cate-gorie	BWS1	BWS1	BWS1	BWS1	BWS1	BWS2	BWS2	>BWS2	BWS3	>BWS3	>BWS3	>BWS3
Kopie	C2 's'	H22 '4'	H22 ' v '	H1 ' v '	H22 'g'	H1 '4'	D6 'g'	D17 's'	C64 'e'	S3 'a'	S3 'z'	S37 'p'
I, Mlux	4,54	4,54	4,54	4,54	4,54	4,54	4,54	4,54	4,54	4,54	4,54	4,54
ΔE	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr
1,5	25	28	28	42	65	104	163	416	818	niet bereikt	niet bereikt	niet bereikt
5	104	108	115	174	260	550	niet bereikt	niet bereikt	niet bereikt	niet bereikt	niet bereikt	niet bereikt
L	lichter	lichter	lichter	lichter	lichter	lichter	lichter	lichter	lichter	iets lichter	iets donker-der	iets lichter
A	groener	groener	groener	groener	groener	roder	roder	roder	roder	iets groener	stabiel	iets roder
B	geler	blauwer	geler	geler	geler	geler	blauwer	iets blauwer	blauwer	iets blauwer	iets blauwer	iets geler

*Tabel 1 – Resultaten van de 'microfading' experimenten op de kopieën uit het Amsterdams Stadsarchief; I = toegepaste intensiteit; ΔE = verkleuring, berekend uit de reflectiespectra volgens het CIEL*a*b (1976) kleurmeetsysteem; L =helderheid; a = rood/groen bijdrage; b = blauw/geel bijdrage*

	BWS1	BWS2	BWS3
I, Mlux	0,17	0,17	2,4
ΔE	Dosis, klux hr	Dosis, klux hr	Dosis, klux hr
1,5	50 ± 10	140 ± 30	700 ± 30
5	230 ± 20	560 ± 120	3700 ± 300

Tabel 2- Lichtdoses nodig voor het bereiken van een ΔE = 1,5 of 5 voor de Blauwe Wol Standaarden 1, 2 en 3 gemiddelde waardes van 5 metingen[35]

4.3 Research question 3

Can the papers and inks be preserved with the same conservation measures as for other documents, or is special treatment required?

[35] This overview is draught by Han Neevel, senior researcher at the Dutch National Heritage Institution.Amsterdam (2018)

Results of the sampling
The sampling links the physical form and properties of an inventory number (object) to the damage (deterioration) found.

The sampling reveals that 48 % of the inventoried objects are copies. This could mean that one inventory number includes a single copy, or that one inventory number includes multiple copies. Within these copies, 62 % (total of 115) consists of carbon copies. 24 % (total of 44) are hectographs and 13 % (total of 24) stencils. The diazo technique was found in 1 % (total of 2) of samples and the copy book in 0 % (total of 1). In addition to the five most commonly used techniques in the research period other techniques were found, such as the currently-used photocopy/print and the letterpress. A single inventory number may include several copying techniques.

Of the papers, 66 % is machine-made, of which 18 % is carbon-copy paper. Of all [JB is this what you mean] Amsterdam Archive inventory numbers, 16 % are documents made of rag papers.

The damage percentages revealed by the sampling are as follows:
Yellowing in 50 % of papers; tears in 38 %; and folds in 54 %. Documents with so-called historical folds, for example, letters, were designated as folded. Note that yellowing, tears and folds can occur in a single document of an inventory number, but also in all documents of an inventory number comprising multiple documents.

More than half (52 %) of the inventory numbers is packed in standard flat archive boxes. Bound documents comprise 21 % of inventory numbers; 67 % are stacks of loose pieces; 12 % could not be assessed because the objects were photos, or were missing. Of all inventory numbers, 46% have a uniform size and 42 % have various paper sizes.

4.4 Research question 4

Are the conservation methods used in preserving architectural drawings also applicable to office copies?

Of the five researched office copying techniques, only the hectography and the diazo technique were also used for architectural drawings. The Océ papers found in the Amsterdam Archives are based on the diazo technique, which was invented by Van der Grinten of Venlo.

5. Conclusion and discussion

Office copies were indeed made in the 19th and 20th centuries in Amsterdam. The copy book, carbon paper, stencil, spirit duplication and diazo were the most popular, and carbon copies occur most frequently in the Amsterdam Archives. The various copying techniques were used side by side. The most efficient machine was purchased according to the specific use within an organisation or company. This explains the variety of copy types.

The relevance of this research is demonstrated by the fact that 48% of the inventory numbers of the archives of the Municipal Archives of Amsterdam contain office copies. A substantial part of the archives, namely 66%, contains documents of machine-made paper. In principle, machine-made paper is of poorer quality than handmade rag paper. Paper was produced in the paper mill following

specific requirements for a certain office copy technique. There were a great variety of paper types, sizes and inks.
Paper for copy books had to be thin with good wet strength to allow sufficient ink penetration for readability. Carbon copies were often made on thin carbon-copy paper. The thin paper made it possible to make thicker stacks, resulting in more copies per copy operation. The greasy ink, based on oil, of stencils adheres best to a fibrous, porous paper with an open structure. Paper for spirit duplication must be slightly absorbent, and was therefore sized with alum-rosin and a clay filler was added. The chemical analyses clearly show these differences. The aniline inks with methyl violet were used for spirit duplication. Aniline inks appear in the typed letters in a letter pressed book. Sometimes aniline was used for carbon-copies and stencil inks. These inks are very sensitive to light. The light-fading tests show that the maximum lux hours of the Blue Wool Standard class 1 are not achieved, especially with the thin inks. Thus all copying techniques using aniline inks are very sensitive to light, and should not be exhibited without a strict lighting policy. Aniline inks are easy to recognize by their blue-violet colour. These inks should not be exposed to light.

The stability of a paper can be determined from the various components from which it is made and the manufacturing technique used. Paper made from cellulose from rags is much more stable than paper made of wood cellulose. Twenty-two of the 23 examined paper samples are of wood pulp. The mechanical pulping operation creates more by-products, such as lignin, compared with chemical pulping. Most paper samples have chemically-pulped fibres, which means there is practically no lignin present. Lignin causes yellowing in paper. Clay is often used as a filler. This softens the paper, making it easier to process and less likely to disintegrate. Clay is also a cheap filler. Paper is purchased per grammage, hence, the heavier the paper, the more money it could be sold for. Alum-rosin sizing was found only in spirit duplication copies. Alum-rosin has a negative effect on the pH of papers. The surface pH of the spirit duplication samples is the lowest. The folding resistance of all samples is greater than 20 folds. This means that the papers are not brittle and therefore still fairly physically strong.

In general one can say that the paper composition of office copy papers in the 19th and 20th centuries does not differ from other machine-made papers.

