Manual of

Document Microphotography

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Michael J Gunn

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Preface

The contents of this book represent the fruits of twenty years' involvement with the micrographics industry in general and with document microphotography and micropublishing in particular.

As such the author's task has been that of compiler rather than creator since the information for good microfilming practice lies scattered in various books, journals, periodical articles and other publications.

Throughout the writing of this volume the author has been conscious of the very great debt which he owes to earlier writers on the subject and this is evidenced by the number of references cited. No claim for original contribution or basic research in the field of microphotography is made, but it is sincerely hoped that this volume will make much of the available material more easily accessible for both users and creators of microforms alike.

I should particularly like to acknowledge my gratitude to Phyllis Cain, sometime of University Microfilms Limited, whose enthusiasm for microforms was an early influence on me.

I would also like to thank the many companies active in the micrographics industry, including Agfa-Gevaert, Bell and Howell, Ilford and 3M (UK) Limited, who have supplied me with much information. An especially large debt is owed to the innumerable members of Kodak Limited who have patiently answered the many questions which I have put to them during the past twenty years and who have most liberally supplied me with information and illustrations for inclusion in this book.

A special word of thanks must go to Stephen Albert, founder of World Microfilms Publications Limited, whose suggestion it was that I should write this book.

I would like to thank Arthur E.W. Wilson of Kodak Limited for making many helpful suggestions, and Allen B. Veaner, University Librarian at the University of California, Santa Barbara who read the manuscript.

I should also like to thank my son, Alexander, for producing several of the line drawings and last, but by no means least, I would like to thank my wife, Jane, and daughter, Victoria, without whose constant help, extreme patience and astonishing forbearance this book could never have been completed.

Kirkhill House, Wick, Caithness
March 1984

Introduction

Why microphotography?

In a shrinking world the impulse to reduce in size anything which may be reduced is clearly a strong one. This desire to 'save space' is nowhere more strongly felt than in the realm of written or published material in the form of books, manuscripts, newspapers, journals and periodicals.

Since the introduction of printing in the fifteenth century, the output of textual material has rapidly increased to its now astronomical and unmanageable proportions (the so-called 'documentation explosion').

This increase in demand on publishing has led to a squandering of the timber resources of this planet, which in turn has served to increase the cost of paper. This fact, allied to other production cost increases, has prompted the search for alternative methods of disseminating information.

One of the ways in which this may be achieved lies in the use of photography. Microphotography* is that branch of the photographic art which deals specifically with the reduction in size of images, and which enables a document to be copied and distributed with comparative ease.† This is because the copying process is relatively simple and may be conducted by any reasonably intelligent person with the minimum of training. Furthermore, unlike traditional methods of printing no type-setting or proof-reading is required. An author's original type-written manuscript is quite sufficient for publication in microform.‡

Additionally, the prohibitive costs associated with short-run printing do not apply to works produced in microform. It is therefore quite practicable to publish only one or two copies of a work—unthinkable if traditional printing techniques are used.

Furthermore, distribution costs may be kept to a minimum as postage for a book on microfilm is approximated one-sixth of that for the same book in hard copy.**

Space-saving, lower production costs and substantially reduced distribution costs are major factors which contribute to the increasing use of microforms.

These are, however, by no means the only factors involved. Consider, for example, a hypothetical case of a research student who wishes to study some finer point in the evolution of the political structure of certain European states during the medieval period. What better way than to examine the relevant state documents of the period. For the research to be truly authoritative a great number of museums, libraries and archives distributed throughout a large number of towns and cities might need to be visited. This is so because the original materials, due to their age and rarity, might not be moved safely without taking elaborate and costly precautions to secure their safety. Clearly such a venture would not be practicable. A simple and economic alternative lies in the microfilming of the relevant material by each of the libraries in question. A master negative of any material photographed is retained by the library or

*Microphotography may be defined as the reduction of documents, photographs, drawings, etc., on to some type of miniature film, generally 16 mm, 35 mm, 70 mm; or 105 mm in width. A further refinement of the definition is that a reduction ratio of 5 or more is employed thus rendering the image illegible to the naked eye. Microphotography is essentially the practice of making large objects smaller and should not be confused with photomicrography which is the exact opposite.

†There are a number of extremely useful alternative applications for microphotography including the manufacture of microscope-eye-piece scales, graticules, stage micrometers and micro-miniature electronic circuits. These and other applications are of paramount importance to the developing technologies of computers and rocketry but are outside the scope of the present work. For a more detailed description of these applications, reference should be made to Stevens' *Microphotography—Photography and Photo-fabrication at Extreme Resolution*.

‡Microphotographs are currently produced in a number of different formats, e.g. roll microfilm, jacketed microfilm, aperture cards, microfiche, etc. The collective noun for these differing types is microform. See Chapter 2 for a full description of all types of microform.

**The original version of a work, i.e. the author's manuscript, a printed book, original drawing or photographic print is generally referred to as 'hard-copy'. In this context microfilm presumably qualifies for the appellation of 'soft-copy' although the author has never yet heard it so described.

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museum and a duplicate film* sent to the researcher for study. Alternatively, where funding is a problem, the operation may be put in the hands of a reputable micropublisher.

The risk of damage to the original material is considerably reduced and, should other students require access to the same information, a further duplicate may easily be produced. Thus the availability of scarce materials is an important factor promoting the use of microforms.

