ARCHIVING THE AUDIO-VISUAL HERITAGE

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ARCHIVING THE AUDIO-VISUAL HERITAGE

A JOINT TECHNICAL SYMPOSIUM

FIAF
Fédération Internationale des Archives du Film
FIAT
Fédération Internationale des Archives de Télévision
IASA
International Association of Sound Archives

May 20-22, 1987
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1988

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To cause the wind to blow
for Jacques Ledoux
1921–1988

Preface

Helen P. Harrison
Open University, England

In May 1987 a Technical Symposium: "Archiving the Audiovisual Heritage", dealing with matters of particular interest to audiovisual archives was held in Berlin, FRG, in the International Congress Centre. The event attracted over 300 delegates, a fact which bears witness to the increasing concern of the archivist for the preservation of the audiovisual heritage. This symposium was the second to be held dealing with audiovisual archives. In March 1981 the International Federation of Film Archives (FIAF) and the International Federation of Television Archives (FIAT) joined forces to organise a technical symposium which was held in Stockholm in June 1983, and set an important precedent for future cooperation between the audiovisual archive associations.

In 1985 the second symposium was proposed and an organising committee of three av archive associations was formed: members came from the Technical Commissions of FIAF, FIAT and IASA (the International Association of Sound Archives). The event was hosted by the Stiftung Deutsche Kinemathek in Berlin.

There were several reasons for the three organisations dealing with audiovisual materials to come together to organise a symposium. It represents a logical development from collaboration between film and television (video) archivists to include the sound archivists. Sound is used on the other materials, visual material may be transferred to a sound carrier and sound can be processed on optical material. It is becoming more difficult to consider the materials involved in isolation from one another. The media are no longer exclusive and the Technical Symposium of 1987 set out to investigate this convergence and any divergence which was also present in three main areas of concern.

The programme of the Symposium was designed to present three particular areas: preservation (or restoration), conservation and the obsolescence of hardware (machinery) and incidentally the software or materials in each of the recording media involved: film, video and sound from the point of view of the audiovisual archivist.

The reasoning was that the different technologies are converging, are indeed using one another's methods in a cross fertilisation process. Dividing lines between the media of film, video which together make up moving images, and recorded sound are becoming blurred or being crossed and recrossed in research and practice.

This was a Joint Technical Symposium in name, as well as execution. The main themes were discussed by the three associations of film, television and sound archives to indicate the similarities in the problems presented to the archivists by the materials involved and the treatments prescribed.

Archivists specialising in audiovisual materials have always had to consider preservation and conservation as a priority. Conservation, preservation and restoration affect all archivists and it is worthwhile looking again at the definitions and processes in some detail to indicate how they are used in speaking of audiovisual materials.

Conservation is about good housekeeping, learning how to handle and store material to do the least damage, not subjecting it to unnecessarily heavy use without ensuring that preservation copies exist. Conservation is active, but it is usually a case of *not* doing something to the material; not putting it in the wrong environment, not handling or touching the surface or running material through faulty equipment which will scratch and damage it.

Audiovisual materials are usually composites with several layers any of which may deteriorate spontaneously or drop off for one reason or another. Preservation is about putting it back together again or repairing damage to the materials' surface in order to make it more acceptable to the viewer or listener. In other words preservation is active, you have to do something to the material. Preservation and restoration techniques are normally carried out by technicians and engineers, not archivists or librarians, and while an archivist may need to know certain techniques exist and understand something about the nature of the material he is administering, he does not need to be able to carry out the actual work of preservation. Conservation yes, preservation less so.

Restoration is the more stringent procedure, and it includes aspects of preservation, that is transferring the visual or sound content of the material on to a format in order to preserve it or restore it to something like its original quality.

Environmental conditions are an important consideration in dealing with audiovisual material and there is a difference in the level of control needed for preservation and conservation. Therefore it is all the more important to conserve material for as long as possible. As in other areas, prevention is better than cure, and certainly less wasteful of resources.

Obsolescence of machinery – probably the most worrying and the most intractable of the problems presented. The oldest recordings including the wax cylinders, coarse groove disks and film can still be replayed, viewed and even restored successfully because the technology to make replacement machines is within the compass of a good craftsman with a reasonably equipped mechanical workshop. More modern formats such as the quadruplex videotape machines may be beyond the capabilities of a small workshop.

The final session of the Symposium presented a subject which warrants further discussion in its own forum: the Ethics of Restoration. How far should an archivist go in "enhancing" archival material to make it more acceptable, playable or viewable to today's and the future public. Have the techniques of "colorization" and other "improvements" any place in the work of an archivist, and if they have not, what should the archivist be doing about it: should he ignore it, protest or ensure that he at least is saving material which is as close as possible to the original intention of the people who created it?

The level of the papers gave the organisers pause for thought. Should technicians be talking to technicians or should they be talking to other archivists working in a variety of environments in developing and developed archives? In the event it was decided that everyone could and should benefit at this stage from the technical progress which has been made and is still to be made by our several Technical Commissions. The papers were therefore presented at a level which could be taken in by a wider general audience, but it was decided that the proceedings would include more detailed technical information.

The papers are given the order in which they were presented to reflect the principle aim of the symposium: to show the increasing convergence of the technologies involved across all materials and to indicate the mutual benefits which may accrue. Naturally many of the papers were audiovisual presentations and every effort has been made to present these in comprehensible form by the use of photographs and diagrams. Unfortunately this has not always been possible with many of the sound recording examples or the moving images, and references to such examples have been eliminated while trying to preserve the sense and content of the papers.
Each of the federations involved appointed a chairman to introduce sessions and speakers and lead the following discussion.

An exhibition of manufacturers of technical equipment for audiovisual archives formed an integral part of the Symposium.

The Organising Committee wishes to acknowledge a debt of gratitude to all those whose energy and enthusiasm made the Symposium possible. In particular Heinz Rathsack, the Director of the Deutsche Kinemathek, who generously supported the project in many ways, not least by dedicating so much of the time and effort of his staff to the smooth running of the Symposium. The Committee is especially grateful to Eva Orbanz of the Deutsche Kinemathek who bore the main burden of the work with a fortitude and humour which helped to ensure the success of the event. The Committee also acknowledges the support received from Unesco which made it possible to invite several delegates. Finally the three associations, FIAF, FIAT and IASA wish to thank their respective Technical Commissions for providing the initiative and energy to carry the Symposium through, and all the speakers who gave of their time and expertise and shared the results of their research and experience with their colleagues and fellow archivists.

Milton Keynes, March 1988

Safety and Energy Technology as Applied in the New Building of the Bundesarchiv in Koblenz

Harald Brandes

Before we moved into the new building of the Bundesarchiv in November 1986, the archive in Koblenz was accommodated in separate office buildings, and all organisational areas worked in limited space. In our new building, the hitherto separated film divisions (that is, the technical division, the feature film and documentary film division, and film access and documentation division) were accommodated under one roof. We have already proved that working under one roof has advantages, besides the saving in travelling time between different work locations.

During the planning of the construction, many objectives emerged: the organization of the daily work was to be optimized, the problems related to nitrate film handling were to be kept as small as possible, and the energy consumption (air conditioning, hot water, and electricity) was to be kept to a minimum. Finally, the film archive had to be integrated into the plan of constructing the Bundesarchiv as a whole.

This is why the whole construction is divided into separate areas (fig. 1). The main building contains all organisational units except for the film divisions. The ground floor of this part of the building includes some public areas, such as a canteen and exhibition areas, the room where documents can be studied, and other rooms where films, cards, stills and access copies of sound can be used. The film archive is situated on the periphery of this main building and detached from it. This isolated location on the ground floor was chosen because of the problems associated with cellulose nitrate film. All other areas are in the basement. There are no working areas above the ground floor.

The new film storage rooms are accommodated in a separate five-storeyed vault. Only safety films that have been technically inspected and treated are stored in this vault. In addition, there are two storerooms for documents and other archival material. Unprocessed safety films, as well as nitrate materials, are still stored in our old premises at the Fortress Ehrenbreitstein.

The film store is connected with the film technical division by passageway in which smaller transport vehicles can be used. Special vans with shelf units have been acquired. Goods lifts are available for vertical transportation of material.

Nitrate material that is not immediately needed for treatment is stored in special intermediate storerooms that have 24-hour air conditioning.

Safety Measures for Nitrate Films

The area where cellulose nitrate films are treated is isolated from the main building by fire doors which are constantly monitored. The area is divided into sections which are separated by fireproof doors. In the passageway, the division doors (which are normally open) will close automatically in case of an alarm from smoke detectors installed in the door areas. Smoke and heat detectors in all film treatment rooms are permanently switched on with a direct line to the fire brigade which in this way will be called at the earliest possible stage of a fire. The location of the fire is indicated on a central fire-alarm panel. Also, direction lamps in all rooms, controlled by alarm devices, will indicate where the endangered room is. All workrooms are isolated from the passage areas by fireproof doors.

Henning Schou:
The first paper is concerned with technical operations and storage in general, and with safety and energy technology in particular. The speaker, Mr. Harald Brandes, will discuss how this technology was applied during the construction of the new buildings of the Bundesarchiv in Koblenz. Mr. Brandes is the Senior Technician at the Film Archive of the Bundesarchiv.

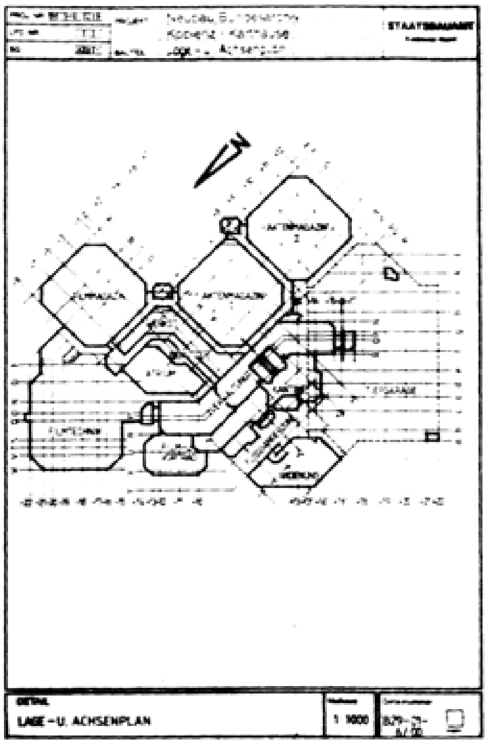


Figure 1

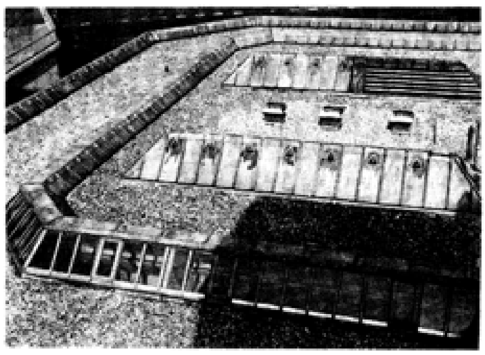


Figure 2

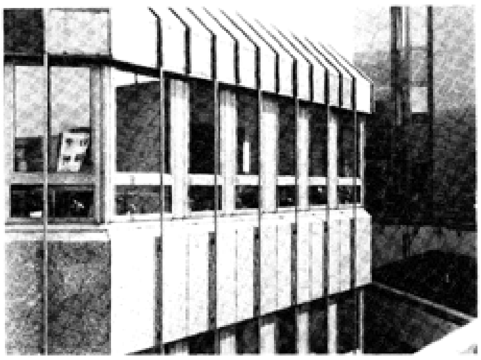


Figure 3

Figure 4

All rooms in which cellulose nitrate film is treated have pressure relief areas in case of a fire. There are also pressure relief areas in the roof constructions of the interior rooms (fig. 2). The windows of the exterior rooms are constructed in such a way that they will be pushed out at a positive pressure exceeding about 0.8 bar. Bars are placed in front of the windows to prevent the panes from being thrown too far away (fig. 3). For safety reasons, the window panes are made of compound glass which consequently does not splinter.

In addition to the monitoring system mentioned earlier, important parts of the building, such as the vaults, the passageways that lead to and from them, and some workrooms, are monitored by movement detectors after normal working hours.

Ventilation

All workrooms are connected to a ventilation system. In order not to expose the staff members to fumes of solvents or other gases, the installation uses purified fresh air only (i.e., no recirculation). The inducted air passes into the ventilation centre through filters. To prevent dust particles, e.g., cellulose nitrate particles, from re-entering the air-conditioning system, there are fine dust filters in front of each waste air outlet. The effectiveness of the large filters attached to the air intake is controlled by means of a residual pressure manometer. The air humidity in the workrooms is kept at levels of about 55% by passing the incoming air through a steam installation. The water, which is necessary for the process of humidification, is obtained from an osmosis installation. In case of a fire, automatic fire safety valves in the ventilation system will isolate workrooms in which nitrate material is treated.

The monitoring of the working environment in each store room is also part of the general work safety in a film archive. A central control unit assumes this task. All important values are controlled by a computer, and regular recording printouts of the climatic values are at our disposal (fig. 4). An area such as the colour film store, in which the required levels of temperature and relative humidity must be strictly adhered to, is supervised by its own monitoring system with a recorder.

Energy Consumption

In addition to staff salaries, the cost of energy consumed by a film archive is an essential factor. This cost ought to be as low as possible. This begins with the construction of the exterior wall which should have optimal qualities of insulation. The construction of the wall from the exterior inwards should be: a 4 cm thick granite slab, then a 8 cm thick insulating layer of rock-wool, ventilation from behind, and finally the walling itself which should be 15 cm thick. In this way, a heat penetration factor (K) of 0.40 is achieved.

The store towers are constructed in the same way. However, the insulation is better there because the interior walls of all stores are made of tubular brick, 49 cm thick. Thus a total heat penetration (K) value of 0.30 is achieved.

In the colour film store, where the temperature is -6°C (21°F) with a relative air humidity of 25%, there is an 11 cm thick insulating cell behind the tubular brick wall. Thus a heat penetration (K) value as low as 0.27 is achieved. In order not to freeze the area surrounding the cooling cells, the air space around the cells is heated to a temperature of +5°C (41°F). Door seals, as well as locks, are secured against freezing through their own heating system. The black-and-white film stores are run at +15°C (59°F) and a relative humidity of 55%.

Running a film archive consumes a great amount of energy. Project planning and realization, including purchase of special equipment, were therefore from the very beginning geared towards achieving the most economic consumption of energy. The heat of waste water and air from exhausts are channelled back into the heating

<u>Peter Konlechner:</u>
When you discussed the structure of the walls, did you mention anything about the vapour barrier?
<u>Harald Brandes:</u>
The wall is constructed like this (from the exterior inwards): granite, ventilation from behind, vapour barrier, insulation, brick wall.
<u>Anna-Lena Wibom:</u>
I understand that you have invented ways of saving water. Have you calculated how much energy you use per square foot or cubic metre to maintain the temperature and the relative humidity you aim for?
<u>Harald Brandes:</u>
There are no theoretical calculations for this on behalf of the planners, and we still have not reached a stage that we

system through thermal pumps (fig. 5). The washing machines used in the treatment of film, as well as the wash tanks of developing machines, use this heated water. Water warmed by otherwise wasted heat also warms up the baths of the developing machines; only the final adjustment to 1°C is achieved by electric heating. The waste of electric energy through heating of the machinery is reduced to one sixth through cooling with cold water from the thermal pumps. The warm water obtained in this way is used to adjust the temperature of processing baths. Also part of the energy needed for heating of the air which is circulated in the workrooms is obtained from the thermal pumps.

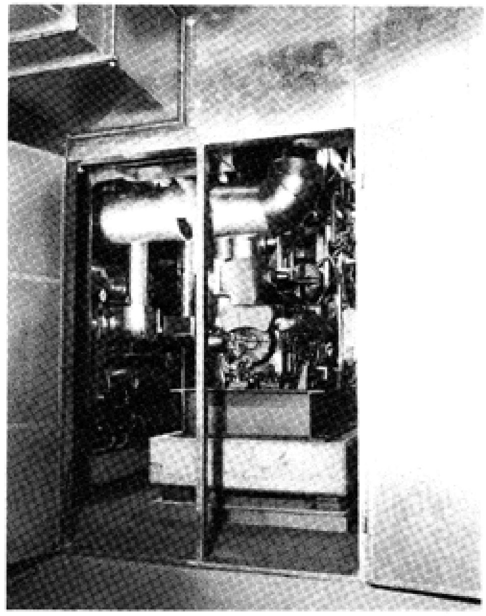


Figure 5

Water Consumption

In many countries, as well as in the Federal Republic of Germany, water is one of the more expensive raw materials which ought to be used economically. This is why we decided to use three different qualities of water in three different water circulation systems.

1. The rainwater from the roofs of the building is collected in a cistern and supplied to all toilets.

2. The available surface water, which is of a quality matching that of the local water of the town, is used as laboratory water for the developing and washing machines. This water is also used for the cooling of the nitrate workrooms. Here, the water is pumped through an extensive heat exchanger attached directly behind the intake sockets of the corresponding air vents. Using this technology in the middle of summer, an effective decrease in temperature of 5°C (41°F) is achieved. The water is thereby heated to 28°C (82°F) whereafter it is collected in a reservoir and used in the laboratory. The necessary water pressure is created in a small pressure unit (fig. 6).

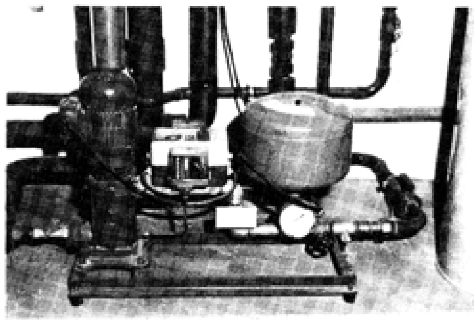


Figure 6

3. Water from the public water supply is used in the normal network of drinking water.

Prevention of Pollution Through Waste Water and the Recovery of Chemicals

An unnecessarily high consumption of photochemical materials is expensive and pollutes the waste water. The consumption may be reduced by collecting the overflow from the baths of the developing machines and reprocessing them in a recycling unit. Subsequently it may be used again in the developing process.

The pollution through waste water and the use of chemicals is further reduced by using vacuum suction as the film leaves each bath (fig. 7). The bath components collected from the surface of the film are immediately channelled back into the bath using a liquid separator (fig. 8). This suction technique also prevents the spreading of remnants from the fixing baths into the final rinse to a large extent, whereby the rinse becomes more efficient.

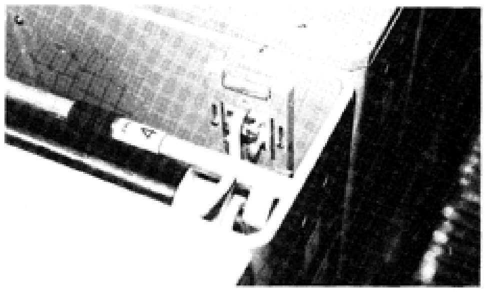


Figure 7

The use of pumps for replenishment of the exhausted baths is more exact than the use of flow meters (fig. 9). When using pumps, it is possible to switch them into minimal performance when blank film and film leader pass through the machine. This also is a way of limiting the unnecessary use of chemicals.

During the description of the heating and cooling of the processing baths I mentioned the operation of thermal pumps. To avoid unnecessary delay in the daily work, as far as the heating of the baths is concerned, the heating of and the circulation in the baths are controlled by a timing device so they have reached the necessary temperature when work begins.

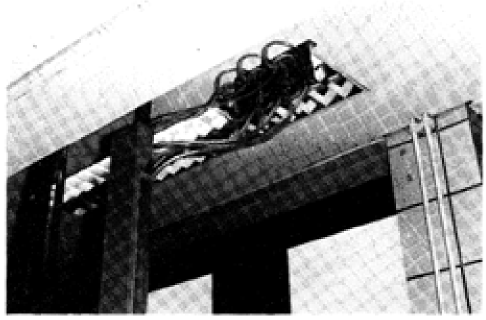


Figure 8

Storage and Retrieval of Colour Film Materials

All colour film materials have to pass through an intermediate acclimatization room

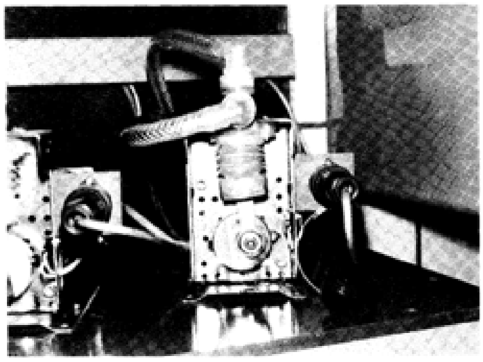


Figure 9

Figure 10

are able to make concrete statements, as the building has not been in operation long enough yet. In my opinion, however, it should be possible even without theoretical calculations to verify that a relatively small amount of energy has to be used when the heat transition coefficient is that low. In addition we only have a very low degree of air inlet in the colour film store. We mainly use circulating air, which means that relatively little heat is added from the outside and through the ventilation.

Anna-Lena Wibom:

I am sure that many of us receive big electricity bills and are therefore interested in learning more about the savings that can be gained from a newly-built vault. I think we all would be interested to hear about your future experiences.

Harald Brandes:

One more piece of information. Some parts of this built-in technology, as for example the suction method of the developing machines, surely can be retrofitted in already existing developing machines, this certainly is no problem. You do not always have to make new constructions in order to save more energy in special areas.

before and after cold storage. This room is kept at room temperature ; yet, the relative air humidity is only 25%. Prior to cold storage, films have to stay in the acclimatization room for at least 48 hours, after which they are vacuum sealed in a foil bag, and subsequently brought into cold storage (fig. 10).

When the films have to leave the store, the procedure is similar. The reels from the cold store are again kept in the acclimatization room for about 48 hours, and the foil bag is then opened.

Prior to cold storage and acclimatization, the film reels may be wound very loosely on a bobbin using a special winder. This may be done to achieve a faster exchange of humidity and to prevent damage to the material caused by shrinkage of the film as it dries. After cold storage and the acclimatization of the films, it is rewound with normal tension. Whether it is necessary to wind film loosely before acclimatization must be established through tests.

Final Remarks

The new building has been in use for more than six months now. The equipment installed caused difficulties in the beginning, and still does to some extent, especially in the area of air conditioning. In spite of this, a conclusion can be drawn.

My colleagues feel comfortable in the new premises which they have accepted. The functional assignment of workrooms has been successful; many work processes that used to be difficult have become more efficient and simpler. During the time of planning and construction, the continuous contact between architects, engineers and the users of the building was important. I am convinced that the success of such constructions will be all the greater, the better this contact is. During the construction of the Bundesarchiv this was possible because our colleagues from the planning and construction division of the building authorities were prepared to cooperate to a very large extent. Thus decisions could be made as the building went up because the engineers were prepared to respond to our requests.

Test of the Swedish Film Institute's FICA System at the Library of Congress: A Report

Paul Spehr

Henning Schou

Unfortunately it has become increasingly expensive to achieve low storage temperatures as the cost of energy has gone up. Technically, it is quite feasible to achieve low and steady temperatures. However, as you lower the temperature, the relative humidity (RH) goes up – and it is generally rather difficult to control the RH at low temperatures. This problem has been experienced by many archives.

So the Swedish Film Institute developed the Film Conditioning Apparatus (FICA). Briefly, the apparatus consists of an acclimatisation cabinet which contains a motorized film winder and a device for vacuum-sealing the acclimatised film in vapourtight bags. Once a film has been sealed in such a bag, it may be subjected to any external relative humidity without suffering damage – provided, of course, the seal is 100%.

Members of FIAF were introduced to the FICA system during a colour preservation symposium organised in connection with the FIAF Congress in 1981 in Rapallo, where the system created quite a discussion about its usefulness. Two years later, at the FIAF/FIAT Joint Technical Symposium in Stockholm, Tomas Dyfverman reported on the design of this machine, and on tests carried out at the SFI. That report has since been published by FIAT as part of the proceedings of the Joint Technical Symposium (International Federation of Television Archives Newsletter, January 1986, 116 pages).