The papers of carbon-copy books and carbon-copy papers are thinner than the other papers. Thin paper is vulnerable, and therefore at greater risk of damage through folding and tearing during handling. Copy books have papers of an average thickness of 0.21 mm, the thinnest of papers used for copies. However, damage is not extensive because the papers are bound in books and have a uniform size. The binding and cover protects the paper.
Carbon-copy paper is however another case. This paper has an average thickness of 0.23 mm, also very thin compared to other papers. Carbon copies occur as single documents in stacks. Perforation holes are often present due to being placed in a file by the archivist. These perforation holes were reinforced with paper or textile rings adhered around the perforation hole to protect it from being torn out. However, not all holes were provided with such protection. Torn perforation holes are a typical phenomenon in thin fragile papers.
One conservation measure, dictated by the Archives Act, is that no metal fastening mechanism may be present. This is because staples and paper clips rust and cause stains, and consequently information is lost. Ring binders are also removed because they contain metal. Removing the ring binder also removes the binding of the paper documents, thus forming a loose stack. This increases the risk of damage due to sliding and protruding pieces of paper.

Most inventory numbers (67%) are stored in loose stacks. Researchers search the stacks chronologically by leafing through them. It is difficult to replace the documents in a nice neat stack afterwards, especially when the stack consists of paper of different sizes (42%). This results in protruding parts that are susceptible to impacts and folds, which cause tears. Atmospheric oxygen also has easy access to such protrusions, and the resulting oxidation causes yellowing and acidification.

6. Recommendations and suggestions for further research

The papers of the five most common office copy techniques are very diverse, but do not differ from the usual paper compositions used in Amsterdam in the 19th and 20th century. The pH is reasonably low. When the wood fibres are mechanically pulped the paper is heavily yellowed. The usual conservation measures apply here. A longer life-span for this type of paper is achieved by maintaining low temperature and relative humidity of the air in storage[36]. The papers could also be considered for mass de-acidification, except for the diazo/Océ copies.
In this study, only the five most common copy types were investigated, leaving many other different techniques untested. How these would react to de-acidification is yet unknown. The de-acidification of stacks of individual documents with various copying techniques is therefore not recommended.[37]

The stacks of documents under one inventory number are covered by one description and treated as one object. It is important that correspondence is kept in chronological order. In research, this order is essential for finding connections and understanding the content. The stacks often consist of various copying techniques, and can also contain original documents. Removing diazo copies from these stacks is highly undesirable regarding content, because the connection continuity is removed. Further investigation into the influence of diazo/Océ copies of neighbouring documents is desirable in order to determine the extent of negative influences, and to be able to implement any necessary drastic conservation measures.

Stacks of loose documents with their different sizes have an increased damage risk, as they can be damaged by transport and use when in an untidy stack in their cover and box. Folds and tears can occur in the protruding parts, and these parts are also more exposed to oxidation. Carbon copy papers are thin and by definition carry the extra risk of this damage, because they are slippery and more difficult to handle. Thus they are the first to be incorrectly arranged in a stack. Digitisation is an option to avoid damage from handling. Provided this is done carefully, the documents are no longer physically consulted after digitisation. Most researchers would be satisfied with a scan of the original document. Careful digitisation would therefore be a good solution to this problem.

For inventory numbers of single documents with different sizes, it is recommended to store them in horizontal archive boxes to prevent sagging. By making the stacks smaller, it is easier to keep the documents in a neat stack when handling them, thus reducing damage to the fragile protruding parts. Smaller stacks also help the researcher to handle piles of copies correctly. Additionally, read-

[36] (2012) British Standards Institute: PAS 198, Specification for managing environmental conditions for cultural collections: London.

ing room rules specifically for this kind of inventory number would contribute to t he preservation of the documents. Archive staff and researchers are not always aware of the vulnerability of the material they work with. Attention paid to leaving clean, straight stacks intact will limit user damage.

Aniline inks with methyl violet as dye are very sensitive to light. In particular, the thin ink applied to the liquid hectographs fades with just a small dose of light. It is therefore inadvisable to exhibit original objects under lighting. The Blue Wool Standard class 1 is already too high and will cause fading on these copies.

In this study, special attention was paid to comparing copying technique properties in the conservation of architectural drawings. The spirit duplication and diazo techniques can be found in the architectural drawing collections. No special conservation measures are needed for the conservation of hectographs in architectural drawings collections. The diazo's, on the other hand, must be stored separately. This measure is recommended because they can emit chemical residues, thus affecting surrounding materials. Diazo/Océ copies are unstable because oxidation and pH change can cause the background to 'rise', thus reducing the contrast with the letters. The high pH is an important factor in the development of azo dyes. If the environment of a diazo/Océ copy becomes more alkaline, then theoretically the diazonium salts remaining in the background could develop into an azo dye. For this reason, de-acidification is not recommended as a conservation measure for diazo/Océ copies.[38]

For adequate and responsible conservation, archivists and conservators should be made aware of the different types of office copies that are kept in their archives. The 19th and 20th century papers in loose stacks seem to be much more vulnerable than centuries-old parchment charters. A slightly different way of handling and packaging (e.g., smaller stacks), or making them available via digitisation will prevent a great deal of damage. It is desirable to distinguish between different copying techniques in order to develop the appropriate conservation strategies.

This sampling yielded a great deal of data per inventory number. The basic questions are amply answered. Cross-links can be made with the generated data.
What is the frequency of tears in carbon copies? Which techniques were applied in which periods? Is there a relationship between the document type (minutes, outgoing letters, transcripts) and the office copy?

[38]Chemical residues here comprise residues of the azo couplers such as phenol and naphthol, or thiourea with its sulfur component. Sulphur affects silver salts in photographic materials, and diazo copies can continue to emit residues of ammonia (the developer).

Appendix 1: Pressed letter book
Period of use in the Netherlands/Europe: 1780 - 1958
Other terms used: letterpress, copying book.
Common manufacturers/brands in the Netherlands/Europe: Gimborn (after 1904), Pelikan, Talens, Parker, N.V. v/h Klutman & Co, Terborg, NL

Copying method:
The pressed letter book was used between 1780 and 1958, but use decreased rapidly after 1920. The copy method is a transfer method based on water solubility. Copies could be made either loose-leafed or on a bound sheet of paper in a pressed letter book. The method had existed for almost 200 years. Therefore, it has many variations and patents. Changes were not so much to speed up the process as to increase ease of use.

The pressed letter book consists of thin semi-transparent sheets of blank paper bound in a simple binding. All sent letters were copied and stored in it. The copy was printed directly from the original. The original letter was written with water-sensitive dye, and/or with a water-sensitive binder, and/or slow-drying ink on a paper that did not absorb moisture too quickly. Copies could be made within 24 hours after making, but letters copied within a few hours were of better quality.

The original letter is placed in the pressed letter book under a blank page with the text side up. The blank page in the pressed letter book is moistened and placed on the original document to be copied so that it comes into contact and can receive the ink. An oiled paper is placed above and below to prevent transfer to other pages. The pressed letter book is closed and placed in a copy press where it is kept under pressure for some time. It is also possible to copy several letters into one book at the same time.

