9

Identification of archive film and interpretation of historical data

9.1 INTRODUCTION

The identification of a reel of film is for two purposes:

- To identify the film title, actors and/or events, period, and the context in which the film was made. The evidence will be principally from the images, and from additional written matter on the film itself.
- To provide the restoring technician with information to produce an authentic restoration. This evidence will be from the images also, but in addition, from the film itself, from the gauge, sprocket holes, edgemarks, dyes, soundtracks and many other characters.

The two aspects above are related and date is usually critical. If the film is not dated the period may be estimated from the photographic material, the element. Identifying a colour process can sometimes date a film within a few years. Alternatively, recognizing an actor, or a theatre billboard in the image, may provide a date and help the technician decide how the film was made, and therefore how to restore it. The most difficult and ever-present problem that a film archive has to face every day is that of identifying materials that are either completely without opening credits or have them only incompletely.

At the end of the 1980s the Dutch National Archive took possession of an immense collection of about 2,000 titles that had been collected by a distributor in the early 1920s. They were mostly films without opening credits, or, at best, with credits translated into Dutch. The archive decided to tackle the work of identifying the huge collection over a period of several years and now almost the entire stock has been identified.

From that collection several masterpieces from cinema history, that had been forgotten or thought to have been lost, have come to light. The effort of the Nederlands Filmmuseum is a good demonstration of how working on collections of unidentified film means giving value to material that otherwise risks being forgotten. For example, let us imagine that an American archive has a French film stored away, important because it is believed lost, but its original title cannot be identified: that film is doomed, sooner or later, to decay and to die without anyone being able to intervene.

Identification demands a lot of experience. All the operations that are now being presented schematically eventually will become a daily working method. Eventually repetition provides the knowledge necessary to allow a worker to simplify and modify routines.

Identifying a film proceeds by a process of elimination.

9.2 THE NEW ACQUISITION

9.2.1 Before opening the can

Before anything else, you must try to ascertain where the film comes from. Look at the can label. If, for example, it has been deposited by a distributor that was active up

until the 1930s, it is almost certain to be a film produced in that period. A careful study of the source of the material simplifies the work of identifying it. Check the number of reels of that particular film and, of course, start with the first one, if possible. Sometimes the can label has no relationship to the film inside.

9.2.2 Opening the can

Normally it is the practice of film archives to substitute rusty old cans with new ones, either in plastic or metal, in order to better conserve the treasure. While this important step is being carried out, it is necessary to meticulously register any and all information that might otherwise be lost forever.

9.2.3 Taking the film out the can

First look at the edges of the film. From this first observation you can see if the film is black and white, colour or coloured (the different tintings show clearly on the border of a coloured film) and therefore already start to calculate an approximate date as to the decade. You will know that an Eastman Colour film can only have been produced after 1950 and that a tinted film base will have been produced before 1930. Of course, in order to analyse the technical information contained in a film you will have to begin to unwind the reel and observe the film frame by frame through some form of simple projector. This initial dating of the film as to its decade will help you to better select the information that you have to look for.

Observing the edges of the film, you will see immediately if the film can be unwound, or if it might be damaged in doing so. If it is a nitrate based film and it is already in an advanced state of decay, swellings on the edges of the film, can be seen, or whitish or powdery discoloration.

Looking at the edge of the reel, you may also see immediately whether the perforations are damaged or not. In the event that there is much damage, you may also find small holes along the edges corresponding to the tracks of the lost perforations. Every piece of evidence should be recorded

Now the film can be unwound, very slowly.

9.2.4 Unwinding film

Sound films almost always have leaders. When they are the original negatives, they can carry the title of the film, the reel number, the name of the producer or the distributor and the name of the laboratory. For example, films, even prints, from the ex-communist countries usually had leaders that permitted the immediate identification of the country where it was produced. On the leaders, the laboratories in the United States, France, the United Kingdom and Germany usually put instructions for the projectionist in the different national languages.

On sound film leaders there could be instructions for synchronizing the film with the records that accompanied it.

If it is a silent film, it usually will not have any original leaders, but ones that have been added later. It is possible that on these leaders a title has been written by hand that corresponds to that of the film.

9.3 THE IMAGE AS EVIDENCE

9.3.1 First impressions

Often after the leaders there may be several metres of a film that has nothing to do with the rest of the roll. It was quite usual for collectors or newsreel companies to use pieces of spare positive film as leaders, spliced onto the real film. In England this was called **gash** film, and the practice was particularly common with newsfilm.

If it is a silent film where sound has been added later (sometimes called post-synchronized) image area will have been reduced by the soundtrack that has eliminated the corners and part of the frame. Normally, to add sound to a silent film a very simple soundtrack was used that contained music, sounds and rarely dialogue. However, many studios continued using cameras with the silent film frame order until the early 1930s, so that these films have 1:1.33 frames interrupted by the soundtrack even though they have been shot in the sound era.

If the reel is from the head and it is the first reel, after the leaders you might find the credits; the film, the director, the studio etc. It may be that only some of the original opening

credits remain and that the title of the film itself is missing. Even then, sometimes only the name of an actor can be enough useful information to make a comparison with that in the filmographies. There are sufficiently complete filmography files for all the major national studios (at least for feature films) to permit the identification of a film's title even with only a few pieces of information.

9.3.2 Silent movies – intertitles

Very often the name of either the producer or the distributor is carried in the text of the intertitle. Knowing the name of the producer of the film is extremely important because this reveals its origin; information about the many distributors is less well recorded.

The intertitles normally contain either one or two series of numbers. If there is only one then it refers to the sequence of the intertitles. If the first one carries the number 30 then it is obvious that you are not looking at the first reel. This type of information is very useful in understanding the completeness of the material under study.

If there are two clearly separate numbers then probably one changes while the other remains the same. The unchanging number is the production number, while the other is the intertitle sequence number mentioned above. The production number may be on the intertitle, and there may be the company name as well. Alternatively the number refers to the distribution, but with the name of the distributor written at the side. The production number is useful in identifying a film, if the production company's catalogue is available.

9.3.3 Writing

There is usually at least one legible piece of writing as image in a reel of film: the name on a store window, the title of a newspaper, the name of a street, the advertising on a streetcar, etc. These are original to the shoot. The language in which they are written may tell us the country of origin.

9.3.4 Actors

A decisive element in identifying an untitled film is the recognition of the actors. If you can recognize an actor you have a good chance of finding the original title of the film. The actor may define the country and the period, and the filmographies should provide the rest.

By observing the hairstyles, clothing, automobiles etc., it is possible to acquire circumstantial evidence.

9.3.5 International collaboration

In general, someone, somewhere, will recognize an actor or provide the data that provides the lead. In 1993, the Cineteca of Bologna became the European Centre for the Search for Lost Films Project, proposed by LUMIERE in order to compile a list of films that the EU film archives consider lost, and help archives to identifying their patrimony.

9.4 THE FILM AS EVIDENCE

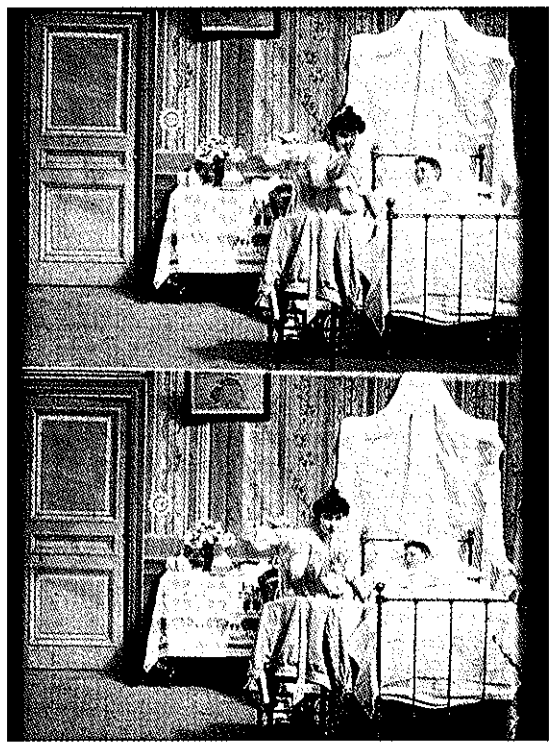
The film itself may be of great importance to the archivist – it may date the production or just date the print. Evidence will come from a wide range of different fragments of information:

- The film base
- The gauge
- Perforations
- Image size and ratio
- Edge data
- Number and frequency of joins
- The colour system/black and white process/tinted/toned/stencil etc.
- The element, negative/positive/duplicate/reversal/separation/colour/sound etc.

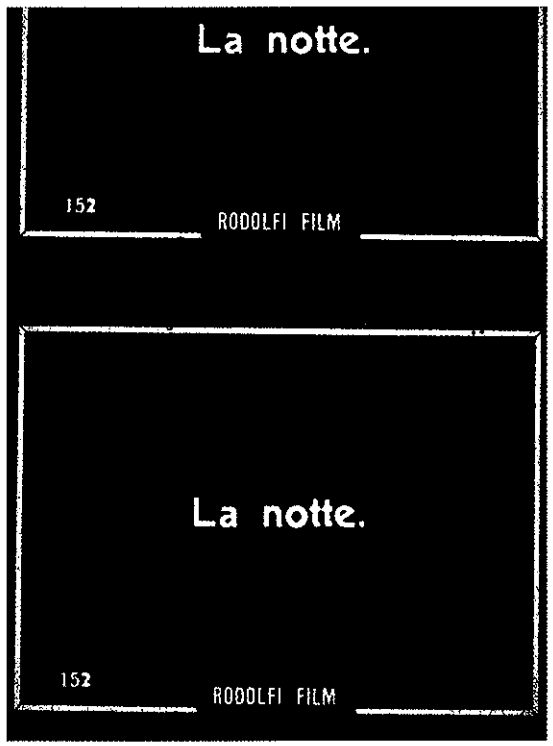
Since the very beginnings of motion picture film, it is believed there have been over 100 commercial colour systems, over 40 sound systems, at least 2,000 film laboratories worldwide, an unknown number of different film manufacturers and stocks and 100 years of innovations. A full list of all the pieces of evidence that could be useful is not possible and, indeed, does not exist. By definition, it also implies that certain identification is often not possible. In turn that means that truly authentic restorations are also not always possible. The FIAF/Gamma Group Madrid Project is a programme, started in 1999, to gather this information.

(*a*)

(*b*)



(*c*)

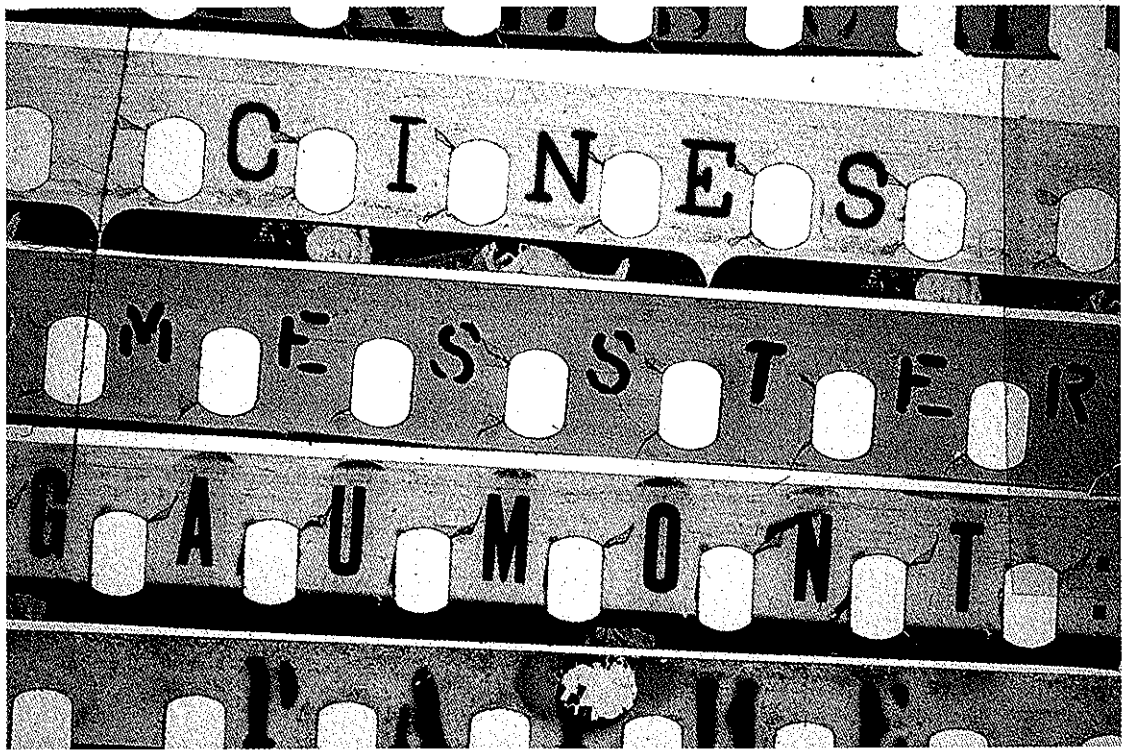


(*d*)

(*e*)

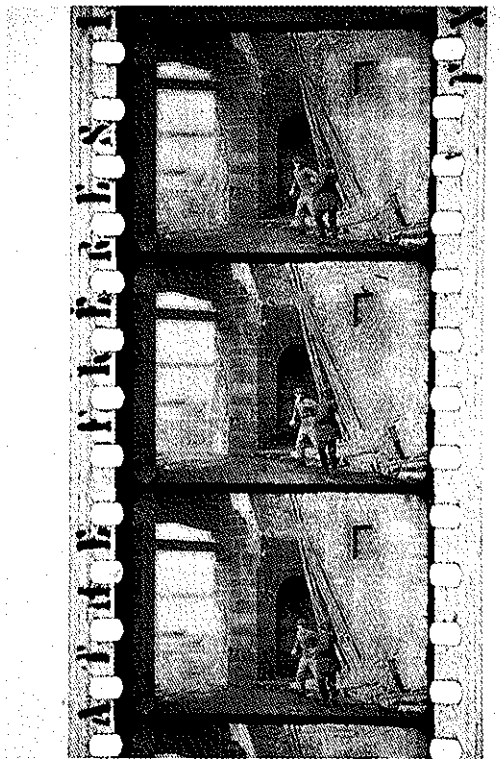
(*f*)

Figure 9.1 (*a*) Éclair intertitle; (*b*) Vitagraph intertitle; (*c*) clues to date in image; (*d*) intertitle with production company mark and intertitle number; (*e*) clue to date in image; (*f*) intertitle and company marks

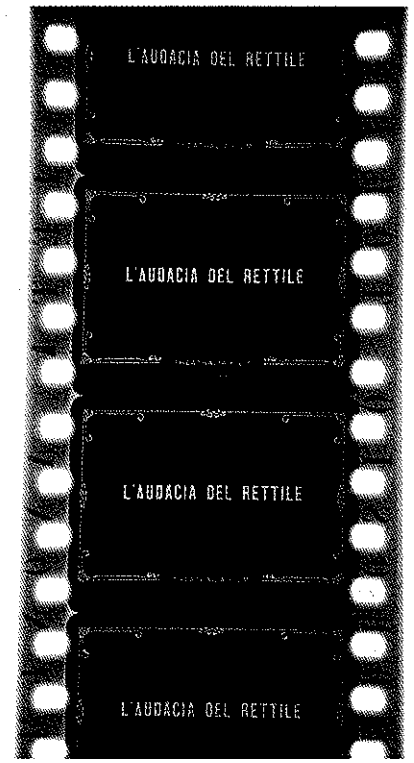


(*a*)

(*b*)

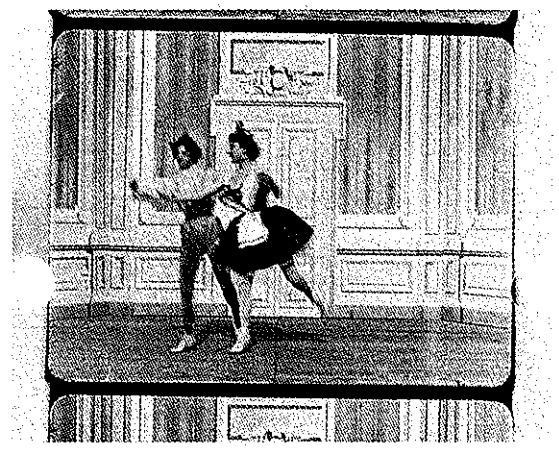


(*c*)



(*d*)

(*e*)



(*f*)

Figure 9.2 (*a*) A range of manufacturers edge marks: notice variation in perforations. (*b*) Italian Vitagraph intertitle on Kodak film made in 1924: more rectangular perforations. (*c*) Pathé edge marks. (*d*) Ambrosio edge marks. (*e*) Possible date code on edge 'barrel' perforation. (*f*) Lumière perforation

Many sources of technical data exist – nowhere near as complete as the data on cinema production, or on the content of newsfilms collections. The data is fragmentary, sometimes second- or third-hand and often difficult to locate. The bibliography to this publication contains as complete a list of references on films, manufacturers, laboratory practices and colour systems as possible. Unfortunately in many cases these publications are few and well scattered, and many archives and restorers will find access to them difficult.

9.4.1 Gauges, perforations and image ratios

In its almost 100-year history, the cinema has seen the appearance (and rapid disappearance) of a large number of film widths, differing in dimensions, images and the number of perforations. Most of these gauges are obsolete today and the equipment for preparing them or projecting them no longer exists. Some film archives have large collections of films in non-standard gauges.

The two principle gauges now used in professional cinematography are 16 mm and 35 mm. The form and dimensions of the perforations were standardized in the 1930s for both the gauges.

Perforations are a useful guide to date for the earliest films but after the 1930s the two 35 mm and one 16 mm standards prevailed, and in reality by 1920 the perforation type is really of little help in dating, except in a few specialist systems.

Images vary in ratio on the 35 mm or 16 mm film and these two may provide clues.

9.4.2 Edge data

There are three types of information to look for:

- special identification marks put on the copies by the production company;
- special identification marks of the raw stock manufacturers;
- special frame numbering sequences, on negative film and some prints, put there by the laboratory.