During 1985, one FICA machine was installed in the Library of Congress on a trial basis and another in the National Film Archive of India. To report on the tests carried out so far, we have the Assistant Chief of the Motion Picture, Broadcasting and Recorded Sound Division at the Library of Congress, Mr. Paul Spehr, and the Director of the

In January 1985, Stefan Lund of AB Film-Teknik in Solna (Stockholm), Sweden, visited the Motion Picture, Broadcasting and Recorded Sound Division of the Library of Congress to propose that the Library test the Swedish Film Institute's Film Conditioning Apparatus (FICA) for preparing colour motion picture film for storage in cold vaults. At that time, Mr. Lund, who is the marketing agent for the Swedish Film Institute, hoped to demonstrate the FICA system at the 1985 FIAF Congress in New York and ship that machine to the Library after the Congress. However, there was not enough time to arrange for the shipment to New York, and the Museum of Modern Art had no space available for the demonstration, so this plan did not develop. Instead, we agreed that a machine would be sent to the Library of Congress after the Congress in New York. Arrangements were made to send a machine from Sweden by air freight in July of 1985.

Before the test could begin, we had to verify the requirements for electrical current for the model of the machine that would be sent to us. We confirmed that the electrical current used for the machine in Sweden was 3 phase, 380 volt, 16 amp, and 50 Hz, while the US requirement is 3 phase, 200–220 volt, 60 Hz; so the two systems are not compatible. The Swedish Film Institute had anticipated this problem and had adapted the machine to accept our parameters. This meant that a 3-phase, 220-volt line had to be available in the area where we planned to install the machine for the test. Fortunately, the Library of Congress has a staff of electricians who are experienced in such installations, so this did not present a problem. If you plan to use the system, appropriate electrical connections will have to be one of your very first considerations, otherwise you will have a handsome machine which will not run, or if it is connected to the wrong electrical current a serious malfunction could result.

The FICA machine received by the Library consisted of a main box containing the operational equipment and one side (acclimatisation) cabinet for processing the rolls of film (figs. 1–4). Each of these cabinets is quite sizeable. The main machine is 6 feet 10 inches wide by 2 feet 9 inches deep by 6 feet 2.5 inches tall (2.24 x 0.83 x 2.39 metres). The side cabinet is 6 feet 6.5 inches wide by 23.5 inches deep by 6 feet 1.5 inches tall (2.39 x 0.48 x 2.27 metres). The units are connected by ductwork, which requires one or two feet of space between the units. There are doors that swing out. In addition to the cabinets you need a small worktable, preferably a film-handling table, shelving to store the reels of film which are to be processed, and a storage area for the bags, cores, boxes or cans, labels, etc. that will be used in the preparation. Altogether this requires a relatively large space – at least the equivalent of a small room. If your archive is as crowded as many archives are, this could be a problem. We found a space in a room that was normally used for storage of supplies and equipment, as well as for some film handling. It was near the regular work areas but was separate enough so that the work with FICA did not interfere with other work by our staff. The room we chose was clean and air-conditioned, so it met our normal requirements for a film-handling area. The preliminary examination of the film was done in another area, and the film was only brought to the FICA machine area after being selected and prepared for FICA processing.

The test machine arrived in mid-July 1985, and Gert Moberg of the Swedish Film Institute flew to Washington in August 1985 to supervise the installation and to train our staff in the proper procedures. His instructions were simple and clear and after two or three days, staff members David Reese and Calvin Morman took over the operation. Mr. Moberg also briefed several other staff members in the procedures for using the

National Film Archive of India, Mr. P. K. Nair.

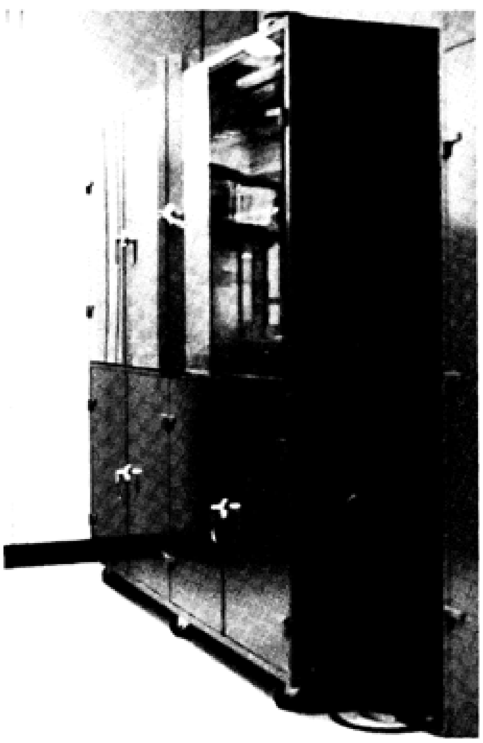


Figure 1

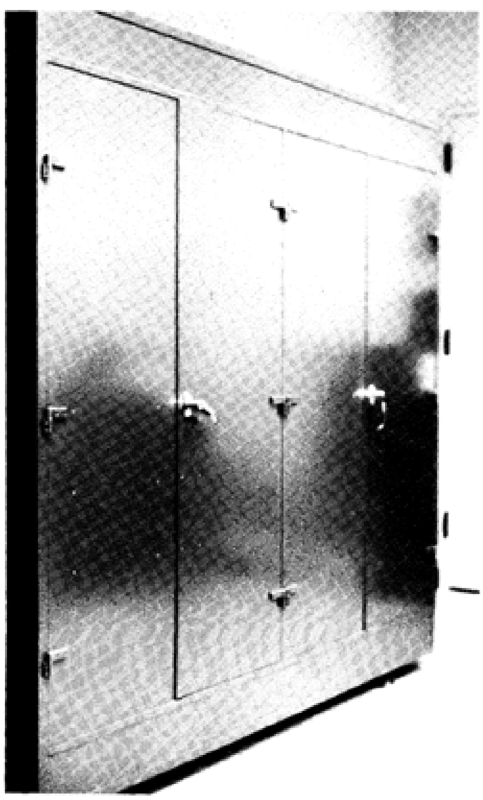


Figure 2

FICA system.

We decided that we would use the FICA system to prepare all new 35 mm feature films which were currently being received as additions to the collection, and we began to set aside these new prints as soon as we knew that we would be conducting the test. By the time the test began, we had accumulated a backlog. The 35 mm feature films were chosen because they are among the unique acquisitions the Library receives on a regular basis, and the copies we received were good enough to merit archival storage. We did not test 16 mm film as we felt there was no substantial difference in handling it.

Since the 1950s through the deposit requirements of the US Copyright Law, we had received 35 mm prints on safety base of many theatrical feature films, and most of these were colour films. The copies we received were not new; but over the years we improved the standards for the quality of prints received until today they are virtually in mint condition. Researchers using the Library's collections have sought to study these films more than any other material in our collection. Until the recent improvement in the stability of colour print stock, and because the copies we received were used, we did not believe that these copies could be regarded as primary preservation material and we allowed researchers to view them here. It was our hope that in the future we would be able to make any necessary replacement through the use of the preprint materials that were in the hands of the producers.

In 1976 we built a cold-storage area for storing colour film. Before we could make a commitment to keeping our 35 mm feature films in the vault we felt that we should be able to make the films available to the public in some format. We decided to test video as a substitute.

In the early 1980s we acquired both an RCA Film Chain and a Rank Cintel which made it possible for us to make video copies of films and use the video copies to provide researchers with viewing copies for some of the films in the collection. It was a major step in resolving the conflict between the preservation of the films and the need to make the films available for serious research.

At first we could not tape every film received, so we selected for video taping and cold storage American titles that were critically acclaimed, very popular or known to have outstanding colour production character. The selection process proved to be time-consuming and arbitrary. The number of films that were going into the relatively large cold vault was making inadequate use of its capacity of 25,000 cans, and there was legitimate concern that worthwhile films were being overlooked.

Several years of experience with cold storage, and discussions about the use of vaults with other archives, made us more confident that films could be moved in and out of cold storage without subjecting the film to serious damage. Considering these factors we decided, in the early 1980s, to store all colour 35 mm features in the cold vault and to use the video duplicating procedure only after the film had been called out for use more than one time. So, just prior to the FICA test, we established a procedure to videotape the film at the time of the third request for viewing.

Each year the Motion Picture, Broadcasting and Recorded Sound Division of the Library receives between 150 and 200 35 mm feature films, i.e., 12-17 features a month. The number of reels per title varies a great deal these days, though 5-7 double reels is most common (that is 10-14 single reels). The films usually come to us mounted on 2,000-foot reels. During the initial test period (which was to last six months) we expected to process between 500 and 700 double reels, i.e., about 19-27 double reels per week. We were not so much interested in testing the capacity of the system, as to test the amount of staff-hours it would take to process the film through the FICA system and into the vaults. Because the films are also called out of the vaults, we could check the process of staging out, using the film, and rebagging the film.

Before beginning the experiment, we found that we needed a scale accurate to a tolerance of 0.05 grams on which we could weigh sample rolls of film before and after processing. The weight lost by each roll of film, which is moisture removed from the film, is the measure of the success of the process. We used a simple scale for the test, but a permanent installation would benefit by a scale attached to a computer that could automatically record the weight at the beginning and the end of the test. Some scales can also generate a label which can be used on the can or box into which the bagged film goes following its processing. Obviously, sophisticated equipment like this is not available everywhere or may be too costly to purchase. But regardless of cost, an accurate scale is essential to the FICA operation.

Figure 3

AB Film-Teknik sent some bags with the machine, but we soon ran out of this initial stock. We tried to find a source for equivalent bags in the US, but had not found one when the test began. When it was clear that we would run out, we had to telex for an emergency shipment from Sweden. It cost US$ 200 to send the bags by air and we had to pay an additional US$ 100 duty on the shipment, so the emergency call proved to be expensive. The bags cost only 9 Swedish Kroner (approx. US$ 0.79) each if 10,000 are purchased, or 16 Swedish Kroner (approx. US$ 1.40) if purchased in smaller quantities. We were using only the double-reel-capacity bag for 2,000-foot (600-metre) size. There is also a bag for 1,000-foot (300-metre) reels which costs 7 Swedish Kroner (approx. US$ 0.61) for 10,000 or more, and 13 Swedish Kroner (approx. US$ 1.14) in orders less than 10,000. Simple mathematics will tell you that 10,000 bags can add about US$ 14,000 to the cost of the operation. We have now found a supplier in the US who can make an equivalent bag at a slightly lower cost.

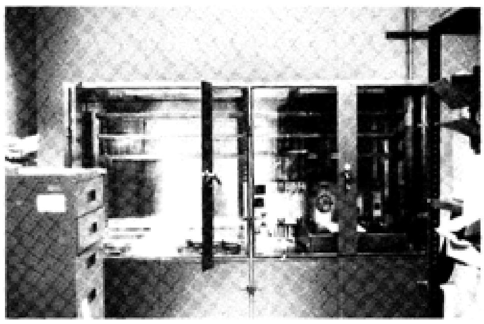


Figure 4

Before the film is processed, it must be cleaned (fig. 5). Until Mr. Moberg briefed us on preparation, we were not aware that certain cleaning solutions leave chemical residues which apparently react differently on the film when bagged in a vacuum as they are in the FICA process. Mr. Moberg recommended that we use an inert solution like Freon TF rather than trichloroethylene or perchloroethylene. This was a consideration that we had not foreseen, and we hope that FIAF's Preservation Commission can give us more information about the possible harmful effects of various cleaning liquids. Perhaps the residue could also affect films not stored in a vacuum?

Figure 5

Once cleaned, the film is taken to the main FICA box, weighed and the weight is recorded (fig. 6). The film is then rewound on the FICA machine's film rewind. The rewind is a constant, low-tension rewind and the result is a consistent, very loose film roll (fig. 7). This roll is placed into the FICA cabinet, where it remains while the moisture is reduced (fig. 8). In the cabinet, the roll is neither on a reel, nor is it in a bag or a can. The FICA machine has durable wire shelves which support the roll while permitting a free flow of air around the roll of film. The air in the machine is conditioned to 68°F (20°C) and a relative humidity of 25%. The freely circulating air gradually reduces the amount of moisture in the roll of film to about 20%. This process takes several days.

The moisture loss in the film is periodically measured by weighing the film. After a weight loss of 20–30 grams, the film is removed from the cabinet so that it can be immediately packaged. We found that the whole process normally took five to seven days. The procedure quickly evolved into a consistent routine with the film being rewound and placed into the cabinet on a Tuesday, removed and bagged the following Monday. Once it is clear that the process is routine, it is not necessary to weigh each film roll.

To bag the film, the conditioned roll is removed from the cabinet, weighed, and (if the scale shows sufficient moisture loss) placed into one of the special FICA bags. The bag is then heat-sealed with a vacuum device that removes most of the air from the bag. This vacuum device must be adjusted carefully as it can remove all air from the bag with considerable force. In one test using an empty film can of metal we crushed the can. One roll of test film was bagged so tightly that it was possible to see the layers of

Figure 6

Figure 7

film through the bag which looked like a tight skin.

The bag is a three-layer laminated container, with an outer layer of polyester, a second layer of aluminium foil, and an inner layer of polyethylene. We had this bag tested by the Library's Conservation Laboratory which reported that it was a very high-quality material and met the Library's archival standards. In the year and a half during which we have used the system, we have not experienced any faults (e.g., leaks) in the bags. Although the Swedish Film Institute recommends that each roll be sealed in two bags, we have been using only one bag per roll.

The next stage is to can or box the bagged film, label it, and store it in the cold vault. This proved to be a vexing problem. Once the roll of film has been bagged, it will not fit easily into a conventional round film can because the bags are square. The bags must be square so that an effective seal can be made. We asked Gert Moberg about the possibility of a curved hot sealer so that a curved bag could be designed and used. He reported that they had considered this and found that a curved sealer was both more expensive and less efficient.

The problem with the square corners in the round can is that they result in a bulky fold-over which usually does not fit between the roll of film and the top of the can without being mashed down onto the film. Considering that the film roll within the vacuum-sealed bag is much looser than a conventional wind, we felt that this situation could result in damage to the film. We asked the Swedes if they were canning the film and they reported that they were using boxes rather than cans. We decided to follow their lead and use a cardboard box, rather than a metal or plastic film can. The film is now environmentally protected by the bag, and the box is providing support on the shelf, protection while in transport, and a place for identification of the film. It took us almost a year to determine the dimensions of the box, get specifications for a box that would comply with the Library's archival standards, and to find a supplier for the boxes. In the meantime the film was being sent to the cold vault and shelved in its bags. An unorthodox procedure, but once the film is stored in the cold vault, it is seldom moved again. To date, we have found no damage to the film.

The boxes we finally ordered were 15.5 by 15.5 by 1.75 inches (394 x 394 x 44 mm) (fig. 9). It was the height that proved unusual and which we considered very carefully since the increased height of the storage container reduces the number of containers that can go into the storage vault. We felt that this height would be adequate to protect the film from damage and minimize the space being lost in the vault. Lest this seem to be a petty consideration, remember that if the height of the container for 35 mm film increases by only a quarter of an inch, it means that only seven containers will fit where eight would fit before.

Since these boxes had to be custom-made, they were expensive: US$ 9 per box. Once the FICA system is in more general use, it may pay a container manufacturer to mass-produce containers, and the cost would be reduced; but until that happens, the container cost will be high. This cost factor can be an important consideration in any final decision about using the system.

The unit, including the additional acclimatisation cabinet, has a capacity of 52 double reels (2,000 feet or 600 metres). We processed about 35 double reels per week, so we did not press the system to its capacity. Working at this pace, the system was very efficient. The Swedish Film Institute believes that two or three more side units could be added, using the air conditioning from the main unit. This could increase the potential capacity to more than 200 double reels of 35 mm film per week and even more of 16 mm film.

During the entire period of use of the equipment we experienced one mechanical failure. This was caused by a defective electrical unit which burned out the heat-sealing unit. We had to telephone Stockholm to confirm the problem and parts had to be sent from Sweden, but they arrived promptly and the repair was done quickly by our own staff. Since we have several trained and experienced maintenance workers, they were able to identify the problem quickly and do the repair. The total downtime was less than two weeks. The problems we experienced were no different to those common to any piece of complex modern technology and the general assessment of our staff is that the machine is very well built, having components of very high quality.

So, what are our conclusions about the use of the FICA system?

Firstly, we are very impressed with the efficiency of the process. Before the test, we were concerned that preparation might involve too much staff time but, in fact, we found that the preparation took less time than we anticipated. It required less than one day's work by one staff member to prepare 35-50 reels of film per week.

Secondly, we find that the discipline of preparing the film for storage is a very positive benefit. Because of the volume of film received by the Library, film is only rarely cleaned and is normally shelved after a cursory inspection for condition. The FICA system forces a more careful inspection, cleaning and bagging as part of the shelving process. The film now goes to the shelf prepared in its proper condition, which certainly improves the potential survival of each of these films.

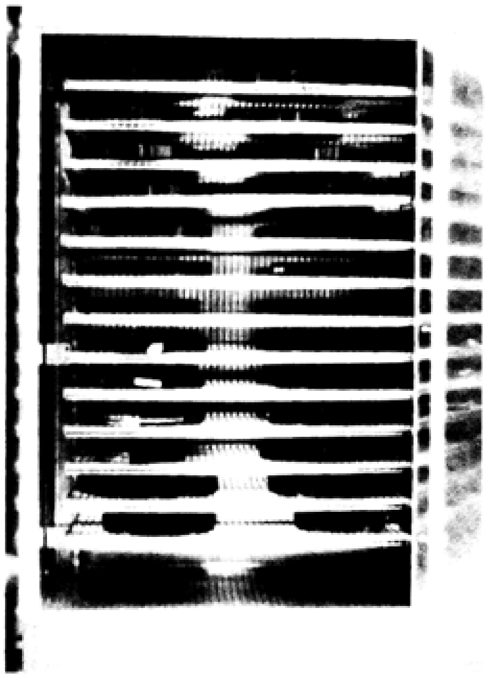


Figure 8

The FICA system protects the film during the acclimatisation before and after cold storage, and while the film is moving from building to building. This is a particularly important consideration in Washington where we have extremes of hot and cold temperatures and the humidity changes radically from day to day and is often quite different inside buildings than it is outside. The film is also protected from the corrosive effects of urban air pollution. Since much of the film in our collection, including all of the film in our vaults, has to be transported between different locations in the city, this protection is very important. The FICA system also provides insurance should the air conditioning in the vaults fail.

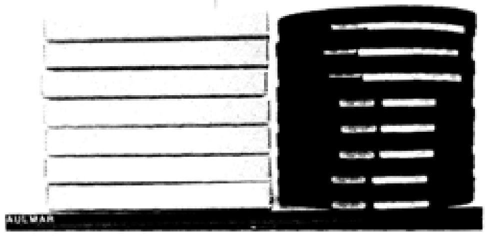


Figure 9

There are also several problems that we feel need to be considered.

Firstly, there is the technical question about the effect of residual chemicals from the cleaning solution in a vacuum environment. I hope the Preservation Commission will try to determine if this is a problem and to what extent it may affect the film. We are also concerned about storing the film with such a loose wind because of the potential for abrasions and damage to the edges of the film. Perhaps the films should be given a tighter wind before they are bagged?

The availability and cost of supplies to support the system (i.e., bags, cans or cartons) are other concerns. If these supplies are difficult to obtain and if they must come from a source outside your country careful planning is essential in order to keep the operation functioning without extended periods of downtime.

Although it was no problem for us, a reliable electrical current could be a problem in countries where there are frequent breakdowns in supply of current. Without reliable current the whole process could fail.

In reaching a final decision about the purchase of a FICA system, the Library of Congress has had to review it very carefully. The most accepted justification for using the system is to make it possible to store films in cold storage where there is an unreliable humidity control system. It happened that our test of the FICA system coincided with the completion of a new, large cold storage complex with three vaults. Because it was a large complex and because we were uncertain about how well the humidity controls would work, we felt that the FICA system might prove to be necessary insurance. However, when they became operational we found that the new vaults had remarkably stable temperature and humidity.

The major argument against purchasing this system is its cost. The machine itself, costing more than US$ 50,000, and the cost of cans and bags, which is at this time more than US$ 11 per reel prepared, make this a very expensive investment. At this point, we are still considering the purchase of the machine and are presently negotiating with AB Film-Teknik for a lease arrangement with an option to purchase the machine. In the meantime, we are exploring ways to reduce the cost of bags and boxes.

The satisfactory performance by our cold storage vaults caused us to rethink the use of the FICA system. Insurance against an unreliable humidity control system is now a secondary consideration, but after testing the FICA system for more than a year and a half, those of us who have been closest to the test are convinced that carefully preparing the film for storage and the continued protection of the FICA bag, stabilising the humidity level of the film regardless of where the film may move is important to the preservation of the films in our collection. We are also very interested in testing the system with other materials preserved, including video and audio tape, and disk recordings.

Experiences Using the FICA Method in a Tropical Climate

P. K. Nair

Introduction

We were introduced to the FICA method of preserving films at the Stockholm Congress in 1983 when a demonstration of the Film Conditioning Apparatus (FICA), developed by the Swedish Film Institute, was held at their vaults in Rotebro. We were told that the FICA method eliminates the difficulties in controlling the humidity at low temperatures, and that it is a scientific and economic way of storing film. This is made possible by the preconditioning of the film, and the storage in specially-made FICA bags.

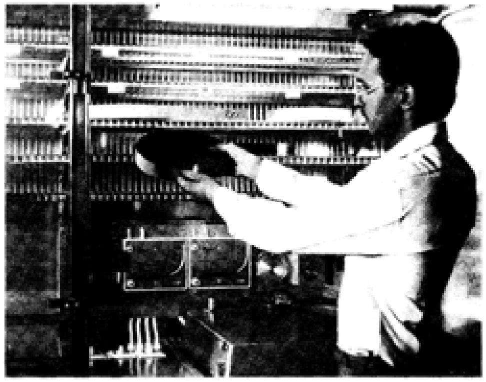


Figure 1

Thanks to the courtesy of the Swedish International Development Authority (SIDA) and UNESCO, the National Film Archive of India (NFAI) in Poona received the equipment in January 1985. We had earlier planned to install the machine in our new building complex, but because of some unforeseen delays in the construction of the complex, we had to find alternative accommodation with the proper electrical outputs.

Finally, the crate was opened in the presence of the two Swedish technicians, Mr. Gert Moberg and Mr. Ronnie Nilsson, who especially came to Poona in January 1986 to install the machine and put it into operation. This was done in one of the air-conditioned rooms of the Film and TV Institute of India (FTII), a sister organisation located in the same premises.

Our fears about the likely damage to the equipment, owing to the long delay in opening the crate, were dispelled when the Swedish technicians successfully put the machine into operation. One of our technicians was taught the various technical operations involved in conditioning and packaging the films.

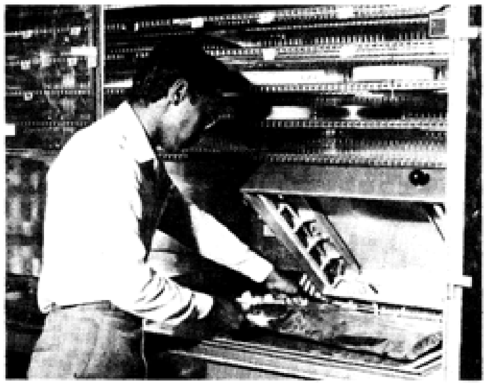


Figure 2

Voltage stabiliser

Our FICA machine requires a 3-phase, 380-to-400-volt, 50-Hz, 10-amp electrical output. In view of the erratic power supply by the State Electricity Board, we had to fabricate a special voltage stabiliser to ensure the correct voltage.

Winding

The film reel is wound with low tension to avoid likely damage during conditioning when the film dries, and to facilitate evaporation of moisture from the reel of film. After winding, the film reels are weighed in a sensitive weighing machine and are put on the shelves in the cabinet for conditioning.

Conditioning

The weight of the reel is measured every 24 hours, and the weight loss is plotted against the number of days. (An example of such a plot prepared by the NFAI in respect of some reels of an interpositive of S Ray's "Shatranj Ke Khilari" ["The Chess Players"] was shown at this stage of the presentation). The conditioning time varies according to the moisture content of the film reel and the type of raw stock. The normal conditioning time is about seven to eight days, and once it is obvious that the moisture content is removed thoroughly, the reel is sealed in a FICA bag.