The copy thus made is in mirror image but because the pages of the pressed letter book are very thin and semi- transparent, the copy is readable from the other side. The ink is more or less pressed through the paper. Multiple copies of one original can be made, but the contrast decreases with each subsequent copy. The binding of a pressed letter book must be able to withstand frequent pressings in the copy/book press.

The loose-leaf copy has the same basic method, only the device with which the pressure is applied is different. This is comparable to an etching press, or a wringer with which the wash once used to be wrung dry.

Ink:
Various types of inks can be found in pressed letter books, but they are all water-sensitive/hygroscopic. There are recipes for making home-made transfer copy ink, but also to make existing ink suitable for copying. Transfer copy ink was also commercially available.
The most commonly found inks in the pressed letter book are iron-gall ink and blue/purple aniline ink. The early books mainly show iron-gall ink because the aniline inks were only developed and available in the late 1900s. Additives were used in iron-gall ink to make them suitable for copying. Hygroscopic substances were added to keep the ink moist for longer, or to make it water-sensitive so that it could be reactivated to make a copy after drying.

Possible additives: sugar, honey, glucose, dextrin, sodium chloride, calcium chloride, sulphuric acid, glycerine, cloves, ammonia, vinegar and carbolic acid.
Dyes such as indigo, logwood or aniline were also added to the iron-gall ink to adjust or enrich the colour.

The use of aniline dye in pressed letter books increased at the end of the 19th century. Aniline dye was used in various ways. Handwritten with pen and ink or aniline pencil, letters typed with aniline-containing ink or aniline-containing carbon paper; all could be copied in the pressed letter book using the transfer method. Aniline inks consist of an aniline dye dissolved in water. Substances were added to

improve the ink properties. Aniline inks are sensitive to light and moisture. Since the copies are bound and stored closed, light and moisture should have a minimal effect on these inks.

Common inks: iron-gall ink, aniline ink
Common dyes: aniline dyes, methyl violet
Common additives: water, alcohol, arabic gum, glycerine, glucose, dextrin, boric acid, carbolic acids, sodium chloride, calcium chloride, sulphuric acid, ammonia, vinegar and perfume, like cloves, to mask the odour of deterioration.

Paper:
A pressed letter book was already bound before copies were made. The paper on which the copies were made had specific properties. The sheets were thin and semi-transparent. The paper had a high wet strength to resist tearing when the page became damp during copying. The ink had to move vertically through the paper, but not horizontally. Cotton fibres are widely used as raw material for paper in the pressed letter book, but also linen, silk, wood-pulp and Japanese gampi paper (after 1868). In order to optimise the paper properties, various additives to the pulp and paper were applied. Mordants were used to fix the ink, and they were often acidic. To make the paper hygroscopic the same additives were often used as for the ink: sugar, honey, glycerine and/or hygroscopic salt. As the paper is thin, there is an increased risk of mechanical damage when handling a pressed letter book.

Recipes

Edel, L.P. (May 1936) Recept mengen er roeren deel 1, 200 populaire chemische recepten voor iedereen, Deventer, Nederland, Uitgave van de N.V. Uitgevers maatschappij AE. E. Kluwer, p. 96	
Ink for documents	
Tannic acid 7.7 g Tannin 23.4 g Ferrous sulphate 30 g Hydrochloric acid 10% 25.0 g Carbolic acid 1 g Soluble blue 3.5 g	Water up to 1 litre (preferably distilled water or rainwater). The blue aniline dye must be especially suitable for making inks, as many dyes are precipitated by tannic acid. The tannin and tannic acid are first dissolved in about 400 cm^3 at 50^0C. The ferrous sulphate is dissolved in 200 cm^3 of warm water. Hydrochloric acid is now added to the solution. The dye is dissolved in a further 200 cm^3 of warm water. The three solutions are now mixed and the carbolic acid added. One can add a small amount of an arabic gum solution to improve the flow of ink out of the pen. The ink must be stored in airtight sealed bottles and then remains for years without depositing. By increasing the amount of aniline blue to about 7 to 10g per litre, the ink can be used as a copying ink.

Films:

Link	Title/ Publisher / date of publication	subject	Consulted on
https://youtu.be/09_NkfnCpsk	Historical Gem: Antique Copy Press, Law Society of Ontario, 2012-08-14	explanation	18-09-2018

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patent numbers	link	patent date	title	inventor
US690862	https://www.google.nl/patents/US690862	1900-07-02	copying-ink	Edward Payson Lawton

US167878	https://www.google.nl/patents/US167878	1875-09-21	Improvement in copying-inks	
US385433	http://www.google.com/patents/US385433	1888-07-03	Letter-copying book	
US476708	https://www.google.nl/patents/US476708	1892-06-07	Movable index for letter-pressed letter books	
US61733	https://www.google.nl/patents/US61733	1867-02-05	Mask b	
US633665	https://www.google.nl/patents/US633665	1899-01-31	Letter-copying press	Wesley L Spaulding
US289983	https://www.google.nl/patents/US289983	1883-12-11	Letter-copying press	
US32363	https://www.google.nl/patents/US32363	1861-05-21	copying-press	
US28020	https://www.google.nl/patents/US28020	1860-04-24	Letter-copying-press	
US503280	https://www.google.nl/patents/US503280	1893-08-15	portable letter-press	

Web pages consulted:

Link	Author, date of publication, publisher, title	Consulted on
https://psap.library.illinois.edu/collection-id-guide	-, -, PSAP Preservation Self-Assessment Program, -	2018- sept
https://www.officemuseum.com/copy_machines.htm	-, 2000-2016, Early Office Museum, -	2018- sept
http://www.conservation-us.org/docs/default-source/annualmeeting/74-further-researches-in-the-preservation-and-conservation-of-letterpress-copybooks.pdf?sfvrsn=4	Dellapiana L. , Lockshin N., -, AIC American institute for conservation, of historic and artistic works, Further Researches in the Preservation and Conservation of Letterpress Copybooks	2018- sept

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Edel, L.P., (1936), Recept mengen en roeren, deel 1 en deel 2, 200 populaire chemische recepten voor iedereen (tweede druk) Deventer, Nederland: N.V. Uitgeversmaatschappij AE. E. Kluwer

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Ainsworth, Mitchell C., Hepworth T.C., (1916), Inks: their composition and manufacture, London, United kingdom: Charles Griffin & Company Ltd.

Appendix 2: Carbon paper
Period of use in the Netherlands/Europe: 1850 - 1990
Other terms: carbon paper
Common manufacturers/brands in the Netherlands/Europe: Pelican, Gimborn, Talens

Copying method:
This copying method is based on impact transfer. Carbon paper consists of a sheet of paper coated on one or both sides with a mixture of binder, pigment and/or dye. Pressure applied to the carbon paper causes the layer to release ink and make a print. This can be either a mirror image or an exact image, depending on the purpose of the copy. The original and copy are produced simultaneously.