Special identification marks put on the prints by the production company

In the first 20 years of cinema history the main studios had very precise marks for their products. This discouraged copying – one of the first anti-piracy methods – and served as a recognizable symbol for buyers. The cinema was in its beginnings and every studio had established special techniques that were guarded jealously. Therefore their films contain a series of signs that often help in discovering the producer.

The bible of these early edge marks is Harold Brown's *Physical Characteristics of Early Films* (1990), published by FIAF.

Special identification marks of the raw stock manufacturer

While special marks made by the film producers on the film margins disappeared almost completely by 1920, those of the raw stock manufacturers are still in use today.

It has for many years been the custom of film stock manufacturers to produce a latent image of their names and often other marks on the edge, beyond the 35 mm perforations, of their films. These are processed as images during development. Some edge marks are stencilled letters not latent images. These marks are sometimes very faint, and if the printer exposes the entire width sometimes the edge marks from previous elements can be printed through to the print film and need to be looked for.

Example of film edge data – Kodak

The practice appears to have commenced in 1913 with the Eastman Kodak Company, who then printed the word 'EASTMAN' in large stencilled letters on one margin. This style was continued until about the middle of 1914 when the lettering was changed to a smaller style, and a dash was included two or three frames from the name. This continued throughout 1915. In the early part of 1916 the films had two small dots in place of the dash.

During 1916 the Eastman Kodak Company began a systematic series of the year symbols on their film stocks made in Rochester, USA, in a manner somewhat like the hallmarking of silver. A comparable series of marks on stock made at Harrow, in the UK, was begun in 1917. Stock made by Kodak in Canada from 1925 onward used another similar series of

THIS IS A DATE CODE CHART FOR EASTMAN KODAK MOTION PICTURE FILM. READ THE SYMBOLS ON THE EDGE MARKINGS OF THE FILM FROM LEFT TO RIGHT, AND COMPARE TO THE CHART. THIS WILL TELL YOU WHEN THE FILM WAS MANUFACTURED AND WHERE. WHITE PRINTING TELLS YOU INFORMATION ABOUT THE NEGATIVE, AND BLACK PRINTING TELLS YOU INFORMATION ABOUT THE POSITIVE PRINT. EXAMPLE: THE BLACK PRINTING READING LEFT TO RIGHT ON A PRINT OF "THE PRODUCERS" IS " + + ". THE CHART TELLS US THAT THIS IS A PRINT STRUCK IN 1968, WHICH INDEED IS WHEN THE FILM WAS RELEASED.

FOR FUJI FILM, THERE IS A 4 DIGIT CODE ON THE PERFORATIONS. THE FIRST 2 NUMBERS ARE THE YEAR THE FILM WAS MANUFACTURED. FOR EXAMPLE "8 3 J M" IS A PRINT MANUFACTURED IN 1983.

EASTMAN KODAK DATE CODE CHART					
1922	1942	1962	● ■	1982	● ■ X
1923	1943	1963	● ▲	1983	X ▲ X
1924	1944	1964	▲ ■	1984	▲ ■ ▲
1925	1945	1965	■ ●	1985	■ ● ▲
1926	1946	1966	▲ ●	1986	▲ ● ▲
1927	1947	1967	■ ▲	1987	■ ▲ ▲
1928	1948	1968	+ +	1988	+ + ▲
1929	1949	1969	+	1989	X + ▲
1930	1950	1970	▲ +	1990	▲ + ▲
1931	1951	1971	● +	1991	X + X
1932	1952	1972	■ +	1992	■ + ▲
1933	1953	1973	+ ▲	1993	+ ▲ ▲
1934	1954	1974	+ ●	1994	+ ● ▲
1935	1955	1975	+ ■	1995	+ ■ ▲
1936	1956	1976	●	1996	X ● ▲
1937	1957	1977	■	1997	X ■ ▲
1938	1958	1978	▲	1998	X ▲ ▲
1939	1959	1979	● ●	1999	● X ▲
1940	1960	1980	■ ■	2000	■ ■ ▲
1941	1961	1981	▲ ▲	2001	▲ ▲ ●

ONLY EXCEPTION 1948 CAN BE EITHER ++ OR ●●●

WHERE STOCK WAS MANUFACTURED

S'AFETY – ROCHESTER
SAFETY – CANADA
SAFETY – ENGLAND
SAFETY – FRANCE

Figure 9.3 Recently produced flyer from Sabucat Productions, California, illustrating the Kodak date marks

marks. In the late 1940s this information was given by Kodak to the National Film Archive, in the UK – originally confidentially, but subsequently generally released.

No such marks were put on the stocks made by Kodak in France and Germany during the 1930s. French stock was marked simply 'Kodak France' and German stock, 'Kodak A.G.'.

In 1927 Kodak took control of the Pathé film stock factory in France. Thereafter, the Pathé stock was still marked with the name 'Pathé', but the Kodak UK symbols may be found on it as well.

The USA system of symbols repeats every 20 years, the UK system repeats every 19 years and the Canadian system every 11 years.

9.5 IDENTIFYING THE ELEMENT

9.5.1 Introduction

The term **element** is used here to define a stage in the sequence of production of a motion picture film. A camera negative, a projection print, a duplicate negative, a sound negative, a B roll cut negative are all elements and can all be elements of the same production. In English or American laboratories traditional jargon terms for each 'element', such as 'mute' for the camera negative and 'track' for the sound track are widely used, and the term element is not well known. **Element** is a useful general term and will be used here because there is no other equivalent.

Identifying the element can be very important in planning the sequence of events of a restoration. However, it is just as true that identifying the element may not be as quick or easy as it seems; a duplicate negative that has been carefully and well made can look very much like the original negative from which it is taken.

A useful technique is to look at the perforations of a film – sometimes it is possible to detect around them images of previous film perforations printed through by contact printing. As many as five images have been seen indicating the image is the sixth generation at least!

The following is survey of the main types of elements. Many of these, especially those that are used in the post-production phases (e.g. editing, mixing, synchronization, dubbing, titling, special effects etc.) rarely find their way into an archive. They are only used in the laboratory and, as soon as the work is finished, become useless and were usually lost or destroyed.

9.5.2 Positives

Projection prints are the most common material that is available to, or found in an archive, just as laboratories store the negatives and duplicates for their customers.

Subject → ORIGINAL NEGATIVE → POSITIVE PRINT

Both colour and black and white positive copies have a transparent base. Sound tracks

were variable density until about 1958, and variable area from 1935 to today. Magnetic tracks were in the usual track position, and even 'magoptical' tracks exist, in which part of the optical track is overlaid by a magnetic stripe applied after the film was processed (usually for an alternative language).

Most archive prints are **release prints**, that is, they were produced for display in a cinema and were one of many that were originally produced from the original negative until about 1925 but from duplicate negatives thereafter.

Prints with frequent joins at scene changes were 'pos cut' and were pre-1930; those in one piece were 'neg cut' and were from about 1925 to today.

More rarely the print will be an **Answer print** (or **first trial print**). This is, literally, the first graded copy printed from a cut negative; it was often thrown because it usually needed to be further corrected to satisfy the requirements of the producer. Answer prints in colour, especially those produced before the use of Video Colour Analysers in the laboratories, could be a far cry from the quality of the final copy. Originally they would be the first trial and error print made. The only way of identifying answer prints, if there isn't anything written on the can or at the end of the film, is to evaluate the quality, if possible by comparing it to another copy. However this may not always be helpful. Technicolor release prints could differ remarkably from each other, as the early systems were obviously not very repeatable. Some laboratories made 'answer prints' with no sound.

Even more rarely found is the **show print.** This was the final print made by the laboratory with all the grading corrections, and was often used for the first private shows, for premiers or as a selling medium. Most ended up with the producer or the director in their private collection!

Rushes (called **dailies** in the USA), are rolls of prints just as they were produced from the original negative as soon as possible after the shooting (and seen by the camera crew 'daily'). They vary in grading considerably. In the 1930s, and in the early days of negative/positive colour in the 1950s, they were often of poor quality. However, by the 1970s the quality was high. Rushes are rare in archives. They can usually be recognized if they are from a feature film production by being silent repetitions of the same scenes shot again and again.

Rushes were generally cut up and joined to produce an edited story called the **cutting copy**. This is usually very easily recognized. The rushes or specially requested new sections of print from the camera negative were (and still are today) joined, often simply by tape but before the 1960s by conventional splices, to put together the story of the final production by the editor. The positive prints are almost always written on (in pencil or crayon) to give special instructions to the negative cutter who will later join all the original negatives together to make the **original negative** element of the production. Sometimes lengths of white spacing, with written or coded explanations for special effects, are cut into the prints. These are sometimes much longer than the final film and were not intended to indicate the real length. Cutting copies are often very badly scratched and marked, even torn and dirty. They were always silent.

Once the editing phase is complete one has a **workprint**, a positive copy spliced with tape or glue, the result of the editor's work which serves as the basis for cutting the negative. Usually the quality of the workprint is quite bad, due both to the printing as well as to the fact that it is often scratched, dirty and torn. It can be useful in reconstructing the original editing. Sometimes a workprint was made crudely and cheaply from the cutting copy by printing onto reversal film.

Occasionally **rushes out-takes** are found. These are rush prints of scenes that were not used in the production and were frequently put back into the can in short lengths with or without rejoining.

9.5.3 The camera negative

This is easy to distinguish from a duplicate negative because it does not have any of the signs of having been produced by a printer. A step printer produces a darker or lighter frameline between the frames; a continuous printer produces a difference in density, sometimes very slight, between the exposed parts (the transparent frameline) and the unexposed parts (for example, the borders and the edge areas between the perforations).

Original negatives have the following features:

- No border around the frame of any sort.
- The edge density between perforations is exactly the same as the density between the frame lines.
- No 'septum lines' of any sort – these are thin straight lines of density produced in a printer by masks and gate apertures of one sort or another not coinciding precisely and occur outside the frame area.
- If it is an edited negative it will have a splice between each shot.

It is almost always possible to identify non-edited material; these could be rushes that have not been edited yet. In this case it essential to know if the film has never been finished or if, on the contrary, it has been; then the non-edited material that you are identifying will most likely be rushes material that was never used and was termed **negative out-takes**.

Some laboratories use the term '**cuts and trims**' for cans of negative or rushes prints that have not been used in a production. It is not uncommon for producers to sell the cuts and trims to film stock shot libraries, after the editing is over, and cans containing several small rolls of scenes, original negatives and prints mixed up together in the same can will probably come from a commercial company such as this. This library material is often well used!

Sometimes cuts and trims are in loose rolls in which the individual lengths are not joined but simply interleaved in to make what is sometimes called a '**peeled roll**'. This is done by both editors with rush print out-takes, but also by negative cutting companies and laboratories during the negative cutting operation. A peeled roll of negatives is a good sign that the material is probably negative out-takes and has not been touched since the production was made.

9.5.4 Black and white duplicate negatives and internegatives

The other possibility, given that you have a negative, is that it is a duplicate negative of an original in black and white or in colour. In the preceding section you saw how an original negative can be distinguished from a duplicate. Duplicate negatives can either be combined, i.e. they contain both the scene and the soundtrack, or separated, in which case the soundtrack has been duplicated or re-mastered separately. Duplicate negatives have all the indications of being printed and:

- most frequently have negative perforations (BH type);
- often have a coloured base – blue, purple, lavender;
- frequently have sharp lower densities on the edges between the perforations;
- often have dark septum lines (see above);
- are usually denser than original negatives (this produces a better subjective quality), but this is not always a good guide;
- often have images of previous generation perforation around the perforations, but only if printed on certain printers;
- have no joins between scenes.

The last clue is the best, as the absence of a join between markedly different scenes is a sure sign that the element is a duplicate of original negatives that have been joined together.

Nowadays the quality of duplicates can be very good, especially if they have been made from dupe positives or interpositives made on special duplicating stocks. However, prior to 1926, when Kodak introduced the first film designed solely for duplicate negative production, the quality of the duplicates was not very good. They had a higher contrast than original negatives and a notable loss of definition.

In order to produce a duplicate or copy negative from an original negative the most common method used since the turn of the century is to print the negative to make a positive and print the positive to make a negative from this.

Subject
→ ORIGINAL NEGATIVE
→ PRINT
→ DUPLICATE NEGATIVE

Until about 1926 only two types of film stock were made, camera negative and projection print, although by varying the development time the contrast could be altered within certain

limits. If a copy negative was required, there seems to have been two ways of doing this.

1. To use the **projection print** as the master, and make a copy negative from it onto camera film. To do this and keep the contrast down was not easy and the resulting duplicate negative was often higher in contrast than the original negative.
2. To use two stages of camera film printing from the original negative. This could be used to produce quite good results from the very earliest times but was rarely done as the safelighting used to print onto camera film was darker and so printing was an awkward procedure.

Some film companies which needed large numbers of duplicate negatives continued to use a modified version of the first method but with quite acceptable lower contrasts until as late as the 1950s, in order to avoid purchasing the expensive duplicating stocks. They produced a **special low contrast print** (by underdeveloping normal print film) as an **interpositive**. Newsreel companies especially did this; they used duplicate negatives as a library of material for cutting into later issues without destroying the original programmes so that most newsreel issues consisted of a patchwork quilt of new negative and duplicate negative. A good example was the British Pathé Newsreel company.

The majority of duplicate negatives made after the early 1920s were made using specialized duplicating film stocks and by the mid 1920s most stock manufacturers made them. The sequence of stages was substantially the same as before but using the new low contrast blue-sensitive duplicating materials.

9.5.5 Black and white duplicate positives, interpositives or master positives

Subject
→ ORIGINAL NEGATIVE
→ MASTER POSITIVE
→ DUPLICATE NEGATIVE

Master positives used as duplicating stages can be recognized as such only after the early 1920s. Thereafter most master positives were intended for duplication only and did not have a dual function and were not acceptable as projection prints. Most had negative type (BH) perforations and were visually lower in contrast, with markedly low density blacks and sometimes grey or coloured bases. All three terms above are used in different laboratories but all refer to the same element.

9.5.6 Colour duplication elements

Prior to the introduction of tripack materials and colour development, the duplication stages of colour processes were difficult to identify without detailed knowledge of the process as a whole. However, Kodak started to introduce colour duplication materials in the 1950s, and recognizing colour intermediates after this is quite easy.

Initially and until today the most extensively used system uses Eastman Colour Intermediate film for both stages of duplication; for the preparation of the interpositive and the duplicate negative.

Subject
→ ORIGINAL COLOUR NEGATIVE
→ INTERPOSITIVE
→ DUPLICATE NEGATIVE

A colour duplicate negative is recognized by all the characteristics listed above for recognizing a black and white duplicate negative except that the base colour is orange due to the integral masking. A colour interpositive is unmistakable; it is a low contrast, low density positive with an orange suffusion due to the orange integral masking. The perforations of this material are always BH. 16 mm versions of this system do exist but are rare. Colour intermediate graininess and sharpness is not good enough for 16 mm.

Another system first introduced at the end of the 1960s uses a single stage and a reversal duplicating material also from Kodak called CRI or Eastman Colour Reversal Intermediate (CRI). This material was used until the early 1990s but is now almost obsolete as the new versions of Colour Intermediate improve in sharpness.

Subject
→ ORIGINAL COLOUR NEGATIVE
→ REVERSAL INTERMEDIATE NEGATIVE

This material is significantly finer in grain and sharpness than most intermediate materials but very critical to process. It is made in both 16 mm and 35 mm.

A CRI duplicate negative is immediately recognizable by the black reversal type surround to the image that includes the perforation areas.

9.5.7 Confusing terms used for intermediates

The labels on the outside of cans of black and white or colour intermediates or duplicating elements can be confusing and misleading. In the English-speaking world of the USA, England, Canada and Australia many different terms are used for duplicate negatives and intermediate positives. Not only are there national differences but also major differences between companies, especially the laboratory companies, some of whom have developed their own semi-technical jargon, particularly with respect to duplicating.

Some of the terms used are:

Intermediate – a general term that could refer to almost any stage in duplication that is not the original negative or a final print or simply mean that the film stock used is Eastman Colour Intermediate.

Internegative – a term used for an intermediate negative made from a positive. This could have been a positive print or a reversal original. In some laboratories it means a duplicate negative. Other laboratories use the term solely to mean Eastman Colour Internegative

- **Duplicate negative = dupe neg = intermediate negative = copy negative** – these terms are all synonyms.
- **Duplicate positive = interpositive = intermediate positive** – these terms are all synonyms.
- **Lavender** – originally lavender-coloured base B/W duplicating film from Eastman Kodak in the 1930s. Can refer to any duplicate negative.
- **Fine grain** – after the lavender film was discontinued until the present, a series of film stocks called Fine Grain Duplicating film have been released by Kodak for producing duplicate positives and negatives. Hence in many laboratories duplicate positives and duplicate negatives are called **fine grain pos** and **fine grain neg**. This slang usage has existed from the 1940s to the present day.

9.5.8 Other materials

Included among the film materials that might find their way into an archive are all the materials used in the production of titles, credits and special effects. These are negatives or positives destined to be passed through an optical printer and recombined in various ways so as to achieve the desired result. There are background or foreground images for credits, credits to be edited by superimposing, short sequences of intermediate materials incorporating simple effects such as fades dissolves wipes or other special transitions from scene to scene – a multitude of different elements.

If dealing with a silent film, you might find entire reels of positive intertitles that were inserted only at the time of editing the positives.

Some special effects involved quite elaborate intermediates but these can really only be identified by specialists in special effect production.

9.5.9 Colour separations on black and white stock

Colour separations were made for a number of different reasons:

1. Colour separation is a safe system for the preservation of colour negatives in a more permanent state than as dye images and these are recognizable by being three separate rolls of identical black and white positive images with differing tonal renderings. The positive images appear low contrast and high definition and with negative perforations.

   Generally these films have all the characteristics mentioned above, of duplication.
2. Negative separations in two or three separate rolls that have the characteristics of original negatives are usually camera originals. It is not always possible to identify for certain what colour system they were used for, since both bipack and

tripack camera systems were used to produce separations that were printed by a number of different methods.