Figure 3

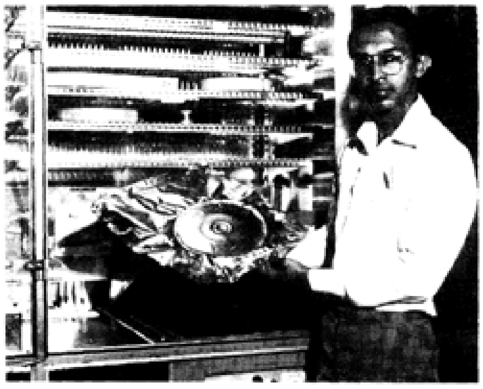


Figure 4

Stefan Lund:
I am involved in the project from Sweden and wish to make a few comments. The cabinet has been redesigned since Paul received his, for easier service and maintenance. The problem with electrical voltage has also been assessed. We think that in the future we will be able to deliver a system which can run on other than 3 phases and 380 volts.

Concerning the bags, we are well aware that in the future we have to store bags in several places all over the world. But you must remember that the cost of bags was actually based on a trial in manufacturing in Sweden. Hopefully we can soon give you a progress report on the availability and prices.

Henning Schou:
Please note that a paper by Messrs Horse and Bloman entitled "An Inexpensive Method For Preservation and Long-Term Storage of Color Films" using the FICA system was published in the "Journal of the Society of Motion Picture and Television Engineers" (SMPTE Journal, Vol. 92) in 1983.

Packing

The sealing of the film in a FICA bag takes place in a vacuum chamber. After the bag has been vacuum-sealed, it is important to check the quality of the seal. If it is not airtight, it must be redone (figs. 1-4).

Weighing

The bag is weighed immediately after it has been sealed, and it is then stored in the vaults. Periodical weighing of each sealed bag must be carried out to ensure that there is no change from the original weight. A steady weight is an indication of the success of the process.

All the sealed bags were weighed again in April 1987, and it was then confirmed that there had been no change in the weights (within 0.1 gram) of the majority of the bags. The change detected in a couple of cases may have been due to the inaccuracy of the weighing machine. (We were using an ordinary weighing machine and not a scientifically accurate one).

Practical difficulties

We had received 150 bags (50 of 2000-foot and 100 of 1000-foot capacity) along with the machine. Once these bags were used, we had to wait for the next supply, which has yet to come. To leave the machine idle for a long time is risky as some of the sensitive parts (like the filter and rotor in the dehumidifier unit) are likely to get choked, and thus obstruct the operation. Needless to say, there has to be a constant stock of bags for the continuous operation of the machine. The situation that one has to depend on periodical import of the bags is not a healthy one. The possibilities of obtaining the technical know-how for the indigenous manufacture of the bags have to be pursued.

Storage of the sealed bags

The film in a sealed bag often does not fit into the average 1000-foot or 2000-foot can. This may create problems of storage, especially in archives which do not have adequate space even for their existing collections.

Nature of Winding

Normally preservation copies are wound emulsion in for long storage. (Editor's note: The FIAF Preservation Commission recommends that films should be stored emulsion out). We are following the same procedure for FICA-box packing, but no guidelines have been given by the promoters of the equipment as to the correct method of winding before packing.

Evaluation

At this stage, with the limited experience obtained from packing only 150 bags and keeping them for a period of one year, one would not be in a position to make a final assessment of the FICA method as an economic way of preserving films in a tropical situation. Unless we go through an experience of packing at least 1000 bags of films of different bases, original picture negatives, sound negatives, master positives, duplicate negatives, interpositives, internegatives, black-and-white and colour emulsions, etc., and also check the quality of prints made from the preservation material sealed in the FICA bags at regular intervals, it would not at this time be advisable to make a firm assessment of this newly introduced process for archival preservation of films.

Film Archives in Tropical Countries – A Brazilian Experience
João Socrates de Oliveira

Henning Schou:
João Socrates de Oliveira from Cinemateca Brasileira will now present his paper on preservation in hot and humid countries.

The problem of preserving cinematographic collections in tropical climates is a complicated matter, which usually goes beyond purely technical considerations and has to face more complex difficulties such as constant political-economical oscillations, and the difficult access to more sophisticated technology. These subjects will not be discussed here but should be kept in mind.

The Speed of Reactions in Hot and Humid Climates

Deterioration can be understood as a group of reactions – spontaneous or induced – which result in the breakdown of an object, a film for example.

For a reaction to occur, certain conditions must exist. Basically the reagents have to be in contact with one another (maybe in different states such as solid, liquid or gaseous), and in the presence of a certain amount of activation energy which would initiate the process.

The materials used in cinematography cannot be considered entirely stable. There is a relatively low level of reactions which are activated by environmental conditions. These reactions occur at ambient temperatures and relative humidity, for example in cellulose nitrate bases or certain types of dyes that form images. On a molecular level this means that as the temperature goes up, the frequency of shocks between the reagents increases the energy involved which results in an increased speed reaction. Van't Hoff's law states that a 10°C increase in temperature doubles the speed of the reaction.

A large amount of water in the air, i. e., high relative humidity, causes an increase of the reaction known as hydrolysis. Depending on its activity, this can make the gelatin of the film emulsion change its physical state. These reactions can also cause certain dyes, which form colour images in films, to break down. In theory and in practice, the speed of deterioration of cinematographic materials is considerably greater in hot and humid climates than in more temperate and drier climates.

Examples of Frequent Deterioration in Our Archive

The most frequent cases of deterioration in our archives are the loss of plasticiser from acetate or safety films. In its different stages, this deterioration affects all types of film but is more critical in sound negatives. Our main problems are caused by a) the oxidation of silver image (in black-and-white films) mainly by sulphuration; b) fading of colour dyes; c) the direct action of external pollutants, and d) the growth of fungi and bacteria, especially in the gelatin.

We have examined a print of the film "Nem Sansao Nem Dalila" (1954) made by contact printing from the original negative. In the first part, we observed scratches and reticulations produced by the crystallisation of products released during deterioration. In the second part, it is possible to observe the results of poor contact between the negative and positive stock caused by acetate base deformations and the unstable gelatin. In the trailer of the film "Bahia por Exemplo" (1974) the dye images have faded.

Examples of Restoration Treatments

a) A print from a faded image and sound combined duplicate negative of the film "Descobrimento do Brasil" (1938). This duplicate has as its original a positive release print

and was made in the beginning of the 1950s.
b) A print which was made from a new duplicating cycle starting from the same faded black-and-white duplicate negative. The sound was rerecorded in a commercial sound studio where the scratches were copied into the original;
c) A dry contact print of an original nitrate negative printed at a slow speed (1 frame per second);
d) A dry contact print made from an original nitrate positive "Inclinicao Pelo Palco" without repair of perforations and splices; and
e) the same original printed in a liquid gate step printer.

Intervention to Stabilize the Masters of the Archives

To stabilise the film masters in the archives it is necessary to provide conditions which reduce the speed of the reactions of the stored material to very low levels.

In our case, we have three different kinds of stores for keeping material. 1) A climate-controlled area to keep the master film at a temperature of 16°C (60°F) and 50% relative humidity. 2) Two nonclimate-controlled areas to keep copies for exhibition with air changes six times per minute. In the hotter seasons, this system is turned on at night and turned off during the day. Relying on the thermal inertia of the building, we are able to get a 10°C difference in temperature between the exterior and the interior with a relative humidity of about 75 to 80%. 3) Two areas which are not climate controlled for storage of cellulose nitrate film.

These conditions are far from being ideal, but undoubtedly they reduce the speed of deterioration to more acceptable levels.

The removal of residual processing chemicals in the black-and-white films is another important stage, since the speed of the reactions decreases as a function of the decrease in reagents available. This care in preventing the films from coming into contact with chemically active material also applies to containers, furniture, etc. We use plastic film cans, but unfortunately we cannot replace all, mainly because of the cost. However, we are slowly working on this.

Finally, one factor we have not been able to get around is the gases that pollute our city. However, we are planning to move our archives to an area outside the city.

The Danger from Fungi and Bacteria Encountered During Permanent Storage of Film Material Vladimir Opela

Henning Schou:
As President of the FIAF Preservation Commission, I established two subcommissions, namely an East-European and a North-American working group, in an attempt to spread the workload of the Commission as widely as possible. I am proud of the excellent work af the East-European Preservation Subcommission headed by Hans-Eckart Karnstädt from the Staatliches Filmarchiv der DDR.

One of the Subcommission's projects is research into treatment of film contaminated with bacteria and fungi which pose a major threat to materials held in archives, especially those in hot and humid countries. The project is co-ordinated by Vladimir Opela of the Czech Film Archive (Ceskoslovensky Filmovy Ustav, Filmovy Archiv) who managed to secure the collaboration of the universities in Prague and Brno. I believe that the research group has so far carried out some 2000 tests using numerous strains of bacteria and fungi.

Mr. Opela will now present a progress report.

In 1974 we completed the transfer of our film collections from various temporary stores (such as old brick kilns, mills, cellars, and a castle) to two archival stores. We also completed the technical inspection of this material. This had taken us five years.

The inspection revealed that three million metres (9.8 million feet) of film, i.e., 5 per cent of all film material deposited in our film archives, had been attacked by microorganisms to varying degrees. If these materials were to be preserved for future generations, it was necessary to minimise the effects of the microbial attacks. In the literature of that time we found that only a few works dealt with these issues. T. G. Eaton, G. A. Greathouse, C. A. Wessel, R. Kowalik, I. Sandurske and other researchers describe various aspects of the microbial damage of such materials, but they only partly suggest methods of restoration and prevention.

Our film archives therefore proposed that the Barrandov Film Laboratories establish a small research group consisting of specialists from film laboratories and microbiologists from the Charles University in Prague and the University in Brno. The aim of this research group was to develop a method of mildew removal from both black-and-white and colour film on cellulose-nitrate and cellulose-acetate bases.

In a set period of two years, the aim was a) to determine what species of microorganisms grow on films, b) to screen substances having an antimicrobial effect, c) to check whether these substances have a detrimental effect on a photographic picture (gelatin emulsion and base) and thus affect the overall film quality. From 1977 to 1983 we removed mildew from approximately three million metres (9.8 million feet) of film materials, and in 1984 we continued this process with film materials from our Bulgarian colleagues. We have now been researching the occurrence of microorganisms in archival stores for some years. In 1985, upon request from the State Film Archives in Hanoi, we began research on microorganisms which had attacked practically all film materials deposited in their archives.

Now, allow me to acquaint you with some results of the research which our colleagues Mr. Polster, Associate Professor Dr. Svobodová, Dr. Konopásek and Mr. Z. Stuchlík have carried out so far.

Film materials may be damaged by biological factors, particularly those of a microbial character. The gelatin layer is extremely susceptible to microscopic fungi/mildews (micromycetes), bacteria and yeast cells. However, both bacteria and yeast cells are very sensitive to the silver content of black-and-white film materials and also considerably sensitive to the colour-forming components in colour films. Because of this growth-inhibiting effect, bacteria and yeast cells do not represent a real danger to film materials stored under the conditions of the Middle-European mild zone.

Unfortunately, mildews are highly resistant to silver and colourforming components in film materials, thus representing the main danger for such materials. Mildews can grow on or within the gelatin layer, damaging this layer both mechanically and chemically (by their metabolites) and to a smaller extent even the base, particularly at the edges and the sprocket holes of the film. Temperature and relative humidity are of great significance for the growth and development of mildews. The optimum temperature for the growth of the majority of mildews is 26–28°C (79–82°F). There are, however, some species called thermophiles whose growth rate reaches a maximum around 50°C (122°F). At the other end of the scale, there are psychrophile mildews which prefer temperatures around 0°C (32°F) or even lower. Unfortunately, common mildews are considerably adaptable and can form thermo- or psychro-tolerant variants. The development of mildew occurs at a relative humidity (RH) above 70%.

On most of the contaminated film material, the research group found mainly members belonging to the genuses Penicillium, Aspergillus Chaetomium, Alternaria, Paecilomyces, Cladosporium, Trichoderms, Mucor, and Scopulariopsis. From the damaged spots visible to the naked eye, we have isolated and identified mainly members of genus Aspergillus, particularly A flavus, A terreus, A glaucus, A versicolor, and A fumigatus. Of the genus Penicillium, we found mainly P expansum, Scopulariopsis brevicaulis, Cladosporium, Sphaerospermum, and Mucor racemosus. From the visibly as well as microscopically intact film material, we isolated spores from the surface of the material using specific substrates and then incubated them under optimum conditions. These spores consisted mainly of mildews belonging to the genuses Penicillium, Aspergillus, Alternaria, Trichoderma, and Mucor. Samples of spores collected from the inner parts of metal film cans contained the genuses Aspergillus terreus, A versicolor, A clavatus, A flavus, A repens, Penicillium expansum, P diversum, P albicans, P cyclopium, P chrasogenum, Trichoderma viridae, and Alternaria chartarum.

We found that the physiological properties of the mildews growing on the film material, as well as those of their spores, differed greatly from those of the wild type. Generally, the mildews had not grown normally, i.e., had not formed mossy, cotton-wool-like or soft-hair-like clones but soft, mainly colourless, floury, gritty clones on the gelatin and the base of the film. In the visible mildew clones, and in the mildews whose filaments were growing through the gelatin layer, we did not observe the formation of any fructifical organs.

The best growth media for the cultivation of mildews proved to be sweet wort agar, fluid sweet wort substrate, Czapek-Dox agar, sometimes enriched with chloramphenicol (0.01%).

The isolated and identified species were cultivated using the above substrates.

During the screening of the antifungal effect of various agents, the following items were observed:

1. Mildew species in examined samples;
2. Natural growth of mildews (which we artificially contaminated) in optimum humidity and temperature conditions;
3. Growth in artificially contaminated samples in optimum humidity and temperature conditions;
4. Resistance of film samples to mildews was determined after treatment of the spores with an antifungal agent on sweet wort agar;
5. The sensitivity of a spore mixture obtained from the samples towards various concentrations of the antifungal agent was examined, using the method of a fluid substrate as well as the method of filter discs.

The main experiment, establishing the effectiveness of the selected antifungal agent, was carried out in the following manner:

Samples were artificially contaminated with a thick suspension of Aspergillus flavus mildew spores (10 per ml of physiological solution). An additional three sets of samples were contaminated with suspensions of Penicillium expansum, Alternaria alternans and one isolated from the mouldy sample, respectively. Afterwards the samples were incubated on the specific substrate and under the optimum conditions (28°C [82°F], 80% RH). The samples treated with the chosen antifungal agent were free from any growth of mildew even after three weeks, whereas the neighbouring substrate was heavily contaminated with mildews. The treatment with this agent guarantees several years of protection for film materials against microbial attack even under conditions which are not generally optimum for long-term storage of film materials.

I would now like to comment on the antifungal technology concerned. As already mentioned, from the very beginning in 1974 Barrandov Film Laboratories (as requested by our Film Archive) started to develop a special technology which would allow total removal of fungi and bacteria from motion picture films. There was also a need to develop some system to prevent all the processed materials from being visually affected.

The first tests were carried out using home-made VUMA film cleaning machines for 16 and 35 mm films. The antifungal properties of chlorinated solvent, such as 1,1,1-trichloroethane, trichloroethylene, perchloroethylene (all with stabilizers), and 1,1,2-trichloro-1,2,2-trifluoroethane (which are normally used for film cleaning and wet-gate printing) were assessed.

The above-mentioned solvents do not affect film bases during the short period they are in contact with them during normal operation. However, extended treatment using trichloro- and perchloro-ethylene will result in loss of plasticizer and thus cause brittleness and distortion of the film base. For the solvents to have any significant antifungal effect, the film must, however, be treated for an extended period of time thus rendering the solvent of limited use as a fungicide.

But the main reason why even ultrasonic treatments with chlorinated solvents are of limited value is the inability of the solvents to penetrate the gelatin and thus kill and remove fungi growing inside the emulsion. Film materials treated with solvent and mechanical wiper blades soon developed visible clones of fungi.

After the poor results obtained in the above tests using organic solvents, a series of tests using aqueous solutions of fungicides were implemented. For this purpose, an old and simple developing machine (a TUMPACH processor) was rebuilt to wash and treat the contaminated film. Both black-and-white and colour film were used in the tests.

When using organic fungicides, colour fading was observed in many cases. The extent of the fading depended on the length of the treatment.

Long-term storage without loss of quality is a prerequisite for proper preservation of motion picture materials. The long-term effects of various mixtures of chemical fungicides therefore have to be investigated, making the tests lengthy.

We also tried to eliminate fungus and bacteria from the water used during the processing of the film. We tested some compounds which should retain the germicidal effect longer than conventional chlorine- and bromine-based products. Isothiazolin, manufactured by the Californian Pace Corporation, proved to be the most suitable. However, further tests revealed that treatment of water used for film processing was unnecessary.

The main aim was now to find a highly effective, water-soluble fungicide, which acts immediately in weak acid and basic (as well as neutral) solutions, and has a long-lasting effect on a wide spectrum of fungi.

We tested many compounds, such as
- KM101 (Gerbstoffchemie),
- CA24 (Biochema Schwaben),
- Preventol GMB (Bayer),
- Metathin GT (Acima), and
- Dowicil 75 (Dow Chemicals).

During the tests, we regularly inspected the antifungal stability and the photographic quality of the test material. For this purpose, we also had reference wedges consisting of black-and-white and colour film, some of which had been contaminated with fungus strains isolated from contaminated archival film. The resistance to fungus was tested regularly and the densitometric values determined on both the contaminated and the sterile wedges. The tests using contaminated wedges were carried out under optimum conditions for fungus growth. Some old, treated samples of original colour negatives, intermediates and prints are being kept in a refrigerator as control samples. They are inspected at regular intervals for possible colour fading.

The whole procedure differs in details according to the degree of fungal growth on the film. There are three degrees of classification with increasing amounts of active fungicides.

If the condition of the film is poor and/or if the fungal attack is severe, wiper blades and rotary brushes are used in combination with a film-hardening solution.

New fungicides are continuously tested. Currently two basic technologies are used. One for black-and-white film and another for colour material.

Both 16 and 35 mm negatives, duplicating materials and positive prints are treated in two steps in a simple developing machine which has been modified for this purpose. In the first step, the film is cleaned and immediately after treated with fungicide for a short period of time. The fungi are washed from the surface and then out of the emulsion. An additional mechanical wipe is applied if necessary.

Following the thorough washing, a stabilising solution is applied. This contains other types of fungicide in addition to the stabilising agents.

In our experience, highly halogenated aliphatic or aromatic hydrocarbons, organo-metals, and mixtures of organic fungicides generally provide sufficient protection against growth of fungi and bacteria on motion picture films. The materials treated ten years ago are still resistant. The above-mentioned technology is covered by a patent.

Final remarks and recommendations

1. Moulds can severely damage film materials. They have very low nutritional and growth requirements. In a dormant state they are able to survive under unfavourable conditions for very long periods. They need relatively high air humidity (i.e., over 70%) for their growth. They multiply over a very short period, e.g., every 20 minutes.

2. Moulds exist everywhere: in the air, on the walls, on the floor, on and in the cans, on the film material, and on the cores.

3. The surfaces of the cans are the main source of contamination of film material. Here, the amount of moulds is one thousand times higher than in the air.

4. To restrict the amount of contamination of film material, the following rules should be observed:
a) Ensure that the relative humidity is never allowed to rise above 70%;
b) Movement of people and film material should be kept to a minimum inside the vaults;
c) Any traces of humidity on the walls or on any other surface in vaults should be removed immediately;
d) Appropriate disinfectants should be used during regular cleaning operations.

If moulds emerge in spite of all these precautions, contact me at the archive in Prague for further advice.

<u>Henning Schou:</u>
We are looking forward to receiving the final report with recommendations not only concerning preventive measures against attack by bacteria and fungi, but also regarding treatment once the attack has occurred and the materials have been damaged. The full report will be published in the FIAF Preservation Commission Technical Manual.

Test for Residual Chemicals in Film Emulsions
Harald Brandes

It is the daily practice of the Bundesarchiv/Filmarchiv to basically examine all recently printed materials (negatives, dupe-positives or release prints) as to residual thiosulphate. As we have to examine large amounts of material, we cannot spend too much time for this and consequently we have chosen a really simple method – the test described by Professor Aeltermann, who worked for Agfa Gevaert in Mortsel until recently:

- We take a dropper bottle with solution A (10 g $AgNO_3$ + 10 ml pure acetic acid per litre) and apply one drop on one spot of the film that shows a regular grey-density.

- We allow this drop to act for 2 minutes, then we remove it with a piece of absorbent paper.

- Then we apply one drop of solution B (1% NH_4OH and 5 g NaCl per litre) on the same spot of the film, where the surplus of solution A was removed.

- We allow solution B to act for 2 minutes and remove the drop with a piece of absorbent paper.

- After drying, the difference of density between the patch and its surrounding area can be measured by means of a colour densitometer.

- The difference of density in the brownish yellow patch is directly related to the amount of the residual sodium or ammonium thiosulphate in the film material:

Difference of density:
0.01 = 0.90 µg/cm²
0.02 = 1.81 µg/cm²
0.03 = 2.72 µg/cm²
0.04 = 3.6 µg/cm²
0.05 = 4.5 µg/cm²
0.06 = 5.4 µg/cm²
0.07 = 6.3 µg/cm²
0.08 = 7.2 µg/cm²
0.09 = 8.18 µg/cm²
0.10 = 9.0 µg/cm²

Henning Schou:
Eileen Bowser and John Kuiper are currently editing the second edition of the "FIAF Handbook for Film Archives". In this book, you will find a fairly extensive chapter on film preservation which includes a section on "Conservation Treatments Prior to Storage". It is important that any residual chemicals are removed from the film prior to storage. If, for example, you have any thiosulphate ("hypo") left in the emulsion, you may see some degradation of the image over time. You may all be familiar with the standard Crabtree-Ross test for residual hypo using mercuric chloride which is so toxic that if you happen to lick your contaminated finger while doing the test, you might not survive the day. The methylene blue test, however, is not risky but somewhat cumbersome.

Harald Brandes of the Bundesarchiv in Koblenz will now describe some simpler tests.

The Archival Quality of Film Bases
Karel Brems

Processed photographic film consists of different elements. These are the film base (the support), the subbing layer (or so-called substratum), and the emulsion layers which consist mainly of gelatin and the image forming substances. The latter may be either silver or colour dyes.

The influence of storage conditions on the gelatin and the imageforming substances has been studied and described extensively. Here we will discuss the influence of the film base and the substratum on the overall archival quality of a photographic film.

A photographic film base should meet several different physical and chemical requirements, such as good dimensional stability, good wet and dry mechanical strength, and good chemical stability over a long period of time (when properly stored). Furthermore, it should remain transparent during its normal lifetime.

Up till now only a few polymeric materials have met all these criteria required by the photographic film industry. These polymers are cellulose derivatives such as cellulose nitrate, cellulose triacetate, and to a lesser extent cellulose propionate and butyrate.

All of these polymers are esters of cellulose and either an inorganic or an organic acid. Only recently another ester, poly[ethylene terephthalate] (PET), has become important in the motion picture industry, and that despite the fact that this ester of ethylene glycol and terephthalic acid has been used for graphic and x-ray film for almost thirty years, because of its exceptional dimensional stability among other good characteristics.

In the early days of the photographic film industry, the only suitable film base was cellulose nitrate. However, due to two unfortunate characteristics, namely high flammability and low chemical stability, the use of cellulose nitrate as a film base was discontinued in the 1950s. At that time, organic cellulose esters (such as triacetate) took over. They had already been introduced for other purposes, mainly as amateur products, in the 1920s.

It has been predicted that triacetate should last for at least a few hundred years if kept under proper storage conditions (refer ANSI PH5.4-1970 and ANSI PH1.43-1971).

Triacetate should not be stored together with nitrate film because the decomposition products of cellulose nitrate attack the acetate film. This was described by J. F. Carroll and John M. Calhoun in their paper "Effect of Nitrogen Oxide Gases on Processed Acetate Film" published in the "Journal of the Society of Motion Picture and Television Engineers" in 1955.

Using cellulose nitrate as an ingredient, e.g., in the substratum, of a photographic material is not recommended because the decomposition products of the nitrate are generated in the material itself. This has a deteriorating effect on the triacetate film base. [Editor: The Eastman Kodak Company has claimed that the buffer capacity of the gelatin emulsion is so high that the minute amount of decompositon product has no effect.]

Recently the archival world has been confronted with the decomposition of triacetate, the so-called "Vinegar Syndrome"; vinegar being the common name for a diluted solution of acetic acid. During this decomposition, the cellulose triacetate is releasing acetic acid, the odour of which you can instantly recognize when opening a film can.