With the mountain of information currently available to researchers in almost every field of study, problems arise when attempting to access select material rapidly. For instance, some of the world's large national libraries require some 12–24 hours to locate a single work in their vast collections! The alternative, that of computerising all information and storing in disc or magnetic tape format is certainly, at the present time, not feasible. This is true in both the economic and the technical sense. Economically the cost of transferring just one book of 200 pages on to magnetic tape or disc is extremely high. Far higher than could be justified by the subsequent gain in access time.

Further, the storage capacity of disc or magnetic tape is considerably less than that which may be achieved by using microphotographic techniques.† Electromagnetic recording techniques are also inferior to microphotography in their ability to deal with graphic information.

Notwithstanding, computer access offers the fastest type of information retrieval, it would therefore seem to make good sense to combine the virtues of each medium. A number of techniques for computerised access to microfilmed data have been developed and it is not too difficult to contemplate the growth of 'computerised rapid-access microlibraries' (acronym CRAM) in the future.

A further reason for the introduction and use of microfilms lies in their value as a security precaution. This has been noted already in the case of rare or unique material but it is equally applicable to information of a more ephemeral nature, such as bank cheques.

To summarise, we have six reasons, some cultural, some economic, why microphotography is used increasingly:

(1) Space-saving.
(2) Reduced production costs ease of duplication.
(3) Reduced distribution costs.
(4) Availability of scarce material.
(5) Rapid access to large data banks.
(6) Security against loss or damage of original.

There are other, subsidiary reasons, but these are the most important and sufficient to answer the question 'Why microphotography?'

NB. The terms 'document', 'original' and 'hard-copy' as applied in this work may be regarded as synonymous. They refer not only to textual and graphic information displayed upon paper, parchment, papyri and plastic but also to X-ray photographs, transparencies, and even solid objects—indeed anything which is placed upon the copyboard of a camera for the purpose of microcopying.

*Several thousand duplicate films may be produced from a master negative without any undue deterioration of image. This 'printing-life' can be extended almost indefinitely by the use of direct-duplicate intermediate printing masters. For a discussion of duplicating techniques see Chapter 12.

†Photographic materials have the highest information-storage capacity known to man and at extreme resolution are capable of storing 1 000 000 000 bits of information per square inch. This is equivalent to storing the entire contents of a 24-volume encyclopaedia on a 7 cm² film-plate (*Techniques of Microphotography*, Kodak Publication No. P-52 (1976)).

Contents

1

History and origins of microphotography

Who would believe that so small a space could contain the images of all the universe?
Leonardo da Vinci (1452-1519)
(on the human eye)
Codex Atlanticus, 345^{v}

The desire and need to transmit information from one point to another, both economically and rapidly has prompted man to produce some of his most spectacular inventions—writing, printing, photography, the telephone, teleprinter, radio, television and video-recording—all outstanding examples of man's ingenuity (see Table 1.1).

Not the least interesting of these inventions is a much-used, yet little-discussed, branch of photography known as microphotography. That it is much used may be verified simply by visiting the nearest bank or hospital, for anyone who has written a cheque or been a hospital patient will have made use of microfilm, albeit indirectly. The enormous number of cheques issued daily have, for many years, been recorded on microfilm by the banks involved enabling them to maintain a record of each transaction for the prescribed period. Indeed, this was one of the earliest commercial applications of microphotography devised originally by George C. McCarthy, the president of a New York bank in the late 1920s.[1]

Hospitals also utilize microfilm to store almost all patients' records, including electro-cardiographs, electro-encephalographs and X-ray photographs (see Figure 8.9). The method allows vast amounts of information to be stored conveniently in a fraction of the space required for hard-copy records and further allows a more efficient means of studying case-histories.

That microfilm is little discussed is perhaps a hang-over from its early days when it was, in common with other specialist photographic techniques, a complicated process practised only by a small number of skilled technicians. A further shadow has been cast over microfilm by the nefarious activities of the cloak-and-dagger brigade whose ingenious methods of smuggling secret information by means of micro-dots reached its sensational zenith with the arrest and subsequent trial of the Krugers in 1961.[2] One of the earliest uses of microfilm is the oft-cited example of René Dagron's pigeon post by which means the besieged French were advised of German troop movements during the blockade of Paris in the Franco-Prussian War of 1870–71.[3]

Early attempts at miniature writing seem to have been frequently connected with military matters or the transmission of secret information.[4] Such attempts were limited by the method of reading, generally a simple magnifying glass. The magnification achieved by such lenses does not generally exceed four diameters and the amount of reduction was, therefore, quite small. A Dutch spectacle maker, Zacharias Janssen, is credited with the invention of the earliest compound microscope in about 1590. The invention of this device allowed magnifications in excess of 200 diameters to be used and was one of the most important steps towards the evolution of modern microphotography.

During the same century another of these evolutionary steps was taken when the Italian architect and artist Daniel Barbaro fitted a lens to the camera obscura (1569).[5] The camera obscura (Latin: darkened room) is a device for projecting a reduced-size image of a distant object or scene on to a translucent screen. The earliest record of such a device is to be found in Euclid's *Optics* and it was a well-known scientific curiosity for hundreds of years being frequently used by artists to reproduce drawings in correct perspective. Leonardo da Vinci seems to have been aware of the possibility of improving the device by adding a converging lens (the earliest camera obscuras having simply a small pin-hole to allow the image-forming rays to enter) but there is no record of him actually having done so.