3. Negative separations with the characteristics of duplicates (see above) can be from a wide range of origins. The commonest are separations made from a colour reversal original. For example, even as early as the late 1930s reversal Kodachrome was used as the original camera stock for a Technicolor print process.
4. In a few rare cases the separations were made on a single strip of film with the red, green and blue separation images in sequence, called **sequential frame separations**. Original negatives in this form will probably be animation film shot as single frames. Duplicates will be prints from these originals or may be from a wide range of less common systems.

All separations should be examined by a specialist in colour systems.

9.5.10 Reversal materials

Reversal materials are those film stocks processed to a positive image in one processing stage. Some films processed by reversal have negative images: for example, an image from a negative printed onto a reversal film will be a negative. Colour Reversal Intermediate is a stock designed for copying negatives in a single stage, but generally reversal films are either camera original materials or are for copying existing positives.

Recognizing reversal film is straightforward: in a reversal film the parts **not** exposed by the light are dark (in other films they are clear). The unexposed parts of the film, for example the borders, the space between the perforations and the frameline itself, are dark, whereas in all other films they are transparent.

Reversal film was originally used for filming anything that did not require a negative in order to make a number of prints. Today black and white reversal is extremely uncommon and restricted to certain scientific use, but from the 1940s to about 1980 black and white reversal was widely used by colleges and small industrial film units. Colour reversal films are mostly non-professional or for specialized use, such as high speed photography or satellite recording, or are special high speed, fast process stocks for television news and current affairs. Over the past few years this use has diminished rapidly in favour of electronic news-gathering techniques or colour negative.

9.5.11 Colour reversal print systems

Several manufacturers made low contrast reversal camera original films which were designed to be printed. The camera original film was never projected but was treated as a printing master (just like a negative). The lower contrast of the camera stock resulted in a better exposure latitude than projection contrast films. All these were colour systems and a good example in use for over 30 years was the Ektachrome Commercial system from Kodak. Gevaert had a similar system.

9.5.12 'Direct' positives (and negatives)

For printing purposes, but especially for producing positive copies from work copies during editing, when cost is important and quality not important, several other film materials exist (or existed) to produce a 'direct' positive without using the complex reversal process. Sometimes a low quality duplicate negative was (and still is) made by this process. Most of these elements will appear to be reversal images with black areas outside the image. Some of these materials had quite bizarre chemistry and were not silver salt based technology at all. A notable system with a short but erratic life was MetroKalvar, in which the image consisted of bubbles of gas in the film matrix! The more conventional 'diapositive', or 'direct' materials on the market today are all silver based and use a simple negative type film process to yield a low quality and often low density image. These direct film stocks were probably first introduced in the 1960s.

The process, in graphic English laboratory jargon, results in a '**slash**' print, or '**slash**' dupe. 'Slash' is also used by some laboratories to mean any cheap and cheerful print of dubious quality. For readers less familiar with English slang, 'slash' has a host of meanings, all derogatory and some vulgar!

9.6 SOUND ELEMENTS

9.6.1 Identifying different types of print soundtrack

Sound is present on positive projection prints as an optical track, as a magnetic track, or even as a combination. In order to reach this 'combined' state sound has almost always been recorded as a separate element, edited and transformed into the required format and only combined at the last printing stages. Sound elements most likely to be discovered include magnetic originals, magnetic edited versions, optical sound negatives or optical sound positives.

In some cases, in order to produce a 35 mm soundtrack at lower cost, a 17.5 mm wide film was used, which is a 35 mm slit in two lengthways; so it has only one line of perforations, exactly identical to those of the 35 mm negatives.

Details of sound tracks are to be found in the chapter on sound restoration and in Part 1.

Magnetic sound track made its appearance in distribution copies with the advent of CinemaScope in 1955, introduced by Fox with the film *The Robe*. CinemaScope not only used an anamorphic lens to project the picture onto a wide screen, but provided stereophonic sound as well. This was made possible by the placing of four magnetic tracks across the film. Since they were completely separate, each one provided sound to different speakers that were strategically placed in the cinema hall. (The disadvantages of magnetic sound were mainly connected with the fact that the four tracks were applied or 'glued' onto the film after its printing and developing and then had to be recorded, which significantly lengthened, complicated and increased the cost of the film laboratory work.) Tracks tended to become unglued, demagnetized and, with use and the passing of time, lose the metallic layer of the track. Finally, not all cinema halls were ever re-equipped to handle magnetic sound, so copies were distributed that had both a single combined optical sound track as well as the four magnetic tracks. Slowly, the four magnetic tracks disappeared.

Stereophonic sound has returned to the cinema with the modern Dolby system, which used an optical sound track. A Dolby stereo copy can be identified only by looking very carefully at the sound track. It can be seen that the four tracks are not absolutely identical, as they would be in a mono sound track.

Magnetic sound on film returned to be very successful from 1966 until the late 1980s when magnetic sound tracks were applied to 16 mm reversal colour film used for news and current affairs. This was applied after slitting the raw film. Kodak's Ektachrome EF and VNF films were the most widely used.

Some 16 mm prints made with double bilateral tracks have, in the past, been 'post striped' with a narrow magnetic track covering one of the track images. This can then carry a different sound track from the optical. This system was used for two languages by several training film companies and by inflight movie companies during the 1970s. These prints are sometimes called MAGOPT prints.

9.6.2 Identifying sound-only elements

Separate sound elements are easily distinguished from picture elements – they are either magnetic tracks or have optical track images and no images. Some 35 mm, 16 mm and 17.5 mm was perforated and coated entirely with magnetic coating. Most 35 mm and 17.5 mm film was perforated and striped in the regions of use rather than all over and appears as clear film with linear stripes of coating.

A sound negative film element has a negative sound track in the sound position. The central area of the track will be low density, and the outer areas high density. The base is usually coloured or grey. If there are many blooped joins this could be an early original negative (pre-1953 approx.). If it has many scene changes and no joins this is a final track, probably made from a magnetic master if after 1953.

A positive film track on clear film with no picture and a high density image is probably a pre-1953 editor's work track (or a mistake by a laboratory that forgot to expose the picture!). Labels on cans are often very important in estimating what sort of sound a can contains and a lot of local laboratory terms have been used. Some useful ones to know (in English) are:

- **M+E** Music and effects – usually a track of all the mixed sound excluding the dialogue.
- **Mute** Not what one might expect. This refers to a picture negative for which there *is* a sound track roll.
- **Track** The sound track roll that goes with a mute.
- **Silent** This means there is not a track to go with this picture.
- **Sync** followed by an instruction: **Level** or **24 frame** etc. This indicates how a sync mark on the picture negative leader relates to a similar mark on a track roll leader, to assist an operator to get the two elements in sync. The presence of these instructions on a negative can, or the presence of the sync marks themselves, usually a big crayon X or S, or a hole punched in the negative leader, indicates that somewhere there is a sound element.

10

Principles of film restoration and film reconstruction

10.1 INTRODUCTION

In the past 20 years, many restored and reconstructed versions of great films have been presented and have attracted the attention of large audiences. Among the first were *Napoleon* (dir. Abel Gance; 1927), reconstructed after a life-long research by Kevin Brownlow; *Intolerance* (dir. D.W. Griffith; 1916), with the original tinting restored by Raymond Rohauer; and *Metropolis* (dir. Fritz Lang; 1926), reconstructed by Enno Patalas. It was after these three reconstructions that a larger interest in the problems and principles of film reconstruction arose. In particular Patalas' archivist reconstruction of *Metropolis*, which took a stand against Giorgio Moroder's commercial re-issue of the film with a contemporary, typical 1980s soundtrack, had pointed out the need for some principles of film reconstruction.

In general terms it is possible to distinguish different 'kinds' of film restorers. There is the archivist restorer, working as a kind of archaeologist on the materials, trying to reconstruct the history of a print and the production process of a film. Or there is the artist–restorer, using the old materials as a source for a new product, sometimes with respect for the old materials without damaging these physically or intentionally, but sometimes also intending to make something completely new and personal without any respect for the original materials. Or there is the commercial entrepreneur restorer who just wants to make money with an old film, without taking into consideration elementary principles of preservation or moral conduct with regard to restoration and reconstruction.

Within FIAF, archivists have discussed these problems and principles during the 1980s and 1990s, and although no fixed set of rules or a code of ethics of film restoration has yet been established, a general awareness among film restorers with regard to ethical principles, applicable to both film restoration and film reconstruction, is very strong now. In addition, FIAF recently formulated its own code of ethics with regard to the rights and duties of film archives in more general terms. From this code it becomes clear that FIAF archives see themselves more and more as equivalents of other museums and archives which do have applied codes of restoration ethics from, for example, ICOM (International Council of Museums), AIC (American Institute for Conservation of Historic and Artistic Works) or ECCO (European Confederation of Conservator–Restorers' Organisations). This chapter has been written from the point of view of film archives that do not want to distort the nature of the original material or the intentions of its creators.

At the beginning of this book the distinction between restoration and reconstruction was made. While 'restoration' refers to visual quality of the image, 'reconstruction' refers to a philological activity of putting the programme or narrative – below referred to as the 'text' of a film – back to something like an 'original'. Since restoration can alter the quality of an image considerably, it is important to keep in mind that both activities, restoration and reconstruction, are subject to an ethics of restoration.

The main emphasis of this book is on the technical aspects of film restoration, but this chapter will demonstrate that film restoration

cannot be done merely from a technical point of view. It is also an activity of interpretation and opinions, of taste and editorial decisions; it can also be influenced by prosaic circumstances like practical or financial restrictions. Along the route of a film restoration decisions are made all the time, decisions that can influence the final result and the quality of the restoration process considerably.

Due to the technical complexity of the restoration process, film restoration and film reconstruction can never be done by just one person. However, in the end, only one person should be responsible for the final result. For this person technical facilities and possibilities are the instruments which help him or her to reach their goal. Therefore, for the decision making process, a good knowledge of film production and laboratory processes, as discussed in this book, is fundamental.

The responsible person is generally called the *film restorer*. This chapter will give an overview of the work and responsibilities of the film restorer. It is also an attempt to provide the restorer with a set of principles for restoration and reconstruction.

10.2 THE FILM RESTORER

Every film has its own unique set of problems and it is therefore impossible to give a definite set of solutions for every situation. A restorer of a film must be able to identify these problems, must be able to interpret them, and to make the necessary decisions following a set of principles, sometimes of a technical nature, sometimes of a non-technical nature. It is therefore necessary that a film restorer knows the technical principles of the restoration process very well, can make decisions for the correct conservation routes, for the right choice of film materials, and can foresee the quality of the final results. The restorer should be able to discuss these technical aspects with the laboratory and therefore should be familiar with most of the techniques discussed in this book. The laboratory technicians will have a greater ability and experience than the restorer in their specific sectors of operation. However, the restorer should be able to recognize the potential of the original material available and the photochemical process. The restorer should be able to choose the right duplicating route and be able to judge the quality of the duplication work. Therefore the film restorer must be familiar with most elementary duplicating routes. In particular, in film reconstruction, it is often necessary to use a combination of duplicating routes. This can be due to technical reasons, for instance when a film exists in an archive as an incomplete negative, and also partially as a print.

But film restoration is not just a technical issue. Non-technical considerations are a substantial part of the labour of film restoration and film reconstruction. Sometimes practical or financial problems may affect the decision making process. In these cases the film restorer has the cultural responsibility to work to the highest standards and not to compromise. More complicated, however, are the historical and more philosophical considerations, for which the restorer or archivist cannot consult a laboratory technician. On the contrary, on these issues the film restorer should have a clear view and share this view with all other people involved in the restoration process.

A film restorer who wishes to respect certain principles will also have particular technical demands. In the past, ordinary commercial laboratory practices could not fulfil these demands and therefore many film archives have, in the past, started their own laboratory in order to be able to handle shrunken films, to adjust non-standard chemical processes, or to apply other unconventional procedures. Today some of these in-house archive laboratories still exist, but several commercial laboratories also now specialize in film restoration.

10.3 THE 'ORIGINAL' AND OTHER VERSIONS

Films exist in different versions and editions. This is true for the silent period in particular, but even today dubbed versions, abridged versions for television and other versions are still made. Among film restorers an overriding principle became accepted, which was to establish which version of any given film should be restored. Every alteration to a film, whether textual or technical, must be considered in relation to the definition of the version

that the restorer is going to restore. In order to define a given edition of a film we must be able to reconstruct the text, based on all the available historical information. All the data has to be compared and its reliability verified. Every intervention carried out has to enable further interventions, and every action must be reversible and documented. The demand of reversibility means in film restoration that nothing of the original material should be altered in such a way that the restoration cannot be done again. 'Reversibility' in film restoration means therefore 'repeatability'.

There could be many editions of a film, and there could be many reasons for this. The first are production characteristics. For instance, as we shall see below, in the silent period films were made with different cameras at the same time. But also in later years different version of films are not uncommon. Another reason could be that the film maker has made alterations. Some film makers tried to improve the film all the time and therefore a film was never completely finished. Thirdly, censorship was an important factor in altering films. Sometimes films were intended for a particular market. Pre-Revolutionary Russian films that had a tragic ending for the Russian audiences got a happy ending for the foreign market. Or a film was lavishly coloured for the internal market and very simply coloured for the foreign market.

In the silent era there were often more negatives because duplicating film materials did not exist and because second negatives were needed to send to another country for foreign distribution. If there was only a single negative, only a limited number of copies could be produced and then it had to be thrown away when it became damaged. The easiest way to produce more negatives was by having more cameras running at the same time, or to re-shoot entire films. A good example is *Rescued by the Rover*, first made by Cecil Hepworth in 1905, when films were not distributed but sold directly by the producer to the cinema halls. *Rescued by the Rover* was a great success and the producer printed so many copies that the negative could not be used any more. Hepworth was forced to shoot a second version and again, a few months later, a third. *Rescued by the Rover* narrates the exploits of a dog (Rover) that saves the life of a little girl. Due to the fact that the three versions were made a few months apart, it is possible to note that the young actress has grown quite perceptibly through the three versions of the film. If one wants to restore *Rescued by the Rover*, it is necessary to decide first of all which of the three versions is to be worked on. Mixing shots from the various editions would create a film that, in fact, never existed.

Establishing the aims of a restoration/reconstruction means not only that criteria for version or edition should be determined, but also the characteristic qualities of the image: format, contrast, density and colour. It is not sufficient to say that a restorer will, or must, restore the 'original' version, since there could be many concepts of the 'original'. Also a censored version of a film could be considered as an 'original' version, since it is that version that was seen by the audiences. In general terms, the options available to the restorer are to restore:

1. The film as it is in the restorer's hands.
2. The film as it was seen by its first audiences.
3. The film as was seen by later audiences.
4. The film as it was intended by the film maker(s).
5. A version that is meant to be seen by a modern audience.
6. A new version, a reworking of the original version through a contemporary artist.
7. A version for commercial exploitation.

In deciding which version to restore, it is important that the restorer's considerations are registered in the documentation of the restoration. This documentation should not only contain all factual actions and interventions on the material, but also the motivation and argumentation for decisions made during the restoration.

10.4 RECONSTRUCTION

Everybody who works on the restoration of a film is aware of the concrete, tangible and material quality of a film print. With this physical reality the film restorer works every day, using both hands and eyes. He knows how

important it is to 'read' a film print not only on a narrative or content level, but also on a concrete, material level. Splices, different kinds of filmstock, frame lines, even scratches can give essential information for the restoration process. It is not exceptional for instance that on a narrative level it seems that frames are missing, while in the print no splices can be found. When the print is a first generation print, then it is very likely that the film has always been shown this way.

The tangible aspect of a film is always kept hidden from the spectator, who knows only the other side of the life of a film – when it becomes cinema by being projected on the screen. Reconstructing a film means working on both the material reality of the film, as well as on the visual and content appearance on the screen. This means that when we speak about the reconstruction of a text, we do not merely speak of a jigsaw puzzle of pieces and fragments in order to make something as complete as possible, we want also to construct something that can be perceived in the minds of the spectators as something with a certain integrity. The work of reconstructing a film can only be done by working both on the film itself and on a concept of the final presentation at the same time. In the end a film only becomes alive when it is projected.

Reconstructing a film means to establish in the first place which elements and data are available. Usually a film restorer has to work with three parallel sources of data.

First, there is the film itself; sometimes there is only one print, but in many cases there is a lot of material. From film prints emerge two sources of data.

(a) on a content/narrative level
(b) on a technical level.

Secondly, there is all non-film information which can be compared with the information from the film itself:

(a) non-film materials related to the content or narrative of the film: reviews, brochures, leaflets, photographs and other documentation;
(b) non-film materials related to the production techniques of the film.

Thirdly, a film restorer will always work with a concept of the film as it appeared on the screen in the past and as the restored version will appear on the screen, since only in the projection will the restoration come to completion.

10.4.1 The film text

The preceding chapters looked at the identification of historical and technical data of a film. These data are fundamental for the work of film restoration and film reconstruction and are the necessary input for the decisions during the process of film restoration. Working on the film itself means, in the first place, to identify correctly the technical and historical data of a film. For the purpose of restoration and reconstruction a correct interpretation of these data is essential. A restorer should be very careful not to be too positive about his or her interpretation of the data without first looking at the documentation and also at the image itself. Too often the film tells one story but the documentation suggests another. Like today in television news or documentaries, also in the past, films contained materials from different periods. A camera image of 1905 can be duplicated in 1915, selectively enlarged and inserted into a drama of 1920, just because it was a picture of the bridge the director wanted. This happened for many years throughout almost all newsreels. For instance in a British Pathé newsreel of 1937, a duplicate negative of a 1918 sequence was spliced in because it showed a scene of Berlin.

Technical and historical data help not only to select the best materials but also to reconstruct a film. As mentioned above, splices, or the absence of splices, can tell something about mssing or inserted sequences. Edge marks, frame lines or colour systems may tell something about the sources of the materials. In all cases it desirable to have more prints available for comparison and also to search for negatives and first generation materials in order to obtain the best restoration quality possible.

In the text below the main emphasis is on silent films, since these films differ most from our contemporary film production techniques. The general problems are also applicable to sound films.