<u>Henning Schou:</u>
We now come to a topic which concerns us greatly within the International Federation of Film Archives. Following a visit to the Film Archive in Manila, Harold Brown of the National Film Archive (London) observed specimens of triacetate film in which the base had become limp and the surface had taken on a "crazed" appearance. Some magnetic film had shed a large amount of white powder. Harold also examined other triacetate specimens received from different parts of the world. The affected film stocks were made by four different manufacturers.

One researcher has postulated that the breakdown starts with the plasticiser which then initiates the self-destruction of the cellulose ester. As a result, the film becomes soft and later very brittle if allowed to dry; in other words, quite useless. Because the breakdown is characterised by the strong smell of acetic acid, it is known as the "Vinegar Syndrome". So far, "Vinegar Syndrome" film has been reported in France, Brazil, India, Britain, Australia and the USA where David G Horvath researched the extent of the problem and submitted a 91-page report, "The Acetate Negative Survey", sponsored by the University of Louisville and the National Museum Act.

This discovery has come as a significant blow to the world of film archives which so far has considered black-and-white safety films archival material. The preliminary observations are serious, and the decomposition process, the extent of the problem, and possible means to prevent the breakdown or to stop it must be studied as a matter of urgency.

Ms. Michèle Edge, a postgraduate research student working with Dr. Norman Allen at the Manchester Polytechnic, is currently researching the problem, sponsored by the National Film Archive *in London and Kodak UK. They hope to be able to find a stabilising agent, which can be injected into the film base by diffusion. If one succeeds in injecting a small amount, say 1%, of such a stabiliser, it should be possible to stop any further decomposition by neutralising the small amount of acid which causes the autocatalytic decomposition to proceed. Dr. Allen is hopeful that it will eventually be possible to stabilise even cellulose nitrate films. In conjunction with this work, the effects of the introduction into the film of various stabilisers will be investigated.*

Ms. Edge's findings so far have been summarized in a paper entitled "The Degradation and Stabilisation of Historic Cellulose Acetate/Nitrate Based Motion Picture Film". [Editor: Paper presented at the Symposium on Storage of Recorded Images organised by the Royal Photographic Society of Great Britain, Oxford, 21–25 September 1987].

The Image Permanence Institute at the Rochester Institute of Technology is looking for sponsorship to research the decomposition of up to 17.000 film samples.

However, to this day there is no known way of bringing the decomposition to a halt once the autocatalytic decomposition of cellulose acetate safety films has started.

Agfa-Gevaert in Belgium has assessed the problem, and Dr. Karel Brems will now present a progress report.

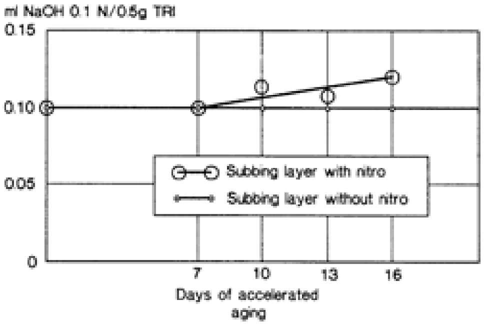


Figure 1
Free acidity test according to ANSI pH 1.28-1984

At Photokina last year, Agfa-Gevaert was contacted by Mr. Brandes of the Bundesarchiv in Koblenz and Mrs. Orbanz of the Stiftung Deutsche Kinemathek. They asked us whether we were prepared to do some research into this phenomenon, and they later provided us with 44 samples of decomposing safety film from archives in four different countries. Unfortunately we were not able to obtain information concerning the various conditions under which the samples had been stored.

In the March 1987 issue of "Bild und Ton", Dr. Pollakowski of the DEFA Zentralstelle für Filmtechnik in Berlin Ost, published results of research into 13 film samples showing vinegar syndrome. In his paper entitled "Wie sicher ist Sicherheitsfilm" ("How Safe is Safety Film"), Dr. Pollakowski assumes that the cellulose nitrate used in the substratum of the film initiates the deterioration of the triacetate film base.

In the Agfa-Gevaert Research Laboratories, we tested a triacetate base, a triacetate base with a cellulose-nitrate-free substratum, and a triacetate base with a substratum containing cellulose nitrate. After accelerated ageing at 67°C (153°F) and 50% relative humidity (RH), we measured the free acidity of the film according to ANSI PH1.28-1984 (fig. 1).

Although after 14 days the free acidity remained within the recommended tolerances, it was obvious that the free acidity increased more in the film base containing nitrate substratum than in the one without.

We also tested the 44 samples showing the vinegar syndrome for the presence of cellulose nitrate by using diphenylamine. However, we also used infrared spectroscopy because the results of the diphenylamine test were not conclusive. 25 of the 44 samples contained cellulose nitrate; 19 did not.

If the presence of cellulose nitrate in the substratum is the primary, if not only, reason for the deterioration of triacetate as stated by Dr. Pollakowski, we can only conclude that the 19 nitrate-free samples must have been contaminated by other deteriorating film samples containing cellulose nitrate. This can only be confirmed by the people who provided the samples. If the samples have not been contaminated, that is, if the presence of cellulose nitrate is not the only or primary reason for the deterioration of the triacetate base, we have to look for another explanation.

It is well known that triacetate can undergo hydrolysis with release of acetic acid. This chemical reaction may be catalysed by either acids or alkalis. According to K. Richau, H. H. Schwarz and V. Kulela in their paper "Einfluß der Hydrolyse auf die Struktur von Umkehrosmosemembranen aus Zelluloseacetat" published in "Acta Polymerica", No. 34 (2) (1983), the speed of the hydrolysis is minimal at pH 4–5. Kenneth D. Vos, Floyd O. Burris and Robert L. Riley in their paper "Kinetic Study of the Hydrolysis of Cellulose Triacetate in the pH Range of 2–10" in the "Journal of Applied Polymer Science", Vol. 10 (1966), also found a minimum in the rate of hydrolysis at pH 4–5. The relation between the reaction rate and the pH is very steep, which means that when the pH shifts away from pH 4–5, either to lower or higher values, the rate of hydrolysis increases very rapidly (figs. 2, 3).

Another aspect of the hydrolysis is that the lower the acetylation degree the higher the reaction speed. This means that a fully esterified acetate (triacetate) undergoes hydrolysis slower than diacetate, for instance, as mentioned in the book "Cellulose and Cellulose Derivatives" by Ott, Spurlin and Grafflin.

In an alkali-catalysed hydrolysis, the released acetic acid will gradually neutralise the alkali, and as a result, the pH and the reaction speed will eventually go down and reach a minimum at pH 4–5.

In an acid-catalysed hydrolysis, however, the released acetic acid lowers the pH and thus increases the reaction rate. In other words, the reaction is autocatalytic, that is, once it starts, it will continue at an ever increasing rate. As far as we know, nothing has been found to stop this reaction.

Now that we know that the hydrolysis of cellulose acetate is catalysed by acid and alkali, and increases with decreasing degree of esterification, it is worthwhile considering some aspects of the production of cellulose triacetate. The triacetate ester is the reaction product of cellulose and a mixture of acetic acid, acetic anhydride, and a strong acid (like sulphuric acid or perchloric acid) as a catalyst. The degree of esterification and the concentration of residual acid depend on the production method (fig. 4).

There are two ways of preparing cellulose triacetate. The technology is described in detail in "Cellulose and Cellulose Derivatives". In this context, I will only mention the difference between the two methods.

The first method is called "the homogeneous method" which is also known as "the solution process". Here, the cellulose fibres slowly and completely dissolve in the reaction medium during the esterification. The reaction is then stopped by the addition of water which reduces the acid concentration. However, this causes a certain degree of hydrolysis (de-esterification) (fig. 5).

The second method is "the inhomogeneous method" which is also known as "the fibrous acetylation process". By adding a sufficient quantity of a liquid which does not dissolve cellulose acetate in the acetylation bath, the reaction product is prevented from passing into solution, and thus a fibrous esterification results. The reaction is stopped by extensive washing with the nonsolvent. As a result, a true triacetate is obtained because no hydrolysis has taken place.

The second method has two advantages. Firstly, because of the fibrous structure of the triacetate, the diffusion is much faster, and it is therefore much easier to remove all acids of the esterification process once the reaction is terminated. The end product is a so-called stabilised triacetate because of the lower risk for hydrolysis. Secondly, the resistance to hydrolysis is higher because of the higher degree of esterification. As a result of these two advantages, the product has the highest possible guarantee of chemical stability, provided it is not contaminated by other products.

The photographic film material on triacetate base manufactured by Agfa-Gevaert in Belgium has always been made using the fibrous process. However, Agfa triacetate motion picture films manufactured between 1951 and 1964 in Leverkusen were made from triacetate produced by the solution method. From 1964, the production of motion picture film has been entirely concentrated in Belgium.

Another important element of the production of a photographic material, besides the film base, is the subbing layer, the so-called substratum. Because of the detrimental effect of the deterioration products of cellulose nitrate on the stability of triacetate, the use of cellulose nitrate in the substratum should be avoided. It was therefore amazing to find that the specification for the nitrate content of processed film as mentioned in ANSI PH1.28-1973 is no longer mentioned in ANSI PH1.28-1984 nor in the DIN Norm 19.070 of September 1985. From the available records dating back to 1945 we know that cellulose nitrate has never been used in subbing layers in our plant in Belgium. Available records from Leverkusen show that cellulose nitrate was certainly not used after 1958.
Because of the risk of hydrolysis of the triacetate, only weak acids should be used in the preparation of substratum layers. Moreover, these weak acids should be very soluble in water so they can be easily removed during processing.

This brings us to another aspect of the preparation of a film print, namely the handling of film material in the processing laboratory. During processing, film material is treated in different processing solutions, some of them alkaline, others acidic, ranging from pH less than 1 up to 12 and more.

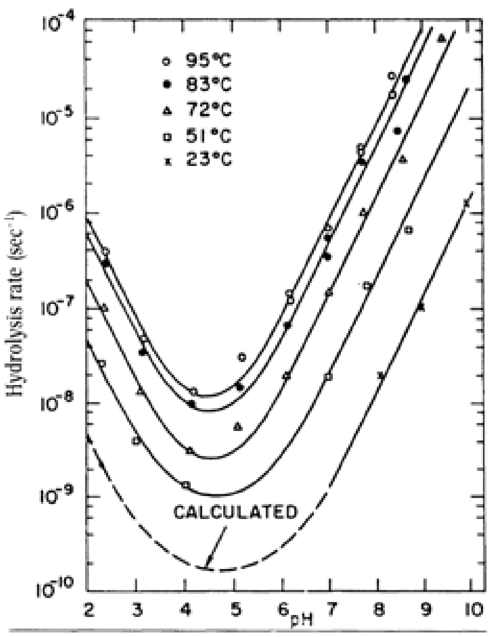


Figure 2

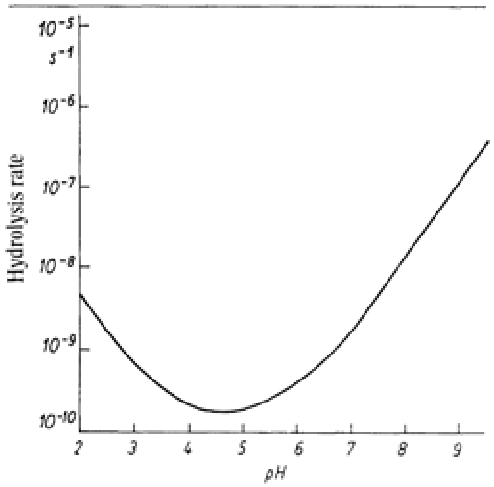


Figure 3

$$\left[(C_6H_7O_2)-(O-CO-CH_3)_3\right]_x + H_2O$$

cellulose triacetate

$$\downarrow$$

$$\left[(C_6H_8O_3)-(O-CO-CH_3)_2\right]_x + CH_3COOH$$

cellulose diacetate — acetic acid.

Figure 4

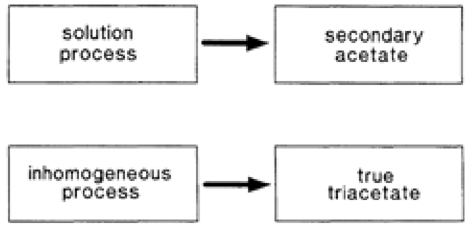


Figure 5

We can not exclude the possibility that the trend towards shorter and more active processing steps introduces an additional risk to the stability of the film base. For instance for colour positive materials, the ECP-II process has replaced the ECP-I process almost completely in the last 10 years. The ECP-II process differs from the ECP-I process in higher temperatures, shorter processing times, and the use of a highly acidic sulphuric acid stop bath after the development. Although we do not have very many figures at this moment, we have indications that the free acidity increases faster after ECP-II processing than after ECP-I processing. This can be concluded from the analysis of colour positive 982 film processed according to both specifications and tested for free acidity according to ANSI PH1.28-1984 after accelerated ageing, not at 100°C (212°F) and 20% RH but at 67°C (153°F) and 50% RH. Comparison of materials treated in different processing conditions are being conducted.

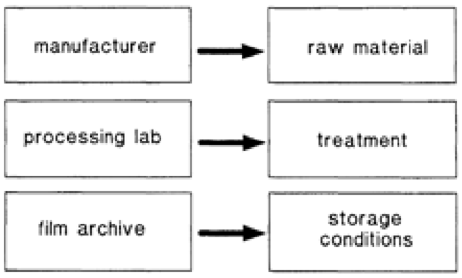


Figure 6

Viscosity Retention of PET

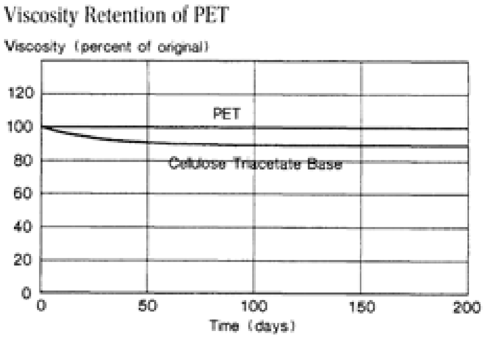


Figure 7

Viscosity Retention of PET

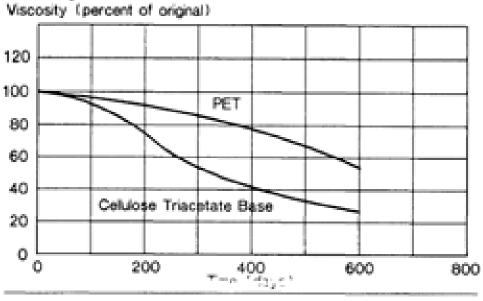


Figure 8

To summarize: in the interest of the whole film industry, everyone involved in the handling of film material should be aware of their responsibility:

1. The manufacturer of the raw material should deliver a product with the highest possible degree of archival quality.

2. The processing laboratory should treat the film according to the processing specifications. We believe that the best way of getting the highest possible archival quality for the triacetate base is to adjust the pH of the film base to 5 or higher after processing. We are gathering more information concerning this subject.

3. In film archives, cellulose acetate and nitrate materials should be stored separately. We believe that film should be conditioned at 25–30% RH at room temperature, vacuum-sealed, and stored at as low a temperature possible, preferably at -18°C (0°F) (fig. 6).

The literature mentions that triacetate film base, if not contaminated by other layers or other products, and if stored under the proper storage conditions, will last for at least a few hundred years. However there seems to be a discrepancy between this statement and the recent practical experience in the archival world. We therefore believe that poly[ethylene terephthalate] (PET) is a safe choice as a base for film material for archival purposes (figs. 7, 8).

To confirm the chemical stability of PET base compared with cellulose triacetate, we tested both of them for free acidity according to ANSI PH1.28-1984 for acetate and ANSI PH1.41-1985 for PET and once more we found that PET has substantially greater chemical stability than cellulose triacetate. This is in accordance with the results of P. Z. Adelstein and J. L. McCrea as published in their papers "Permanence of Processed Estar Polyester Base Photographic Film" in the journal "Photographic Science and Engineering", Vol. 9 (1965), and "Stability of Processed Polyester Base Photographic Film" in the "Journal of Applied Photographic Engineering", Vol. 7 (6) (1981).

Agfa-Gevaert manufactures colour positive material 982 and sound negative material ST8 on polyester base, and if there is a real market demand, we are willing to consider the production of black-and-white positive material on polyester.

<u>Harald Brandes:</u>
You mentioned that this process of acetate decomposition cannot be stayed off. The more interesting it would be for the archives to hear how early it is recognizable.
<u>Karel Brems:</u>
I think you can find that out by doing the free acidity test.
<u>Carlos Arnaldo:</u>
Do you see any relation between poor washing of film, to remove residual hypo, and the decomposition of triacetate?
<u>Karel Brems:</u>
No, I do not think so. The only relation I see is that, because of shorter treatment times, the level of remaining acid is higher.
<u>Hans Karnstädt:</u>
So far we have discovered four cases of vinegar syndrome in our archive. Without exception these cases occurred in black-and-white materials. You mentioned 44 samples at your disposal – were they also black-and-white materials? No colour materials?
<u>Karel Brems:</u>
No, no colour materials.
<u>Dietrich Schüller:</u>
It was most interesting to hear what you said about the vinegar syndrome, and that is the point where we could have a cross-media advantage, perhaps. There is a substantial amount of triacetate sound tapes in sound archives, and I must say that in my archive we have not had any problems so far. I wonder whether other sound archivists have ever noticed something similar, which could perhaps give an indication as to where the trouble comes from. If there is no problem with audio tapes then it may be related to those layers which are peculiar to films. (Karel Brems: Could be, yes) But my question is addressed to other audio archivists as well. Have they noticed any similar decomposition of their holdings?
<u>Rex Belgrove:</u>
We have had magnetic tape with so-called vinegar syndrome at our archive. We have found quite a lot now with vinegar syndrome – and most of it is being stored under temperate conditions. One film going off is dreary enough, but we are concerned that the one tape could affect others stored in the same vault.
<u>Gert Moberg:</u>
What is the effect of high humidity?
<u>Karel Brems:</u>
It would certainly increase the speed of the hydrolysation.
<u>Gert Moberg:</u>
Would that lead to new recommendations for the humidity of film storage?
<u>Karel Brems:</u>
Yes, I would say that you should store it in a relative humidity of, say, 25–30% and a temperature as low as possible. [Editor: This is not a <u>new</u> recommendation]
<u>Henning Schou:</u>
Recently I had the good fortune of spending some time in the Public Archives of Canada with Dr. Klaus B. Hendriks, who has an extensive data bank on computer. We did a brief computer survey and found one article which stated that, because of high humidity, the plasticiser of the safety film, triphenol phosphate, had been hydrolised, that is, split into phenol and phosphoric acid. Those of you who have seen film suffering from the vinegar syndrome might have noticed a crystalline deposit of phosphoric acid on the surface of the film. The theory is, that this hydrolysis initiates an acid-catalysed decomposition of cellulose acetate base.
<u>Philippe Poncin:</u>
I have two questions: firstly, as to your suggestions of introducing new materials on the market, what would the price difference be, compared to the existing materials?
<u>Karel Brems:</u>
I believe that the price would be the same.
<u>Philippe Poncin:</u>
And what about the other manufacturers?
<u>Henning Schou:</u>
We have also received an offer from Eastman Kodak in Rochester. As long as you order a minimum of 38,000 feet, they are prepared to make fine grain master positives (type 5366) and fine grain negatives (type 5234) on polyester. Kodak also claim that they will be able to supply these stocks at approximately the same price as for acetate stocks.
<u>Philippe Poncin:</u>
My second question: as there is a possible development within the area of film material, has there been any research of new metallic materials that could be printed in a different manner?
<u>Karel Brems:</u>
This kind of research is certainly not being done in Mortsel at the moment.
<u>Harold Brown:</u>
I have heard it suggested, that polyester base is not entirely immune from this syndrome. Could Mr. Brems comment on that?
<u>Karel Brems:</u>
Polyester is also an ester, not of cellulose but of ethylene glycol, with an organic acid. Because all esters are able to hydrolyse, there is always a risk, but the degree of hydrolisation is different for different substances. So it is not a total guarantee, that is for sure.
<u>Paul Spehr:</u>
I would like to ask about the identification of the various kinds of acetate films that we may have in our archives. Those of us who have been collecting over a long period of time have many different kinds of films from many different periods. Some advice on how to identify it would be useful.
<u>Henning Schou:</u>
I believe that you mentioned earlier that you had recorded some infrared spectra. That is one way of distinguishing between nitrate, acetate, butyrate and so on. Unfortunately, that technique is pretty time-consuming.
<u>Paul Spehr:</u>
To what extent could the vinegar syndrome affect other kinds of photographic materials such as still photographs and microfilm?
<u>Karel Brems:</u>
It could be a problem, too.
<u>P.K. Nair:</u>
We know there is a difference between the nitrate image and the safety image, in terms of image quality of black-and-white contrast. Will polyester film have any effect on the quality of the image?
<u>Karel Brems:</u>
No, I believe the influence of the polyester base on the photographic quality of the image-forming layers is very, very small; even smaller than the influence of triacetate or cellulose nitrate.
<u>Henning Schou:</u>
It would be quite tempting to recommend the use of polyester film as archival material instead of triacetate. However, I believe that there are still some unanswered questions in connec-

tion with the archival value of polyester. The first one is: do we know enough about the phenomenon called "core set"? This may take the form of irreversible curl caused by the polyester resetting around a narrow core. The second question is: will the hydrophilic gelatin layer adhere to the inert polyester base for centuries? After the invention of polyester in 1946, the material was used (as far as the motion picture industry is concerned) mainly for narrow-gauge formats such as 8 mm and 16 mm because of the problems associated with adhesion. Only recently, after the coating technology has been improved, has it been used in the manufacture of 35 mm motion picture films. Today, when coating gelatin onto polyester, a large number of polyester layers are applied with an increasing amount of gelatin in each layer, until pure gelatin is reached. Dr. Adelstein of Eastman Kodak has conducted numerous accelerated ageing tests on polyester. However, I would like to see more tests which would make us confident that the gelatin would adhere to the base for centuries. It would be a disaster to make archival preservation copies on polyester and then perhaps in 10–20 years' time find that the emulsion lifts off the base. Then we might be left with a problem similar to the current nitrate nightmare.

Peter Konlechner:

Among technicians who are using the different kinds of bases, especially projectionists, there goes the saying (probably unproved) that polyester base film wears out machinery remarkably quicker, and they also say, because the base is so strong mechanically, the projector will break before the film.

Karel Brems:

Yes, but I can tell you that we have some customers who are almost exclusively using polyester these days, and have done so for a few years, and they do not have that experience.

Henning Schou:

I can add that Agfa, I think anonymously, once conducted a study, to find out how polyester would be received, not only in the laboratory, but by the potential market. The results of the survey are published in the SMPTE Journal Vol. 64 (1955) pp. 674–678. In those days, there was a great concern that polyester might ruin equipment. However, if you are setting up a printing laboratory for polyester, it should be quite possible to introduce microswitches, which (if you lose a film loop) could automatically stop the machine before it breaks.

Tony Lewis:

I believe one of the major problems, as far as the laboratory technician is concerned, is the ability to splice polyester-based film. It seems to me that one of the major researches ought to be carried out so that we can easily splice it without having to use tape, which is an unknown quantity when one puts it onto the emulsion of film.

Henning Schou:

There is an alternative to tape when splicing polyester and that is to use ultrasonic splicing. One could also adopt the policy of using polyester for preservation copies only – and still use acetate for duplicate material which may be used for reconstructions etc.

Uffe Lomholt Madsen:

Because of the lack of nitrate raw film to produce leaders and tails for prints shown in museum cinemas, we use new safety leaders and tails. Has safety film any bad influence on nitrate stock, or only the contrary?

Karel Brems:

Only the contrary, I think. I do not believe that triacetate film has a bad influence on nitrate film.

Henning Schou:

Once you have identified your films as having vinegar syndrome, do you have any recommendation on how to treat them? You may consider washing them in, say, a carbonate solution so the pH is adjusted to the recommended value of 5 or higher. Do you have any evidence that once you have adjusted the pH, that you have actually brought the hydrolisation to a halt?

Karel Brems:

Not completely stopped but slowed down, I believe.