The carbon paper is placed between two sheets of blank paper. The top sheet is for the original and the bottom sheet for the copy. The carbon paper lies with the ink side against the paper to become the copy. The original is typed and the copy is made simultaneously beneath it. With one original, 10 legible copies could be made at the same time, depending on the properties of the typewriter and the carbon paper. It was a cheap way to make a copy directly from the original.

The first form of carbon paper was patented in 1806 and was invented to easily and quickly duplicate handwritten letters. Carbon paper was not immediately popular. A certain amount of pressure is required to make a copy, and this is not possible with pen and ink. An original could only be made with a pencil, graphite marker or metal scriber, but, after the invention of the typewriter, the development and production of carbon paper increased rapidly.

There were many types of carbon paper for various applications. Standard carbon paper for the typewriter was available in 3 thicknesses: thin, medium and thick. The right thickness of paper was chosen according to the intended purpose. The thinner the sheets, the more copies could be made at once. Carbon paper could also be a component of other copying methods, such as the hectograph and the pressed letter book.

Ink:
Carbon paper used to make copies with a typewriter was required to be thin and strong, and is coated on one or both sides. When printed or impacted, carbon paper releases a quantity of the colour mass to the blank paper behind it. The colouring layer is made in various grades that differ in hardness/brittleness. It consists of a mixture of a colorant, a hard wax and a non-drying oil. By varying this mixture, which consists mainly of paraffin and wax, the properties could be adapted for the purpose. The composition of the coloured layer of carbon paper is similar to that of wax crayon/pastel crayon.

Good standard carbon paper should be capable of providing 12 to 15 legible copies. The more often the paper is reused, the paler the copies become due to the reduction of the release of the ink layer. This also applies to copies at the bottom of the stack. These have less strike impact and therefore less ink release, making the copies paler coloured.

In order to identify carbon copies, it is useful to be able to identify the originals. The most important characteristic is that carbon copies are always in one colour, while the original can occur in two colours. Black carbon copies are usually based on black pigment and oil. They are generally neither water sensitive, nor light sensitive. Blue/purple carbon copies are usually based on aniline ink and are therefore sensitive to light and moisture/water. There were also many combinations on the market that incorporated both black pigment and blue/purple aniline dye. Some carbon copies were originally very pale, because the ink had transferred less due to it being one of the rearmost copies from a stack, or being a copy from reused carbon paper. It is therefore difficult to determine whether a copy has faded, or whether it is a pale print.

Pigments used: mainly a black colour; carbon black, lamp black
Dyes used: mainly blue and purple aniline ink

Binders: oil, wax, paraffin

Paper:
Carbon paper is made of thin, strong paper and is available in standard, medium and light weights. Only the lightweight variety is suitable for making many copies at once. To ensure that the stack does not become too thick, the copying paper is made of well-sized papers with a low grammage: 30 to 45 grams. This paper is called carbon-copy paper. Tissue paper was also copied upon. This extra-thin paper was then glued onto a thicker paper.

Recipes

Edel, L.P., (januari 1966), Recept mengen er roeren deel 1, 200 populaire chemische recepten voor iedereen (negende druk), p. 294, 295	
Carbon paper (violet)	
Paraffin 100 dl *Crystal violet 50 dl* *Oleic acid 35 dl* *Bleached Montan wax 90 dl* *I.G. wax E 400 dl* *Yellow Vaseline 420 dl*	*The crystal violet must first be melted with the oleic acid. Then the waxes are mixed by melting them in the order of melting point, the highest first. Methyl violet is then added to the melt. Finally, it is smoothed on a rolling press.*
Carbon paper, black	
I. *Paraffin 6 dl* *Violet blue 5 dl* *Berlin blue* *Crude Montan wax 15 dl* *Carbon black 20 dl* *Vaseline oil 32 dl* *II.* *Candelilla wax* *Beeswax* *Montan wax* *Lubricant*	*Blend together in the ratio that meets the required consistency.* *From this wax mixture one takes 75 dl* *Dye (black, soluble in oil) 10 dl* *Peerless Carbon black 15 dl* *The mixture is ground over heat.*

Edel, L.P., (mei 1936), Recept mengen en roeren deel 1, 200 populaire chemische recepten voor iedereen, p. 99

Carbon paper	
Methyl violet 30 dl *Dissolve in:* *Oleic acid 60 dl* *Melt together with:* *Sesame oil 350 dl* *Carnauba wax 350 dl*	
Black carbon paper	
Candelilla wax *Beeswax* *Montan wax* *Lubricant*	*Blend together in the ratio that meets the required consistency* *From this wax mixture one takes 75 dl* *Dye (black, oil soluble) 10 dl* *Peerless carbon black 15 dl* *The mixture is ground over heat.*

(1949), Warenkennis en technology, Oss, J.F. van, Privaatdocent in de warenkennis aan de Universiteit van Amsterdam, Deel II (5de druk), p. 305	
carbon paper:	
	Carbon paper is made from thin, strong paper, in standard, medium and light weights. Only the lightweight type is suitable for making many copies at once. The releasing layer is made from a dense mixture of a dye, a hard wax and a non-drying oil. The components are carefully heated and stirred to mix. Then they are milled cold between rolls, or ground and mixed in a ball mill. The uniform mass is melted and pressed onto a paper band using rollers: a squeegee removes the excess colouring material. The roll of paper then passes through cooled rolls and left to 'mature' for a few days so that the 'wax' crystals can grow to the right size. Non-curling carbon paper is also made: the back is then treated with a mixture of wax and non-drying oil, so that both sides react equally to humidity, etc. *On pressure or impact, carbon paper gives off a little of the rather brittle colouring mass to another paper. The colouring layer is made in several qualities that differ in hardness by varying the wax mixture. This consists of paraffin and wax, the brittleness of which has been brought to a specific level.* *Good quality standard carbon paper should be able to deliver 12 to 15 legible copies at a few spaces of the machine. Carbon paper is tested with the same method used for typewriter ribbons. It is sold in boxes of 100 sheets. In the major countries, standard norms are prescribed for various inks types, typewriter ribbons, carbon paper and similar.* *In addition to printing ink, Dutch statistics only mention 'other types of ink'. As this group not only includes iron-gall ink, but also fountain pen ink, stencil ink, etc., little can be learned from this.*

Films:

Link	Title/ Publisher / date of publication	subject	Consulted on
https://youtu.be/Njl_GtQeG5c	Remington Rand Office-Riter Typewriter (1958 Commercial), MattTheSaiyan, 2011-10-30	historical visual material	2018 - sept
https://youtu.be/RaroCSSB9ts	Remington 'Quiet-Riter' typewriter commercial (1958), MattTheSaiyan, 2011-10-25	historical visual material	2018 - sept
https://youtu.be/FCpZ3CP7IAs	Typewriter Training: 'Basic Typing I: Methods' 1943 US Navy Training Film, Jeff Quitney, 2014-10-13	historical visual material	2018 - sept
https://youtu.be/froDUTWOgU8	Ron 'Typewriter' Mingo, World's Fastest Typist, Todd Mingo, 2009-03-27	amusement/historical visual material	2018 - sept
https://youtu.be/1gleP1Pt_-c	Typewriter Training: 'Advanced Typing: Shortcuts' Jeff Quitney, 2015-08-25	historical visual material	2018 - sept
https://youtu.be/xv906t1jnuc	Ron 'Typewriter' Mingo, World's Fastest Typist, Todd Mingo, 2009-03-27	amusement/historical visual material	2018 - sept
https://youtu.be/RlqDFPLUhig	1953 HITS ARCHIVE: The Typewriter - Leroy Anderson (his original version), MusicProf78, 2013-10-26	amusement/music	2018 - sept
https://youtu.be/ANaL80AsKVM	Liberace Typewriter Song, howmanlee, 2013-09-2016	amusement/music	2018 - sept
https://youtu.be/2Wgu5hnrAnI	Old Typewriters (1950), British Pathé, 2014-08-27	historical visual material	2018 - sept