By the year 1600 both the means of reducing and the means of enlarging a microphotograph existed. The missing link in the system was the light-sensitive material upon which the photograph would be made. Sadly it was to be more than 200 years before this was discovered and it is tempting to consider whether artists, who contributed so much to the improvement of the camera obscura, were largely to blame for this long interval. Since ancient times painters had care-

	Date	Methods of communication, information, storage and dissemination	Recording device	Recording medium
B.C.	25 000	Cave paintings	Fingers and brushes	Earth pigments
	5 000	Clay tablets. Cuneiform writing	Stylus	Moistened clay
		Hieroglyphic writing		
	3 000	Papyrus. Cursive or Hieratic script	Reed pen	Water-based inks
		Development of alphabets		
		Study of Optics. Camera obscura Wax tablets	 Stylus	
	200	Parchment	Quill pen	Water-based inks
A.D.	100	Paper		
	1500	Printing	Woodcut Movable type	Oil-based inks
	1820	Photography	Camera	Silver emulsions
	1840	Microphotography	Camera and microscope	Collodion
	1890	Cinematography	Cine-camera	Silver gelatin films
	1922	Television	Baird's mechanical apparatus then Cathode ray tubes	Phosphors
	1950	Computers (Electronic)	Transistors	Magnetic discs and tapes
	1955	Video	Video tape recorders	
	1962	Holography	Lasers	Bichromated colloids

Table 1.1 The Communcations Pedigree. Microphotography in its historical perspective

fully selected their pigments with a view to permanency. Although fugitive dyes were much used in the cloth industries painters abhorred them and the use of silver for adorning illuminated manuscripts was frowned upon because of its tendency to turn black.[6] Our modern colour processes make very effective use of the dye principle and of course without the blackening of silver the photographic medium might never have been born.

In 1726 the German chemist Schulze carried out some experiments designed to investigate the darkening effect of the sun's rays; this was followed, in 1777, by the investigations of the Swedish chemist K.W. Scheele. In his experiment, Scheele placed a piece of paper, treated with chloride of silver, under water and exposed it to the action of light. Adding silver nitrate caused a precipitate of new chloride of silver and when dilute ammonia was added to this an insoluble metallic silver residue was left. Scheele further noticed that the violet rays of the spectrum effected a greater change upon the silver chloride than the red rays. This experiment appears to be the first application of chemical and spectrum analysis of the photographic effect.

Other chemists and physicists continued to be fascinated by the action of light upon various substances but it was another artist, Thomas Wedgewood, son of the great potter Josiah, who can truly lay claim to having taken the first photograph. In the year 1802 Wedgewood had stated that white paper, or leather moistened with a solution of nitrate of silver, is unaffected by any change when placed in the dark, but when exposed to the actinic rays of the sun gradually darkens, becoming grey and finally near black. Wedgewood also noticed that the degree of blackening was more rapid in proportion to the intensity of the light. He was also able to show that the red rays of the spectrum had little or no effect whilst the violet and blue rays effected the most powerful change upon the light-sensitive medium thus verifying the experiments of Scheele.

In 1802, at the Royal Institution in London, Wedgewood and Sir Humphry Davy produced the first photograph by Scheele's observations. The major problems with these early attempts was the fact that the pictures faded rapidly on exposure to light, especially actinic light. It was thus necessary to view them in subdued light (preferably red) and store them in light-tight covers. Once the photographic principle had been successfully demonstrated the next step was to find a method of making the image permanent, a method of 'fixing'. In 1799 Chaussier had discovered sodium thiosulphate and, as early as 1819, Sir John Herschel had noted its action as a solvent of silver haloids. But it was not until the announcement of the Daguerreotype process in 1839 that Herschel recommended its use in place of the common salt then used to fix daguerreotypes.

During the years 1800–1840 the subject of photography occupied the minds of many great men. Artists, physicists, chemists, mathematicians; all were fascinated by the potential of the new medium. One of the many scientists attracted by its possibilities was a Manchester instrument maker, John Benjamin Dancer (Figure 1.1). If any single person may be justly referred to as the father of microphotography that man is J.B. Dancer. Marton[7] and Stirling[8] have shown that Dancer was a prolific inventor of scientific and optical apparatus. Certainly he was an enthusiastic microcopist and the announcement of the daguerreotype process led him to attempt the production of a miniature photograph utilising the microscope as the means of reduction (Plate 1). His earliest attempts, made perhaps in 1839 or 1840[9] seem not to have been entirely successful. This was doubtless due to the limitation of the daguerreotype itself. Although capable of very high resolution it was not transparent and had therefore to be viewed by reflected light. Apart from focused sunlight other light sources available at the time did not have the intensity required to record a much-reduced image satisfactorily. What Dancer really needed was a photographic medium which was transparent; the reduced image could then be recorded by transmitted light.