Henning Schou:

I discussed this with Dr. Peter Adelstein, who previously worked with Kodak and is now a consultant to the Image Permanence Institute in Rochester. He was not sure either. I think that would be a very valuable research project.

Could I finally mention again the significant report from the University of Louisville, written by David Horvath. It contains a very good description of the symptoms associated with vinegar syndrome based on some 29 tests.

Criteria for Air-Conditioning in Audio Visual Archives
Clifford Harkness

Dietrich Schüller:
Clifford Harkness of the Ulster Folk and Transport Museum in Holywood (Northern Ireland). Clifford is also secretary of the Technical Committee of IASA.

Unfortunately, the title criteria for air-conditioning in audio visual archives is somewhat deceptive. It suggests the writer is a specialist on air-conditioning systems, which is not the case.
Instead, the paper is based on experience gained as a user of air-conditioning in an archival environment, and in particular will discuss the design and operation of a typical air-conditioning system as well as highlighting some of the associated problems. Several years ago in a state of ignorance of the techniques and difficulties of archival air-conditioning, we accepted a system which, with the benefit of hindsight, had little chance of achieving the required conditions and even at one stage became a fire risk to the collection itself. This bitter experience led us to review what had gone wrong, in that particular case. Once bitten, we had no intention of considering a second system with the same degree of ignorance.

The curatorial role for the archivist calls for an understanding of the need for a controlled environment. Archival conditions almost certainly depend on an air-conditioning system and a knowledge of how the respective archival conditions are achieved, is something to be recommended. It is often stated that a little knowledge is a dangerous thing. However, there is real value for the archivist in having at least a little knowledge of the basic principles involved in air-conditioning.

The air that surrounds archival collections is often far from friendly, so, air-conditioning provides the basis for preventive rather than corrective care of archival materials. If you accept that argument you must also accept air-conditioning as a crucial part of any archive's long-term commitment to preservation.

So, what is involved in basic air-conditioning? Consider first system environment and the boundary element, climate. FIAF, FIAT and IASA have, in term of temperature and humidity, identified and recommended the environmental conditions for respective AV materials. But no matter where you are in the world, the recommended internal conditions are often far removed from the actual state of the local external climate. It is therefore obvious that the seasonal variation of the impinging external climate is a first consideration for the system designer. The exact characteristic of the external climate will have a bearing on the technique and efficiency of the design solution; also, less obviously, a factor such as local barometric pressure is relevant, particularly when designing for archives located at high altitudes. Fortunately, most meteorological offices keep suitable records, and when considering a design proposal you should be satisfied that the design engineer is familiar with such data, and that it has been accounted for.

The second factor in the system environment, is the building in which the archive is contained, and as with climate, the designer is faced with a series of variables peculiar to the structure. The complex of buildings at the Ulster Folk and Transport Museum, contains documentary, sound and photographic archives, alongside office accommodation for museum professional staff, and from an air-conditioning point of view it provides significant design problems. So, what does the air-conditioning designer need to assess, in this, or any surface building? First it is essential to assess the total load placed on the air-conditioning equipment, quantified in term of heat and moisture, that the air-conditioning equipment must either extract or introduce to maintain the required conditions. Assessing the total load can be a complex process and is prone to error. However, it is useful to be aware of the principle loading factors which apply to a building such as the museum's but they are only partially appropriate subterranean archives. To keep to the more difficult case, we need to consider loading factors within two headings, perimeter and internal.

Firstly perimeter loading factors:
1. The solar gain and loss via glass. Is an assessment of the area of glass and type (e.g. plate 6 mm thick or double glazing) with associated solar gain. External glazing is normally a poor thermal insulator and an obvious path for solar heat.

2. The thermal properties of the walls and roof. The degree of thermal insulation can be important for many archives. In particular, film requiring storage at sub-zero temperatures produces a risk of frost damage to the structure. Heat and moisture will tend to flow through brickwork and on meeting cold surfaces condensation and icing may occur at some point. The formation of ice within brickwork has an obvious damaging effect and care must be taken to provide sufficient thermal insulation. Even sound or television archives, which store magnetic materials well above zero, should be cautious, if the archive includes external walls which are subject to frequent sub-zero temperatures.

3. Temperature difference of fresh air either by introduction or natural infiltration. Temperature is not the only factor, and the humidity levels will almost certainly be at variance with required conditions.

4. Orientation of building, accounting for solar heat gain via the surface areas, with allowance being taken for shading effects.

The internal loads consist of:
1. Lights (variable heat source)
2. People (source of heat and moisture)
3. Machines, including any heat given off by the air-conditioning equipment itself.
4. Other sources of heat or cooling from within the building. (Passage of air between archive and adjacent areas).

Internally generated loads are of interest when designing for areas occupied during working hours. However, archive stores are not normally working areas, and the first three factors tend to have little relevance. So, in theory, most AV archives offer minimal loading and by distancing the archive away from perimeter loading effects some of the design problems can be reduced.

The next issue concerns some of the techniques employed in basic air-conditioning. But before moving on it is worth pausing to review the meaning of a few terms used in relation to air-conditioning.

Temperature and relative humidity are common terms used to specify storage conditions. Whilst temperature as a term is well understood, a few words about relative humidity might be useful. Air at a given temperature, such as 20°C (68°F), can hold only so much water before it reaches a point of saturation, and this is classed as a 100% relative humidity. If the temperature of that saturated air is raised to 30°C (86°F) the relative humidity would in fact drop below 100% and equally if the air is cooled below 20°C (68°F) the relative humidity rises, and beyond the point of saturation the excess water vapour will condense on any cold surface. The temperature where condensation begins is termed the dew point. The important factor to establish, is that relative humidity is related to temperature, and reasonably the temperature is related to heat. A major function of air-conditioning is the supply and extraction of heat. Total heat has two components, sensible heat and latent heat. The supply or extraction of sensible heat provides a change in temperature, and examples of sensible heat sources are an electric bar heater or solar radiation. The latent heat component of air, however, is the heat required to produce a change of state from water to water vapour, without a change in temperature, and the latent heat value is contained in the water vapour element of air. Therefore two samples of air at 20°C with a relative humidity of 70%

	CONDITION 1	CONDITION 2
SENSIBLE HEAT	20°C	20°C
LATENT HEAT	70% RH	40% RH

Figure 1
70% RH presents a higher latent heat component than 40% RH.

and the other 40% have the same sensible heat value but a different latent heat value (figure 1). Air-conditioning is often required to cool a room to maintain conditions. Cooling will extract sensible heat, as well as latent heat and sufficient extraction will convert moisture in the air to a liquid state which can be drained away. In other words, if you want to dehumidify air cool it, and modern air-conditioning methods use this technique.

Turning to the equipment itself, at the heart of the system is the cooler used to extract both sensible and latent heat. This slide cooler operates on the same principle as a domestic refrigerator. Relatively warm moist air is passed over a chilled coil, the air temperature drops on contact with the coil, and the relative humidity rises up to, and then beyond saturation. Excess water will condense at the dew point on the cold surface of the coil, and the water drips into a pan to be drained away. The extracted heat must, however, be dissipated from the refrigerant gas before being returned by compression as a cold liquid. The purpose of the condenser is to dissipate the extracted heat, and the unit is normally housed outside the building where some form of cooling can be provided (fig. 2).

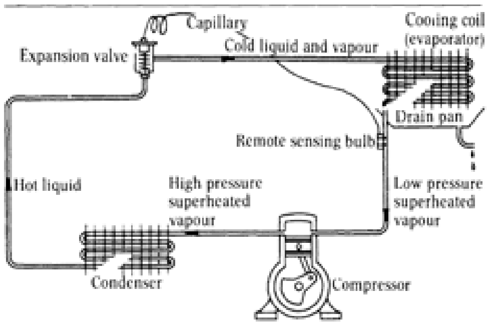


Figure 2

The next component to consider is the fan. The fan is needed to distribute the conditioned air and we rely on sufficient air flow through the plant, and air ducts, to ensure good air mixing. In low temperature air-conditioning a complex relationship exists between cooling coil size and air flow rate. Any design error here can cause icing on the cooling coil and severe fault conditions can result. Noise generated by the fan, and air flow in ducts, is of little concern except when working in adjacent areas (fig. 3).

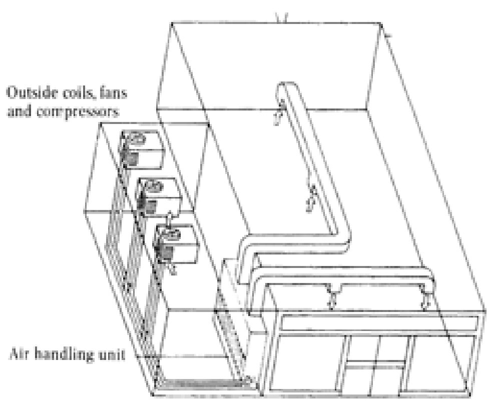


Figure 3

The heater, which is assumed to be electric, is needed to introduce sensible heat and will often operate to bring the chilled air coming off the cooling coils up to the required air temperature. Cooling and heating can be on at the same time, for example when humidity sensors call for lower humidity and bring on the cooler to extract moisture, whereas the temperature sensor says it is getting too cold, and turns on the heater. But, because relative humidity is related to temperature, the heater in raising the temperature, drops the relative humidity and therefore the humidifier which is last in the chain will probably need to introduce moisture to the air stream. Therefore even a basic system of cooling, heating, humidifying and air flow, can present a series of components in which the function of one may be concurrent with others.

Archive air-conditioning falls within the term close control and given that the cooling and heating ability has been well chosen, the control system must be sufficiently comprehensive and reliable to monitor and adjust the operation of these basic components. Indeed, good design of the control system is crucial to the success of any system and should, in particular, include the maximum of fault monitoring, with safety cut outs, and alarm facilities. Electronic control and in particular microprocessor based control systems, now offer sophisticated, reliable and cost-effective solutions. In passing, it should be noted that control system design and air-conditioning design involve two disciplines and very often different design personnel who all have to rely on a common understanding if success is to be achieved at the end of the day. It is not unknown in custom made air-conditioning systems for a fault situation to arise, where the man who designed the air-conditioning equipment will blame the fault on the control system design, or vice-versa.

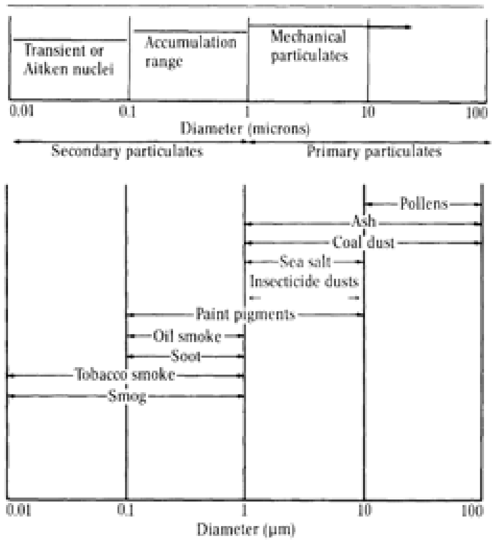


Figure 4
Classification of particulates
Size ranges of some particulates

Two main sectors assist one another in archives: the air mix and the filter. It is common to mix a percentage of fresh air with the recycled conditioned air, by means of dampers. This process is primarily to reduce stuffiness in occupied areas, but depending on the external air temperature it may be used, in some cases, to reduce heating or cooling loads. However, for archives, the introduction of fresh air can provide a useful positive pressure within the storage area. By introducing more air that you extract, an air flow is created from, rather than to, the room which reduces the ingress of air-borne pollutants (fig. 4). Whilst most air-conditioning systems will include a dust particle filter its efficiency is probably less than we would desire. Suspended dust particles fall within three ranges. The larger mechanical range particles will ultimately settle, but the smaller particles within the transient or accumulation range can remain suspended until they hit or adhere to something. The museum world has some experience of filtering air within stores and galleries and museum standards could usefully be adopted by audiovisual archives. Effective filters, well below one micron, do exist, and special test dusts are available for assessing overall efficiency. Unfortunately, dirt particles are not the only concern. Our modern environment has varying levels of gaseous pollution, and it is equally desirable to provide adequate filtration for this. Sulphur dioxide, nitrogen dioxide and ozone may be present in sufficient levels to create concern and film archivists in particular will need to consider the extraction of gases from ageing film stock. Water spray, and filters based on activated carbon are the two established ways of removing gaseous pollutants. The water spray filter involves passing the air through a continuous spray of water which absorbs the acidic gases, but not ozone. The alternative activated carbon filter is, however, effective against ozone, and such filters come in packs which are simply placed in a way that all air must pass through. The extent of filtration required depends of course on the levels of local environmental pollution, but as a guide, top grade filtration should be capable of reducing sulphur dioxide to less than 10 Ug/m^3, nitrogen dioxide to 10 Ug/m^3 and ozone to trace level 0.2 Ug/m^3. General environmental concern about acid rain etc. may produce greater care about the quantity of air pollution that we artificially create, but in the meantime filtering for protection is essential. A word of warning on filters; some air-conditioning uses electrostatic particle filters and whilst these are effective, their high voltage plates are producers of potentially damaging ozone and therefore cannot be recommended in an archival application.

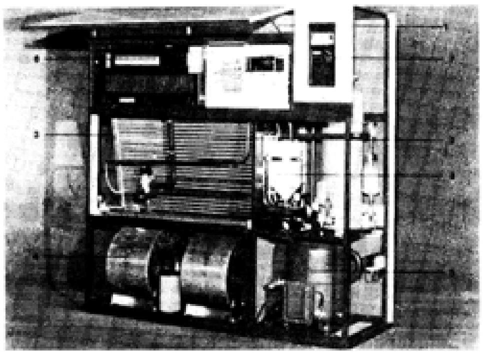


Figure 5
1. filter section, 2. evaporator coils, 3. hot gas reheat coil for energy conservation, 4. multiple fans, 5. compressor in separate compartment, 6. electrical panel, 7. SENTALARM, 8. Humitronic humidifier.

A vast market now exists for air-conditioning units, particularly to provide a comfortable working environment (fig. 5). Manufacturers have largely met this market by developing package units. Most package units house all the basic components mentioned already, with the exception of the condenser unit, which is often, but not always remote. The development and popularity of the package unit has greatly reduced the capital and design costs involved in air-conditioning. This may seem good news, but unfortunately, for archivists the majority of package units are not designed, or readily adapted, for low temperature work. The designer is therefore faced with bringing together a selection of discrete components to build a suitable system. The system configuration is, whether package unit or not, likely to be what is called a split system. It is a versatile arrangement and frequently used by designers.

No matter which type of archive, the air-conditioning designer is never faced with a simple task. At least six issues frequently emerge:

1. Whilst the designer can give you nearly any temperature you require, it becomes increasingly difficult to achieve medium to low humidity conditions at lower temperatures.
2. Supply of suitable equipment may present a problem and is likely to be classed as special by the manufacturers.
3. Increased capital cost related to (2). Manufacturers are inclined to impose an extra charge for interrupting the production line to make a one-off archive unit, and many, understandably, are reluctant even to accept an order for such equipment.
4. The suitability of existing rooms should be carefully assessed for air-flow leakage, and possible condensation or frost problems. New buildings should be constructed with the storage conditions and needs of the air-conditioning equipment very much in mind.
5. The reliability of an archive system should be a primary concern. Alarms for various states of malfunction are now common, but complete failure can create a significant rise in room temperature and therefore a back-up facility to maintain conditions is desirable.
6. Selecting the system designer, it will probably be hard to find a firm of local air-conditioning engineers with relevant experience. For unusual applications the mainstream designer will probably need to consult with equipment manufacturers, and various professional bodies providing guidance to heating and air-conditioning engineers.

Bearing these issues in mind the need for caution should be stressed. It is advisable in the circumstances to consider the preparation of a comprehensive specification, ideally by a consultant or modelled on relevant specifications prepared by a comparable archive with a satisfactory system. Tendered designs should state the operating parameters of the equipment providing the main functions as well as the control system components, the safety features, and the equipment maintenance requirements. A site survey by the designer should be automatic and should include agreement on the siting of any remote alarms and the important provision of shutting down the air-conditioning in the event of fire detection, or a fire extinguishing system being activated in the archive.

By highlighting the real and potential problems, the paper may seem to reach a defeatist view of archival air-conditioning, but such is not necessarily the case. Certainly a knowledge of many archives operating with sub-standard or no air-conditioning at all, gives cause for concern. Not to instal air-conditioning because you cannot afford it, is hard to justify. It is something you must afford, certainly for the archive store, and if possible, also, for the technical handling areas. The provision of air-conditioning is a relatively minor expense when set against the value of the materials being stored. It is not necessary to attempt a costing of a typical installation, but the following manufacturers breakdown of costs for a standard package system over five years may be of interest. Of the total costs, 20% covers purchase of the equipment, 10% on routine maintenance and the remaining 70% goes on power consumption costs. Now such a breakdown may make those with financial control want to hold onto the purse strings that bit tighter, but we should keep things in perspective. The energy consumed by air-conditioning is relatively small when compared with usage and wastage in other areas of the archive building, and it is often possible to provide some energy saving features in the design. In fact, the manufacturer that provided the breakdown of costs, estimates that the provision of supplementary heat from the buildings' hot water heating system will, in about five years, offer savings equal to the purchase cost of the equipment.

The aim of this paper was to generate a more critical view of air-conditioning, and also to raise the value the archivist gives to the subject, so that ultimately we shall see an improvement both in provision and standards.

Preservation is our prime responsibility and we have the technology and knowledge to provide the proper storage environment.

Indeed, to operate without it, seems to question the value of our other preservation efforts.

Let us hope that those who follow us, in the case of archives, should not have to ask why we could not get it right!

Illustrations in the courtesy of: "Museum Environment", 1st edition, Gary Thomson, Butterworth; United Kingdom Electricity Council; Hiross Air Conditioning.

William D. Storm:
Clifford, did you have any opportunity to find out what the effects of fungus and mould is in an air-conditioning system? Can it become airborne through an air-conditioning system or have you not investigated that yet?

Clifford Harkness:
I have not investigated it, but I would suspect that fungus is going to be quite happy at a relative humidity of 70% or over, and certainly all of the relative humidity levels that we are considering are from 50% down. There is probably a degree of inhibiting effects, as far as they are circulated within the air and suspended particles whether they are fungus or whatever. The filtration system should be fairly effective against a particularly high degree of filtration. It is possible to filter out to extremely high standards of the type you would find in operating theatres, or medical situations, and even the air-conditioning may be designed to give what we term eliminary airflow, where the airflow is moving down, and therefore carrying everything down to ground level to be extracted.

Harald Brandes:
Maybe you should indicate that it is relatively simple to regain the warmth you get by means of the evaporator, and which usually flows from a room into the air, if you use a heat exchanger, in order not to have to heat the room electrically as well.

Clifford Harkness:
I am aware of the development of a heat pump, which uses the heat to be diverted as you are doing. But the people providing air-conditioning systems warn us to be very careful in cost terms, and make sure you can justify it economically. But if the conservation is important it is worth doing.

Effects of Fire on Sound and Audiovisual Recording Supports Jean-Marc Fontaine

<u>Dietrich Schüller:</u>
The next speaker is Jean-Marc Fontaine from the Ministère de la Culture et de la Communication, from France. He is perhaps the only man in our group who ever has set audiovisual material on fire purposely.

Context and Objects of the Study

The department of the Phonothèque Nationale et de l'Audiovisuel of the Bibliothèque Nationale poses an important and diversified heritage: its stock, springing from historic sources (the oldest recording goes back to 1891) and also of scientific and private origin. Moreover it has been permanently supplied by the Depot Legal for almost 50 years. Preserving and protecting such a considerable heritage, representing all the stages of the sound recording technology, and from 1975 also on image, is indeed a heavy responsibility.

Since 1980 we have been called on to cooperate with the policy of preservation initiated by the head conservator, Marie-France Calas, and we are participating in a survey of a preservation centre dealing with collections. Among the numerous concerns arising from such a project, those connected with fire protection certainly play an essential role.

With the objective of offering the kind of protection one has the right to expect from such a centre, and in order to be able to make all useful arrangements from the architectural point of view, with regard to the installations in the buildings and finally during work, a certain number of data have to be collected. As we noticed how insufficient our knowledge of these aspects was, we initiated a study in cooperation with and on behalf of the Phonothèque Nationale, related to the way different sound and audiovisual supports react in case of fire, and also concerning the means of fire detection and extinguishing that could be used.

Approaches of the Study

The study of how products exposed to heat and combustion react, has to acknowledge the <u>nature</u> of different materials. It is exactly the reactions of degradation caused by fire, that give significant indications as to the nature of products, at least as far as the principal components of formulation are concerned. The identification partly carried out by means of elementary analysis also to a large extent call for the techniques of thermic analysis. Thanks to these measures, the physico-chemical process of degradation caused by heat and of decomposition due to pyrolysis are more comprehensible. The most current techniques are still the thermogravimetric analysis (ATG) and the differential thermic analysis (ATD). The analysis of compounds and residual gas complete this study by specifying the risk of toxicity. A synthesis of the data obtained in this way and which we have at our disposal, was made. Such measures ought to be taken in the case of all products we are interested in.

The second stage is the examination of how sound and video carriers react when exposed to <u>flames</u>: delay of combustion, increasing temperature, reduction of oxygen in the test cell, nature and proportion of the poison gas developed, production of hydrogenated compounds, etc.

Such a study, dedicated to magnetic tapes with conditioning, has been made by Lipska[1] including, among other things, the reduction of weight during combustion. The experiment we will be talking about belongs to this stage. It was carried out by an institution specialising in studies of fire, the Centre d'Etudes et de Recherches des Charbonnages de France (CERCHAR).

Experimentation

Under realistic conditions, you study the first moments of a fire that has developed on any kind of carrier. Then the effectiveness of the various devices of fire detection and extinguishing is assessed. The consequences of these controlled (or less controlled) attacks on the tested products as well as on the recordings themselves are measured subsequently. It is quite obvious, when you are talking about a record or a tape, that you rather have to think of the assembly of the carrier and all things surrounding it. A significant case, for example, is the compact disk of La Traviata, edited by the Phonothèque Nationale. Considering the plastic case, the libretto on glossy paper, and the cover made of cardboard, the disk itself hardly constitutes more than 8% of the total weight. Without libretto or cover, the disk does not weigh more than 14% of the total weight.

Thus we suggest the following kinds of package:
1) 78 records: bare, in a paper cover, hardback cover, cardboard boxes
2) Long playing records: bare, in plastic or paper cover, in album, cardboard boxes
3) Magnetic ¼" tapes: bare on metal hub, in metal or plastic reel, in plastic cover, plastic or cardboard case
4) Mini audio cassettes: introduction with and without plastic cover
5) VHS and U-matic video cassettes: introduction with or without plastic or cardboard cover
6) Compact disks: bare, with case and libretto

The products under discussion whether of organic origin (wax, shellac, synthetic polymers, mineral (the fillers) or metallic (the centre of certain records, the powder of magnetic tapes, cassette mechanisms, reflecting layer of compact disks) will be very difficult to describe in detail, even if we were able to comply with this description: extremely numerous combinations of material whose stages of ageing are also very different. Such an inventory would however be very desirable.

Stages of Experiment

1. Preliminary analyses were carried out in order to estimate the reactions of the products according to the following criteria:
Calorific source: measures of calorific potentials;
production of poison gas: analysis of the chlorine and nitrogen content, whose compounds are extremely dangerous.

2. Tests regarding the extent of a fire, its detection and early extinguishing:
In a cell of 30 m^3 shelves with samples were prepared. The total dimensions were the same as those of the storerooms of the project itself at the Phonothèque Nationale. Two types of shelf were tested for certain experiments: wooden and metal ones. The carriers of each group of recordings were presented according to the processing defined above. The samples comprising reference recordings were distributed in portions. The fire was set off by the wood pile method and during the first moments in which the fire develops, the following measurements were taken:
distribution and development of temperatures in the room and in the centre of the samples;
latency of the different types of detectors under study (flame detectors, ionic, smoke detectors, heat detectors), allocated in five positions of the ceiling;
amount of carbon monoxide and production of microscopic particles;
photographic records of the loss of visibility in the test room due to smoke development.