10.4.2 Reconstruction of silent films from positive prints

Positive projection prints are the finished version as shown in the cinema. Many of these films have defects because of intensive use. Moreover, in particular in the early days, a film was never considered as something of which the integrity should be respected. In the silent period it was very common that someone removed, replaced or inserted something. In many cases, however, no other material is available. If negatives are lost, a film restorer is very fortunate to find one or more prints which are from the period. The big advantage of these prints from the silent period is, however, that they are often coloured and that they still have their intertitles. And when the negatives do exist, positive material may still be of great value since these positive elements may serve as valuable references for the reconstruction of the film, in particular of colours and intertitles.

If several prints are used to make a final restoration it is important to determine the differences in image quality, colour quality, format, generation etc. Through interventions during the duplicating process it is possible to avoid the final restoration looking like a patchwork. It is therefore important to decide if a balance of image quality in the final restoration is desired, or not.

Intertitles

Original intertitles in positive prints and in their original language are usually in place. For use in foreign countries intertitles were most of the time replaced with titles in the language of the country of release. Sometimes these titles were made by the production company in the original country of production, often with mistakes in the spelling. When the titles were made locally, the films were exported with flash titles, titles of just a few frames, and the distributor could insert the titles on the places where a flash title appeared. Not all flash titles are originally from the period the film was produced. In some collections the intertitles of films were cut down to just a few frames in the 1940s and 1950s, probably to avoid the duplication of considerable lengths of titles and to save money.

If there are still flash titles in the print which should be restored, they will not be more than a few frames (normally three), of which two will be ruined by the join with the preceding and following sequences and therefore useless. Only one frame will remain, sometimes damaged as well. Therefore, in general, it will be necessary to remake the titles from scratch, trying to match as exactly as possible those of the original.

Reconstructing intertitles

Typeface and framework graphics are both very important. The intertitle is part and parcel of the image of the film and its graphics have the same value in the organization of the work and in every sequence. To prepare new intertitles using different graphics for the typeface and the framework from the original would be quite unacceptable.

Often the production houses had their own easily identified graphics style that was used in one film after another. On other occasions, for special works, artists were hired to draw suitable graphics for titles. This was so for many of the German Expressionist films and, generally, for many films from the 1920s onwards.

When titles are made today they are usually type set with desktop publisher software. The printouts are then filmed with a rostrum camera. This is a very practical and ecomic way to do it, but the final look has a quite different effect than original titles. While the original titles seem to be an organic part of the film, also in their small damages, their instability and image quality, new DTP titles appear as some kind of high-tech slides. The effect of a frozen slide is quite difficult to avoid, but it is only in recent years that interest in the authentic quality of intertitles has grown and interesting developments are to be expected.

The text is obviously of great importance in the comprehension of a film. However, if the only copy of the film available is a positive with intertitles in a foreign language and we want a restoration with titles in the original language, then we have to face the problem of re-translating the text back into its original language. If the production notebooks or the censor's authorization still exist the problem is solved. In the absence of these documents the transla-

tion must be done with great care. Sometimes literary texts exist on which the film might have been based and which can be useful in reconstructing the text of the intertitles.

If the translation of the foreign language version was done by the production company itself, then its name and trademark appeared on the intertitle itself. Cines, in Italy, even put on every intertitle, beside the production number, the initial letter of the version: F for French, S for Spanish, and so on. The small imperfections in the translations make it in this case even easier to retranslate the text back into the original language, recovering the original wording with greater precision.

Censor's marks

Sometimes the censor's interventions are indicated on the positive copy. For example, in the Danish copy of *Maciste all'Inferno* the censor cut out all the more audacious scenes that take place in hell. The cuts are clearly marked by the impressed stamp of the Statens Filmcensor, who restricted viewing of the film to those over 16. These indications can be very helpful in the reconstruction of the 'complete' text.

10.4.3 Reconstruction of silent films from original negatives

Silent film reconstruction poses particular problems not relevant to later sound period productions, with maybe a few exceptions. The problem comes with negatives as it was common to manufacture the various scenes or sections separately and assemble them by splicing pieces of print together. This technique was not universal but the different methods of producing intertitles, the scenes and the different colours made joins in the print inevitable.

Positive cutting after the negatives had been used to make separate rolls of print, and two other aspects of silent film production – the existence of intertitles and the tinting, toning and stencilling methods used to colour prints after processing – all determined the way in which negatives were stored.

Intertitles and negative rolls

The methods used by the different production houses varied. Many negative rolls had no intertitles, but only small crosses scratched onto the emulsion or written in Indian ink at the location the intertitle was intended. If this is the case, then only by finding the censorship documents or the production notebooks will it be possible to re-establish the text of the intertitles.

In other cases the intertitles were substituted by a short piece of film on which the beginning of the intertitle has been written by hand, sometimes in pencil. In this case, using the text of the intertitles you can at least verify if they correspond with the negative, or if there are conspicuous differences.

Un-assembled negatives

The other problem with the silent original negatives is that, frequently, they are found unassembled, perhaps in the form they were used to print the different scenes in the laboratory. There are two typical cases:

- Completely dis-assembled: in this case the film has been reduced to separate scenes after having been originally assembled in sequence.
- Scene by scene: in this case the film negative always existed as separate reels or scenes. Normally they will be found as a series of small reels equal to the number of shots in the film. Many early production companies used this approach.

Assembled according to the different colours

These negatives were not in scene order, but in colour effect order. In this way the laboratory was able to print all the scenes of the same colour at the same time, tint or tone them together and assemble them only at the end. The colour that was to be used was usually indicated at the beginning of each reel, in Pathé by a number.

Again using Pathé as an example, the negatives prepared in this way normally have a small number in the upper or lower corner of the first two frames of each shot so as to indicate the order of succession for editing. By separating the various sequences and following these small numbers it is possible to reconstruct the editing of the film.

10.4.4 Non-film material data

The non-film material includes scripts, shotlists and also the articles published when the film was presented in the past, the promotional material (photographs, posters, leaflets, brochures, catalogues) and the official papers that every state produces as part of routine control of the production (permission from the censor, reports, lists, accounts). Sometimes a score can be very helpful or even personal memories. It depends also on the goals of the restoration if the non-film materials of the very first presentation are of importance for the restoration, or documents of a later date within another context. For instance, the Sovjet film *Kain I Artem* was shown in Holland in a censored version – no propaganda and no suicide scenes. Thanks to a Dutch critic who was aware of these cuts we know that the incomplete print still existing in Holland is the 'original' version of the film as it was shown in Holland.

All these non-film data sources often survive even when the film has long since dissapeared. For instance, thanks to these documents it was possible to determine that of the silent period of Italian cinema, only 20 per cent has been preserved. The titles of all the 9,816 feature films that were produced in Italy between 1905 and 1930 are known. For each one at least something has been preserved: a newspaper article, a photograph, the script, the censor's permission, a poster, or we know the actors, or the success it achieved.

Documents can differ widely in their trustworthiness. While the censor's authorization has to be, by its very nature, a precise and reliable account of the film, a newspaper article can contain serious errors. And it is not always possible to collect enough elements to permit a reconstruction based on the documentation. In addition, it is too often the case that the historical documentation is itself scanty and fragmentary, so that it is not possible to establish beyond doubt what the original text should have been.

In these cases, when there is any doubt, interventions to a copy must be made in such a way as to be reversible, so that further restorations can be made later if new information becomes available. It is therefore essential to document every step of the operation very precisely so that later it will be possible to redefine some of the passages.

10.4.5 Appearance on the screen

To the immaterial effects belongs all the information in the projected picture that might be useful in the reconstruction. This has to be systematically collated, from the numerical order of the intertitles, to the language used, or the director's obvious style. To make use solely of the information seen on the screen is extremely dangerous. It takes no account of the history of the film, and even directors that have a well-defined style are often forced by circumstances to adapt their style to various requirements. This approach for reconstructing a film is only suitable as an adjunct to other information, or if it is supported by other documentation, such as mentioned below.

10.5 QUESTIONS OF RESTORATION QUALITY

As was said earlier, film restoration is essentially duplication and it is impossible to make a perfect copy of the original. Film restoration always creates a lacuna, a difference between the original and the duplicate. And then there are at least two ways to judge this lacuna, either by judging the gap between the actual source print and the new copy, or by judging the gap between the result aimed for and the result obtained. The aim of a restoration will be defined by the film restorer but can be determined by the restoration policy of the commissioner, for instance an archive.

It is important to distinguish the particular visual and aesthetic qualities of a film print. As we have seen in section 10.3, version or edition also refers to the characteristic qualities of the image: format, contrast, density and colour. It is important to recognize that a tinted silent nitrate film has certain characteristics, that it is fundamentally a black and white print with a tint that applies to the transparent parts of the image and not to the blacks. It also important to recognize the saturation of colours in a Technicolor print – as it is important to recognize the particular characteristics of a Perspecta stereophonic sound print.

In terms of restoration it is important not just to preserve the information of image and sound, but also these characteristic – aesthetic

– qualities of image and sound. And sometimes it is desired to improve the visual quality of an image, for example by increasing the contrast. If it is impossible to make something exactly the same, it may be possible to recreate something of the same effect as in the original, also when certain techniques or materials are not available anymore. It is evident that contemporary colour film stock has its intrinsic limitations which are not comparable with the characteristics of an original imbibition print, for instance. It is therefore important that a restorer is aware of the possibilities of alternative techniques: for example, that in the Desmet colour system instead of a colour internegative a low-contrast black and white dupe is made; or that films that are shrunken or fragile cannot be printed on a standard continuous contact printer.

For the film restorer these alternative techniques open the way to simulation or to recreation of original colours, or of original image quality, or of original sound. Sometimes this approach can be quite experimental and lead to new technologies that are not necessarily computer-based. In recent years the awareness has grown that this simulation approach, but also the use of digital restoration technology, can only be successful if we know exactly all the parameters that characterized the film prints of the period. However, the exact data are often not easily available and therefore there is now a growing interest in establishing a database with all kinds of technical data, for instance with all the recipes for tints and tones, or with all the film stocks produced from the beginning up to today and their characteristics. It will be to the advantage of film restoration itself, and to the benefit of historical research of film, that film restoration becomes the subject of a more scientific approach, and as soon as possible.

Lack of such a scientific approach constitutes the big difference between film restoration today and restoration practice in other arts. For instance, the Mauritshuis in The Hague recently restored two Vermeer paintings. These restorations were not only done in a dialogue with a committee of internationally renowned restorers and art historians, but also with institutes for atomic and molecular physics, with chemical research laboratories and with institutes for X-ray photography. In fact, X-ray diffraction analysis, ultraviolet light photographs, beta-radiography etc. are quite common in fine art restoration. Some museums, like the National Gallery of Art in Washington, even have their own Scientific Research Departments. In most film archives you won't even find a microscope!

The fact that art historians followed the restoration of the two Vermeer paintings indicates already that there is a long tradition of interest from art historians in the work of restoration. The quantity of literature on this topic is enormous. It is very eloquent that, for instance, the new problems which the restoration of contemporary art has raised have resulted in considerable academic debate. In film restoration this is very rare, although several archivists also have positions at universities. It is also suprising that the problems of film restoration or the history of film technology have barely been incorporated in academic film studies. This would be useful not just for archives alone, but also for film studies, as the study of original nitrate prints in recent years has already demonstrated that several aspects of film history will need revision.

10.6 THE DIGITAL FUTURE

The quality of the reproduction of the original image and sound will probably change radically with the new technologies: a reproduction may still not be perfect, but many aspects of it could come close to perfection. Problem areas are at the start and the end of the digital restoration process. The first demand to the industry is that digital scanners should be able to scan the shrunken and vulnerable nitrate prints, like a Telecine machine. When a traditional duplication is first needed for a digital scan many advantages of digital restoration are lost. The second problem is that the digital data will be recorded back onto ordinary film stock with its intrinsic limitations of, in particular, colour saturation.

If we concentrate on what is achieved at the workstation, it becomes evident that a separate theory of digital reconstruction is necessary. As we have seen above with non-digital alternative techniques, the approach for reconstructing the quality of the image itself is relatively recent. Too often the responsibility for a good reproduction has been left to the technician and in the future the technician – in the shape of a workstation operator – will become even more important. Up till now archivist–restorers were always able to control one way or the other the restoration process. They knew what they could demand and expect from the traditional laboratory, just because they knew the possibilities as well as the limitations of photographic duplication. But in the era of digital restoration it will become difficult to understand the possibilities and there will cease to be many limitations. Archivists will have great difficulty in 'directing' the operators, because the archivists will not always know what to aim for and what to demand from the operator.

Here it becomes evident that the concept of the 'orginal' in film restoration needs further elaboration. In the case of restoring the original image and sound, the 'original' is often still an abstract, theoretical concept. One can try to reproduce a Gaumont Chronochrome and the result may look wonderful, but how do we know what it really looked like and whether the restoration resembles the original? To know what to aim for, the concept of the original has to become very concrete, because with the new technologies for the first time a film can really be repaired in its smallest elements, image and sound.

If we consider 'original' in its strict sense, image and sound quality could become 'as new'. But then one should ask whether it is desirable to strive for a perfect rejuvenation of image and sound. Here we must make again the comparison with fine art objects. We have said that film is not an artefact that is restored, like a fine art object. But if film restoration is essentially duplication and the creation of a lacuna, with digital technologies the lacuna could be extremely small and therefore the repair of a damage, splice, scratch or deterioration, and even missing frames, is with digital technologies much more like restoring the artefact in fine art restoration. For a museum presentation this is desirable to some extent, but for researchers and future restorers this can create a great problem. It is absolutely imperative that a digital restoration can be analysed and done again from the start.

10.6.1 Ethics of digital duplication for access

Digital scanning of film images still takes an enormous amount of time and money. For access purposes, however, there is a practical and economical alternative: scanning on Telecine and storing the electronic video signal in a digital video format.

Telecine scanning will probably be a routine job. An archive or a laboratory will try to scan as many metres as possible, in order to keep the prices low or to maximize profit. It is therefore important to have some fundamental ethical rules for Telecine scanning.

Telecine scanning creates a digital duplicate format which has no direct reference anymore to the original and some data will always be lost (e.g. resolution). The alterations of image or sound made during the transfer can never be reversed or analysed in a rational way. It seems therefore imperative that a transfer will first be made as close as possible to the original and that subsequent 'restorations' are made on later generations of that digital duplicate.

This means that a 1:1 image duplication is recommended. If for instance VHS duplicates are necessary for access, then the speed can easily be adjusted. For professional use there is absolutely no problem. Modern editing devices as we know them today can make any speed adjustment required.

If a mechanical wet gate is not possible a noise reduction or 'electronic wet gate' is also something that probably should be avoided on the master tape. In general it seems that the loss of information is substantial, whilst the advantage is marginal. It is uncontrollable whether the noise reduction reduces only scratches or also other very small parts of the image and in extreme cases the image loses something of its sharpness and becomes 'woolly'. With grading, zoom and framing the image can be altered quite considerably. It is to be expected that an archive will say that no information should be lost in the duplicate and that grading must be done in order to come as close as possible to the archival print. This is more or less the same attitude as in traditional photographic duplication. One problem is, of course, how to compare the electronic image with the print and how to

keep a certain standard when you play the image on a arbitrary monitor.

A second, extremely important, problem is when certain restoration activity is also involved, like dealing with faded dyes. Here again the concept of the 'original' turns up as well as the concept of restoration. For routine restoration/preservation some very general guidelines are necessary. For restoration, in the sense of getting as close to the original as possible or to a museological presentation copy, a completely different approach is necessary. Here we encounter the same problem as mentioned above: even archivists often do not know what to aim for.

10.7 DOCUMENTATION

Documentation of the restoration and reconstruction activities has been neglected for a long time in the field of film restoration. In the restoration of fine arts this is quite common, but only in the past few years have film restorers started to look for standardized procedures to document all acts of restoration.

Since film reconstruction is essentially a process where at the beginning and end two different elements are there, it is important to document all the interventions made during the process. This is important for historical reasons. Through this documentation anyone can study the original copy and it permits anyone to understand all non-historical (aesthetic, ethical) decisions made during the process. But there are also practical reasons. If necessary, and if the source materials are still available, a reconstruction can be repeated easily. Also, if restoration is re-done after many years, it will be easier to understand if and why certain interventions were made.

Every film reconstructor has their own way of documenting what has been done. Notes, graphics, designs – all kinds of systems are possible, using standardized concepts or not. In attempts to bring more unification to the ways film restorers describe their labour, the European Gamma Group has proposed a system using a spreadsheet. This was tested on the famous German classic *Menschen am Sonntag* and proved to be immensely valuable. (More details of this restoration are given in Chapter 21 and an example of the spreadsheet appears in Figure 21.1.)

In this example you will not yet find all the laboratory data: all the exposure values for every shot could be inserted, but also data with regard to filmstock, contrast, washing etc. Moreover this model could be used to document all kinds of characteristics of the original print: for example, description of the colours of films from the silent period, or objective colour references of these colours.

10.8 WORDS OF WARNING

Some of the errors of previous restoration work have to be seen to be believed and the list that follows is by no means complete, but represents just the more obvious mistakes found in a famous 35 mm British newsreel collection.

- Full frame images printed by contact onto Academy format.
- Full frame silent images printed full frame but with a sound track lamp blacking out one edge.
- Images copied so many times with slight optical enlargement each time that the image is now 50 per cent bigger and thus has lost image all round.
- Full frame silent images at 16 fps intercut with Academy at 24 fps.
- Interpositives used as projection prints.
- Black and white reversal copies on high contrast camera stock from projection prints (known as 'soot and whitewash' prints).
- Stories recut so many times without recording the changes that the original sequence is no longer recoverable.
- Continuous jumping of the image due to shrunk negative being printed by contact on a conventional printer.
- Image on the print smaller than the projector frame due to an uncorrected shrunken negative printed by contact.
- Combined sound and picture duplicate negatives made with different length negative and track due to lost frames.
- The removal or insertion of sections of material that do not belong to the original text.

... and so on.

Especially in the 1950s and 1960s archives were very worried about how to approach silent cinema, afraid of offering old-fashioned material to the public. Often restorers acted on this concern and attempted to bring the material up-to-date by modifying the intertitles and eliminating some of the scenes. For this reason working on material that has been already duplicated can mean making the extra effort to try to eliminate what can be considered as later interventions that have nothing to do with the original. Some of these changes to programme material are, of course, themselves interesting as reflecting the attitude of the times to both film and to the rest of society, so the final reproductions that were created are worth keeping if they were as finished prints. A new restoration can be prepared based on the new approach, as a separate entity.