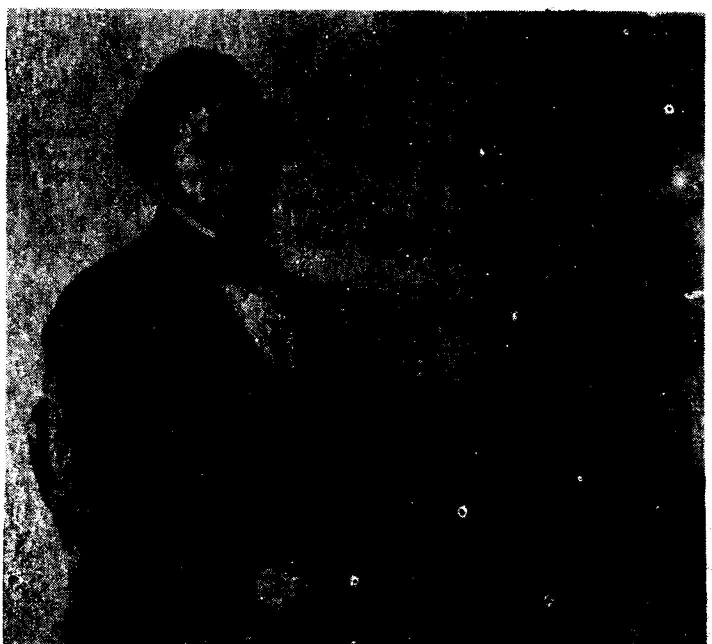

Figure 1.1 John Benjamin Dancer (1812-1887) the inventor of microphotography. (Photography collection, Humanities Research Center, The University of Texas at Austin)

Fox Talbot's Calotype process, announced in 1841, was not of much use as the paper base of the negatives severely restricted definition. In fact, Dancer was obliged to wait for eleven years from his earliest experiments in microphotography until 1851 when Frederick Scott Archer announced his wet-collodion process. Scott Archer was a sculptor who, with a number of other artists, was a member of the Calotype Club. This club had been formed to utilise the Calotype process perfected by Fox Talbot and when, in 1848, Niépce de St Victor published his albumen method, Scott Archer was amongst those who used it. The albumen process was extremely difficult to work and Scott Archer attempted to find an alternative technique whilst still maintaining the process's most notable feature—the glass base or emulsion support. Successful experiments using wet collodion encouraged Scott Archer to publish his method in 1852. Apart from its transparent support the collodion process allowed considerably shorter exposure times to be used, thus solving two of Dancer's most serious problems in the making of miniature photographs. Dancer immediately experimented with the new process and the Chapman Collection contains examples of microphotographs signed and dated by Dancer in 1852.[10].

Verification that the process used by Dancer was indeed wet-collodion came when Newman and Stevens conducted an analytical investigation of two Dancer microphotographic slides in 1978.[11]

Dancer's method involved a two-stage reduction in which a small negative intermediate was used to produce the final reduction positive. In 1853, shortly after Dancer's collodion opaque microphotographs were produced, Dr Hugh Diamond (Figure 1.2), an amateur photographer and subsequent editor of the *Photographic Journal*, succeeded in making the earliest microphotographic transparencies.[12]

A considerable amount of interest was being generated in the mid-1850s upon the subject of micro-

Figure 1.2 Dr Hugh W Diamond (d. 1886) maker of the first microphotographic transparency. (National Portrait Gallery, London)

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scopic photography. About this time a controversy arose as to who had actually produced the very first microphotograph. In 1857 a well-known photographer and editor of the *Photographic Journal*, George Shadbolt, published a method of making extremely minute photographs[13] and claims were advanced on his behalf as the originator of the technique. These claims brought an irate response both from Dancer himself and from those who knew of his work.[14] Shadbolt finally conceded to the overwhelming evidence of Dancer's claim. Shadbolt is, however, rightfully credited with coining the word 'microphotography'—a word which, even today, is still confused with the totally different technique of photomicrography.[15]

The practical problems of microscopic photography appear to have occupied the minds of a number of individuals during the period 1845–1865. Following Dancer's demonstration of a microdaguerreotype, *c.*1840,[16] and his subsequent, more successful collodion microphotographs of 1851–1852, a number of scientists, photographers and microscopists seem to have been fascinated by the possible applications of the technique. One of the earliest references appears to have been made by James Glaisher (1809–1903) in 1851[17] (Figure 1.4). Glaisher was reporter to the Class X Jury of the Great Exhibition of that year. The Class X Jury under the chairmanship of Sir David Brewster was concerned with 'Philosophical Instruments and Processes depending upon their use' and, in the Report on Photography,[18] Glaisher voices his disappointment at there being '. . . no [photographic] copies of ancient manuscripts,—no miniatures of printed books (a prophecy of future micropublications?), or that of condensing in volume for preservation in museums, etc. the enormous mass of documentary matter which daily more and more defies collection from the mere impossibility of stowage . . .'

Two years later Sir John Herschel makes mention of '. . . the publication of concentrated microscopic editions of works of reference—maps, atlases, logarithmic tables, or the concentration for pocket use of private notes and manuscripts, etc., etc., and innumerable other similar applications—is brought within reach of anyone who possesses a small achromatic object-glass of an inch or an inch and a half in diameter, and a brass tube, with slides before and behind the lens of a fitting diameter to receive the plate or plates to be operated upon'.[19] This is a clear reference to a device similar to modern hand-held microfiche viewers! Again, in the *Encyclopaedia Britannica (1857)*, Sir David Brewster wrote 'Microscopic copies of dispatches and valuable papers and plans might be transmitted by post and secrets might be placed in spaces not larger than a fullstop or a small blot of ink.'[20]