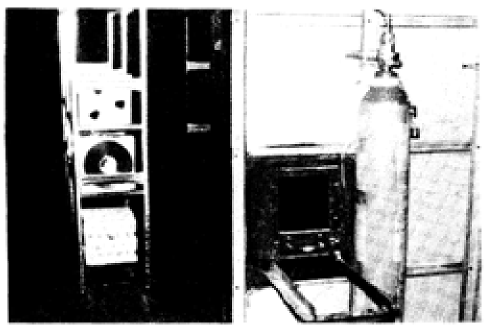


Figure 1

When the temperature in one part of the room (ceiling above wood pile) reaches a certain fixed limit, the extinguisher under study (HALON 1301) was set off (fig. 1).

The consequences of these operations for the samples were observed as well with regard to their physical state, by means of analysing the recorded information for each type of carrier during the different delayed processes. Thus we will be capable of carrying out adjustments to the switching mechanism of the extinguisher and check whether it is harmless for the exposed samples.

3. Test regarding the extent of a fire and a slow process of extinguishing:
A fire was allowed to develop within the range of all supports for quite a long time, about 15 minutes. The reduction of the oxygen content was measured in addition to the already mentioned analyses.
It is important to point out here that the slow extinguishing of the HALON 1301 has proved to be ineffective, the phenomenon of renewed ignition makes it necessary to fight the fire by other means, that is by a staff equipped with adequate protection (independent oxygen masks).

4. Complementary studies:
There are numerous studies accompanying these experiments. Heating samples in an oven is no simulation of conditions during a fire, as the thermic regime is not at all comparable. Nevertheless, it is possible here to estimate the reactions of different materials in a systematic manner. It is easily proved that the plastic cases for example of audio cassettes, videocassettes and compact disks, far from offering protection during conditions of heat, on the contrary are a source of direct damage of the carrier.

Moreover, there is a precise statement of the degree of tolerance of the recording with regard to heat, for each type of carrier, no matter if mechanical (record), magnetic (audio and video tapes) or opto-mechanical (compact disk). This leads us straight on to the analyses carried out on the recordings.

5. Analysis of recorded information:
The samples obtained from the burnt material showed us the state of the recording, as far as any reading was possible; this sometimes requires much effort, where manual skill as well as the performance of the machine are involved.

Fast extinguishing by the agent under study in the experiment carried out by CERCHAR, proved to be important for the result of the analysis that was made on the samples. The analysis was carried out by Laboratoire de Mécanique Physique-CNRS UA 868-St-Cyr-l'Ecole, Professor J. Sapaly.

On the other hand, we examined the process of degradation in recordings when tested with slow extinguishing. Sound examples show a gradual (and generally rhythmic) reduction of recorded analogue information on records and magnetic tape. Listening to sound recordings in this experiment will also stress the total muting of the digitally recorded information on magnetic tape (with the participation of French Television) and compact disk from the moment when the error correction devices are overwhelmed. The acoustic analysis practiced on the analogue material is no longer sufficient for digital measurements. The measurements are carried out after the error detection and correction stages and after the D-A converter. Here we can illustrate one of our big problems, produced by a degradation in the form of discontinuities in a digital recording (fig. 2).

Video recordings on magnetic tape suffered a lot due to the poor heat resistant quality of the cases. Comparisons between doped iron oxide and chromium oxide have shown the relative sensitivity of the latter towards heat, even at temperatures below the Curie point.

Conclusion

The results of these experiments will be published as soon as the project is finished, by the Bibliothèque Nationale within the frame of its agreement with the University of Paris, VI-CNRS (UA 868). These studies will allow us to assess the degree of resistance in the different carriers exposed to the first stages of fire, in relation to theory, and this again in relation to the degradation of the recordings.

Figure 2

The data, marked with numbers, makes it possible to calculate the volume of partitioned sectors in store rooms and to specify possible incompatibilities in carriers, compared to considerations relating to security. The application of detection and extinguishing devices, and of protection for the staff by means of competent service, will be carried out considering the obtained results, and so of course will the restraints on the site, the other types of installations (especially air-conditioning), special methods of use etc. The kind of shelves will be defined in relation to the experimental data; thus the nature of the shelves, wooden or metal, is not insignificant, on the contrary its role is important in the kinetic of heating a space, and its consequences on the deposited documents are direct, documents whose kind of processing has to be carefully designed as far as possible.

Such a study syntheses the total knowledge we have of sound and audiovisual carriers: of the materials themselves, the recordings on them and the whole extension of attacks, as fire unfortunately is only one danger among many others, which we should not forget.

Dietrich Schüller:
Thank you, Jean-Marc Fontaine for this spectacular presentation. I look forward to the results of this study, and the recommendations which may be derived and result in the right design of the storage system, and the right design of the fire detection and the fire extinguishing system.
Henning Schou:
Did you say that you had actually carried out some DTA and gravimetric analysis of the decomposition process?
Jean-Marc Fontaine:
I indicated that the thermo-gravimetric analyses are quite a different process, the first part. Certitude is the other part of it. We have not carried out exact new measures within this frame, and these experiments have to be considered global ones. If we make analyses, these have to be done systematically and I have to admit that we do not have the financial means for this at the moment.

[1] Lipska, A et al. 'The combustion of reels of magnetic tapes, in: Report UCID, 18976. Lawrence Livermore Laboratory, Feb. 1981, 23 p.

Decay and Degradation of Disk and Cylinder Recordings in Storage
Gerald D. Gibson

Dietrich Schüller:
Now Paul Spehr from the Library of Congress will read the paper of Gerald Gibson about the decay and degradation of recordings in storage.

Comparatively little is known about the preservation, conservation, or ageing problems or properties of disk and cylinder records from directly related scientific study. Much of what we know, and the basis for most practice, is carried over from other fields of research. The primary independent document in this field, Preservation and Storage of Sound Recordings by A. G. Pickett and M. M. Lemcoe, was published by the Library of Congress in 1959. Based upon research that was carried out in the mid-50 s, this out-of-print volume is still valid today. Not covered in the Pickett & Lemcoe report are cylinders, laser disks, some of the more unusual disk formats, digital recordings, and the general procedures and techniques developed for storage and handling based on their recommendations. The information shared in this paper comes from a wide range of sources, but primarily the practices of the Libarary of Congress, which have been tested only in the day-to-day world of trial and error. A number of archival collections around the world are in the midst of testing their procedures and/or carrying out related, but independent research. Some areas being explored are the analysis of the various cleaning chemicals offered for sale in the United States and the effects of heat upon A/V carriers and signals.

The resulting information should be shared and added to an expanding pool of documented knowledge in the field. Until such time as this takes place there is no choice but to rely upon trial, error, and experience.

Although this paper should cover all disk and cylinder shaped materials that might be in the collections, shortage of space means that it will concentrate upon the formats that are most common and most likely to raise particular problems. Thus, the coverage will be cylinder recordings, commercial disk recordings – including CD – and the more common of the instantaneous disks. The one disk format that is widely used which is not included is magnetic disks, regardless of their use (fig. 1).

Figure 1
Disk family

Disk recordings vary in size from approximately 1 inch to 23 inches or more in diameter, and from 1/64th of an inch or less to 1/4 of an inch or more in thickness. They are made of the solid substances known to us, including plastic, shellac, glass, wax, metal, rubber, tinfoil, wood, paper, and even chocolate candy. Their makeup may also include a combination of such things as a core of metal, wood, glass, plaster of paris, or paper, and a playing surface of plastic, wax, shellac, or acetate. (When referring to coated, instantaneous disks used for audio recording before being supplanted by magnetic tape in the 1940 s, the American term, "acetate" will be preferred here rather than "lacquer", which is used more frequently in Europe. Acetate includes all disks coated with either ethyl cellulose, cellulose acetate, or nitrocellulose.)
The signal on a disk may be analog or digital, recorded acoustically, electrically or optically, using either a lateral or a vertical cutting head and playback stylus or a laser. Recordings may be one of a kind, or part of a mass production in the millions with world wide distribution. They can play at speeds of less than ten to greater than 500 revolutions per minute (RPM). Their styli – when they have one – may have a tip radius from .5 to 35 mills, with intended tracking weights of less than 1/4 of a gram to several pounds in a groove which varies from microgroove to standard coarse groove widths. The modern commercial disk formats ('LP', 45 rpm, and CD) are generally standardized, as were the earlier 78 rpm and acetate disks and cylinders. This has not always been the case. Whether because of technical or commercial reasons, disks have had hill-and-dale recording, inside-out tracking, and lateral cut grooves. Multi-channel sound has been achieved with such techniques as binaural and bilateral grooves, and encoded – and enhanced – mono signals (fig. 2).

Figure 2
Busy Bee Record

Figure 3
Cylinders

To ensure that the public used their recordings on their playback machines manufacturers have done such things as putting two spindles on a turntable, with the second being a large rectangular post, so that the owner of the machine would have to buy records which would accommodate such a double spindle system.

Though not one of the common formats in our collections in terms of numbers of items, cylinders - the earliest form of sound recordings - are frequently encountered. They were the only successful form of collecting audio for the first fifteen or so years of the history of sound recordings, and they were an accepted form, indeed in some areas they were the preferred form - until well into the 1930s. Cylinders come in sizes almost as varied as those just mentioned for disks, ranging in diameter from 1 5/16" (Bell & Tainter) through 5" (concert size), with lengths from 1/2" (talking doll) to 8" (dictaphone) or more (fig. 3).

The "standard" size was 2.1875" × 4.25". The recording signal and mode were limited to hill-and-dale and mono, although the number of grooves per inch varied from 100 to 200, with the time varying accordingly.

Figure 4
Wax cylinder problems

Wax cylinders are particularly susceptible to moisture, mould, and mildew. Such things as blowing on their surface to remove dust is particularly harmful. The mould appears to grow most readily at 75–85°F (24–30°C), thus making the control of temperature, as well as RH, particularly important.

An additional problem with wax is that over the years the unsaturated material components have oxidized, causing the wax to harden and become very brittle (fig. 4). This is especially noticeable with the four-minute Edison wax Amberols (1908–1912). Consequently, recordings with such problems must be handled and inserted onto the mandrel with the greatest possible care. Celluloid cylinders are, also, susceptible to moisture and dampness. Among other problems, it damages or destroys the cardboard inserts of Indestructible cylinders or the plaster of paris interiors of Edison Blue Amberols, causing them to swell to the point that they will not fit onto a mandrel or for the recording surface to split.

Figure 5
Cylinder box, original

The question of package design for cylinders, wax and celluloid alike, is still unresolved. The original cartons are too high in acid to be acceptable (fig. 5), and to manufacture the same design today in an archival material has, thus far, been too costly. All alternate designs which have been suggested have one or more problems.

The design presently used by the Library of Congress (a rectangular box whose top and bottom are folded into inward facing pyramidal shapes to support the cylinder from the inside) answers many of the problems by keeping the cylinder upright, preventing the surface from coming into contact with solid objects, expanding to accommodate varying heights, preventing dust reasonably well, as well as being comparatively inexpensive (fig. 6). However, if closed too tightly the top and bottom will act as a wedge which easily splits the fragile and brittle recordings. Any suggestions which may solve this problem would be gratefully received.

Figure 6a
Library of Congress cylinder box

Celluloid cylinders are, in fact, made of cellulose nitrate with an additive of camphor. Though well known in some circles, this fact seems to have escaped most if not all, sound archivists and collectors. As those concerned with historic film are aware, cellulose nitrate is flammable and, if in an advanced stage of deterioration, is potentially hazardous. This fact was called to our attention at the Library of Congress in the spring of 1985. The Preservation Testing Office was given cylinders from the collections made by several different manufacturers, each selected because of its deterioration. After subjecting them to various heat, chemical, and atmospheric tests it was confirmed that they were made of cellulose nitrate, with an additive of camphor. The temperature at which spontaneous ignition of these deteriorated cylinders took place was 150°C (302°F) and it should be noted that nitrate based film in good condition has an ignition of 90°C (194°F). The conclusion of the Library's Preservation and Safety Offices was that, although flammable and nearly impossible to extinguish when ignited, even poor condition celluloid cylinders are not considered a fire or safety hazard. Any potential hazard can be minimized by reducing the possibility of accumulation of gases from decomposition. This can be accomplished by packaging celluloid cylinders in archival quality cardboard containers with an alkaline buffer. The container will allow the dissipation of gases, while the alkaline buffer will help to neutralize any acidic vapors. The packaged items should be stored in a cool, well ventilated area with low to moderate RH (50°F/10°C and 45% RH).

Figure 6b
Library of Congress cylinder box

However, in the event of a fire in the general area of celluloid cylinders, all staff and fire personnel should be warned of the nature of the materials and the fumes which are given off during their burning. In such an event only personnel with independent breathing systems should go into the area.

The principal problems of preservation associated with disk and cylinder recordings are warpage, breakage, chipped edges and rims, delamination, and micro-biological deterioration (figs. 7–10).

In mass produced disks and wax cylinders the single greatest problem is groove wear, particularly so for such items as wax cylinders and shellac disks.

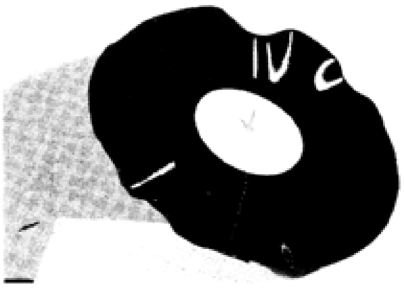


Figure 7
Warp

For instantaneous disks and for some mass produced disks and cylinders, the major problem is delamination, or separation of the recording surface from its core or backing. In general, the problem to be faced is how to manage the handling and storage of these items so that they can achieve the lifespan built into them. Problems of warpage, breakage, and edge and rimchips are readily preventable by careful handling, cleaning, packaging, and storage. Prevention of delamination is, unfortunately, impossible. It occurs in varying degrees regardles of the handling, packaging, or storage of the item. Of particular concern with instantaneous and, hence, generally one-of-a-kind acetate disk, it occurs with virtually all laminated recordings, including commercial disks and cylinders. The principal steps which can be taken to slow this process are careful handling and proper maintenance of the storage conditions: packaging, temperature, and RH. As with any deterioration, these cannot totally control or prevent delamination. Thus, important items must be backed up with preservation transfer copies. To date, although we have attempted to induce it, the Library of Congress has had no delamination of laser disks. We hope that exception continues.

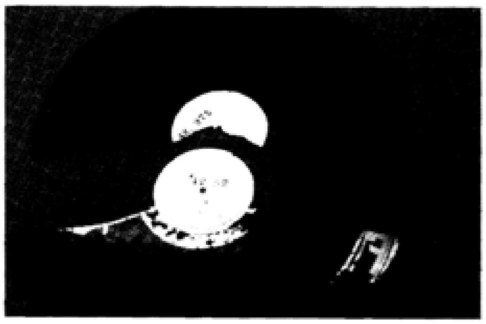


Figure 8
Break

There are a number of products on the market that claim to reduce the static electricity on the surface of the disk, thus cutting down on dust attraction. Other products available are cleaners designed to aid in removal of dirt and dust. Our experience is that they have varying levels of success. Regardless of the success rate, most archivists have great reservations about applying anything to their collections that will alter or coat them and that, in all probability, will have to be removed at some point in the future. The use of such treatments should only occur in extreme cases, for example if the recording will clearly be lost or of no further use without the application then it could be considered.

A potential problem specific to disk recordings is the presence of a label, usually paper, affixed directly to its surface. The label, with its glue or heat-seal, and its inks and dyes, introduces a new set of problems to disk preservation. Experience has shown that preservation related questions can be answered favourably. Glues may dissolve, as may inks, dyes, and paper, but they can be protected if care is used in the cleaning and handling process; and the paper should be of a fairly high quality, reasonably low in acidity, and resistant to fungal growth.

Figure 9
Chip

As with most things in this field, there is little certainty about the value of cleaning. Information tends to be based upon trial and error, not upon controlled, scientific study. Certain procedures are favoured because they have worked well in particular situations and because they do not appear to harm the item. Only time will confirm

Figure 10
Delamination

Figure 11
Dirty acetat

Figure 12
Same acetat, cleaned

these conclusions. Although playing of recordings is outside the scope of this paper, one thing is certain when talking about cleaning recordings: playing a dirty record is one of the most damaging things which can be done to it: Dirt is ground into the surface of the recording, where it creates abrasions and unwanted variations in the playing surfaces. This in turn causes distortion in the transmitted signal, complicates and exaggerates the aging process, and, in extreme cases, actually obliterates the signal and prevents its being used (fig. 11, 12).

One should not assume that new recordings are clean. Almost certainly they are not. The only proof needed for this is to wipe the surface of a new recording with a soft, clean, white cloth. Any item that is to be played should be cleaned first, without exception. Further, any item to be stored should be cleaned prior to packaging and storage, otherwise, particularly where the surface comes into direct contact with the storage container, enough damage can be done to prevent future retrieval of an acceptable signal.

From experience there are two preferred mechanical methods of cleaning grooved recordings: ultrasonic and vacuum type record cleaning machines. The ultrasonic machines are custom built and, currently exist only at Sveriges Radio in Stockholm and at the Library of Congress in Washington, D. C. Quality vacuum type machines are manufactured by such firms as Keith Monks, Nitty Gritty, and VPI. Laser disk cleaning machines offered for sale have not yet been fully tested. If the only means available is to clean the recordings by hand, by all means do so, but carefully. When hand cleaning use the same cleaning solutions and rinses as suggested elsewhere in this paper. Clean by gently wiping them with a clean, soft, cotton velvet cloth which is turned often. Wipe in a circular motion, with the grooves. Laser disks should be cleaned by wiping the surface in a spoke, or radial direction, going across the "grooves".

The type of cleaning solution to use depends upon the recording to be cleaned, the material/s of which it is made, and the dirt and debris to be cleaned from its surface. Except in emergency situations, avoid cleaning fluids containing alcohol for all recordings. In no cases should it be used on shellac disks, since various kinds of alcohol dissolve shellac. Although it does not dissolve polyvinyl chloride, the primary ingredient in vinyl disks, some experts caution against the use of alcohol on vinyl because of the threat of loss of plasticizers or stabilizers. Also, because of the wide variety of materials used in their manufacturer and the possibility of breakdown of the bond between their surface and base, alcohol should not be used to clean laminated recordings. Similar prohibitions should be applied to the cleaning of cylinders.

Having said this fluids containing alcohol appear to be most effective for cleaning recordings in the author's experience. As a prudent compromise, it is suggested that an alcohol solution should only be used as a last resort to clean any recordings, and then only for initial cleaning, with an immediate and thorough distilled water rinse. In most cases, the Library of Congress uses a solution of 4 to 1 distilled water and such as the DiscWasher D-4 for vinyl records, or D-4 + SHELLAC FORMULA for shellac recordings (Undiluted Freon TF for acetate disks), rinsed with distilled water. Alcohol is used only in extreme cases. Care must be used on application of any liquid to laminated recordings. Experience has shown that a wood or paper type base will expand if it gets wet, causing the recording surface to warp and break; and, regardless of the base, if the bond between base and recording surface is broken, the recording is lost.
Personally the author has found the "super-cleaning fluids", such as Nitty-Gritty's "FIRST", and LAST's "Power Cleaner", to be very good on home collections. On the other hand, unless specifically cited in this paper, the Library of Congress does not treat its recordings with chemicals.

Once a recording has been cleaned, it should not be put into the same dirty container from which it was taken. Or, if you must keep the container because of historical or content information, clean it carefully and use an inner sleeve or liner with it. In general, paper inner sleeves should be avoided because the paper tends to break down over time and to contaminate the surface and/or grooves of the recording with dust-like paper debris. A liner chemically similar or identical with the item should not be used as like items tend to adhere to one another. Also, according to some reports, materials similar in composition allow stabilizers or plasticizers to migrate between the items. Thus, polyvinyl sleeves should not be used because they are too like the polyvinyl of LP records. Instead, use an inner sleeve made of or lined with high density polyethylene or polyurethane. Such sleeves are available in the U.S. from such firms as DiscWasher, V.R.P., and Mobile Fidelity. For disk storage where the original jacket is not retained the Library uses sleeves based on Pickett and Lemcoe's recommendations of polyethylene-foil-paper board. These are manufactured by Shield Pack, Inc. (fig. 13).

Figure 13
Library of Congress disk preservation sleeve

An institutional collection requires different consideration and treatment. The rationale for this apparent double standard is that while a collector may choose to "improve" the short term sound of his own recordings to please the ear, an archivist's concerns must be with long term deterioration and preservation, not personal tastes, when dealing with the institution's archival collection.

The realm of the laser disk is still so new that we are only beginning to understand its problems. None the less, several generalities can be made: they should be stored in the same vertical position as any other disk, audio or visual; they appear to respond favourably to the same environmental conditions (temperature, humidity, light, etc), and as other disks their surfaces need to be protected from dirt, scratches and abrasions, and from undue handling, while care should be taken when handling is necessary.

As with all new media, there are still a number of questions to answer and problems to resolve with the optical disk. Among them are what is the potential life of the package; how important are heat and humidity to their long term stability and successful data retrieval; is light of particular frequencies and wave lengths a significant factor in deterioration, and, if so, are they the same u/v wave lengths that we wish to avoid with other plastics; will the clear surface scratch easily or discolour with age, or because of heat, humidity, and/or light; and under what conditions, if any, will the laminated disk separate?

Finally, there is the fairly recently recognized problem of 'Laser Rot'; a situation where the image begins in good condition, and then, over time, deteriorates into what has been described as "technicolor confetti". The phenomenon has already been noted with those film-video titles (Gone With the Wind and Star Wars, to name but two) that were mass produced in large quantities in a very short period of time. When inspected under a microscope the problem disks show no visible, detectable deterioration or variation from disks not experiencing this problem. It is presumed by the industry that the problem has to do with quality control during production. Some major questions come to mind: will this problem be found in disks with smaller, and presumably better controlled, production runs? Will the problem increase as the disks age? Are we experiencing the first phase of the optical disks' equivalent of wood pulp paper?

As if this variety of form and medium were not enough, we must also be aware of digital versus analog. For the work that most of us do, it is adequate to know that for every generation away from the original recorded event an analog signal loses information. There is no such loss in reproducing a digital signal. However, as it was reaffirmed at the AES (Audio Engineering Society) meeting in Los Angeles in November of 1986, the equipment to make instantaneous digital audio recordings, both disk and tape, is not yet standardized. Referring to this point in its project to develop a national audio preservation program for the US, the Association for Recorded Sound Collections' Associated Audio Archives (ARSC/AAA) has formally taken the position that: "the combination of digital audio recorders, magnetic recorders using magnetic tape, and digital formats is not appropriate for the generation of archival preservation transfer copies of sound recordings at this time (March 1987) for the following reasons:

1. There are no nationally accepted Standards for the various digital recorders and formats,
2. The audio industry has yet to resolve its conflicting systems, (and)
3. Neither equipment nor formats have yet been tested or proven reliable in an archival setting for making archival preservation transfer copies of sound recordings."

When the industry and the various national and international standardization bodies do come to some agreement, particularly for the instantaneous, write-on digital disk, it is possible that, presuming the shelf life is reasonably acceptable, digital recording will become the preferred archival rerecording and storage standard. Until that time we should support the ARSC/AAA position: as archivists we must take a wait and see attitude for digital signals for archival storage.

As stated at the beginning of this paper, the primary basis for efforts in preservation of the material is trial and error, but we must do better than that in the future. Since the field is far too large for any one institution to successfully explore coordinated research is needed into the various aspects that affect the long term storage and retrieval of the data and materials in our collections. We must actively work together to build a shared pool of knowledge essential in making the decisions which will prevent premature failure of the items in our care. Only in this manner can we assure that the information that they carry will be transmitted to future generations.

The author is particularly grateful to Merrily Smith, Chandru Shahani, and Robert McComb of the Library of Congress's Preservation Office for assistance on the chemical and technical matters, to Mel Harris and Steve Bush of the Library's Safety Office on matters concerning health and safety, and to two men on his own staff, Larry Miller for his information on disk cleaning and George Kipper for the information on cylinders.