The concern of the restorer for the tastes and preferences of the day is quite clearly a mistake if the objective is to reconstruct the original text and visual appearance.

An allied problem that can be seen in many newsreels of the period from 1930 to about 1960, was that of old silent library footage intercut with modern material without stretch printing to convert from 16 fps silent rate to 24 fps sound rate for modern projectors. This jerky, speeded up action seen on the screen was genuinely believed, by a large proportion of the general public, at that time to be what the cinema had looked like prior to 1930!

Television companies showing old news footage in the 1960s changed the public's conception by showing this film at its original speed. This was partly made possible by operating telecine machines transferring film to transmitted signals at 16 fps, and partly by the television companies paying for expensive stretch printing which prints every other 16 fps frame twice to a produce a visually acceptable result when shown at 24 fps. Even as late as 1965 there were very few laboratories in London, for example, which could stretch print. Today no 16 fps film can be shown at 24 fps without the public noticing.

Part 3

IMAGE AND SOUND RESTORATION

11

Film damage, repair and preparation

11.1 INTRODUCTION

This chapter includes the identification and treatment of physical damage to films, and the preparation of films for printing and duplication. This work is mostly done in the laboratory, usually by the **assembler** or **negative handler**. This person establishes the physical condition of a film and does what is needed to prepare it for printing: repair, cleaning and other treatments, and provides instructions to other technicians about the proper handling of the film. Identification of physical damage also takes place in archives to monitor the quality of the holdings, and plays a role in the selection of materials for restoration.

11.2 PREVENTION OF FILM DAMAGE

Apart from the deterioration of film bases over time, all films are sensitive to influences from the environment and defects introduced by use. Projectors and viewing equipment may cause scratches, emulsion is affected by fungi, and moisture, dirt, dust and fingerprints are all possible dangers to the preservation of the image over time.

However, most of these problems can be prevented by proper handling, and when treated with care the same film can be printed many times. Although there are various treatments that can counteract present defects of films, one of the main responsibilities of an archive or laboratory is to create working conditions that prevent film damage.

11.2.1 Hygiene

A film handling area should be clean. Particles of dirt and dust may attach themselves to the surface of the films and show in projection. They also may contribute to the decay of the film over time.

The ideal film handling area is a fully air-conditioned room. In this so-called clean area the incoming air is filtered, temperature and humidity are controlled, and there is a positive pressure. This pressure is achieved by extracting from the room a lower air volume than is provided, which creates a higher pressure in the area than in the adjacent rooms. No dust can enter from outside against this constant draught. Clean areas are designed by specialized clean air engineers and are operated with special care – no open windows, special cleaning equipment – to be really effective.

As clean areas are expensive, many laboratories and archives will have to do without full air conditioning. This means that film handling areas need regular dusting, vacuum cleaning and washing. Worktables and equipment should be wiped regularly, preferably with lint free cloths. Eating, smoking and pets should not be allowed in working rooms, to avoid dust and damage to films.

11.2.2 Gloves

The basic rule in film handling is to hold the films only by the edges. As the skin leaves marks that may cause damage it is good practice to avoid touching the picture area. The wearing of gloves is helpful to prevent fingerprints and to spare your hands. Cotton gloves recommended for use on films, as rubber or plastic gloves are easily cut by the edge of the film and give perspiration problems.

For some jobs it is preferable to use bare hands. The repair of perforations is a precision job that requires the use of the fingertips.

When winding old or damaged films, one may encounter splices with protruding corners. In these circumstances cotton gloves are a greater risk, as the film may catch them. When working with bare hands it is essential to hold the film only by the edges.

11.2.3 Cinematographic equipment

Films are easily damaged in winding, viewing, printing and projection equipment. The incorrect use or installation of machinery can do serious damage to film. Especially for archival films, the equipment should be carefully chosen and sometimes adapted for the purpose. Equipment should be installed and maintained by skilled technicians, and operators properly trained. Others should not be allowed to work on it without supervision. The following are some common points of attention.

Winders

Wherever possible it is recommended to use horizontal or flat bed winders that are less likely to cause problems and produce a more even wind than vertical winders, although in the USA vertical winders have their advocates. If a pair of vertical winders is mounted so that the film does not pass straight from one to the other, the film edges can be scuffed or chafed. This can cause scratches, or worse. Powered winders are a greater risk. Old or damaged films are not necessarily wound only on hand winders, but always with attention and a low speed, that allows a quick stop if a splice parts or the film breaks.

Sprockets

When working with archival films the sprocket rollers on any piece of apparatus should be regularly monitored, to see if they can handle the shrinkage of the film. If a shrunken film is forced around a sprocket, the teeth can foul the perforation and cause distortion or tears. When new films are transported by worn sprockets – which can safely handle films with a certain amount of shrinkage – the teeth can catch and tear the perforations.

Footage counters and synchronizers

The film should always pass in a straight path from the feed side to the take-up side without sideways travelling or misalignment. When the film is pushed sideways the film may roll off the sprocket with the risk of teeth digging into the picture area.

Spools

Always use spools and winding plates which are flat, level and run true. If bent, they can easily touch the film surface and cause abrasion, or aggravate existing damage.

11.3 PHYSICAL DEFECTS AND THEIR TREATMENTS

For the examination of the physical condition of a film one needs a ×10 hand lens and a flat bed winder with a light box. This equipment is widely used by assemblers in film laboratories and permits a view of both emulsion and the back (often called the cell, a corruption of Celluloid, side) of the film. The reflected light of the light box gives a good view of scratches and surface defects. In archives a viewer is often used, as archivists are usually more interested in the picture.

To check the quality of prints in laboratories microscopes are also used, with ×10 to ×60 zoom lenses and fibre optic light sources. This equipment is not necessary for old archive films but can be helpful for the examination of high quality films, like new duplicates. For the judgement of physical defects one needs a trained eye and experience. This is not only simply a technical job, it is also an 'archaeology of the print' that may help the observer to reconstruct its history, by closely reading the marks that time and different users have left on it.

11.3.1 Shrinkage

Film shrinks by loss of water, solvent and plasticizer. Water is present in both the base and emulsion. The solvent, added to the film base during manufacturing, subsequently evaporates in time. Similarly the plasticizer, which is added to make the film base more flexible, is also lost. Shrinkage occurs to both nitrate base and acetate bases, but nitrate and diacetate shrink more, and more quickly, than triacetate bases. In general the shrinkage happens equally to both emulsion and film base. When this is not the case the shrinkage can cause serious damage to the image: the emulsion may suffer from creases or fragmentation, seen under a lens as a crazing or reticulated pattern.

Shrinkage is related to the combination of the stock characteristics and the storage conditions of the film over time. When stored in a hot and dry environment film loses moisture much quicker than in a cool and humid atmosphere. Films of the same age may have different degrees of shrinkage.

Usually all the reels of a film are more or less uniformly shrunken. In some cases the shrinkage is irregular, due to compilation of different materials or nitrate decay. Leaders and intertitles are well known to show a different shrinkage than the rest of a film.

This degree of shrinkage is an important fact in planning a film restoration. When a film is duplicated, the shrinkage will determine which printer can handle it. Printers are usually designed to transport unshrunken film, and must be modified to have shorter or adjustable distances between the sprockets teeth, or by shorter or variable frame pull down distances. The degree of shrinkage that can be handled by a particular printer depends on the printer design and its modifications.

Shrinkage meters

The degree of shrinkage can be measured in several ways. By comparing a film with a length of new film it is possible to judge the approximate shrinkage without equipment. A simple method is to compare 100 frames of the old film with 100 frames of a brand new film. The shortage in frames of the measured film roughly equals its percentage of shrinkage.

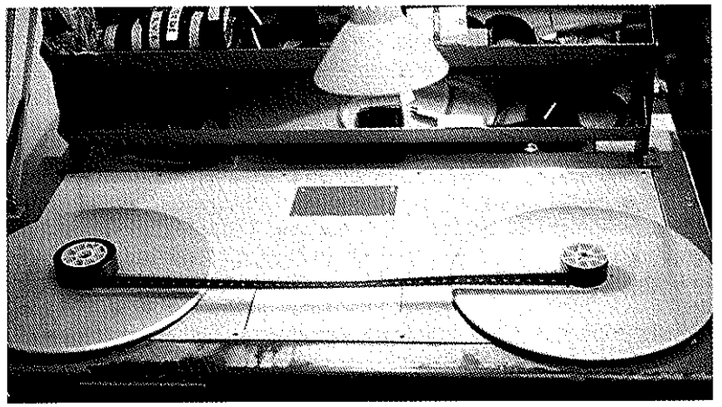
Simple shrinkage meters or pitch gauges are portable bars with two pins to locate the perforations of the film and marks which show its percentage of shrinkage. These are relatively inaccurate. Several accurate pitch gauges are on the market. One is the so-called Maurer type shrinkage meter. This instrument consists of a channel to put the film in, with a lid to keep it straight. One perforation of the film is placed on a fixed pin on the end. At the other end is a movable pin that is attached to a light spring and a dial gauge via a pantograph. This pin is fitted to the 100th perforation – or to any other standard position – numbered from the fixed pin. The dial gauge indicates the shrinkage of the film. A standard rule is used to calibrate the zero position. Modern electronic pitch guages measure shrinkage by guiding it over a sprocket. The percentage of shrinkage is measured over 1 foot and directly given on a display. When the degree of shrinkage changes during the film, it can be readed directly. This kind of equipment is calibrated with dimensionally stable polyester film strips. Shrinkage is measured in %. Most film equipment will handle film that is slightly shrunk, to about 0.4%. However some nitrate film may be shrunk by 2.5% yet be in otherwise excellent condition.

De-shrinking

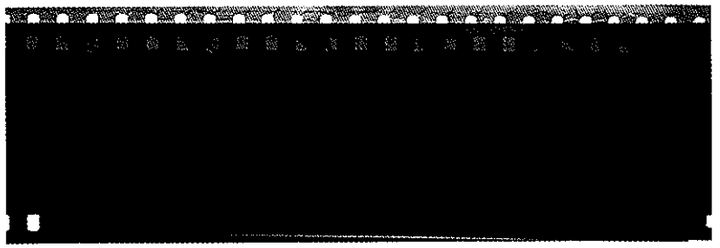
If a shrunken roll of film is placed in an enclosed atmosphere of acetone, glycerol and water it will slowly expand. When it is kept there for some days (or weeks, at low temperatures) it will re-extend and approach its original dimensions. De-shrinking can be very efficient in enabling shrunken film to be printed on an unmodified printer. As the effect is not permanent, the film has to be printed immediately. The de-shrinking process can be accelerated by using a reduced pressure chamber to increase the vapour concentration in the atmosphere surrounding the film, and temperature is critical. Out of the de-shrinking atmosphere the film will shrink back, sometimes quickly, to approximately its former condition.

Some laboratories have devised their own equipment for de-shrinking. A basic set-up consists of a closed tank in which the film is placed on a grid, above the solution of acetone, glycerol and water (1:1:3 by volume). The film should be brought in loosely wound, and with the emulsion out. There are also commercial systems available, for example, Redimension. In this system the film is placed over an open tray of solvents and plasticizers in a closed metal container, or in a reduced pressure container in a warm place.

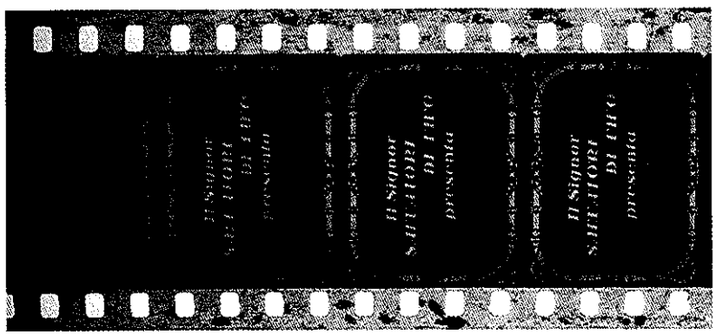
Since the introduction of printers that can handle severely shrunken films as a routine – like the Debrie TAI and the BHP Modular – there is less need for de-shrinking processes. For most laboratories it is not a routine job, also because it takes up much time and space.



(*a*)



(*b*)



(*c*)

(*d*)

Figure 11.1 (*a*) Flat bed rewind table with an illuminated panel. (*b*) Film shrinkage, one film is modern unshrunk film. (*c*) Very dirty film. (*d*) An original film join or splice

Details of these processes and of the range of shrinkages some typical printers can handle are given in Part 4.

11.3.2 Brittleness

Shrinkage and brittleness are clearly related problems. Due to a loss of moisture and plasticizer the film base or emulsion gets brittle, and can easily sustain damage in handling. Early tinted and toned films in particular are known to have a very brittle emulsion. The technical manuals of the period advised against the use of certain dyes, that seemed to be the cause of this problem.

Brittleness can temporarily be reduced by re-humidification, especially if emulsion shrinkage is the main reason. This can be done by placing the film roll in a closed, humid atmosphere, simply by placing a wet sheet of blotting paper into a can. The film should be kept out of direct contact with the water by lying it on a close wire mesh above the paper. The can lid is kept closed. The film should be rewound daily and the blotting paper re-wetted. After several days the film will have regained some suppleness. The procedure should not be pursued for too long, as the emulsion can become sticky, introducing other handling problems. This treatment is not suited for decaying nitrate film, which is already sticky. The film should be duplicated directly after re-humidification, as it will start loosing moisture again and may shrink back to its former condition within days.

A commercial rehumidification process is Rehumid, similar to the Redimension process for de-shrinking. This system uses a mixture of water and solvents instead of just water, and does allow the process to continue without excessive softening of the emulsion. As with de-shrinking processes treatments to reduce brittleness are not frequently used in laboratories nowadays. The use of solvents and other chemicals may reduce the life of a film. Most of these techniques have never been evaluated from this point of view.

11.3.3 Buckle

Buckle is a condition in which it is impossible for the film to lie flat. If the edges are shrunken more than the middle, the film will take up the shape of an arch, and if the middle is shrunken more than the edges, the result is known as edgewave. Storage of a film in very dry conditions can cause arching, as the outside of the reel will lose moisture more quickly than the inside. Edgewave is usually caused by projectors, which heat the picture area more than the margins of the film. It can also be caused by bad polishing treatments, carried out on the picture area to reduce scratches.

If a film is buckled it is difficult to duplicate it on a contact printer. It will not stay in perfect contact with the print stock, which may result in blurred parts of the image. In some cases these film can be duplicated best on a flat gate step printer, such as the Debrie Matipo, in others a rotary gate (Bell and Howell Model C or BHP Modular) is better. Experimentation is essential.

11.3.4 Scratches

It is widely accepted that an old film is characterized by its scratches. There is an academic school of thought that considers these scratches as a part of the cinematographic inheritance. As it is known that early films were shown to the audience this way, the defects are seen as the authentic 'patina' of earlier times. However, others see the scratches as meaningless and annoying defects, that should be eliminated. Modern duplicating techniques – like wet gate printing – can be very helpful to achieve this.

Early prints are often scratched as a result of working conditions in laboratories and cinemas. Until the late 1920s most prints were directly made from the camera negative, not from duplicate negatives. When the original negative was scratched, the scratch was printed into every subsequent print. The tolerance to scratches is different to today. Whereas they were considered normal, so that technicians and operators were less inclined to avoid them, nowadays laboratories are very clean, and wet gate printing has become almost a standard. This means that scratches can be avoided successfully and old films are usually treated to remove as many scratches as possible.

There is an entire vocabulary to describe different types of scratches. Intermittent diagonal scratches are known as rain, continuous

parallel scratches as tramlines, short fine cross scratches are called cinch marks, and so on.

Some scratches can be removed or filled, others cannot. The first thing to realize is that a scratch can only be treated when it is an actual surface defect. Printed in scratches, for example where the original scratched negative is missing, and only a print exists, cannot be removed by any photographic technique. Only digital restoration can be used to produce a scratch free image. These printed scratches will appear as white on the print, as they were black in the negative, or black on the print if they were on a previous print or master positive. Scratches on film always appear on the screen as black, and in colour prints may also be seen as coloured lines.

The degree to which a scratch can be treated and the method depends on the side of the film which suffers the defect: the film base (or cell) or the emulsion. Scratches on the base, also known as backing or cell scratches, are more easily treated than emulsion scratches. Fortunately, the most scratches are usually on the base. Although this side is harder than the emulsion, it is more vulnerable as it comes more into contact with hard surfaces, such as aperture plates and sprocket drive rollers.

Scratches on the emulsion are more difficult to remove. When they are shallow and only affect the top layer of gelatine they can be repaired, but deeper scratches can badly injure the emulsion and result in loss of photographic image. Films that have emulsion layers on both sides of the base – as used in early two-colour systems – are prone to these scratches.

11.3.5 Film base scratch treatments

The appearance of a scratch on the film base can be eliminated on prints and duplicates by wet gate printing. During the duplication the scratches may be filled with a liquid, of the same or similar refractive index as the film base, so that they become invisible. A detailed description of this method can be found in Chapter 13. This is by far the most effective method of scratch removal.

Two older methods exist for the actual treatment of scratched film, varnishing and polishing. These are less and less used nowadays, but treated prints can be found in almost every collection. Varnishing or lacquering consists of the filling of scratches in the base with a varnish. In polishing the original production method for film base is used: the film base is softened and pressed against a flat surface, so that the scratches are filled with base material. All scratch treatments of this sort, especially polishing, should be used only as a last resort. Once treated, the effect, good or bad, successful or unsuccessful, is permanent.

Varnishes and lacquers

The material used to fill in the scratches should have the same refractive index as the film base. Wood varnishes, copal or yacht varnishes were used because they were flexible and strong. The varnish was applied in many ways: by brushes, rollers, sponges and total immersion. Sometimes it was applied on both film base and emulsion. These processes were used on scratched prints and also on new release prints, before distribution. Any scratches that occurred then might be restricted to the lacquer. The damaged lacquer could be removed with a solvent, and relacquered again. Negatives were rarely varnished as the process reduces the print quality. Nowadays varnishing is not recommended as a method for scratch removal. Future removal of the lacquer can be difficult, and there is reasonable certainty that the treatment has a negative effect on the stability of the film.