In 1858 the *American Journal of Photography*,

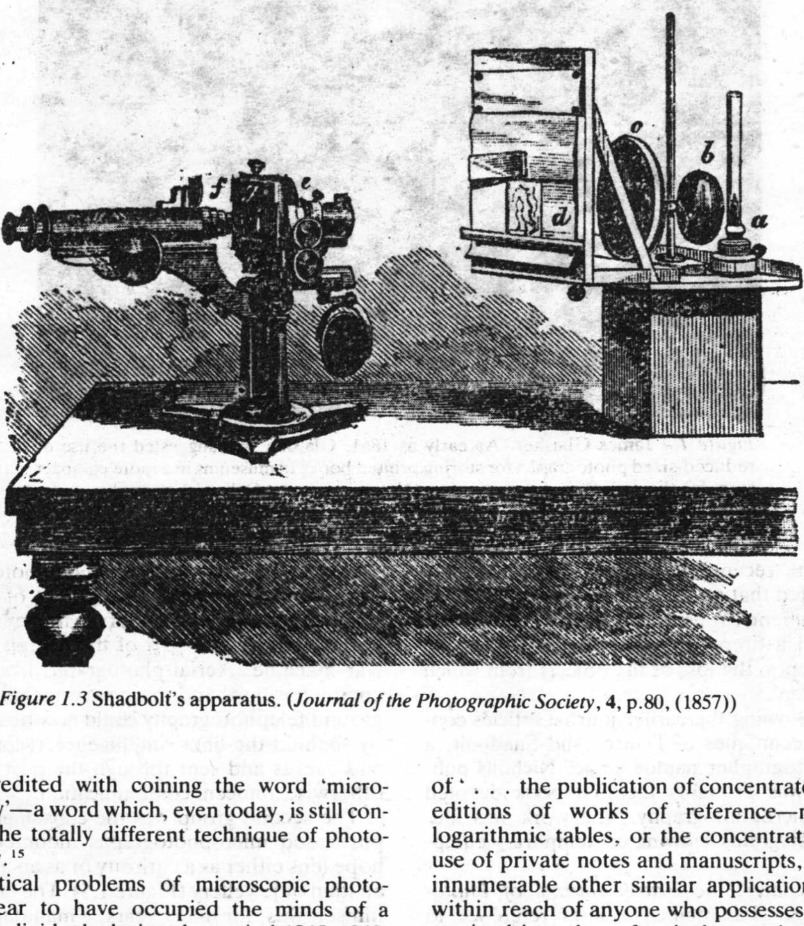


Figure 1.3 Shadbolt's apparatus. (*Journal of the Photographic Society*, **4**, p.80, (1857))

Figure 1.4 James Glaisher. As early as 1851, Glaisher had suggested the use of reduced-sized photographs for storing printed books in museums in a more compact form for the purposes of saving space. (National Portrait Gallery, London)

referring to the 'recent burning of the New York City Hall', suggested that a '. . . microscopic negative of all legal documents, wills, mortgages, etc., be made and stored in a fireproof vault underground to be resuscitated upon the loss of the objects from which they were taken'.[21]

In 1860, following the earlier journal articles concerning the techniques of Dancer and Shadbolt, a practical photographer named James Nicholls published what was probably the first book devoted entirely to microphotography. The work was illustrated with diagrams showing contemporary equipment.

Four years later, the *British Journal of Photography* for 1864[23] contained a brief reference to 'Microscopic photography' as practised by a certain Monsieur Dagron soon to achieve fame for his spectacular use of microphotography during the Franco–Prussian War of 1870–71. That same journal for the following year, 1865, devotes almost three pages to a detailed description of microphotography by the Belgian, H. Willemin.[24] These and other contemporary references show there was continued interest in the practical applications of microphotographs during the period 1850–70. That this interest did not bear fruit in the ensuing years, is the result of a number of different factors.

Initially the demand for microphotographs came from two widely-divergent sectors of interest. The first group was the military who saw microphotography simply as a part of the overall photographic war machine. Aerial photographs from balloons of enemy positions and troop movements together with ground telephotography could now be supplemented by 'behind-the-lines' intelligence recorded by spies and agents and sent through the post as part of an otherwise innocent communication.

The second group was the consumer market who purchased microphotographs mounted on a Stanhope lens either as a curiosity or as an integral part of an item of jewellery (Figure 1.5). The famous Dagron himself was, for many years, a manufacturer of such baubles and one occasionally still comes across them in antique shops.

We can see that neither of the above groups viewed microphotographs as a long-term method of compact data storage. Neither was it regarded as a novel means of information distribution—save that the military found its ability to be secreted undeniably useful. Partly because of this, microphotography found very little use as an information medium during the period 1870–90. And this, despite the fact that as early as 1865 G. Wharton Simpson had proposed its use for library and bibliographic purposes.[25]

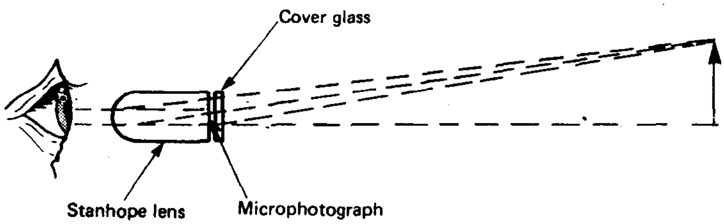


Figure 1.5 Stanhope lens. A convex lens designed by Charles Stanhope in the 18th century for use as a simple microscope of higher power than can be obtained by an ordinary magnifying glass. It consists of a cylinder of glass formed as if cut round the diameter of a glass ball. The spherical curvature of the lower surface is slightly reduced. In later forms the cylinder was lengthened and the lower surface made plane. Microphotographs were attached to the plane surface with Canada balsam and a cover glass was added for protection