Websites:

Link	Author, date of publication, publisher, title	Consulted on
https://nl.wikipedia.org/wiki/Carbonpapier	-, 2018-02-24, wikipedia, Carbonpaper	2018 - sept
http://www.madehow.com/Volume-1/Carbon-Paper.html#ixzz4wamsHCe1	-, -, how products are made, carbon paper	2018 - sept
https://en.wikipedia.org/wiki/Carbon_paper	-, 2018-08-22, wikipedia, Carbon pa-	2018 - sept

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https://wonderopolis.org/wonder/how-does-carbon-paper-work	-, -, wonderopolis, how does carbon paper work?	2018 - sept

Patents:

patent numbers	Link	patent date	title	inventor
US1085331	https://www.google.nl/patents/US1085331	1912-11-16	Carbon-paper	Clyde M Glen
US633665	https://www.google.nl/patents/US633665	1899-01-31	Letter-copying press	Wesley L Spaulding
US2866711	https://www.google.nl/patents/US2866711	1956-03-30	Carbon paper inks and method for making same	Donald M Hart
US2392658	https://www.google.nl/patents/US2392658	1942-05-15	Methyl violet ink toners and carbon inks	Werner F Goepfert
US1328188	https://www.google.nl/patents/US1328188	1916-12-05	Carbon-paper and ink composition therefor	Marie V Ohashi
US2426248	https://www.google.nl/patents/US2426248	1944-07-01	Manufacture of carbon transfer ink	Sugarman Nathan

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Ainsworth, Mitchell C., Hepworth T.C., (1916), Inks: their composition and manufacture, London, United kingdom: Charles Griffin & Company Ltd.

Appendix 3: Stencil
Period of use in the Netherlands/Europe: 1871 - 1990
Other terms used: mimeograph, typograph, papyrograph
Common manufacturers/brands in the Netherlands/Europe: Gestetner, Derma Print

Copying method:
The stencil copying method has existed in several forms, all of which are based on the same principle. The base document'(the stencil) is a porous/open sheet of paper or textile through which the ink is printed. This copying method is similar to screen printing and is classified under stencil printing in printing techniques. The method was widely used between 1871 and 1950 by businesses, and then up to the mid 1980s by schools, clubs and associations.

The stencil printing process has much variation. The method developed due to the rapid mechanisation of the business world. The first stencil device was manual and appears very similar to a screen print frame with its mesh and inked roller. Soon machines were developed where mechanical stencil copies could be made at high speed. Business demand for a faster and a higher copying rate not only sparked development of the device, but also of the paper, ink and the way in which the 'base document' was produced.

Base copy, base document, mother sheets:
This base document consists of a porous carrier impregnated with wax. By scraping off the wax layer, the porous carrier is exposed and the ink can be pressed through it.
The base documents are made of paper, textile or plastic. The first base paper documents were made of perforated sheets of paper. These dots are often still visible in the print.
The basic sheets available from office wholesalers were known as mother sheets.
A base document can be made by hand. Various tools and pens were developed for this purpose. The base document is then traced from an original.
Another common method was to type it with the typewriter. The impact of the stroke pushes the wax aside. When using a typewriter to make the base document, a carbon copy is often typed at the same time. After use, the base document can be stored in a folder and used again months later. To make a legible copy, the legible side is faced towards the drum of the stencil machine. The ink is then pressed through from top to bottom. The mother sheets have a perforated strip of cardboard on the top edge to enable attachment to the round drum of the stencil machine.

A stencil copy can often be identified by the kind of text. These were often copies of texts for general correspondence, leaflets and flyers. It could be both handwritten and made with the typewriter. One mother sheet could make about 500 copies.

Ink:
Commercially available stencil inks that were generally oil-based. However, there are also early known recipes based on aniline ink and glycerine. Due to developments aimed at producing faster and more copies, the properties of the ink also had to be adjusted. It was important that stencil inks not bleed, be smudge resistant, but also dry quickly so that the ink could not transfer to the top sheet of paper in a stack of copies. In addition, a copy had to be immediately usable.

In recipes, boiled linseed oil diluted with white spirit is widely used. Other additives were resin, resin-based soap and solvents. Generally, black was copied with an oil-based ink and carbon black pigment. The oil is sometimes visible in the form of a halo around the letters. The ink is generally waterproof.

Paper:
The paper produced specifically for stencilling is called cyclostyle paper, mimeograph paper, or stencil paper and has the following properties: slightly porous, fibrous, open in structure, and highly absorbent for oil-based inks, which allows the ink to dry quickly.

Recipes

Edel , Drs. L.P, (red.), (1966), Mengen en Roeren volume 1, 2000 populaire chemische recepten voor iedereen, negende druk N.V. Uitgeversmaatschappij E. Kluwer Deventer – Antwerpen, p. 299:	
Stencil ink	
Basic Aniline Dye 2 dl Acetic acid 10 dl Tartaric acid 1 dl Tannin 5 dl Tragacanth emulsion 80 dl	

Mengen en Roeren, 2000 populaire chemische recepten voor iedereen. Naar het Amerikaans bewerkt door Drs. L.P. Edel, eerste druk 1936 N.V. Uitgeversmaatschappij E. Kluwer Deventer – Antwerpen, p. 101, 100	
Mimeograph ink	
Carbon black 10.5 dl Soluble Violet 1.1 dl Aluminium hydrate 3.8 dl Stand oil Paint 1.1 dl Castor oil 65.5 dl Lanolin 18.0 dl	Grind well on a 4-roll paint mill, dilute with castor oil before use.
Mimeograph solution	
Powdered soap 240 g Castile Soap 150 g Glycerine 120 g Add water to make 4 L	

Films:

Link	Title/ uploader / publication date	subject	Consulted on

https://vimeo.com/111405135	Gestetner Mania - MAGICAL RISO - 1001 Printing Experiences, Charlotte Lagro, 2014-11-10	Dutch collector	2018 - sept
https://youtu.be/XFIUmoDWA74	Mimeograph Machine (stock footage / archival footage), FilmArchivesNYC, 2014-07-17	historical visual material	2018 - sept
https://youtu.be/wROBwKtc7yk	How to make Printmaking of art at Mimeograph by Tomoko Kanzaki, Mimeograph Printmaking, 2016-04-09	hand-printed stencil	2018 - sept
https://youtu.be/gYjj62eGwc8	Mimeographing Techniques, (1958), A/V Geeks, 2018-10-02	historical visual material	2018 - sept
https://youtu.be/2TSVuH5yiFo	Gestetner Works (1927), British Pathé, 2014-04-13	historical visual material	2018 - sept
https://youtu.be/PCTFpWtwroQ	gestetner documentary, Anil Saxena, 2016-09-23	historical visual material	2018 - sept

Web pages:

Link	Author, date of publication, publisher, title	Consulted on
https://hiveminer.com/Tags/mimeograph,printing	-, -, hiveminer, mimeograph printing	2018 - sept
http://www.rixke.tassignon.be/spip.php?article1903&lang=fr	rixke, 2014-03-31, Rixke, Afdrukken van documenten	2018 - sept

Patents:

patent numbers	Link	patent date	title	inventor
US242919	https://www.google.nl/patents/US242919	1881-06-14	gestetner	gestetner
US536720	https://www.google.nl/patents/US536720	1895-04-02	gestetner	gestetner
US1771563	https://www.google.nl/patents/US1771563	1927-01-17	Duplicating with the aid of stencils	Gestetner David
US4535690	https://www.google.nl/patents/US4535690	1983-01-28	Duplicating stencil	Jonathan Gestetner

				Cyril Green Thomas Hanrahan
US835303	https://www.google.nl/patents/US835303	1906-11-06	Stencil-printing machine.	David Gestetner
WO1997025383A1	https://www.google.nl/patents/WO1997025383A1	1996-01-10	Emulsion ink	John Christopher Adams Peter James Stotereau

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Edel, L.P., (1936), Recept mengen en roeren, deel 1 en deel 2, 200 populaire chemische recepten voor iedereen (tweede druk) Deventer, Nederland: N.V. Uitgeversmaatschappij AE. E. Kluwer

(1949), Warenkennis en technologie, Oss, J.F. van , Privaatdocent in de warenkennis aan de Universiteit van Amsterdam, Deel I, II, III (5de druk) Amsterdam, Nederland: Elsevier Publishing Company Inc.

Appendix 4: Hectograph, spirit duplication
Period of use in the Netherlands/Europe: 1878 - 1975
Common manufacturers/brands in the Netherlands/Europe: liquid duplicator
Common international manufacturers/brands: Ditto (dittography)
Other terms used: hectograph, copying pad, spirit duplicator, liquid hectograph

Copying method:
Hectograph is an ink transfer method in which a direct copy is made of the original. This is the same copy method as for the pressed letter book. Ink transfer is based on transferring ink while the original remains intact. This method utilises the water solubility of the inks that are transferred.

Spirit duplication makes a direct copy (as the pressed letter book does).
The hectograph makes an indirect copy. With an indirect copy, the ink is transferred to a master copy, and then copied. The hectograph was used for copying documents, but also for architectural drawings. Spirit duplication was developed to make office and administration document copying faster and possible on a larger scale.

The hectograph basic method.
The original is manufactured with an ink that is soluble in water and has a high percentage of dye. This is usually an ink based on an aniline dye, mostly methyl violet. The original could be typed, or handwritten with aniline pencil or ink. The hectograph itself is a plate of gelatine/glycerine a few centimetres thick and slightly larger than the sheet of paper to be copied. The original document is placed on this plate with the text on the gelatine. The document is lightly and evenly pressed with a roller. The gelatine and the original are kept in contact for about two minutes so that the gelatine slab can absorb most of the ink. Due to the properties of gelatine/glycerine, the ink does not run or dry out. This keeps the ink moist long enough to make copies. The original is then removed [JB: correct?] and a copy made by placing a blank sheet of paper on the gelatine plate with its master copy imprint, and pressing it evenly with a roller. The copy paper is then removed from the gelatine plate.

Each copy made reduces the percentage of ink on the gelatine. Hence each subsequent copy becomes paler. It was possible to make 50 to 200 copies of an original. The ink 'sank' into the gelatine plate in 8 to 24 hours, after which the plate could be reused for a new master copy. There are several variations of the hectograph, but the principle remains the same. Clay was sometimes used instead of gelatine, or the plate was replaced by gelatine paper, where the paper is coated on one side with a gelatine mixture. Variations arose in the application of the ink. The ink could be applied using a stencil, but also available were carbon paper, typewriter ribbons and pencils that were suitable for making master copies for the hectograph.

The manual hectograph was further developed into mechanical spirit duplication so that more and faster copies could be made. This liquid duplicator was much more common in offices than the manual method.

Spirit duplication
Spirit duplication also uses the ink transfer method. A base document is produced and copied. For this purpose spirit masters were commercially available. These spirit masters consist of two sheets. The first sheet has a glossy coated back and the second sheet is similar to carbon paper. This is coated on the front with a layer of wax with a high percentage of dye. The front of the first sheet is typed, inscribed, or drawn upon. This transfers the wax on the second sheet to the back of the first sheet, thus creating a mirror image on the back of the first sheet. The first sheet then has the same text on both sides: a direct image on the front, and a mirror image on the back. An original is produced simultaneously with the base document.

The sheet with the base document is attached around the drum of the liquid hectograph with the shiny side (the side with a mirror image of the text) facing outwards. This side is used to print the copies. The

copy paper (on which the copy is to be printed) is passed through the liquid hectograph to become evenly moistened with a mixture of solvents. In the machine, the copy paper and the master are pressed together by pressure rollers. The solvent dissolves a little ink from the base document, which can then be transferred to the copy paper. About 40 good copies of a master could be made. The copies become successively paler, because the ink from the master's ink is slowly used up and the concentration of dye decreases. Hence, some copies of the liquid hectograph are very pale when made. It is therefore difficult to determine whether a copy has faded, or whether it was originally a pale print.

It was important that the duplicator fluid evaporated quickly and the paper not expand too much, in order to prevent it creasing between the pressure rollers. Initially, a mixture of isopropanol and methanol was used. Both solvents were cheap and easily available. However, this mixture was highly flammable and thus unsuitable for electrically powered liquid hectographs. In 1938, Johan Bjorksten invented an alternative mixture that was non flammable. This comprised 10% trichlorofluoromethane, and 90% of a mixture of 50% methyl alcohol, 40% ethyl alcohol, 5% water, and 5% ethylene glycol mono-ethyl ether.

Ink:
The ink used to make copies with the hectograph and the liquid hectograph is always water soluble and based on an aniline dye. The colour of the aniline dye could differ, but was never black. Generally violet or blue aniline dye was used. This dye was inexpensive and contrasted well with the paper.
Hectograph carbon used to make copies for the hectograph is different to standard carbon paper. Both the binders and the dyes are different. The dye is based on aniline dye instead of black pigment.