Removal of lacquers

Sometimes it will be necessary to remove a lacquer, e.g. when it is discoloured or damaged. As it was applied to a scratched film it can be expected that the film beneath the layer is also damaged and needs further attention. Old lacquers need to be tested to find the right solution for removal. Usually a 1,1,1-trichloroethane or perchloethylene solution is tested first. This is done in a solvent cleaning bath. If it does not works, other solvents are tried, like methanol, carbon tetrachloride and cellulose thinners. As these solvents are very toxic this work can be carried out best by a specialized laboratory, and certainly with specialized air extraction.

3M Photoguard

Photoguard from 3M is a liquid polymer coating cross-linked by ultraviolet irradiation. It was used after 1975 on release prints and duplicate negatives, and is much tougher than old lacquers and varnish. Photoguard can be removed only by specialized techniques operated by the manufacturer's franchise. If it is considered necessary to remove these coatings the manufacturer or their local franchise has to be contacted. In some case removal may not be possible and the coating must then be considered as a permanent feature of this film.

Polishing

During the polishing the base is softened with a solvent and pressed onto a surface against which the film base hardens. The scratches will be filled in with the softened substrate, and is invisible once the new base surface has been formed. Both acetate and rotating glass wheels have been used as the new surface. This surface should be flat, smooth, polished and blemish free. As the process operates with a contact time of only 4–6 seconds, a large 35 cm diameter wheel can polish about 20 m per minute.

A first pass using a matting wheel can treat serious scratches. This wheel had a finely ground sanded surface that creates a matt film surface. Intertitles and high contrast images were sometimes left in this stage. Print and negative images were then given a second treatment with the polished glass wheel. This method filled in even gross scratches, although some overall definition was lost. If the job was done badly, or dust allowed to be incorporated the results could be worse than the untreated film.

Over the years there have been many manufacturers of polishers – Arri in Germany, Carter in the USA, and several patented systems, like the Davies and Doel-system in England. Since the late 1980s is it less and less done, as wet gate printing is more effective. However, when the equipment is still available an archive or laboratory should keep it, for the treatment of small sections or laboratory 'accidents'.

11.3.6 Re-washing

Re-washing can treat scratches on the emulsion side of a film. This is successful only when the damage is rather superficial. The emulsion of the film is immersed in water, allowing the gelatine to soften and swell. The edges of the scratch will anneal and as the film dries they will stay together. Deep scratches can only be slightly improved, and if any emulsion is lost the effect may be negligible. Nevertheless, the effect of re-washing on smaller scratches can be very good. Only the top layer of the film should be wet, so the wetting time is usually kept as short as possible, and special solutions can be used to swell the top emulsion layer.

Several manufacturers made special machines and solutions for re-washing, and in some laboratories equipment is used that re-washes and cleans the films in one single operation. Kodak has a re-washing process called RW1, and many laboratories use a process solution from the ECN2 process, the Prebath, for re-washing. A formula for a re-washing solution that softens emulsions rapidly and evenly is given in Part 4. After the re-wash solution there should be a water wash, as used in normal processing. Any of these processes is suited for black and white archive films.

11.3.7 Drying marks

Drying marks are the result of uneven drying of the emulsion during processing. Droplets of hard water that evaporated from the emulsion surface have left a raised 'shore line' often with fine particles stuck to the emulsion. When soft or distilled water is used during processing there are virtually none of such marks. Some archive films show very old drying marks, dating from their original process up to 80 years ago. Usually they look like a trail of droplets or a continuous tide mark down the length of the film. All drying marks, even when very old, can almost entirely be removed or at least reduced by re-washing the film. Just as with scratches, the removal of these marks can be a source of argument, as they may have been there from the very first showing of the print.

11.3.8 Dirt

Dust, stuck on dirt and fingerprints contain chemicals or fungus spores that may cause harm to a film over longer periods of time.

Pollution with oil or grease will make it slippery, and more attractive to dust particles. Especially early release prints suffer from oil, which leaked from unproperly maintained projectors. All dirt and oil that is not caked to the emulsion can be removed by film cleaning methods, as described in the last part of this chapter. When dirty films come into an archive they should be cleaned before long-term storage. Greasy projection prints should be cleaned as well, as the slippery surface may cause handling problems. In general clean working conditions help to reduce a build-up of dust and dirt, and fingerprints can be avoided by touching the film by the edges.

Process dirt is the name of small particles that stick to the emulsion. It is a physical defect that arises during the processing of the film. When the processing solutions are polluted with dust and fine gelatine particles these may pick up on the emulsion surface. Process dirt can be removed successfully by re-washing the film. The defect is usually found on older films, as modern processors eliminate the problem by using continuous filtration systems that keep the processing solutions clean.

11.3.9 Ferrotyping

Ferrotyping is synonymous to 'glazing', a method to give photographic papers a shiny surface by drying the emulsion on a hot steel surface. In cinematography 'ferrotyping' is a term to describe glossy marks on emulsions. These changes in the normal matt appearance of the emulsion are caused by a combination of tight winding and humid storage. The damp lets the emulsion swell and when it is pressed against the adjacent convolution it takes on its smoothness and glossiness. The effect is often local, in irregular, patchy shapes.

Ferrotyping is not serious in itself, as the photographic image is unchanged. Sometimes the ferrotyped areas have sharply edged boundaries which show on the image as dark wavy lines. As these lines might be visible on a next generation of film they should be removed before duplication. Some ferrotyping is easily removed by a water wash. To quicken and intensify the treatment a solution can be used that swells the gelatine. For this purpose a re-washing solution, used for emulsion scratch removal, can be helpful.

11.3.10 Damage to perforations

Nowadays film equipment is more and more designed to treat the film gently. Printers and telecine equipment often transport the film without sprockets, drives and other parts that may cause perforation damage. But this is a recent development: in the past the strain on the perforations was a constant in every film transport system. As perforations are vulnerable, damage to perforations is a problem every archive and laboratory will have to deal with. To avoid further damage, especially shrunken films should be watched closely during handling on synchronizers and viewers.

When stressed, the edges of the perforations burr. As the tension increases, they may bend, distort and ultimately tear. Burrs and minor damage may cause the film to be transported unsteadily and the image to jump. Small tears, also known as **split perforations** or **crows-feet**, usually have little effect on the image steadiness. These tears may be quite slight, just a millimetre along the length of the film from the corner of the leading edge. As they make film weaker they can result in more serious damage in the future, like completely torn perforations, a tear going from the perforation to the film edge. More drastic damage to the perforation may occurs when a film runs out of sprockets, or entire sections of perforations are pulled through.

11.3.11 Repair of perforations

The practice of film repair is one of intervention and it is generally held that it should be restricted to only what is necessary. As cinematographic equipment has different capabilities in handling damaged films what is necessary depends on the required use for the film. Torn perforations in a print that is to be projected or shown on viewing equipment need more repair than a film that is to run on a telecine. Repair should be done immediately before the actual use of the film. It is not recommended to repair films before long-term storage, as repair materials like adhesive tape may deteriorate and affect the film over longer

periods of time. Repair of damaged perforation is often done in one session with a complete check of the physical condition of a film, at the same time as the renovation of splices.

If a film is repaired for duplication the work will depend on the printer to be used. Some modern equipment is suited to handle seriously damaged films. Printers like the Debrie TAI need only good perforations on one side to transport a film steadily. Sigma and BHP Modular printers and Cintel and Philips Spirit telecines can even handle short lengths of film without any perforations. The necessary repair for this kind of equipment consists of the cutting off protruding edges of the torn perforations. Missing perforations may not need to be restored, saving hours of work.

Repair by adhesive tape

The easiest and quickest way to repair damaged perforations is by special perforated adhesive tape, e.g. Perfix. This is available in rolls for 35 and 16 mm film and covers the perforations and outside margins of the film. Usually the tape is designed to use with special equipment that applies it automatically along the film, but it can also be used manually. When repairing with adhesive tape it is essential to cut away distorted or torn edges to allow the tape to lie flat. Especially on shrunken film it is better applied by hand in pieces of more or less a frame length. As the equipment can usually handle the stiffness of the extra layer, it is advisable to stick the tape to both sides of the film to hold down projecting edges.

Another method is to use normal adhesive splicing tape. The tape is applied across a damaged section, overlaying the margin of the film on both sides. As the tape sticks to itself it creates the missing film area. A tape splicer is used to punch the perforations into the splicing tape. This splicer should be well maintained, and have sharp perforation cutters. Any tape covering the image, or sticking out from the sides can be cut away by hand. This method can be rather effective for the repair of lost perforations. A disadvantage is that the adhesive splicing tape can be distorted after printing, and should be removed to avoid the spreading of adhesive on the archival print.

Repair by cement

Sections of missing perforation can also be restored from another film. This method is particularly useful for badly shrunken films. A piece of scrap film is taken with the same degree of shrinkage as the damaged film. From this piece a run of perforations is cut that overlaps the missing area by two perforations. It is cemented base to base on the healthy perforations at both ends of the damaged section, one perforation overlapping at each end (for cement splices and formulas, see the section on splices). This method is very elegant, as the repaired section is comparable to the original material, and the results have good archival permanence. A disadvantage is the increased thickness of the cemented edges, that may cause problems in some printers. Old style flatbed printers can often cope with this; for other printers sometimes extra adhesive tape is applied over these areas. Some printers cannot handle the increased thickness at all.

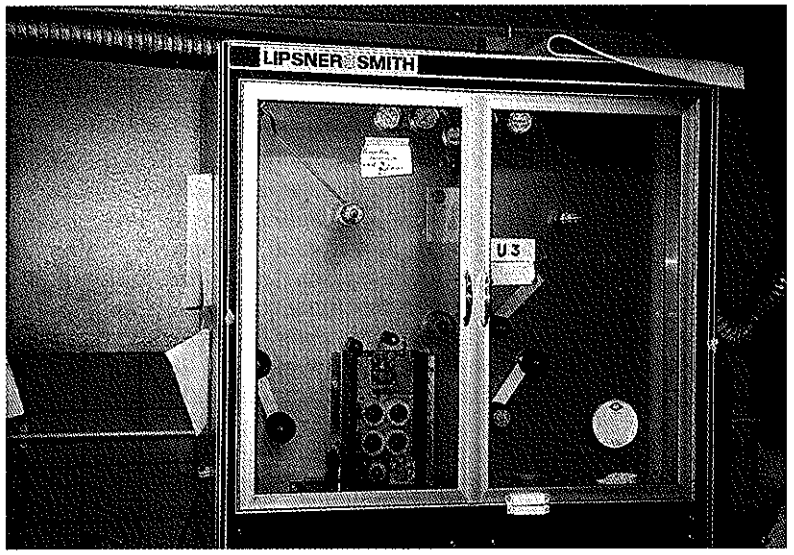
11.3.12 Tears

Repair

All tears are repairable, provided that no pieces of film are missing. However, a repaired tear will be visible in the image and reduce the quality of the print.

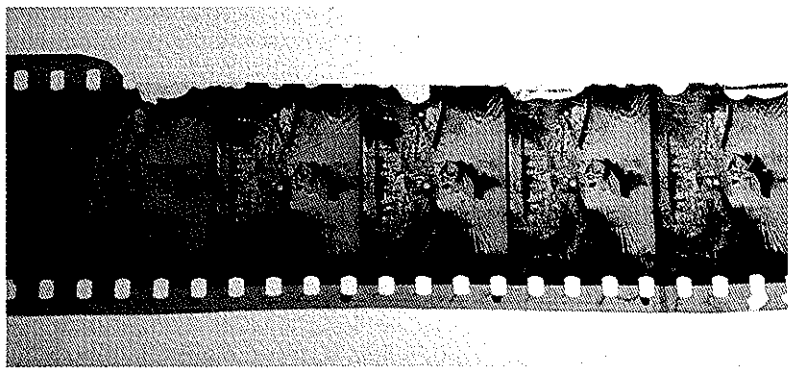
The first stage is to bring together the torn edges. The edges of tears are almost always jagged, so the work of fitting them together is delicate. It must be done carefully, trying not to leave any space between the edges that would show as white lines in projection, black lines after printing. Fundamental to the repair is to maintain the original film dimensions and perforation positions. A helpful method to achieve this is to use masking tape or double-sided tape to fix the film to a light table and assemble the pieces on the tape. It is recommended to remove dirt and grease from the pieces, by using a cleaning solution on a lint free cloth.

When the pieces are positioned they can be stuck together with adhesive tape. This is applied to both sides of the film, preferably in a tape joiner. Avoid air bubbles under the tape as they would be visible in the image. When perforated tape is used there should be a good match with the perforations of the film. If this

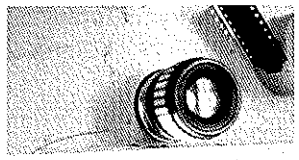


(*a*)

(*b*)

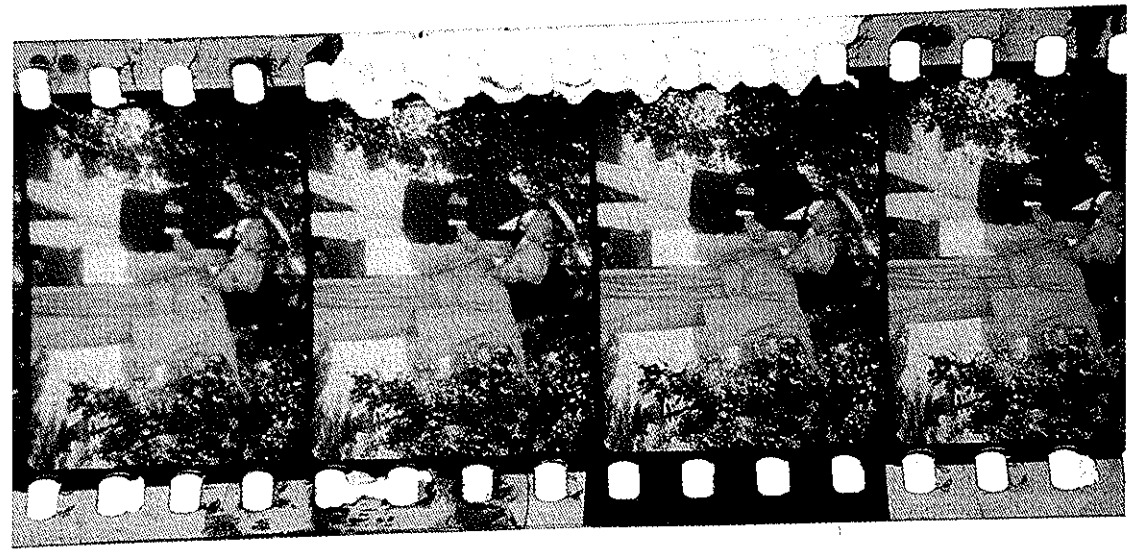


(*a*)



(*d*)

Figure 11.2 (*a*) A Lipsner–Smith ultrasonic solvent film cleaner. (*b*) Inspecting film at Soho Images in London. (*c*) Film damage, perforations missing completely on one side. (*d*) Repairing damaged perforations with perforated tape at L'Immagine Ritrovata, Bologna. (*e*) Replaced damaged perforations. (*f*) Torn film can only be repaired by transparent tape



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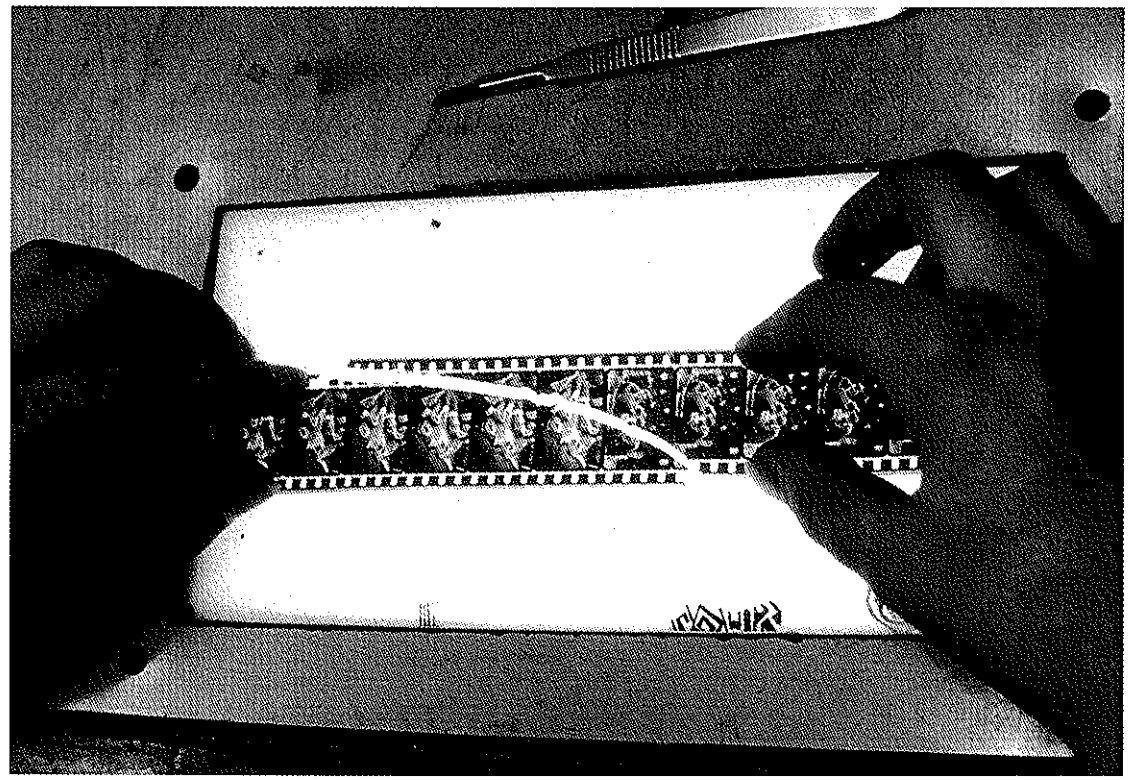

(*f*)

procedure is hindered by shrinkage, it is possible to apply the perforated tape in short sections of one frame at a time. Another solution is to cover the image area with broad splicing tape, and leave the perforations free. When the repaired film is duplicated it might have difficulties with some printers. Some modern equipment, like rotary contact printers, is not very tolerant to the two extra layers of tape, which make the film stiffer than normal.