Other reasons for the slow acceptance of microfilm as a copying, duplicating and disseminating medium were mainly of a technical nature. The early methods of making microphotographs were both tedious and exacting. The wet-collodion technique was particularly demanding and the pioneers of microphotography produced some exquisite examples of miniature photographs only under the most difficult and rigorous conditions. Early microphotographs were generally mounted on a glass plate or microscope slide and, unless handled with great care, were extremely prone to damage.

A number of developments were necessary before microfilm could become an easily-used research tool and a viable alternative publishing technique. Briefly these developments may be listed as follows.

(1) The use of a dry emulsion would be a great convenience compared to wet-collodion. The first dry gelatin emulsions were produced by R.L. Maddox in 1871.

(2) Glass microscope slides were easily broken and the introduction of a celluloid base for sensitive emulsions was a useful improvement. This idea was first proposed by H. Goodwin in 1887, but the cellulose nitrate used was unstable and it was not until much later when a suitable solvent for cellulose—triacetate was isolated that safety base film was introduced.

(3) Individual slides or plates were fine for a small number of documents but if very long runs of journals, periodicals or collections of books were to be microfilmed then it would be sensible for roll film to be used. The first roll-film camera was marketed by George Eastman in 1888 but it was to be more than 40 years before his company, Kodak, were to produce their first purpose-built roll-microfilm camera.

(4) Improvements in lens manufacture continued throughout the latter part of the nineteenth century and in 1890 Rudolph and Abbe designed the first anastigmats manufactured by Zeiss.

(5) In the same year, 1890, Hurter and Driffield commenced their monumental study of the behaviour of photographic materials. Their work created the new science of sensitometry and enabled workers in all branches of photography to achieve consistent results by the application of their methods.

(6) A great advantage of the wet-collodion method had been the fineness of the grain thus making the technique capable of high resolving power. To some extent this had been lost with the introduction of dry gelatin film but in 1891 Professor Gabriel Lippmann, working in Paris, succeeded in manufacturing a silver emulsion with an average grain diameter of 0.01 microns.[26] Whilst this was not directly applicable to microfilm it was of great interest to microphotographers attempting to probe the limits of resolution. In fact concentrated Lippmann emulsions are amongst the highest resolving power emulsions known to photography today.

(7) Methods of illuminating early microphotographs were, in the main, unsatisfactory. Exposure was achieved by sunlight when available, or candle-light reflected from parabolic mirrors. As early as 1840 the Frenchman, Berres, utilised the electric arc to make photomicrographs on daguerreotype plates[27] and, at about the same time, Dancer was using paraffin lamps with flat 'bats-wing' burners to make his microphotographs[28]. Such arrangements must have been very inconvenient but they persisted for quite some time as we find that Wulff, in Paris, was still using paraffin lamps in 1873.[29]

The microscope itself was frequently used as a projector and, in the latter half of the nineteenth century, lantern slide-projectors utilising lime-lights were often employed. From the point of view of quality, the microscope offered the finest image. However, it was useless to attempt prolonged reading of a microphotographic document through a microscope—it would simply have been too tiring for the eyes. Additionally prolonged viewing of a lantern-projected image would be annoying because of the lack of quality. Of all the obstacles to the acceptance and greater use of microphotography, that of image projection is perhaps the only one remaining to be solved. Even today, good though many microfilm-readers undoubtedly are, some still fall short of even basic requirements and a number are a positive torture to use.

In 1880 Thomas Alva Edison invented the carbon filament lamp and improvements upon this and other methods of electrical illumination had far-reaching effects upon both the taking and projecting of all types of photographs.

It is clear that from around 1890 most of the preconditions for microfilming as we know it today were in existence. Despite this fact, microfilm found no large-scale sponsor to promote its use and it was, for many years, still regarded either with suspicion or amusement. As an example of the latter a short article in the *British Journal of Photography*, 1900, suggests the use of bees as carriers for microphotographed documents.[30] Certainly this was one-up on Dagron's pigeon post!

Figure 1.6 René P P Dagron (1818–1900). He fired the popular imagination with his spectacular use of microphotography during the Siege of Paris in 1870–71. (Bibliotèque Nationale, Paris)