Recommended Storage Conditions
Cylinder Storage

1) Where size allows, handle cylinders by inserting two fingers (middle and index, usually) into the cylinder, spreading them just enough to hold the cylinder securely. Those too large for this should be held by inserting four fingers into the cylinder while placing the thumb on the edge or rim. Only touch cylinders from the inside or on the extreme edges since touching the sound grooves deposits oil and grime into the sound modulations.
2) The storage container used should be closed in such a way as to make a reasonably dust-free seal yet, for celluloid cylinders, allowing for circulation of air to permit dissipation of gases. In addition, the container should be constructed in such a way as to prevent the playing surface from coming into contact with either the container or packing materials. (Some cylinders were sold wrapped in cotton batting. This was intended to protect the recording while in transit, never for long-term storage. Over time the wrapping often has adhered to the grooved surface. Once it is there it is almost impossible to remove completely. If you have cylinders with such materials still around them carefully remove it).
3) Store cylinders at a constant temperature of 50°F/10°C, 45% RH.
4) Store cylinders in an upright position – on edge, not on the grooved surface – in such a way that they will not be exposed to sudden jolts or shocks.
5) Avoid sudden changes in temperature. Allow a cylinder to adjust to room temperature (approximately 70°F/21°C) before handling it if at all possible. Even the heat from a hand or cold or warm mandrel may crack a cylinder. Always allow both to come to room temperature before playing.

Disk Storage

1) When handling a recording or when placing it in its sleeve never touch the playing surface, either with your hands or with the surface of the sleeve or its liner. Instead, hold

<u>*Henning Schou:*</u>
I was a bit concerned when Paul read Gerry Gibson's comments about the celluloid cylinders, that some experiments were carried out that are quite similar to those that Jean-Marc Fontaine mentioned, namely the study

the disk between the fingers in the center and the thumb on the outside of the disk. With the sleeve slightly bowed, slide the recording in. Remove any "shrink wrapping" type of wrapping materials from the records and their containers.
2) Store cleaned disk recordings in a sealed sleeve made of a laminate of polyethylene-paperboard which is lined with a soft aluminium foil of 0.001 inches thickness, and polyethylene. The disks should not be packaged and sealed until they are properly cleaned and are in equilibrium with the intended storage area.
3) Store in a darkened room, where possible, but always away from sunlight and from artificial lighting of shorter wave lengths; store all disks in a vertical position without pressure on the surface or the opportunity for off-vertical attitude, using only clean, unabrasive surfaced packaging as suggested in (1), above; do not permit sliding contact of disk surface with other surfaces.
4) Stack temperature should be maintained at 68°F (20°C) and 45%, +/-5% RH for often used recordings, and 50°F (10°C) same RH for seldom used recordings.
5) Playback and packaging room/s should be maintained dust free and at a recommended temperature and RH for often used recordings. Disks exposed to other environments should be conditioned in the playback area for 24 hours prior to playback and for an equal period in the storage area atmosphere before being returned to storage.

of ignition temperatures of the cylinders, and they found that they would ignite at 160° or 150° C (320° or 300° F), whereas more modern ones in good condition would not ignite until 90° C (194° F). I would question that information. Gerry concludes that the Library's preservation and safety officers were not concerned, because they said that although the flammable material is nearly impossible to extinguish when ignited, even poor condition celluloid cylinders are not considered a fire and safety hazard. Recent experiments have contradicted that, especially some research carried out by Dr. Jan Hansson while working in the laboratories of the Swedish defence forces. He has found that cellulose nitrate stored at a fairly high temperature like 80° C (176° F) will ignite spontaneously after some 27 hours, and with a lower temperature such as 40° C (104° F) it is a matter of three weeks, but still suddenly they burn.

Paul Spehr:

To comment on that, the Library of Congress is actually very conservative in testing nitrate material, and our preservation staff did look into this quite carefully on the levels of flammability. In part the decisions had to do with the kinds of storage areas, where the material was being kept, and the volume of materials being stored in the area. They are concerned that it is a very flammable material, but of course a lot of other materials fall into the same general range of flammability, including some of the cases that are used for materials in the library, so there is some compromise involved in this, but in the testing they did with the material they were seriously looking for reasons to move the cylinder collection out to our nitrate film vaults, and decided that they did not need to.

Henning Schou:

There are actually two different experiments here. One is if you take the celluloid cylinder and gradually heat it up, you will find that it ignites at 150° or 160° C, that is 320° F. However, if you keep a cylinder at a temperature like 40° C (104° F), then as the nitrate breaks down, it gives off a certain amount of heat, and if that cannot be dissipated, will accumulate inside the material, then you suddenly find that you experience spontaneous ignition.

On the Use of Laser Disk Technology in Information, Archive and Documentation Systems

Werner A. Deutsch

General Information

George Boston:
May I now introduce Dr. Werner Deutsch of the Österreichische Akademie der Wissenschaften (Austrian Academy of Science, Commission for Sound Research). Werner is a psychoacoustician by trade, and how he has got into digits and optics I am not entirely sure, but no doubt he will soon enlighten us.

The conventional media for storing information: paper for text, disk and magnetic tape for sound, film for moving images, etc. have to enter into strong competition with the digital storage area, if the substantial progress of technology is to be exploited. The consequence of this development will be persistent changes in the area of information processing: the areas of computing, television and communication will merge. Already they are overlapping to a large extent (fig. 1).

A few examples of data: digital audio, analog audio, digitized images, video stills, video film, computer graphics, "conventional" data processing, etc.

The initiatives leading to integration came simultaneously from the different areas. Digital video or analog TV, computer controlled, cannot only be used in the videoclip industry, but also in interactive systems of teaching and learning with elaborate capabilities of dialogue, e. g. for the maintenance and supervision of process control, in educational medical programmes treating situations of crisis and even flight simulation. On behalf of the communication area, the libraries, documentation centres and archives, there is an endeavour to extend access to documents, in which case for example the digitized historical document, supported by an enhancement of signals, often will achieve a better quality of image or sound. Furthermore, even manuscripts can be textually assessed and stored. Finally the area of computer technology is giving the interface between human being and machine the attention that is necessary in order to improve the basis of communication. Text, image and sound are integrated, and by means of the technical possibilites of programming that large data banks have, as well as through artificial intelligence, they become first-rate information and expert systems. Still you cannot foresee which positive (and/or negative) influences the total textual assessment of large information sources will have on human thinking, neither what you can do with information when there are practically no physical limits left.

```
         +-------------------------------------+
         !              Television             !
         !                                     !
+--------+----------------------------+        !
!        !        +-------------------+--------+--------+
!        !        ! XXXXXXXXXXXXX     !        !        !
!        !        ! XXXXXXXXXXXXX     !        !        !
!        +--------+-------------------+--------+        !
!Communication    !                   !                 !
!                 !                   !                 !
+-----------------+-------------------+         Computer!
                  +-------------------------------------+
```

Figure 1

The experts agree: the future terminal – or rather work station – will perform several functions simultaneously. There will be high-resolution and interactive television, equipped for facsimile transmission and capable of hard copy (printer). Moreover, it will be equipped for being used as an intelligent computer. If there is occasional doubt as to the acceptance of the first experiments in this direction, this could be caused by the fact that the final user has not yet been offered the kind of quality and clarity in an integrated system that he usually considers to be a matter of course in the different individual areas of video, sound and computer.

The Role of the Optical Disk as a Universal Medium of Storage

Optical processes of recording have been developed for about 20 years now. Today optical disks are used in almost all areas where signals are stored, no matter whether these are video, audio or digital data. Using gallium arsenide diode lasers of the smallest dimensions and with corresponding recording surfaces (consisting, for example, of tellurium alloys), considerable storage possibilities can be developed; amounting to 40 Mbytes on a 3 ½" disk and to more than 2 Gbytes on a 12" plate. Thus about 100 000 typed pages can be covered.

Three different categories of optical storage systems have to be distinguished:

1. Optical ROM (OROM, CD-ROM)
2. Write once, read many (WORM)
3. Write many, read always (WMRA), erasable

The OROMs and CD-ROMs represent the highest technical development. Within the next few years the greatest economic success can be expected in this sector, as relatively cheap play-back machines are likely to meet with a ready market. The OROMs and CD-ROMs contain prefabricated information, similar to the CD, and cannot be overprinted by the user. Mostly the data is received in a preprocessed state from a video or digital tape, whereupon the master is made by means of laser; from this master prints are made. The costs of producing a CD (from the master tape) according to the size (diameter of 5 ¼″ to 12″) and depending on the complexity of the studio and computer expenditure necessary for premastering and mastering, amount to between US $ 7.000.– and 20 000.– (in the case of especially complex video or data bank problems up to US $ 200 000.–), a duplicate will be about US $ 6.–. Play-back equipment for CD-ROMs can be obtained from about US $ 1.100,–, 12″ video disc players are about the same price. Many distributors of data bank information make the play-back equipment available, as included in the subscription-rate (usual costs about US $ 1.200,– annually). Numerous companies offer their services in producing (mastering) CD-ROMs and video discs. Internationally about 400 well known distributors of information ("information industry") exist, extending their programs to practically all areas of the public.

To a certain degree, WORMs are similar to OROMs, although they can be printed once by the user. They are capable of protecting once printed-over disk parts against overwriting, which guarantees that the laser can only print disk sectors that have not been written on before.

Thus the information does not have to be introduced in one single process of mastering, as in the case of the OROMs, but can be written in pieces (file by file), sequentially. The used block lengths often amount to 512 bytes (IBM-PC sector length) or 1.024 bytes. WORMs are chiefly available in the sizes (diameter) 5 ¼″, 8″ and 12″. Many manufacturers use a spiral instead of a concentric arrangement of tracks, as in the traditional record. Moreover, two kinds of recording velocities are being used: a) constant linear velocity (CLV), and b) constant angular velocity (CAV). The CLV method grants the same recording density, no matter if you are on the utmost edge of the disk or within it, that is, the disk has to run slower on the outside than on the inside. This is the best way of using the storage capacity of the medium. This, however, also implies additional hardware and software expenditure (= costs). The CAV method keeps the rotating speed constant, which leads to a denser printing of the interior tracks. WORMs will mainly be applied to cases where archive data, or backup of magnetic disk etc. are to be stored for a long period of time. This is the reason why WORMs are suitable as computer periphery for especially data intense application. The installation cost of WORM systems with an optical running gear is about US $ 21 500.– as a minimum expense for the large disk diameters, including the necessary hard- and software for the connexion with a microcomputer (e. g. IBM XT or AT). Some manufacturers produce so called jukebox systems with up to 100 12″ disks with a total capacity of 200 Gbyte. The medium (the disk) currently is about US $ 200.– in the 12″ version. In the meantime, numerous cheaper systems have been developed, being capable of storing about 200 Mbyte on a disk with a diameter of 5 ¼″. The fields of application of these large systems are mainly in the area of big libraries and archives, as for example the Library of Congress and the US National Archive, but also for military purposes and in patent offices. The smaller systems are chiefly to be used in the "private" data bank sector.

There is a certain critical point, controllable as it is, still to be found in the recording media (disks). The bit error rate originally is within a range of 10^{-5} and has to be reduced to the size necessary for computer application, 10^{-12}, by means of complicated error correcting algorithms. WORM media are preformatted. In doing this, defective and useless sectors can be distinguished, as in the case of traditional magnetic disks.

The controller uses a table of defective sectors and skips them or evades on alternate tracks.

Currently the most usual kinds of recording are: a) "bubble forming", and b) "ablative pit forming"; the first writing method means that a laser beam allows the lower layer of a medium to evaporate, a process during which the upper layer produces a bubble (blister). During the reading process the reflected laser beam leaks into the place of the bubble and the written bit is identified. By means of the pit forming method a hole or a pit is burnt into a surface by laser, material is removed. Once again the difference in reflectivity assigns the written bit.

At present, erasable and once again writable optical (magneto-optical) systems, WRMA, are currently only available as prototypes (e.g.: Verbatim, 3½" - 40 Mbyte and Daisar Corp., 8" - 700 Mbyte). Here the main emphasis of the research is done in order to improve the medium; one of the previous stages of development (Kerdix Inc.) goes back to a writing material that originally was developed for audio recordings (Nakamichi USA Corp.). The principle of recording differs from the optical disks to the extent that the laser beam is not used in order to burn a pit or a "bubble" into the material. The magnetic material is merely heated, in order to make it magnetizable when the coercive force is locally reduced. Highly coercive media (2.000 to 3.000 Oe) with vertical magnetic orientation are operating. Compared to the "pure" optical disk, the recording densities are somewhat lower, the bit error rates, however, are to some extent improved, being comparable to the traditional magnetic media. The experts are expecting a more widespread use of the erasable magneto-optical storage systems within the next five years.

Finally, a few other technological development trends should be mentioned, that are now being worked at in the sector of optical recording: a Dutch product (DOCDATA) uses a laser tape deck with up to 100 cassettes arranged in a carousel that will have the enormous storage capacity of 600 Gbyte. The writing method on "laser tape" consists of welding two film layers by means of laser. Further developed optical disks will be able to store not only 1 bit but possibly 8 bit, a whole digital word, with one single bubble burnt in by laser, in as far as the system is capable of differing various gradual stages of reflection. Also in this case the storage capacity of a disk would be multiplied.

The Problem of Lack of Standardization

Presently there is a large supply of hardware and software in the area of laser disk memory, the only common denominator being that they have little or no standardization. This state will probably last for some time, as the individual product planners will be trying to keep away from the chaos of standardization as much as possible. This will take place on two levels: on the one hand there is the argument that the single applications naturally have to display such a high specificity that only one option of the technical medium is selected. On the other hand there will be an effort to become independent, especially with regard to the architecture of software, device and operating system. In this context, the transportability of software will surely contribute towards the longevity of the products.

Examples of currently existing incompatabilities of the optical media will indicate the need of standardization: different OD types and formats
formatted, non-formatted, written in spiral or concentric form;
different sizes
12" digital video disk with its own drive unit; 12" optical disk - WORM (write once read many); 8" optical disk; 5¼" optical read only (OROM) with a drive unit capable of writing; 4.72" CD-ROM with its own drive unit.

This leads to numerous questions and consequences for the integration of optical disk systems: are disks and drive units of different manufacturers interchangeable? Are there alternatives to individual manufacturers of drive units, of media, or are you dependent on one company, is there what you call "second sourcing"? Can a disk made by manufacturer no. 1 be read (written) on the drive unit made by manufacturer no. 2? How compatible are the formats, the error rates? Finally: is it really possible to make the systems compatible?

The SCSI (small computer system interface) is suggested, seeming to make a minimum set of commands suitable for standardization. A total compatibility using all interface variants is not likely to occur very soon. The question of the SCSI expansion still remains unsolved: what happens when several computers are to gain access to one drive unit, and the other way round, when a work station is to operate on several drive units (the problem of networks)?

Graphic display: which dot resolution power (out of 640 x 350, 640 x 480, 720 x 410, 1.024 x 1.024 etc.), which relation between output (analog, digital); printer output; etc.

Possibility of video output; possibility of processing computer graphics as video;
Possibilites of digital audio; processing of digital audio; continuous high-fidelity recording and replay, cutting, mixing, audioprocessing;
Input of X-Y devices (mouse, cursor track ball);
Connection of traditional background store media; hybrid data banks; remote access of data banks;
The computer as interface of all standard input/output unities; peculiarities and bottlenecks of the current operating systems like PC-DOS, UNIX, VAX/VMS etc.
Is a sufficient number of applications available for the system integration?

At the moment no previously defined methodology of access exists for the final user, neither are there many utilities for the systems engineers. There is no uniform user interface, everybody has an individual one, e. g. Mc Graw Hill, H. W. Wilson, Information Handling Services, Reference Technology etc. The agreement on one data bank manager and a common enquiry language as well as a consistent indexing and formatting methodology would be an advantage.

Components necessary for the integration of optical disk systems
1. Data: digital audio, analog audio, digitized images, video stills, video film, computer graphics, "traditional" data processing, etc.

2. Data processing: first on magnetic tape, magnetic disk or similar; establishing a data integrity, indexing and retrieval, file structure.

3. Soft- and hardware for premastering: the file structure is designed for the optical disk, production of file directories, setting up the error correction codes; production of the master disc, matrixing, production of dupes.

4. Computer hardware and operating system: the file manager has to master a large number of files. A user should be able to dispose of more than 10 000 files (a representative case) on one single disk. The size of the file with a maximum of 1 Gbyte for example, exceeds the upper limit of the PC-DOS, amounting to 32 Mbyte!

5. The optical disk hardware.

6. System integration.

7. Support for users.

Prospect

The American market research company Link/Infotech has made a survey in cooperation with 6000 libraries on the subject of applying CD-ROMs within the next five years. A few consequences resulting from this could be applied correspondingly to the other formats:

Concerning the question of standardization: in libraries, the Sony/Philips CD standard has obviously been accepted generally, that is, a uniform disk size, data coding and decoding as well as error correction are being used here. This leads to a certain compatibility, which does not necessarily mean that CD-ROMs are actually interchangeable.

Concerning the question of availability: at the moment there are very few manufacturers of CD-ROMs. There also are problems with regard to the interfacing of ROM disk drives. These, however, are solved for most microcomputers (especially in the USA).

In the process of premastering considerable computer installations and staff resources are required. Machine readable data first have to be brought to CD-ROM format (e. g. Sony/Philips, also cf. AT & T Bell Systems). The arrangement of files on the disk may influence the quality of queries decisively. The question remains as to how rapidly the necessary conditions can be created in order to support such CD-ROM product designs.

Software research: significant software components are to be developed, especially driver software for CD drives and application software for data retrieval. It might very well happen that the use of CD-ROMs will chiefly depend on the development of this software, whose availability is an unavoidable prerequisite for the production of CD-ROMs.

Bibliography:

NBS Special Publication 500-111 (1984): Standardization Issues for Optical Digital Data Disk (OD^3) Technology. Workshop held at the National Bureau of Standards, Gaithersburg, Maryland, June 1–3, 1983.

Proceedings of the 1985 Videodisc, Optical Disk, and CD-ROM Conference and Exposition, December 9–12, 1985, Philadelphia, PA.

George Boston:
Thank you Werner, what you have done is show that the future of the optical disk is going to be as confused in terms of formats as all of the preceding methods of storing various types of information.

William D. Storm:
Do you know if any ageing tests have been done on CDs or optical systems? We have been doing an extensive study in the USA on this, and so far we have found only one manufacturer that has done any kind of testing for life expectancy.

Werner Deutsch:
I have no information about that. Generally people give a guarantee for 10 years, or that is what they write in the advertisements. There has been some work in the standardisation group, and there are some publications on ageing, including one done at the National Bureau of Standards about five years ago, but it is a guess at what could happen rather than based on experimentation. Also I am sorry but I do not remember if it was glass or if it was other material.

Christopher Roads:
In answer to that I went down recently to the PA technologies factory making these disks in Cambridgeshire in England and they have carried out very severe ageing tests on the PA technology disk. This is a 5 inch optical disk which is made of a particularly pure form of polycarbonate and platinum, only those two substances. The cycling has been so severe, to a very high temperature that they extrapolated from that an expectation of life of perhaps 100 or 200 years.

Jean-Marc Fontaine:
In order to tell you the name of a manufacturer in France who actually makes research in the area of disk production, that is of durable disks, it is DIGIPRESSE, just to call attention to these manufacturers.

On the Problem of Storing Videotapes
Gerhard Welz

Philippe Poncin:
The first paper for FIAT will be by Gerhard Welz, an engineer who works at Grundig. His paper was actually written while he was working at the Institut für Rundfunktechnik, München.

1. Introduction

The technique of magnetic telerecording has been known for more than 30 years. The process of recording the electrical signals of image and sound information on magnetic tape is common to all variants. To begin with, this was the field of radio and television. The practical advantage of this method is the possibility of repeating any recorded event. Topical events, and other productions, are stored on magnetic tapes and these tapes are stored for later use. At first the equipment was very bulky, complex and expensive, but within the last few years technical development in the field of video signal recording has caused widespread distribution of this technique by means of compact and cheaper machines. There is an increasing interest in video recording, not only in industry, but also in the private consumer market, and it is taken for granted that the stored information can be conserved without problems for as long as you wish.

1.1 Problems

In earlier times information in the form of writing and image was 'stored' on different materials, and surprisingly enough, quite an amount of this information has been preserved in good condition over centuries. Only the human eye and the knowledge of the 'written code' are necessary in order to decipher the ancient writings and to retrieve the stored information. No 'reading machine' like the one we need for the reproduction of video signal recordings is necessary.

Since the introduction of the video recording techniques for television in 1956, a large number of different standards have been launched on the market. Thus, in the course of time various non-compatible, individual processes were created, on tape reels as well as on cassettes. Recordings within a certain standard also show differences between the three internationally introduced colour television systems: PAL, Secam and NTSC, which are an impediment to tape exchange. With technical development, individual standards disappear from the market, but the total number continually increases.

Today we are dealing with parallel formats – some professional which have studio quality, and some produced for private consumption.

The 2 inch recording format introduced for television in 1956 has not been manufactured since 1981, but still exists in many places as archive material. The 1 inch B and C formats are the current internationally accepted studio standards. Also, the 3/4 inch U-matic standard has three incompatible versions, lowband, highband and SP. The advantages of simple handling and especially the introduction of the magnetic tape cassette, meant that the U-matic cassette is widely distributed from broadcasting to industry. Recently the component recording has been advancing into the professional sector, leading once again to the parallel production of several non-compatible standards. The formats of Betacam[1], M[2], Quartercam[3] are competing with the latest versions of Betacam SP[4] and the M II formats[5]. Very soon we will be confronted with further processes, the digital video signal recording in D 1 format and machines for the recording of high-definition TV signals (HDTV).

In the consumer sector we are confronted with a variety of formats: Betamax, VHS, Video 2000 and recently also 8 mm video.

The problem of storing video tapes does not arise exclusively because of the variety of standards, but is based on the fact that the density of storage has been increased in the magnetic tape. The read-out of densely packed information (which is the case in home recorders) is not possible without difficulties whereas broad information tracks with an additional safety margin – common among the professional standards – promise the highest possible degree of reproduction safety in this respect. This statement is only partially valid as far as future formats are concerned, as the increase of storage density reaches the physical limits, and the safety margin between the video tracks is partly dispensed with.

One problem of storing video tapes is whether the corresponding playback machine ought to be preserved in addition to the magnetic tape. The question is: under what conditions is long-term storage of video tapes possible.

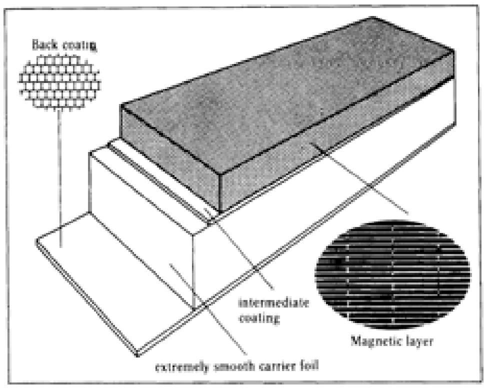


Figure 1
Layer construction of a video tape

2. Recording Carriers

2.1 Magnetic tape

In order to grasp the problems of archiving better, it is necessary to deal more closely with the mechanical and physical characteristics of the magnetic tape. Figure 1 shows the layer construction of a video tape.

The carrier for the magnetic coating consists of a polished polyester foil whose magnetic characteristics – for example with regard to suppleness – determine the tape run. To avoid the varying tape tension forces, which are created in the changing modes of operation between stop after replay and rewind, from causing changes of dimension in the polyester foil, the foil is stretched before the process of coating. The foil of professional tapes is relatively thick, 20 µm; the video tapes of home recorders are much thinner, with a minimum of 9 µm. The recording medium is the magnetizable coating. There is a homogeneous distribution of needle-shaped particles in the magnetic film, which are aligned on parallel lines to the tape edge (in 2 inch tapes diagonally towards the edge). About 40 % of the volume of layers consist of magnetic grains, a further 40 % are needed for the fixing agent. This is an organic bonding agent enclosing the grains which are pulverized in their raw state and connected to the carrier foil. The remaining 20 % of the layer volume has to be imagined as minute pores, which impart a porous structure to the surface and are responsible for tape noise and possible dropouts. However a small amount of surface roughness has to be maintained in order to avoid adhesion on the even surfaces in the tape guide of the recorder. The thickness of layers is continuously reduced when storage capacity is increased and wave lengths shorter. Today with an initial measure fo 12 µm for 2 inch tapes, consumer tapes are only 4.5 µm. As figure 1 shows, due to technical reasons there can still be an extremely thin intermediate coating of 0.3 µm between the carrier foil and the magnetic layer. This, however, is only used in special cases. As a contrast, the approximately 1 µm thick back coating has been introduced generally in order to improve the winding characteristics of the tape, so that a certain amount of friction is imparted to the even carrier foil. In addition good electrical conducting capacity, that is a low surface resistance of the back coating, prevents static and the attraction of dust particles that could damage the magnetic layer of the unwound tape. Figure 2 shows an assembly of the layer construction for all tape formats. Comparing the studio formats with the ½ inch tape, you will see that the polyester foil also has become thinner. If a ½ inch tape is to meet the requirements of professional stability, great demands will be made on the carrier foil.