Blooping

When a torn film is repaired it is sometimes unavoidable that a piece of image is missing. In projection this gap shows up as white. To reduce its visual impact the area can be blacked out with **blooping ink**. This is a dense, optically opaque ink developed to cover clear areas in sound film. Blacked out areas attract considerably less attention on the screen than white areas. Blooping is only useful for positive films: for negatives it is better to leave the missing areas clear, so that the printed image is black.

Blooping is indispensable to remove clicks and damaged areas that produce extraneous sounds from optical sound tracks. A splice in a soundtrack produces a click, a disturbing sharp noise, since a small clear area is left between the edges of the two films. Blooping ink removes these clicks by covering the clear area with ink. This should be done only when the volume of the sound is low. When there is loud noise or music the click will be less noticeable than a gap in the sound, so it is preferable to leave it there. Blooping ink can be removed with most cleaning solvents if the effect is too obvious. There are also preformed stencil shapes and self-adhesive peel-off patches of dense material on the market to help with this process. However, blooping ink has more permanence and is equally easy to apply, but may be removed by solvent film cleaning.

11.3.13 Splices

Splices join sequences of film. These can be made with glue – so-called cement splices – or with adhesive tape – tape splices. Silent prints have many cement splices, as usually the cutting was done on the positive. These splices occur most frequently at the insertion of intertitles and at the colour changes of film sequences, although most uncoloured films were positive cut too. The transition to negative cutting coincided more or less with the introduction of optical sound. Sound film prints usually have few splices, and where they occur these may create disturbing noises in the prints. Cement splices in a 35 mm print are less disturbing than in a 16 mm film print. In a 16 mm print the overlapping parts of the splice in the negative extend into the adjacent picture area, and appear as a light bar in the first and last frame of every cut. To avoid this 16 mm negatives are often cut in A and B rolls, although this was not common until the 1940s.

Cement splices

Cement splices use a solvent glue to dissolve the film base and fuse the two superimposed pieces together. Since the emulsion cannot stick to the film base the emulsion in the cemented area is scraped off. The thickness and the width of the splices can vary. Early joins are often very thick, as there has been little scraping, and the overlap is usually broader than in recent splices, up to a third of the picture area. Usually smaller splices are used for negatives, and broader and stronger ones for positive films. Normally the joins are made in the frame line area. Until quite recently almost a full frame was lost to make the overlapping area for the join, but with modern splicing techniques this can be avoided.

Splices are not only used for the joining scenes of prints and negatives, but also for repair. Cement splices that are found in the middle of scenes, and splices in sound films are almost always made by operators after a break of the film during projection. In this case a jump cut will be seen since one or more frames were taken out to make the join. Over time the cement joins tend to weaken and some may completely fail: the join is then said to 'dry'. This deterioration depends on the film base, the quality of the join, and the solvent mixture used. Joins made in the 1930s are more likely to dry than later ones, since chemical additives that improved the life of the joins became available in the 1940s. The solvent, so-called film cement, is almost always a solution of acetone and other chemicals.

Cement splicers

The standard cement splices are, and were, made with small portable splicers, available in different designs for negative and positive films. A negative splicer produces narrower joins than a positive splicer. Usually the splicer has a small device for the scraping of the emulsion, otherwise this can be done by hand with a file, a sharp knife or a scissors blade. The scraped film sides are held on pins, the film cement is applied to one of the joining sections, and the splicer is closed to join the two pieces with some pressure. In a few seconds the cement is hardened and the splice is ready.

Cement splicing requires practice. The amount of cement is critical: too little cement results in separating edges and too much takes longer to dry and the risk of squeezing cement into the picture area. When starting to make cement splices it is recommended to practise on pieces of scrap film. To test a splice the film should be twisted: if it parts the pieces are not adequately joined. These standard cement splices involve the loss of at least one frame of the film.

In many laboratories large foot pedal operated joiners were used. Some were fitted with heated plates to speed up the drying process. These are rare today.

A Hamman splicer creates a very narrow splice, that fits within the frameline of a 35 mm film. The cut and overlap area is diagonal and made within the thickness of the base, so that no scraping is required. A Hamman join can be nearly invisible and as strong as a standard cement splice. These joins are widely used for modern negative cutting, as they pass through the printer smoothly, resulting in a steadier picture. Hamman splicers are also available in wider design, useful for positive films. Like standard cement splices the making of a good Hamman join requires a lot of practice. As the overlapping area is entirely in the film base, no frame need be lost using this splicing technique.

Film cements

Current commercially available film cements are designed for acetate film, and widely used in archives and laboratories. These cements can also be used for nitrate films, but are less effective than some special formulas. Formulae for acetate and nitrate based films, and for joining acetate to nitrate film are to be found in Part 4. Harold Brown, a former member of the FIAF Preservation Commission, has collected these recipes.

As film bases comprise slightly different compounds the effect of a film cement can sometimes be unpredictable. When a cement does not work well on a particular base, try another one. To make the solution somewhat more viscous one can dissolve some of the film base in the cement. When everything fails to join a particular film – this happens on rare occasions – a special solution can be made. This formulation dissolves the film base and, in effect, welds the two pieces together with the dissolved base material. This formula can also be found in Part 4.

Tape joins

Splicers that use adhesive tape instead of film cement were not extensively used before the 1960s, when this tape became a common product. Tape splices are quick and easy to produce. The ends of the film are cut off on the frameline and pinned on the tape splicer without overlap. The tape is pulled over the join by hand, and rubbed to remove remaining air. This is done on both sides of the film. The splicer cuts off the tape and punches the perforations open. Tape joins are easily applied and removed, without damage or risk to the adjacent frames. Another benefit is that they can be made without loss of frames. Tape splices are mainly used for positive films, as tape splices on negatives show on printing. Amateur 8 mm film formats always have tape joins.

A disadvantage of tape splices is their lack of permanence. Nowadays adhesive tape is made of durable polyester, but the bond between polyester, glue and film will inevitably loosen in time. In older films adhesive softens and oozes out from the splice. Sometimes the splices stick to adjacent layers of film with a serious risk of causing damage to the film when rewinding. When they show signs of deterioration, tape slices should be removed and the remaining adhesive wiped off with a solvent. Softening tape splices seem not to affect the image, but it is accepted they have a negative effect on both nitrate and acetate decay. It is recommended to use professional splicing tape, that

will not discolour and will put up with being wet, to some extent.

Fusion joins

Special joining methods have been developed for the joining of polyester film, for which there is no solvent available that can act as a film cement. There are different systems available, so-called hot-weld or ultrasonic splicers, that join the pieces of film by heating and melting them. Other systems work with tape that is bonded to the base by heat. All negative cutting of polyester base films is done with fusion joins; for positives, tape splices are also used. As ultrasonic and hot-weld splicers are not able to join polyester to acetate film, these splices should be made by tape. Some joiners join the film ends together in a flat weld at the frame line, sometimes called a butt join.

Repairing splices

Old splices need to be checked before duplication to be sure they will not come apart on the printer. Telecine machines with capstan drives are less critical than printers with sprocket drives, but so much damage can be done by a break on a machine that splices should be examined before every job. This can be done by simply twisting the film. If the splice starts to part, it will be unsafe on the printer. When a join is unsafe it can be remade by cement or tape.

Weak cement splices can often be peeled apart, and the overlaps rescraped and recemented. The overlapping area can be trimmed with scissors, to reduce a broad cement splice to smaller proportions. The recementing can be done by hand, or on a cement splicer modified to handle the shrinkage of the film. One should always stick to the original positions of the perforation, whatever the frameline position may be. If the spliced area is damaged, and frames would be lost to make a new one, a tape splice can be made. In this case the remaining overlapping areas of the old cement splice are cut off.

Some repairers reinforce the old cement splices by placing a tape join over the top. This can be done by small 8 mm tape that will show on the duplicate. For tape repairs generally 16 mm and 35 mm adhesive tape are used. On the duplicate of the repaired film this tape will be visible as thin lines, especially in the light areas of the image. When repairing with adhesive tape one should avoid gaps between the spliced ends, as these are a weak structure likely to snap in the printer. Air bubbles and dirt under the tape should also be avoided, as it will be visible on the new duplicate.

Most cement splicers can be modified to handle shrunken film by replacing the pin plate designed for short pitch. Older tape and cement splicers with worn pins will already accept a degree of shrinkage, and pins on new splicers can be filed down on the edges to achieve this. For early films it is recommended to keep an old splicer with removed outer pins. These will be able to handle even the most shrunken materials.

11.3.14 Damage by fungus and bacteria

High humidity and high temperature will promote the growth of fungus and bacteria on the emulsion of films. However, films that are not stored in poor conditions have also been found to be attacked by organisms. Nitrate and acetate films are affected equally. Only some colour films seem less susceptible, because their processing included formaldehyde, a very good fungicide. It has been noticed that tinted films are frequently affected by fungal growth, as some dyes are a good substrate.

The distinctions between fungi and bacteria are imprecise, but it is possible to distinguish between the two under a microscope. The fungal hyphae can be seen as strands, whereas bacterial colonies appear circular or patchy even under a hand lens. At higher magnification bacteria look amorphous as the individual cells are not obviously arranged in chains. The appearance of fungi or bacteria on a film can be very serious. However, some colonies are entirely superficial and can be wiped away or removed by a cleaning solution. Others will have damaged the emulsion so much that it will start to separate from the base.

Strands of fungus growth can gouge troughs in the emulsion surface. This effect is known as **etching**. These troughs are permanent scars in the emulsion surface and may also show on a duplicate of the film. Fungal hyphae can burrow extensively, sometimes forming a network of tunnels below the emulsion surface. Sometimes just one coating layer suffers from this damage.

In many cases the growth of fungus and bacteria will stop without any influence from outside. Probably the conditions that the organism liked have ceased to exist and it is either dormant or dead. In any case it is important to take a close look at the fungus or bacterial growth before treating it. Treatment can be done in the following way:

1. Removing the growths.
2. Minimizing the effects on printing.
3. Preventing further infestation.

Removing growths

Inspect the film under a microscope; use a needle point to probe the image area to check whether the growth is on the surface or below the surface. Gently find out if the emulsion is still firm and in good contact with the base.

If the emulsion is firm the film should be rewashed. This usually removes all the surface growth and cleans out any grooves cut by fungi. If the growth is all on the surface no further action will be needed except to ensure that any possible remains of the organism are dead. There does not appear to be any method of removing hyphal strands from inside the emulsion and they may remain as a fine dried black network.

Minimizing the effects on printing

Wet gate printing has a positive effect on surface damage caused by fungi. When there are tunnels inside the emulsion layer, the damage is more difficult to reduce. One treatment is to fill them with a liquid. Organic liquids, like mineral oils, will penetrate into the tunnels and reduce their appearance. The film has to be stored in the liquid for some days or placed in a vacuum chamber, like those used for the **Vacuumate process**, with the film immersed in oil. The film is then hand cleaned and printed on a contact printer. The visual appearance is quite good but never perfect. After the printing the film should be cleaned to remove the oil. As there is no information on the long-term effect of this treatment it should be regarded as a technique of last resort.

Prevention of further growth

Many biocides are on the market to prevent the growth of algae in process machines, and these are effective in killing fungi and bacteria. These solutions are said to have no effect on the permanence of the film. The oldest is domestic bleach or sodium hypochlorite. This solution is very effective in the prevention of infections but is not persistent when dry. Dearcide, sodium trichlorphenolate or Morpan BC80 (benzalkonium chloride) as 1% solutions in water are also good biocides that kill any hyphae or spores on films with fungus or bacterial damage.

One word of warning regarding the use of special rinse baths for colour materials. Many colour films from 1955 onwards required a last rinse of a formaldehyde solution as a stabilizer and hardener. These films rarely suffer from fungi probably because they have some residual formaldehyde remaining and this is very toxic. If such a film is effected the last rinse should be a solution of 6 ml of 37% formaldehyde in 1 litre water with a drop of Photoflo to simulate the original last process stage. Formaldehyde is a very effective biocide and will protect the film from further growth. If in any doubt this last rinse can be used for all incorporated coupler integral tripack colour films.

Health and safety

Very few fungi cause illness in people but it is possible that allergies could develop in people who are sensitive to high levels of spores. People with a history of lung disorders, people who are taking antibiotics and people wearing contact lenses should avoid working with fungus-infected films.

Everyone handling infected films should wear gloves and a full nose and mouth mask with a fine filter (down to 4 microns). Movement of infected films should be kept to a minimum to avoid spreading spores or infective hyphae, and films should remain in a container until needed.

As all biocides are toxic, the recommendations for handling them must be checked before use and the instructions followed. All rinse baths containing formalin (a solution of the toxic gas formaldehyde gas in water) must have a surface cover or extraction, and the area must be regularly monitored to keep the concentration of formaldehyde down below the recommended TLV.

11.4 WAXING

Prints were often waxed to smooth their transport in the projector and increase their useful life. This process may have started very early. There are many recipes for waxes in early and later literature, generally consisting of dissolved beeswax or paraffin wax in Xylene, later replaced by 1:1:1 trichloroethane. The film was either waxed overall by dipping in the wax solution or over a waxed cloth roller, or, more economically, by application to the edges only. Usually the film was buffed afterwards to polish the applied surfaces and dry the wax. A waxed print is transported through a projector more quietly than an unwaxed print, especially on old projectors.

Old waxed prints are often extremely dirty as old wax picks up dirt easily. The solvents used for film cleaning easily clean off all wax.

11.5 VACUUMATE

Restoration House Inc. of Canada introduced the Vacuumate process more than 30 years ago as an overall treatment to improve the suppleness and lubrication of films and to give some protection from fungi. It has been used especially for cinema prints prior to being sent to the tropics and to treat films that have already been affected by fungi or bacteria.

The process takes place without unwinding the roll and without passing the film through any liquid. The reels are placed in a vacuum chamber and the pressure is reduced to 30 mmHg. The temperature is controlled to 25°C. In a sequence that takes about 2½ hours five separate chemical mixtures are released into the chamber. These vaporize and are taken up by the film emulsion and/or the film base.

11.6 FADING OF BLACK AND WHITE IMAGES

Black and white images are very stable, as the grains of metallic silver are more durable than the film base. However, the most decisive factor in conservation is how effectively the film has been washed. When the salts, used for the fixing of the film, are not completely washed out of the gelatine layer the silver image will fade. This is a result of conversion of the silver to a thiosulphate salt. In some cases this fading may be corrected by bleaching with a ferricyanide colour bleach followed by redevelopment with a black and white developer. This treatment is not always successful, but it can significantly smooth out the blotchiness of faded black and white images. This is a safe procedure – it may not work, but it does not impair the future life of the film.

11.7 DYE FADING

The fading of colour images is a more common problem than the fading of black and white images. Films from the silent era, produced with early colouring methods, may be faded by projector light. Early chromagenic dyes, produced during the development of subtractive colour film, were unstable and frequently lost both yellow and cyan, leaving a magenta image.

There have been many dyes used in colour photography over the past 50 years and their stability to ultraviolet light has improved, to the point when today the dyes can withstand ten times the UV exposure that would destroy the 1935 Kodachrome dyes. Technicolor dyes, for a long period Metanil Yellow, Rhodamine and Patent Blue, are also quite good, but there were periods when poor stability seems to have been a problem.

11.7.1 Causes of dye fading

Storage conditions, particularly high temperatures and humidity.

Irradiation from the projector lamp. The high ultraviolet content of some projection arcs fades dyes, and this can be seen as a faded central spot or area in each frame. This is the most common cause of fading of coloured films from the silent era.

The chemical and physical properties of the emulsion matrix material.

Low formaldehyde concentrations in some colour process stabilizer solutions can shorten the life of some incorporated coupler colour dyes.

11.7.2 Fading of tinted, toned and handcoloured films

Toning is the process of changing the silver image for another image chemical. Some alternative images are much less stable than metallic silver, and most fade to some extent. Iron-tone blue, also called Prussian Blue, fades slowly with ultraviolet light from projectors and it also appears to darken considerably with age. Some of the orange tones, especially uranium ferrocyanide, appear to darken and to change colour to a duller, redder hue. Some toned images have faded unevenly, a problem for which there is no conventional photographic solution.

Sepia toning is the conversion of the silver image to silver sulphide, which has a warmer, browner hue than the neutral grey of silver. Sepia toning also changes over time, but is known to be unaffected by residual fixer salts. The colour becomes more neutral and the colour effect is lost but the density is usually maintained. On the other hand most toning is quite difficult to identify after all these years and not enough is known about some original colours to predict the changes that have occurred.

Tinted film, where the base or the emulsion is coloured overall, is generally more stable than most toning, with some notable exceptions. Heat from projector lamps has the effect sometimes of reducing colour saturation, especially of some reds. In general it seems that yellows and reds were more stable than greens and blues. Some of the old blue dyes fade unevenly in a most characteristic and unpleasant way. Tinting of the base seems to be more stable than the laboratory processed emulsion tinting. Stencilled colours and brushed on colours are generally as stable as tint dyes, as the same dyes were used for both.

11.7.3 Stabilization of dyes

Most chromagenic dyes are stable when maintained at a constant pH of about 5.0–6.0. The final stabilizer, rinse or process bath is usually a buffer, a solution used to provide a stable pH condition in the emulsion. Many dyes are known to be at their most stable if the emulsion has some residual stabilizing chemicals left. Formaldehyde is widely used in the last process stage for some films as it improves the stability of the magenta dye. Eastman Colour Print film and Ektachrome Commercial film required the SA-1 or the ECO stabilizer to maintain magenta dye stability.

The Kodak S-9 stabilizer had a carefully defined pH. SA-1 and ECO stabilizer solutions contained formaldehyde. It now seems likely that a considerable amount of fading of the dyes of this period (1950–85) may be due to faulty processing at the time the film was made. Formaldehyde in the process solutions was rarely analysed or chemically controlled at that time, and the pH of stabilizers was widely disregarded since neither contributed to the visual quality of the film at that time. Only wetting agent concentrations, which helped drying and reduced drying marks, were regularly checked.