Dyes used: aniline dye; these were available in many colours.
The most commonly used aniline dyes were: crystal violet, basic violet, brilliant violet, methyl violet, hectograph violet
Binders: water, alcohol, glycerine
Composition of hectograph plate: gelatine, glycerine additives; carbolic acid, salicylic acid (mould prevention)
Composition of duplicator liquid: isopropanol and methanol, or 10% trichlorofluoromethane and 90% of a mixture of 50% methyl alcohol, 40% ethyl alcohol, 5% water and 5% ethylene glycol mono-ethyl ether.

Paper:
A special paper was available for the hectograph. This paper had an internal sizing of alum-rosin or gelatine to make the paper less moisture-absorbent. The advantage of a less absorbent paper is that less ink per copy was transferred and so more copies could be made from one base document. Optical brighteners were also added to increase contrast as some copies could be rather pale.

Recipes

(1949), Warenkennis en technology, Oss, Dr. J.F. van, Privaatdocent in de Warenkennis aan de Universiteit van Amsterdam, Volume II, 5de print, p. 303
Hectograph ink
Hectograph ink also belongs to the group of aniline inks. The dyes must be water soluble and much glycerine is often also present. Stamp ink contains much extra arabic gum and glycerine, and usually carbon black. Coloured ink is usually a solution of Berlin blue in oxalic acid with gum; usually blue. Other colours are obtained from dye solutions with gum.

Edel, Drs. L.P., (red.), (januari 1966), Recept mengen en roeren deel 1, 200 populaire chemische recepten voor iedereen, Negende print, p. 295
Hectograph ink

I. acetone 8 dl glycerine 20 dl acetic acid 30% 10 dl water 50 dl dextrin 2 dl dye 10 dl II. Fuchsin, methyl violet, rodamine, emerald green or Victoria blue 30 dl Methylated spirits 30 dl Glycerine 8 dl Carbolic acid 15 dl	In the good old days, the hectograph was the only instrument with which one could easily and cheaply duplicate written documents. One writes with an ink that contains a large excess of soluble dye. When written on a mass consisting of glue and glycerine, this substance absorbs a large portion of the dye. On a sheet of clean paper the mass then releases part of the dye and a copy is obtained. The type of dye plays an important role in the number of legible copies that can be made. Strangely, precisely in America, this equipment has been revived and perfected - as Ditto (dittography) - and is used in large quantities. One does not work with rolls but with sheets of a glue mass, and one can also make direct copies of a negative using a sheet of paper that is moistened with a good solvent for dye.
Hectograph mass	
Skin glue, powdered 2 dl Water 4 dl Glycerine 2 dl	Let the glue swell in water and dissolve by heating, add the glycerine, and allow excess water to evaporate.
Hectograph paper (carbon)	
Crystal violet powder 96 dl Methylated spirits 96% 120 dl Dissolve over heat Carnauba wax, grey 24 dl Montan wax 48 dl Beeswax, unbleached 24 dl	Melt in a water bath at 100°C. While stirring, pour the methylated spirits solution into the melted wax mixture, and heat until the methylated spirits has completely evaporated. Bone oil 95 dl Add these to the coloured wax mixture and stir well. This wax mixture is applied in the molten state with an ironer on dense paper - smooth cellulose paper on one side, or, better still, a paper that also contains rags. Allow the coated paper to cool slowly (S.Oe.F.W. 1955, p. 45.)
Modern hectograph substance	
Polyvinyl alcohol 150 dl	

Glycerine 507 dl Antimony trifluoride 10 dl Titanium dioxide 40 dl Ethylene glycol 130 dl Calcium chloride 40 dl	
Duplicator liquid	
I. methyl alcohol 20 dl ethyl alcohol 10 dl II. methylcellosolve 10 dl ethyl alcohol 87 dl water 3 dl III. 2-methyl-2,4-pentanediol 10 dl ethyl alcohol 96% 90 dl	

Films:

Link	Title/ Publisher / date of publication	subject	Consulted on
https://youtu.be/ccYLLzpeVnU	HOW TO USE A 1960s DITTO MACHINE MIMEOGRAPH SPIRIT DUPLICATOR PHOTOCOPIER 43624, PeriscopeFilm, 2018-05-17	historical visual material	18-09-2018
https://youtu.be/XFIUmoDWA74	Mimeograph Machine (stock footage / archival footage), FilmArchivesNYC, 2017-07-14	historical visual material	18-09-2018
https://youtu.be/4aLuF-W8S7I	hectograph Printing Press, AZSwimCoach, 2008-07-2	hand-printed hectograph copy	18-09-2018
https://youtu.be/lUGf19571vI	Hectograph printing, Memory Lane Heritage Village, 2014-03-15	hand-printed hectograph copy	18-09-2018
https://youtu.be/TJOs9piJYgc	Hectograph, Op. 186, Various Art-	amusement/music	18-09-

	ists - Topic, 2015-02-04		2018
https://youtu.be/n2jwWFVgQjA	Spirit duplicator, Audiopedia, 2016-01-14	explanation	18-09-2018

Web pages:

Link	Author, date of publication, publisher, title	Consulted on
https://en.wikipedia.org/wiki/Copying_pencil	28 July 2018, at 23:06 (UTC), Wikipedia, Copying pencil	18-09-2018
https://www.britannica.com/technology/hectograph	The Editors of Encyclopaedia Britannica See Article History	18-09-2018
http://www.penciltalk.org/2008/07/the-hidden-life-of-copying-pencils	Penciladmin, 07-07-2008, The hidden life of copying pencils	18-09-2018
https://cool.conservation-us.org/coolaic/sg/bpg/annual/v17/bp17-05.html	Liz Dube, 1998, The American institute for Conservation, The Copying Pencil: Composition, History, and Conservation ImplicationsThe Copying Pencil: Composition, History, and Conservation Implications	18-09-2018
https://www.atlasobscura.com/articles/how-xerox-invented-the-copier-and-artists-pushed-it-too-its-li-	Ernie Smith,	18-09-2018

mits?utm_source=Atlas+Obscura+Daily+Newsletter&utm_campaign=eb01396bd2-Newsletter_11_23_2016&utm_medium=email&utm_term=0_f36db9c480-eb01396bd2-63104165&ct=t(Newsletter_11_23_2016)&mc_cid=eb01396bd2&mc_eid=d7b02e2672	21-11-2016, atlasobscura, How Xerox Invented the Copier and Artists Pushed It To Its Limits	

Patents:

patent number	Link	patent date	title	inventor
US2254469	https://patents.google.com/patent/US2254469	1938-12-05	Nonflammable solvent	Bjorksten Johan
US2188590	https://patents.google.com/patent/US2188590	1938-02-04	Non-smudging transfer sheet	Bjorksten Johan William J Champion
US2281261	https://patents.google.com/patent/US2281261	1941-01-23	Hectograph composition and blanket and method of preparing same	Bjorksten Johan William J Champion
US2223280	https://patents.google.com/patent/US2223280	1938-01-31	Hectograph mass and method of preparing copies therefrom	Howard E Collins
US427077	https://patents.google.com/patent/US427077	1890-05-06	hectograph printing-press	
US2382796	https://patents.google.com/patent/US2382796	1942-08-07	Hectograph printing ink	Nelson S Knaggs
US359170	https://patents.google.com/patent/US359170	1887-	copying-paper	

		03-08		
US904590	https://patents.google.com/patent/US904590	1908-02-24	Composition of matter to be used in making copy-ing-pads.	Eduin O G Winckler
US422430	https://patents.google.com/patent/US422430	1890-03-04	Printing-ink	
US2118888	https://patents.google.com/patent/US2118888	1936-09-30	Master copy sheet	Edward Z Lewis William J Menihan

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Leher, S., (?), Ink Manufacture, (translation of the fifth edition by Morris, A., Robson, H.), London, United Kingdom

Brannt, W.T., Wahl, W.H., (1919), Techno-chemical receipt book, New York, USA: Henry Carey Baird & Co. Inc.