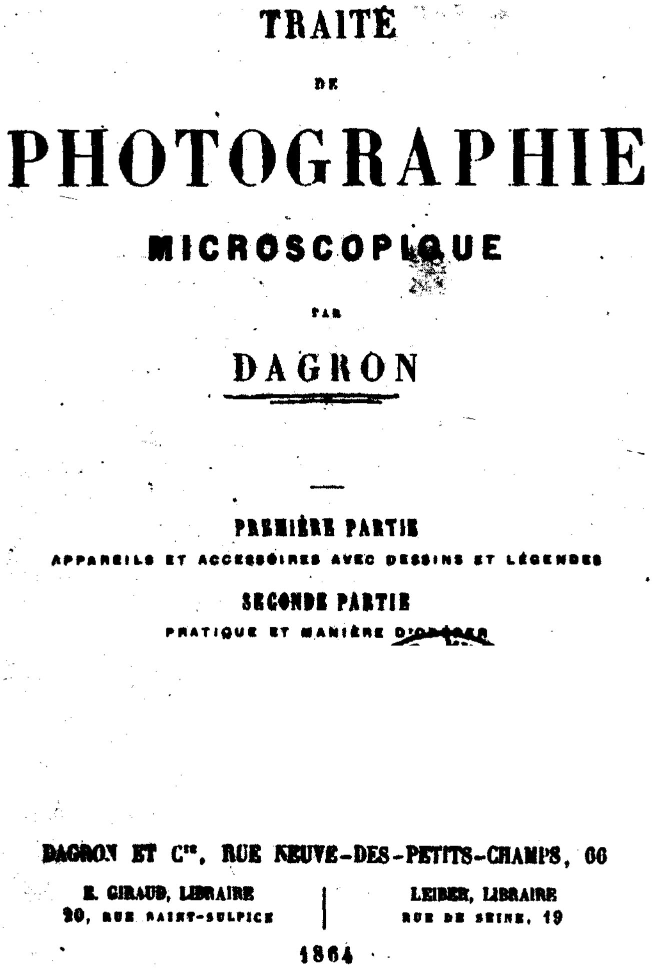
Having once more mentioned Dagron's name, it would prove useful at this point to consider the great Frenchman's achievements in relation to microphotography.

René Prudent Patrice Dagron (Figure 1.6) was by profession, a chemist and portrait photographer operating in Paris in the 1860s. As a supplement to his main income, which was derived from portrait work, Dagron specialised in the manufacture of microscopic views. These miniature photographs were mounted on a Stanhope lens and then inserted into such items as rings, tiepins, lorgnettes, and pen-holders. The inspiration for these novelties probably dated back to Sir David Brewster's tours of France and Italy. Whilst in Paris in 1857 he exhibited a number of J.B. Dancer's microphotographs to members of the Académie des Sciences. They attracted considerable attention and, as Dagron was one of those present, it is reasonable to assume that he foresaw immediately the potential of these tiny photographs. In any case, by 1864.[31] Dagron had achieved a reputation as a skilful microphotographer. This skill was soon to be put to a more practical and spectacular application than the manufacture of souvenir novelties.

On July 19th, 1870 war was declared between France and Prussia. Within two months the army of the Prussian Crown Prince arrived before Paris, and the siege of the French capital began. On the 12th September, 10 days after the surrender of the Emperor Napoleon III and the French Army of Chalons, a Delegation of the newly formed Government of National Defence was established at Tours, some 200 km from Paris.

The authorities at Tours considered various ways of maintaining communications between themselves and the now beleaguered French capital. The first pigeon despatch, dated 27th September, arrived in Paris on 1st October. About this time, a chemist in Tours by the name of Barreswil proposed using reduced photographic prints of despatches in order to increase the amount of information carried by each pigeon. During that same month a professional photographer called Blaise successfully produced microphotos of despatches on photographic paper. Blaise's microphotos varied in size but generally had one side not much larger than 40 mm. He later doubled the content of each miniature photograph by printing the reduced despatches on both sides of the paper. Blaise and a photographer called Terpereau were responsible for producing 17 such double-sided microphotographs.[32]

However, although a usable microphotographic despatch service was in operation from early October it became apparent that improvements were necessary if the system were to be maintained. One of the major problems seems to have been the shortage of pigeons, and especially of properly trained birds. It was, therefore, essential for each pigeon to carry as much information as possible. With this in mind the French government awarded Dagron a contract for the setting-up, outside Paris, of a microscopic despatch service. The contract was concluded on



TRAITÉ

DE

PHOTOGRAPHIE

MICROSCOPIQUE

PAR

DAGRON

PREMIÈRE PARTIE

APPAREILS ET ACCESSOIRES AVEC DESSINS ET LÉGENDES

SECONDE PARTIE

PRATIQUE ET MANIÈRE D'OPÉRER

DAGRON ET C^ie^, RUE NEUVE-DES-PETITS-CHAMPS, 66

E. GIRAUD, LIBRAIRE
20, RUE SAINT-SULPICE

LEIBER, LIBRAIRE
RUE DE SEINE, 19

1864

Figure 1.7 Title page of Dagron's *Traite de Photographie Microscopique*. Published in 1864, this was one of the earliest books devoted entirely to microphotography. (Science Museum, London)

November 11th and the following day Dagron and his associates left for Clermont-Ferrand aboard two balloons (appropriately named 'Niépce' and 'Daguerre'). A change in the wind direction drifted the balloons eastwards towards the German lines and the 'Daguerre' was brought down by the Prussian guns. The 'Niépce', carrying Dagron, landed at Vipry-le-François which was in enemy-held territory and it looked as if the whole enterprise might be doomed to failure. However, Dagron was nothing if not enterprising. It is said that he and his associates dressed as peasants and bluffed their way through the German lines.[33]

Dagron finally reached Tours on the 21st November having been prevented, by the provincial authorities, from setting up an independent unit at Clermont-Ferrand, as had originally been intended. Dagron had lost most of his equipment with the two balloons and it was not until December 4th that he managed to produce a satisfactory microphotograph. Even this was far short of the quality he had originally hoped to achieve but, on December 11th, he finally attained success. On December 15th the Delegation moved to Bordeaux and it was here that Dagron began work in earnest.