A further problem is that cinema release prints were often cleaned using water, especially if needed for a second release, and many laboratories used a simple water wash to anneal fine projector scratches. After this the film should have been re-stabilized, or re-buffered, but rarely was. In consequence these treatments, which wash away the residual chemicals, may have accelerated the process of fading.

Little research has been done to establish whether re-stabilizing these faded colour films now would prevent the fading from continuing, or slow the process. However, several archives have re-stabilized or re-buffered valuable colour film in the hope that this will be of some value. The best that most manufacturers can suggest is that if the original stabilizer or buffer formula can be found re-stabilizing would not hurt. Eastman Kodak's recommendations to use a sulphite bath for cleaning and rewashing did not, and still do not, emphasize enough the need to follow up with the original process stabilizer or buffer solution.

11.8 FILM CLEANING

Film can be cleaned by a number of different methods: by water, by organic solvents or by adhesive surfaces. Cleaning of all film between the various stages of restoration is essential,

just as film is routinely cleaned in modern film laboratories between production stages. There are differences between cleaning as carried out by conventional film laboratories on modern film and the cleaning of archive film.

Fresh negative film in modern laboratories is always cleaned between each handling or printing stage using a solvent in an ultrasonically vibrated bath to remove dust, fingerprints and minor dirt particles. The procedure is one of ensuring that nothing is present that could impair the printing process and be seen on the print as 'sparkle', tiny spots of clear film where a speck of dust was stuck to the film, or be a source of abrasion.

Cleaning archive film for the first time can be as simple as this, but archive film is frequently unbelievably dirty; so dirty that it would seem that it had never been cleaned in its life, which may be the case. Projection prints that have been on a cinema circuit could have had almost anything done to them from being covered in spilt coffee to being run onto the projection room floor because the take-up system failed (a very common problem).

Early silent films that have not been touched for many years may have so much applied grime that a cleaning process may remove measurable amounts of material. In one such case a well used 5 min (500 ft) Pathé Pictorial print of 1952 weighed 12 g less after ultrasonic solvent cleaning! The subject of cleaning is complex and the following issues are special to archive film.

11.8.1 Cleaning before repair?

It is usual to inspect film and sometimes to carry out repairs to film before cleaning prior to printing, and in the case of negatives this is the best policy. However, old prints and some old well-used newsreel negatives are so dirty that cleaning may be needed before any work commences to avoid spreading the dirt or the dirt and grime creating additional scratches and abrasions. In any event, all film should be cleaned after repair and immediately before printing.

11.8.2 Selecting the method

There are many ways to clean film. Processes that use rotating buffers are rarely used on old film as they risk damage to insecure splices and torn perforations.

Solvent cleaning is essential for really dirty film. The choice of solvent is restricted today by the Montreal Convention. Water cleaners are effective too but less so than solvents, although water is more effective for detaching particles stuck to the emulsion and in this case the section above on rewashing should be consulted.

Modern particle transfer roller systems are not effective on old archival film, but are very more appropriate for keeping clean modern restorations and for local use on printers and processors.

11.8.3 Essential procedures before cleaning

Testing

The first procedure before any cleaning is carried out is to take a white cloth with a little perchlorethylene on it, the normal solvent used for solvent cleaning, and wipe about 30 cm of the film gently about three times and look at the dirt removed on the cloth. If the dirt is dark and very obvious cleaning must be done in a cleaning system allocated to dirty film and cleaned a second time in a 'clean' machine (unless a 'Clean band solvent cleaner' is used, see below). This is particularly essential on solvent cleaners in laboratories handling new negative film, which will be contaminated by the dirt taken off really dirty archive film. All cleaning machines have filtration but this is not able to remove grease and oils and a 'reclamation' process will be needed to clean up the solvent before it can be used for fresh film. The good practice is to keep a cleaning machine specially for the first clean of archive film.

If the film was tinted and colour is removed onto the cloth, solvent cleaning may cause some dye loss. Unfortunately, if dye is removed no cleaning method may be possible without colour loss and this dilemma may have no solution – the image may be left dirty, or clean and without all the dye! In an informal series of tests at Soho Images in London it was found that dye loss from tinted images in a solvent cleaner was extremely rare, although very serious when it occurred.

Magnetic tracks should be tested for cleaning as some solvents will remove the magnetic coating. A cloth with cleaning fluid should be used on an unimportant part of the film. If a brown colouring appears on the cloth, no further attempt should be made to clean the magnetic track with that solvent.

Lacquers and coatings

Some print films were (and some still are) coated with a protective layer of varnish-like lacquer to protect them from scratching. If a film is coated it can usually be detected on either side under a hand lens either from the edges where the coating appears to chip away or from fine drying marks or patterns that make the surface appear irregular or with a 'painted' appearance. Some films were coated on the emulsion side only, and others on both sides.

Solvent soluble coatings can be dissolved in isopropyl alcohol or by normal perchlorethylene cleaning fluid. These lacquers were applied from the mid 1930s on and were very common on early 1950s colour film. They could be scratched but if scratched it often did not extend down to the emulsion. The lacquer could be removed with a solvent (thus removing the scratch!) and the lacquer reapplied. Some of these coatings come off easily and others may need several solvent cleans. If this type of coating is found it is always better to remove it. It is usually pale yellow with age, and removing it will remove a proportion of the scratches. Permanent coatings are modern polymers, and are not removed by solvent (see the mention of Photoguard above).

Water cleaning

Water can be an alternative to solvents if the marks are water-soluble (Photoguard prints wash well), but this is difficult to test on the bench unless a piece of the film roll can be found with no image value. A cloth moistened with a mild surfactant or wetting agent such as Photoflo and water can be wiped across and the result inspected as before. This piece of film rarely dries uniformly and should not be re-used. The re-washing procedures used for emulsion scratch treatment are very effective cleaners.

Sufficient length of protective leader should be added to the front and end of each reel and the leader should contain sufficient information for the reel to be identified while out of its can. This would normally be the title, the reel number, a description of the material and any identifying number such as the location number or other ID number.

11.8.4 CFCs and the ozone layer

Solvent cleaning with 1:1:1 trichloroethane (1:1:1 TCE) has been the mainstay of all film laboratories for over 30 years. It is effective and fast, and replaced solvent cleaning with other more toxic solvents, notably trichloroethylene and carbon tetrachloride. The Montreal Convention has removed 1:1:1 TCE for the future and perchlorethylene is now used instead. There are a number of other solvents that archive laboratories have used for specialized cleaning purposes.

The Montreal Protocol on Substances that Deplete the Ozone Layer is the international agreement designed to protect the environment, with the power to ban substances that may be harmful to the ozone layer. The ozone layer is found in the stratosphere, between 10 and 25 miles above the ground. Ozone is a gas whose molecules have three atoms of oxygen (O_3). The molecules are spread very sparsely throughout the stratosphere but are nevertheless vital to the environmental system because ozone is capable of absorbing harmful UV-B ultraviolet radiation from the sun. Ozone is continually being formed and destroyed naturally because ultraviolet radiation from the sun breaks down oxygen (O_2) molecules into two atoms which combine with other oxygen molecules to form ozone (O_3). Ozone molecules in turn break down to produce O_2 and the process begins again.

There has been some difficulty in finding an alternative film cleaning solvent which has all of the benefits of trichloroethane without the ozone depletion problem.

Perchloroethylene is more toxic and less efficient as a cleaner but has been selected by several film cleaning machine manufacturers as the successor to 1:1:1 TCE. In Sweden another solvent is being used as the alternative.

11.8.5 Perchloroethylene (Perklone or Persolve)

This is a good film cleaner but toxic and with an unpleasant odour. The low evaporation rate

causes some problems with drying at high speeds. It decomposes in heat to form poisonous phosgene gases and hydrochloric acid. The vapour is heavier than air. (This solvent is also used by most laboratories for wet gate printing because the refractive index, 1.506, is close to that of film base; see Chapter 13 on printing.)

11.8.6 Other solvents

A number of other organic liquids are regularly used in film laboratories for a variety of purposes. **Isopropyl alcohol** is used in one commercial film cleaner, and is used to clean joiners and work tops.

11.8.7 Safety

Considering the extreme volatility of the solvents most widely used in the cinematographic laboratory (perchloroethylene, isopropyl alcohol, and acetone, for polishing and cements), it is imperative to guarantee an efficient ventilation system. A monitoring method for their concentration in the atmosphere is essential, and a health and safety policy. Staff must be trained to handle both the solvent and the monitoring method. The machines that use these solvents must be connected with the correct ventilation systems. Respiratory-protection devices such as masks with active carbon filters are essential during tank cleaning and accident spills.

Several solvents in use are not flammable under normal conditions but it is still possible that contact with a naked flame would produce acidic and/or toxic gases and all naked flames or cigarettes are absolutely unacceptable. Chlorinated hydrocarbons decompose in heat to produce hydrogen chloride, carbon dioxide, carbon monoxide and, under very strong heat or strong ultraviolet rays, phosgene. Cleaning of tanks or containers that have contained flammable solvents should only be undertaken away from enclosed or poorly ventilated spaces and away from any ignition sources. Empty drums should never be cut by welding torch.

Prolonged contact with the skin should be avoided as powerful solvents will remove the natural greases. It is advisable to wear neoprene gloves when hands are exposed to the liquid. Safety glasses should be used if there is any chance of splashes.

First aid relating to any solvent exposure

- Remove the sufferer to fresh air.
- Obtain medical attention at once.
- Use artificial respiration if breathing stops.
- Oxygen may be administered if necessary.
- If solvent has been swallowed, induce vomiting (by tickling throat with forefinger or by compelling the patient to drink lukewarm salt water or warm soapy water).

Handling and storing solvents

A cool place using mild steel, cast iron or galvanized iron enclosed containers or tanks is recommended for most solvents but individual requirements should be checked. Small quantities of non-inflammable solvents can be kept in glass containers (usually as supplied).

All storage containers must be labelled with the contents.

Most film laboratories and some modern cleaning equipment use some form of distillation for re-use of solvents used in large quantities. The newer solvent cleaning machines incorporate their own integral re-distillation unit, but inevitably there will always remain some solvent for disposal. Flammable solvents require special transportation and fire protection during disposal and must be kept in special (usually) stainless steel containers with special 'anti-flash' closures.

The Control of Pollution (Special Waste) Regulations 1980 applies in the UK and carriers of controlled waste must register with their local Waste Regulation Authority. In all other EC countries there are equivalent regulations and authorities.

11.9 FILM CLEANING METHODS

11.9.1 Solvent cleaners – hand cleaning

Hand cleaning will always be needed for fragile film or seriously dirty damaged film that must be cleaned prior to repair. The usual method is as follows:

A non-abrasive cloth such as Canton flannel or a deep pile cotton plush or velvet should be moistened with the film cleaning solvent, perchlorethylene. The cloth should then be folded in two around the film and the film drawn through the cloth at a sufficiently slow speed that the solvent evaporates before the film reaches the take-up roll. When the cloth dries it should be refolded in order to use a clean surface, re-wet with solvent and the operation continued.

Gloves must be worn to protect the hands from the solvent's drying effect on the skin.

It is essential that this be carried out in an area specifically designed for this job with a high flow of extracted air across the film and away from the operator. The level of the solvent in the atmosphere must be monitored and kept below the statutory concentration (TLV; threshold limit value) for the compound. Manual cleaning should be done sparingly and only when absolutely essential, usually on very delicate film or very persistent individual marks. Mechanical cleaning machinery available today can clean almost anything with very low risks of damage and can be run slowly for maximum effect.

11.9.2 Ultrasonic solvent cleaning machinery

These cleaning machines, made by a number of manufacturers for film cleaning world wide, work on the principle of 'cavitation' similar to low pressure boiling induced by ultrasonic generators. The ultrasonic emissions in warm solvent create large quantities of minute bubbles which contain vaporized liquid. The bubbles are unstable and collapse, releasing energy in the form of shock waves which shock the immersed film and the attached dirt providing an intense surface scrubbing action.

Most modern cleaners run at 50–350 ft per minute; the immersion time is only a few seconds and the subsequent drying time even less. Perchlorethylene, lost to the atmosphere during drying, may be recovered from the extracted air. Eventually the solvent bath is so contaminated that it no longer cleans and before this point (in a well-run establishment!) the solvent is changed, and in most cases reclaimed by evaporation and redistillation, and used again.

There are several manufacturers of ultrasonic film cleaners, including RTI in USA, CTM in France, and Lipsner Smith in the UK. Some units use a rotary buffer on the film as it is immersed in the solvent to lightly scrub the film, and remove loosened dirt and grease, in combination with the ultrasonic generator, and these undoubtedly are most effective. However, damaged film, even well repaired, can be further damaged if sharp projecting edges catch on the buffers, and most specialist laboratories have a cleaner without the buffers for fragile film.

Drying the film after solvent cleaning is by air knives in an enclosed 'drying tower' after the film leaves the cleaning solution. The knives produce an even drying across the two surfaces of the film with no streaking. Air knives are slotted tubes which emit a stream of clean air and are usually of a design to extract solvent from the surface by the Venturi effect, a mechanism that reduces the air pressure locally at the surface of the film by the action of an air jet.

11.9.3 Clean-band solvent cleaner

A practical solvent cleaner design that avoids the problems of buffers and the excessive contamination of solvent from very dirty archive film uses a cotton band or bandage in a roll, wet with perchlorethylene, that slowly wipes the film surface running in the reverse direction to the film transport. The cotton band is used only once before being discarded. These cleaners are very effective for very dirty film, and are surprisingly economic.

11.9.4 Maintenance of solvent cleaning machines

Many solvent cleaners today work on a 'batch' principle and the cleaning solution in the machine will eventually become contaminated with soluble substances and will therefore lower the efficiency of the cleaning operation. Replacement with fresh solvent is necessary to maintain high standards of cleaning and in the most recent machines this is carried out transferring the dirty solvent to a distillation chamber and returning it to the cleaning tank after distillation. Modern film cleaners have built-in distillation systems, which take a few hours to regenerate the solvent in the tank.

Cleaning machinery requires regular and high quality maintenance. Regular checks should be

made on the colour of the fluid as colour is one of the best indicators of contamination. A single roll of film with a varnish lacquer can seriously contaminate a solvent bath.

As with any transport system, badly maintained cleaning machines can scratch film and so film of no importance should be used as a test roll.

11.9.5 Particle transfer rollers

Several commercial designs exist using the special surface character of a soft polyurethane material (technically said to have 'Shore A' character), originally designed by Eastman Kodak. The roller surfaces made from this material are 'tacky' and remove dust and other particles onto their surface. The degree of 'tackiness' is determined by the choice, softness and surface texture of the roller's coating. The rolling contact with the film and the cushioned surface of the roller provide a low risk of film damage by scratching.

The principle was patented by Eastman Kodak as Kodak PTR (Particle Transfer Rollers), but such rollers are now made by a range of manufacturers.

When the PTR is fully loaded with dirt, after a few thousand feet, they can be washed with water or wiped with a damp sponge to remove the accumulated dirt (or a material with a surface stickier than PTR, such as adhesive tape can be used).

These rollers are now extensively used in the film path of projectors, printers, processors and telecine units to clean film of loose particles. The result is cleaner images, less 'sparkle' and also reduction in the build-up of dirt in the mechanisms of the equipment. They can be fitted to any negative handling equipment or used as a 'stand alone' film cleaner wound by hand or powered. They seem to work as well at any speed; for example, they are effective at 600 feet per minute on high speed panel printers.

In order to operate effectively there must be continuous intimate contact between the film and roller. The angle of wrap is unimportant and can range from only a few degrees to over 180 degrees. The tension is not critical but should be sufficient to ensure that good contact is maintained. These cleaners do reduce the amount of dirt on modern film and restorations but they will not eliminate the need for liquid cleaning of archive film.

A number of units on the market consist of a powered rewind transport that passes the film through a number of PTR rollers. These units are useful to conventional laboratories and for cleaning modern restorations of archive images but are not effective enough for cleaning old archive film.

12

Sensitometry and quality control

12.1 GENERAL AIMS OF QUALITY CONTROL

Clay and Walley in *Performance and Profitability* (London, 1957, p. 28) provide the following definition of quality control:

> Quality control is a system for measuring and recording the variables that affect quality in a methodical manner, so that the values and trends can be compared with standards and thus act as a means of control.

Quality control, then, is a system that provides information to management – the actual control, however, is exercised by management and not by the system. The aim of the system should be to make available the right information at the right time so that any decisions taken may be more meaningful and certain. In effect the quality control procedures can be seen as occurring in three separate stages. The first, often called **monitoring**, is measuring relevant useful information about the product or the process; **decision** is the process of estimating the action; and **control** is procedure of making the adjustment to the process.

Most manufacturing industries rely on 'statistical quality control'. Fault probability is linked to the number of component stages in manufacture and the reliability of each of those stages. If, for example, four stages (or components) are involved and each of them is only 80% reliable, then the reliability of the final product is only 41% reliable (0.8 to the power 4). Clearly, the reliability required is governed by the nature of the produce and its price. It is as futile to establish too high a standard as it is undesirable to establish too low a standard. In practice, the method used to monitor the production will be either by sampling or by 100% inspection. Where the latter is practised (as often it must be) by human skills, the effective inspection is likely to be less than 100%. Tests have shown that different inspectors will reject different items, and the same inspector will reject different items at different times of the day!

In this chapter, as in the reality of film laboratory life, there is a sharp distinction made between what is called quality control, that is the procedures needed to monitor and thereby control the individual machines, chemical processes and photographic stages, and quality checking, which is carried out at the end to visually appraise the total success of the entire sequence of restoration.

All monitoring is made more objective if the characteristics of the process can be converted into numbers, and these parameters are widely used in quality control, but almost never in quality checking, mainly because of the subjective nature of vision.

As a result of the quality control techniques in use, it is possible to plot graphs which indicate the stability, drift or random fluctuation of any manufacturing process. Such graphs normally incorporate various limits for managerial guidance – these are usually called 'action limits' and 'control limits'. Sometimes a special lower limit is known as a 'warning limit'.

Quality control should not be considered in isolation and the temptation to see it as an end in itself must be resisted. Good quality control requires effective liaison between all other departments and control technicians must never lose sight of the fact that a laboratory exists to produce film, not to provide work for a Control Department.