Ainsworth, Mitchell C., Hepworth T.C., (1916), Inks: their composition and manufacture, London, United kingdom: Charles Griffin & Company Ltd.

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Edel L.P., (1966), Recept mengen er roeren, deel 1 en deel 2, 200 populaire chemische recepten voor iedereen (negende druk) Deventer, Nederland: N.V. Uitgeversmaatschappij Mij AE. E. Kluwer

Edel, L.P., (1936), Recept mengen en roeren, deel 1 en deel 2, 200 populaire chemische recepten voor iedereen (tweede druk) Deventer, Nederland: N.V. Uitgeversmaatschappij AE. E. Kluwer

(1949), Warenkennis en technologie, Oss, J.F. van, Privaatdocent in de warenkennis aan de Universiteit van Amsterdam Deel I, II, III, (5de druk) Amsterdam, Nederland, Elsevier Publishing Company, Inc.

Annex 5: Diazo/Océ
Period of use in the Netherlands/Europe: 1930 - 1970
Other terms used: Whiteprint, diazotypie, diazotype
Well-known manufacturers/brands in the Netherlands/Europe:
Océ 'Van der Grinten', the Netherlands, product name: Primulin paper and Primulin o.c.,
Kalle & Co, Germany, first patent 1921: product name; Ozalid,
Gay Photogay, France,
Renker en Spang, Germany,
Aerni Leuch, Switzerland,
Hall & Co, England,
Philips (for own use only)

Copying method:
Diazo is a copying method based on light sensitivity. This copying method is the successor of the blue-print (used 1875-1970). Blueprints are very sensitive to light and therefore have only a short durability. Nevertheless, blueprint and diazo have always existed side by side. Diazo has its chemical origins in the clothing industry, where azo dyes were much used. Azo dyes are now widely used in the food industry.

The diazo copying method was initially used for duplicating architectural drawings, but after 1930 it was also used for copying documents. The diazo copy is based on a light-sensitive diazonium bond with which a positive print is made. The result is a white background with dark lines. Several processes have been developed for this copying method: the dry-copy system and semi-dry copying system are the two best known.

This process has two components:
- Diazonium salt: a photosensitive chemical mass
- azo dye (also known as the 'coupler'): a colourless substance

Azo dye is a colourless chemical substance that forms colour in combination with the diazonium salt. These two chemicals are mixed in water in various proportions. The paper is impregnated on one side with this mixture, and then dried in the dark. This diazo paper was commercially available in a prefabri-cated form, but had to be kept sealed from light.

The original document is produced on transparent or semi-transparent paper. This is the base docu-ment, a.k.a the master. Copies are made with this document. The master can be made on a typewriter, or by hand. The desired durability and/or the number of copies determine the quality of the carrier of the base document. The intensity and duration of exposure to UV light is determined by the thickness, transparency and type of base document. The UV lighting device has an adjustment knob for automati-cally selecting the right exposure for a particular type of carrier. The original document is placed on the impregnated side of a sheet of diazo paper.

The dry-copy system of the diazo method has two phases:
- UV light: by exposure to the ultraviolet lamp. The light-sensitive diazonium salt is neutralized on the areas where the diazo paper is exposed to ultraviolet light (i.e., the areas with no image or text). The areas that were masked at that moment appear as pale yellow or white lines on the diazo paper. The exposure phase is then complete.

The base document and the diazo paper are then separated. The base document can now be reused to expose a new copy.

- The exposed diazo paper is then fed through the developer. Exposure to vapours of ammonium hydroxide causes the azo dyes (couplers) to react with the remaining diazonium salt, which then undergoes a chemical reaction causing the unexposed lines to change colour from invisible (or

yellow) to a visible dark colour. Frequently used colours are brown, blue, red/red-brown, sepia, etc.

The colour depends on the types of azo dye and diazonium salt. A great variety of colours were available.

Large quantities of copies were difficult to make with this technique because of the high concentration of ammonia vapours that are released. Often only 4 to 5 copies could be made at a time.

Océ
The diazo process was patented, so other companies were forced to circumvent it. That is how Van der Grinten came up with its own diazo paper called Primulin paper. This paper contained additives to prevent the paper from yellowing. In 1927, Van der Grinten brought a new variant onto the market: Primulin o.c. paper, where o.c. stands for 'Ohne Components' [without dye components]. It was a semi-dry process. As a result, it was no longer necessary to develop with ammonia, and this method was better suited for making multiple copies than the dry-copy system. In 1930, the paper was so popular that it ultimately became the name of the entire company: Océ. The semi-dry copying system was used in the Netherlands more than the diazo dry-copy system.

The semi-dry copy system of the diazo method has two phases:

- UV light: the Primulin o.c. paper is coloured yellow on one side. This side is exposed to UV-rich light. The light-sensitive diazonium salt is neutralized under the influence of water (present in the diazo layer) and UV light. The areas masked by image or text remain yellow, while the areas that were exposed become colourless.

The base document and the diazo paper are then separated. The base document can now be reused to expose a new copy.

- The exposed Primulin o.c. paper is moistened a little on the exposed side with a developing fluid. Océ had several moistening devices/machines on the market, which meant that the paper did not need to be dried, and so could be used immediately after developing.

Ink:
Dyes used:
Azo dyes are still widely used in the cosmetic and food industries.
An azo dye resembles aniline dye chemically: they both consist of the same aromatics.

Paper:
There is little to be found in the literature about the composition of the paper

Films:

link	Title/ Publisher / date of publication	subject	Consulted on
https://youtu.be/BC17ehVHWwU	Ammonia Printing Machine, Riyaz Baig, 2016-08-20	demonstration of device	18-09-2018

Patents:

patent numbers	link	patent date	title	inventor
US1028493	https://www.google.nl/patents/US1028493	1911-	Azo dye	Friedrich

		09-19		Ruenkel
US2027206	https://www.google.nl/patents/US2027206	1932-08-04	Azo dye and method for its preparation	Smith Francis Hervey Black Crayton Knox
US2018764	https://www.google.nl/patents/US2018764	1931-09-04	Azo dye and method for its preparation	Paine Clifford
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