The techniques he used proved extremely efficient and an account published in 1936 showed that '. . .they gave an enlargement of a finer degree of legibility than was possible on modern films and in the best apparatus at comparable reduction ratios.[34] This comparison is perhaps a little unfair in that Dagron used a collodion emulsion[35] which we should expect to exhibit a considerably finer grain size than the type of silver-gelatin microfilm commercially available in

1936. Dagron's achievement, however, was a formidable one and the method which he used showed considerable economy of means.

Messages to be sent were first subjected to abbreviation and the abbreviated copy then printed on transparent sheets divided into 12 rectangles measuring 80 x 110 mm. Each rectangle was able to contain 1 000 characters. The transparent sheets were then divided in two and the two halves contact printed with collodion plates to provide glass negatives of six rectangles each. After development the plates were cut into six pieces so that each rectangle formed one separate messages. So efficient was the 'microscopic pigeon post' that when the siege ended only a few messages awaited despatch.[36]

Dagron's contribution to microphotography was considerable. At the beginning of the Franco-Prussian War in 1870 only a small number of dedicated scientists and photographers were aware of the possible applications of microphotography. Eight weeks later the whole world knew of this marvellous method of disseminating information and it is clear that the Siege of Paris marked an important milestone in microfilm's history. It is also interesting to note that

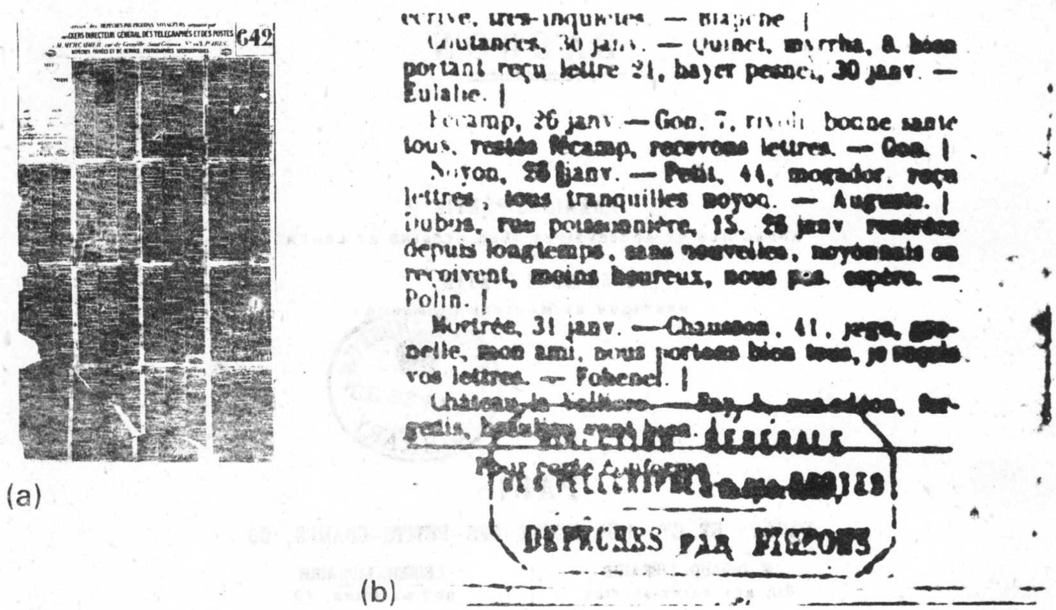


Figure 1.8 Microphotographic pellicle from the Siege of Paris, 1870–71. (a) Original size, (b) enlargement 40 x. (Kodak Museum, Harrow)

master negative. The master negative was then photographed by a special camera having 20 lenses, each of short focal length. Thus 20 positive duplicates were made of the master simultaneously. Each print measured 30 x 55 mm and they were carried in small tubes attached to the pigeon's tail. It was possible for a single pigeon to carry 18 or more of these films, which weighed less than half a grain and contained more than 80 000 words (Figure 1.8).

The process was later modified to making a direct copy of each sheet. A dry plate of 36 x 60 mm was used and the resulting negative was contact printed on to a collodion plate. The collodion layer was then stripped from the plate after development. Each of these films or pellicles contained between 60 000 and 80 000 words and weighed only a twentieth of a gramme. Legibility was excellent despite the high ratio of reduction (40 : 1) employed.

In nearly eight weeks Dagron and his assistants produced two and a half million copies of 115 000 probably more document microfilms were made during the eight weeks of the siege than in the whole of the previous 30 years of microfilm's existence!

Sad to say the end of the Franco-Prussian War was accompanied by a decline in the general interest in microphotography. With the possible exception of the Rothschild Bank, who in 1875 employed Dagron to micro-copy their archives, no individual or organisation came forward to consolidate the gains made by Dagron in the public's mind. Microfilm and its applications became once more the province of the specialist. Indeed for the next thirty-five years microfilm languished in a communications backwater where it appeared to be busy contemplating its own navel. In fact a number of extremely important events were taking place during the period 1870–1900. Foremost amongst these was the manufacture of a new emulsion of microscopic grain size by Professor Gabriel Lippmann in Paris in 1891. The significance of the new 'concentrated Lippmann emulsion' was

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