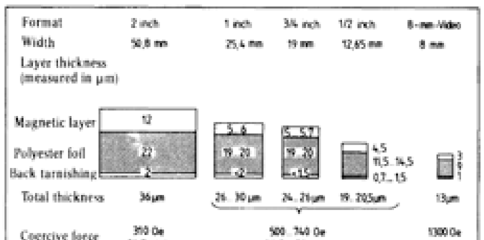


Figure 2
Video tape formats

During the last 30 years the quality of the magnetic layer has clearly improved. Figure 3 shows electron microscopic photos of the coarse, irregular structure of the gamma Fe_2O_3f magnetic powder that was used 20 years ago. Today, the grains are much finer and more clearly needle-shaped, so that more homogeneous coatings can be produced. This improves the recording capacities of both video and audio. Compared to iron oxide powder, chromium dioxide magnetic powder has an even finer and more distinctly needle-shaped structure with other magnetic characteristics.

2.2 Physical influences on the magnetic tape

2.2.1 The risk of erasure

During the process of recording, the signal information in the recording head produces a modulated electromagnetic alternating field whose lines of electric flux polarize the magnetic particles in the coating. When a tape is erased, it is passed through a strong high frequency alternating field and the recorded magnetization is neutralized. This is the reason why external magnetic fields can erase a magnetic tape.

Accidental erasure can occur due to the close proximity of transformers, generators, motors, loudspeakers and strong magnets. Yet it must be remembered that a high magnetic field strenght has to be produced to reduce the remanent magnetization of the tape to zero. Current video tape has a coercive force between 500 and 740 Oe or 30.5–58.5 K A/m. As figure 2 indicates the coercive force of 2 inch standard tape – which was used in the first video recordings in 1956 – was only half as large as today, namely 310 Oe. As a rule a magnetic field three times larger than the coercive force has to be produced on the surface of the magnetic tape in order to erase a recording. Partial erasure, however, is possible with a much weaker field strength. In reality it is quite unlikely that a video tape will touch fields of that size.

The following example shows how the risk of erasure is to be evaluated as a result of physical laws implying that the intensity of a magnetic field decreases in inverse proportion to the square of distance. A modern video tape with a coercive force of 500 Oe requires an obliterating magnetic field strength of 1500 Oe on the tape surface. A distance of 7 cm is sufficient to reduce the field strength to the harmless value of less than 50 Oe. This is the reason why a strong permanent magnet would have to be in direct contact with the tape in order to bring about any serious danger.

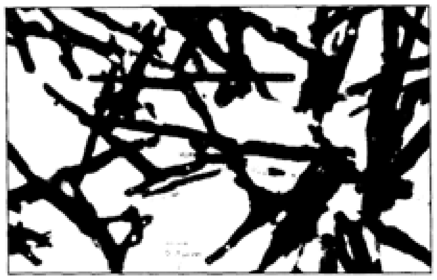
It is interesting to point out that there is no risk of erasure through X-rays during the safety control at airports. Some firms, however, warn against the metal detectors used for passenger control. A partial erasure of recordings might be caused. As for radar and microwave rays, they are no danger whatsoever.

2.2.2 Print-through

Practically all sound recordings suffer from print-through, although the effect varies in strength according to the magnetic characteristics of the video tape. The magnetic lines of electric flux in a recording with long wavelengths interact – via their leakage fields in the wound tape – with the magnetism in the adjacent tape layers. The information of strong sound signals is 'transferred' in a reduced way to the adjacent layer. Thus disturbing secondary noises are produced, especially when loud sounds are followed by low-key passages. Figure 4 shows the pre- and post-echoes grouped around a pure tone. These echoes are produced immediately after the recording has been made, but their intensity does not change according to the duration of storage significantly. One advantage is that even a single rewind will reduce the amount of print-through. Consequently figure 4 shows the pre-echoes after the main signal.

Today, sound disturbances in video tapes due to print-through are of secondary importance, as only tape material with low coercivity is easily magnetized. In modern tapes with their coercive force of some hundred Oersted, print-through is less significant than it used to be. A printing attenuation of 60 dB is achieved without difficulty. During the process of video recording this effect does not occur. The video signal is recorded with frequencies in the MHz area, that is with very short wavelengths whose leakage fields do not extend to the carrier foil or influence the recording of adjacent tape layers. Print-through may be increased through higher temperatures and increased tensile forces in the tape winding. Nevertheless as already mentioned, a single rewind reduces the disturbing effects, and the duration of storage is of minor importance.

a)



b)

c)

Figure 3
Electron-Microscopical photos of different pigments. a) 20 years ago: Gamma Fe_2O_3 magnetic powder, coarse, irregular and deformed, b) Gamma Fe_2O_3 of today, finer and more regular, c) CrO_2 magnetic powder today, a photograph of fine crystals (according to records obtained by Agfa-Gevaert.

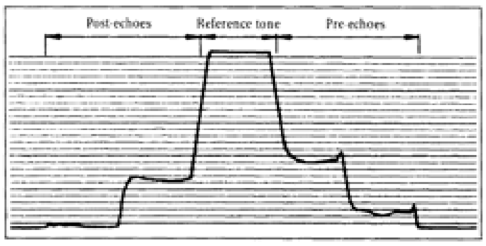


Figure 4
Print effect

2.2.3 Demagnetization through tensile forces
When describing a standard of recording, not only the parameters of the signalling technique but also the mechanical specifications are important. A perfect tape run implies the observance of correct tape tension. In the case of faulty tape tension, the magnetic tape on the running carrier is especially strained on the deflection rollers and in the area of the recording/reading heads. Also physical changes in the magnetizability may occur.

Too fast an acceleration not only causes stretching of the magnetic tape but also leads to signs of demagnetization. In reproduction this effect becomes noticeable as a loss of signals affecting the short wavelengths. In the case of stopping and frequent positioning, the tape is heavily strained. This is the reason why the published technical data on video tape often contains information on FM level dropouts during the operation of pauses and/or information on the allowed maximum duration of pauses.

The elastic quality of polyester foil in current video tapes is so well adjusted to the changing strains in the tape transport that signs of demagnetization are unlikely to occur. However, if large shock and impact forces act upon the tape container during the transport of a video tape, unacceptably large tensile forces might be produced. This should to be avoided. In a 90 minute 1 inch tape, for example, weighing about 4 kg, a considerable turning moment may occur. Containers for tape reel formats are therefore constructed in a way that enables the tape reel in a closed tape container to move freely around its axis. Thus a sudden turning movement can be equalized automatically.

Low tape tension does not cause any physical changes in the magnetic layer of the tape.

2.2.4 Demagnetization through high temperatures
In principle the characteristic features of ferromagnetic materials change with increasing temperature. In general the saturation inductance is reduced at higher temperatures, and at a certain limit, the Curie point, it reaches the value of zero.

This is the reason why self-demagnetization occurs in video tapes (depending on the magnetic structure of the coating) when a certain Curie point of temperature has been reached. For iron oxide pigment this temperature, 450°C (842°F) is relatively high. In the case of chromium oxide however, self-demagnetization will occur at a temperature of 130°C (266°F).

2.3 Environmental influences on the magnetic tape

2.3.1 Temperature and humidity
With increasing temperatures, the physical characteristic features of the polyester foil in the magnetic tape change to such a degree that irreversible tape damage has to be expected. Bearing the minute dimensions of the code tracks in mind and the high precision of the tracking mechanisms in order to be able to observe the close tolerances (in the order of a micrometer) it is quite obvious that changes in elasticity and minimal divergence from the nominal size of the tape may render the reproduction of recordings impossible.

The magnetic tape will suffer the following damage in the case of higher temperatures:
120°C/ 248°F: distortion of the carrier, adhering layers
150°C/ 302°F: a 1.5% shrinkage of the polyester foil
160°C/ 320°F: softening of the carrier and the binding agent, adhering layers
165°C/ 329°F: a 2% shrinkage of the polyester foil: this corresponds to a shortening of 19 m in a tape of 950 m
290°C/ 554°F: Carrier and binding agent change colour and become brittle
540°C/1004°F: Carbonization of carrier and binding agent, spontaneous ignition
Influence of the relative humidity in the case of average temperatures: 55°C (131°F) and 85% RH: adhering of single tape layers.

These temperatures show that the greatest danger a magnetic tape can be exposed to, that is the influence of heat during a fire. Even if the video tape winding device appears undamaged after a fire, reproduction may – as the table shows – become impossible after a temporary rise in temperature, from 120°C to 150°C (248–302°F), because of shrinkage and damage of the layers, not to mention the possible damage of the video heads caused by a defective tape surface.

In daily work, however, significantly lower temperatures may cause problems (as the last line of the table shows). If there is a relative humidity of 85%, you can expect single tape positions to adhere. Tape wear and smears of the head may also disturb reproduction.

Rain and condensation are part of everyday life in tropical areas. When magnetic tapes are transported in motor vehicles, a temperature of 70°C (158°F) is not unusual in summer, with direct solar radiation. Great fluctuations in temperature, which are sometimes the case in winter, ought to be avoided because of the inevitable danger of condensation during operation. If unavoidable, a sufficiently long time of acclimatization, about 24 hours, has to be allowed for adjustment to the workroom. In observations over several years, Canadian Television has examined the connection between fluctuations in humidity and frequent interruptions in video tape recording[6]. The conclusion was that a high degree of humidity is not the only cause of interruptions. Rather it is the interaction of high humidity with other factors.

Because of the minute pores in tape coating and polyester foil, a magnetic tape should never come into direct contact with water. The pores absorb the water, and the tape swells. If a magnetic tape has been soaked in water (due to flooding or fire fighting), it is advisable to dry the tape, rewind it and transcribe it as soon as possible in order to save the recording.

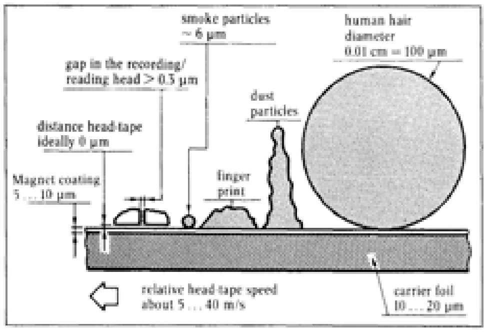


Figure 5
Dimensional comparison between head gap and dirt particles (according to BTS)

2.3.2 Impurities

Mechanical damage of the magnetizable tape surface is one of the worst things to happen. A mark on a fixed part, for example the erasing head, can cause a scratch which when compared to the recorded track dimension is big enough to make the tape totally useless. Such severe damage has to be avoided. Microscopically small dust particles may have a disastrous effect on operational reliability. Figure 5 illustrates a comparison of sizes between the gap dimensions of a video head and different dirt particles. The gap lenght of a recording/reading head for a video signal currently amounts to between 0.3 and 1 µm, the thickness of the magnetic layer is between 5 and 10 µm, and ideally the head ought to touch the tape directly. By comparison, dust and smoke particles and the grease of a finger print are enormous. Such impurities disturb the contact between head and tape and may cause a smearing of the video head. Fortunately, due to the high relative speed between head and tape, the head often thrusts the dirt particles aside like a snow sweeper. Particles adhering to the tape surface, however, are carried to the reroll spool, causing dents in the coating. Dropout – that is signal interruptions – also disturbs the reproduction process.

In figure 5, the comparison with the diameter of a human hair illustrates the dimensions. According to the microscopic photograph in figure 6, a comparison between a video head and a common fly is even more striking. The wire windings recognizable in the picture consist of a 4 µm 'thick' wire, the almost hidden head mirror of the video head representing the dimensions valid for the old VCR system, that is a track of 130 µm.

Figure 6
Dimensional comparison between a video head and a common fly (photo: Grundig)

The machine room must be kept clean. Smoking, eating and drinking should not be allowed. Impurities caused by dust can be avoided if a slight excess pressure is produced in the working room and if the size of the dust particles in the outer air intake is limited to an acceptable minimum by means of special filters. The regular cleaning of the tape running gear is necessary routine work. However, only cleansing liquids recommended by the producer should be used, especially volatile video sprays that do not leave any chemical residue. Even the formerly popular spirit of wine contains denaturants which might affect the magnetic tape in the course of longer storage.

3. Tape Winding

The previous observations prove that the greatest danger for magnetic tape is to be found in the tape machine. Tape winding should be paid particular attention before storage. If the tape is perfect, signs of irregular winding always indicate urgent maintenance is needed to the tape transport.

If the tape tension is too weak, creases or window-shaped deformations develop, causing cinching. The loosened tape layers are able to move and after a longer time of storage undulating tape segments are produced, stretching through several layers. In these spots, reproduction is disturbed. Only immediate rewinding at constant average speed can save the recording.

If the braking time between the feed and the take-up spool is not correct when changing mode of operation, creases may develop. During fast rewind the tape loop relaxes so suddenly that the video heads can be damaged.

If the tape tension is too great, the extreme case may occur that the carrier foil is stretched, and the strong tensile forces intensify print-through. Without fail an irreversibly stretched tape produces image interferences caused by tracking problems and consequently it is useless.

Single projecting windings and levels are especially likely to occur when only certain parts of the whole tape length are reproduced in rapid succession. If an open-reel tape is touched by mistake through the windows of the spool, or if the flanges are pressed together, the projecting windings will crack. Even without manual damage, the levels will gradually cause stretched and curled tape edges disturbing the sound recording on the edge track. A tape that is stored in this state will become increasingly irregular and one day will be extremely difficult to reproduce.

Careful maintenance and cleaning of the tape transport helps to avoid problems. A magnetic tape that is to be stored should not be left in the machine for longer than necessary. Mechanical cuts and joins should be avoided. Before storage, the tape should be wound at an average speed, in a continuous process, to produce a reasonably constant tape tension, and the tape end should be secured with a special adhesive tab that does not leave any residue on the tape.

4. Long Term Storage

4.1 Selecting the tape material

A careful selection of the tape material is required for long term storage. The quality of the magnetic tape is of decisive importance, regardless of the format and the amount of space required for the tape. As mentioned above highly coercive tapes reduce the risk of erasure caused by external magnetic fields. At the same time you get a material with extremely low print-through. Magnetic tapes with thick carrier foils are more reliable and have a higher mechanical stability for recording, reproduction and archival storage. Thin long-playing tapes do not offer the desired safety.

The chemical stability of the magnetic coating is not predictable, and the tape producer is not always able to test long term stability in laboratory experiments. The only sure test is the long-term storage itself. It is advisable to use tapes already established on the market and produced by reputable manufacturers. In the end, only regular supervision prevents surprises. Tapes in the course of time may show a white powder on the surface of the coating. This is the binder which keeps the magnetic coating together emerging. During reproduction the white powder causes interference as the head is soiled. At first the emerging binder can be removed easily by tape-cleaning apparatus. However after some weeks or years, the white powder will reappear. In case of doubt it is advisable to duplicate an affected tape.

4.2. Choice of format

Because of their ease of operation and dust-proof protection, magnetic tape cassettes are more generally preferred as recording formats than tape reels. So far, however, cassette recorders have lower quality. This includes all home recorder standards and the U-matic high-band standard introduced to broadcasting stations. For the following reasons these formats, used professionally and semiprofessionally, are not suitable for long term storage:
Relatively large tolerances, less mechanical precision with the cassette as well as the tape guide and the unfavourable winding properties as the result of low tape speed may cause problems of compatibility. Admittedly there are much more expensive professional cassettes with selected tape material and elaborately produced cassettes, and yet the limited quality of image and sound makes storage seem unsuitable. In addition, there is the even more serious fact that standardized formats may be changed within a few years. At regular intervals we learn about modifications, such as new processes of sound recording. The duration of life of a semiprofessional standard and the availability of spare parts are not long enough for archival purposes. The international studio formats with 1 inch magnetic tape (B/C format) are preferable to the cassette formats mentioned above.

Some professional formats already approach studio quality, and further improved processes with even better quality will be added shortly, for example the Betacam format, the new Betacam-SP and MII formats, as well as the digital video recorder in D 1 format. Metal tape and precision cassettes should measure up to the demands of studio quality in future. At present, the standardized tape thickness of these formats, from between 13 and 16 µm, is causing some difficulty. Their recording quality will have to stand numerous tests in normal work. Nevertheless, future cassette formats will probably supercede the current reel formats for long-term storage.

4.3 Choice of tape

A tape container suitable for archive work should also be a transport container. Pasteboard cases are inadequate.

The container has to protect the magnetic tape from pressure and percussion. 1 inch reel containers are constructed in a way that enable the tape reel and its hub to rotate freely about its own axis. Thus a sudden turning movement can be compensated for automatically, without producing an unacceptable tape tension or cinching in the winding mechanism. Because of their good seals, stable synthetic containers also offer relatively good dust-proof protection and to a large extent they are proof against water jets. The distance between the container surface and the tape allows sufficient protection against accidental erasure.

Fire precautions are most important. Fire regulations require the use of fire resistant containers. According to DIN 53438, the grading of such containers is called K 1 and is defined as 'hardly inflammable – not apt to take fire'. There are also suitable fire resistant/transport containers for U-matic and Betacam cassettes available on the market.

In fire fighting no water should be used. Carbon dioxide fire extinguishers are recommended, as CO_2 does not contain any chemicals that might react with the tape material.

4.4 Conditions of archival work

A tape for storage should be rewound completely and without interruption from the beginning to end and secured with an adhesive tab to ensure good dust-proof protection of the tape. It can also be welded into a synthetic bag. The VTR card, preferably made of non fuzzing paper, should not be put into this bag as well. The tape containers ought be shelved vertically. According to some tape manufacturers, video tapes can also be piled horizontally, one on top of the other. The side corresponding to the base surface has to be underneath in order to allow the magnetic tape to be supported by the reel disk.

Recommendation	EBU	SMPTE
Document	Tech. 3202 1974	RP 103 1982
Temperature	Working room archive: 15 to 27 °C 59 to 80 °F	working room: 20 to 25 °C 68 to 77 °F
		archive: 21 °C/68 °F (± 2 °C/36 °F)
Relative Humidity	40 to 60%	50% ± 20%

Figure 7
Conditions of working room and archive

The optimal climatic conditions recommended for the working room and the archive are documented by the European Broadcasting Union (EBU) and the Society of Motion Picture and Television Engineers (SMPTE). Figure 7 is a compilation of the most important specifications. In the document Tech. 3202 "Storage of magnetic tapes and cinefilms", (1974) EBU describes the general principles of tape storage. Although this document is being revised, the stated environmental conditions are still valid. On the basis of experience the same temperature range from 15 to 27°C is recommended for the working room and the archive, and a relative humidity between 40 and 60% should be observed[7]. In the recommendation RP 103-1982 of the SMPTE "Care and Handling of Video Magnetic Recording Tape" similar storage conditions are described. Although a difference is made between the working room and the archive, the numerical values remain practically the same. The working room should maintain a temperature of 20 to 25°C whereas the temperature of the archive will be in a narrower range 21 ± 2°C. The relative humidity may vary more widely, but should correspond to 50 ± 20% RH[8]. In both recommendations the climate hardly differs between archive and working room. This will save preconditioning time lasting for hours, when a video tape that has been submitted to long-term storage is to be examined.

5. Supervision of the Archive

The tape manufacturers suggest rewinding magnetic tape after a storage period of three to 10 years. Thus the head of an archive has to decide which time interval he finds economically justifiable. The cautious person might check the archive material every three years, but 10 years is an acceptable interval.

The examination of a video tape does not have to take place on a VTR machine. The most important thing is to carry out a complete process of rewinding to relax the forces operating in the spooled tape. This should be done on a tape-cleaning machine, as the rewinding ought to be carried out at average speed and with constant tape tension. Thus you can avoid possible drift of the individual winding bundles and also avoid tape damage caused by wrinkles. At the same time you can make a visual inspection of the tape surface, observe possible emergence of the binder (the white powder on the emulsion side) and simultaneously carry out the cleaning process.

A further aid in regular supervision of archive material and the observation of tape material in the course of long-term storage is the use of single test tapes. These test tapes are recorded with easily controllable test signals. Thus you have a simple method of checking the test recordings periodically, and at the same time you are able to supervise the tape material used for valuable archive recordings. In recent years, unfortunately, problems of chemical incompatibility have occurred on more than one occasion. To be quite fair we have to point out that no tape manufacturer, no matter how renowned, is immune against such long-term effects. Only regular archive supervision protects you from unpleasant surprises.

6. Conclusion

Observation has clearly shown that magnetic recordings of image and sound information, provided that they are stored appropriately can be reproduced after years or even decades. It is more likely that a recorded tape can be damaged through inexpert handling during replay. In the first place mechanical problems of the tape machine have to be taken into account. Cleanliness and care when dealing with tapes are essential factors in the machine room. For highly coercive video tapes the dreaded danger of erasure caused by external magnetic fields is extremely low in the archive as well as in the tape container. The only genuine sources of danger in archives are damage caused by fire and water. Sophisticated fire alarm and fire extinguishing systems diminish this danger. For the video tape itself, the fire-resistant K 1 tape container is excellent for protection and transport purposes.

If you consider a storage period lasting for decades, it must be left to the wise foresight of the archive heads to secure the availability of the current machine standard. The most expensive and yet from the point of view of preservation the safest method is to use internationally well known professional studio standards. Only trained specialists should operate and maintain the more complex machines for safe reproduction. We all regret the increasing variety of recording formats which unlike the film medium can be relatively short lived.

The climatic conditions most appropriate for the archive are summarized in the recommendations pronounced by EBU and SMPTE. The optimum conditions are very similar to those that human beings need in order to feel comfortable: the video tape should not be stored in a place that is too warm, too cold or too humid. In addition, regular methodical inspection helps to avoid problems.

Finally, although a recorded video tape can be safely stored for decades, human beings and machines still remain the critical factor. At the moment video disk does not provide a viable alternative. From the point of view of preservation, the digital video recording on magnetic tape will not help us out of this situation, as the complexity of the installations and the storage medium of magnetic tape do not guarantee long-term storage without problems.

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Archiving the Various Audio and Video Tape Formats
Jim Wheeler

Philippe Poncin:
I would suggest that we have a discussion after the next paper which will be held by Jim Wheeler. Jim is staff engineer of the Audio Video System Division at Ampex corp. He is design engineer since 1962 and member of the professional teams for recording.

Magnetic tape recording was first successfully demonstrated at the Berlin Radio Exhibition in August 1935. The tape recorder was the AEG Magnetophone model K2. The tape was carbonyl iron powder coated on cellulose acetate and was made by IG Farben.

When Harold Lindsay built the first Ampex audio tape recorder 12 years later in 1947, he used ¼" wide tape running at 30 inches per second so that he could interchange tapes with the magnetophone. Eventually, the tape speed was reduced to 15 ips for most professional recorders and 7½/3¾ ips for consumer recorders. This has been the industry standard for the past forty years, but the new digital audio formats will soon change that.

The Philips tape cassette was introduced in 1964 and eventually became the consumer audio standard. The Philips cassette is not a good archival format for several reasons - primarily because of the narrower tracks and the thin tape.

Special Audio Tape Archival Problems

There are five possible archival problems unique to audio tape:
1. Acetate base film
Many of the older open-reel tapes used acetate base film. Acetate will deteriorate with age. Recordings made on acetate should be dubbed to polyester base film tape.

2. Chromium-dioxide (CrO_2)
Some cassette tapes are made with CrO_2. The CrO_2 particle has a history of instability, so these tapes should also be dubbed. The tape manufacturers using CrO_2 have been working on the stability problem and some now have products which they believe are stable.

3. Low Cost Cassette Tape Recorders
As with any consumer product, there are poor quality cassette recorders which can make non-standard recordings or damage tape. This is especially possible with the thin 90 and 120 minute tapes. For archival purposes, use only high quality equipment and 60 minute cassettes.

4. Friction
In the early days of tape-making, some tape manufacturers used lubricants which eventually migrated out of the coating. In such a case, the actual recording is still okay; the problem is the high friction. Such a high friction tape can be "rejuvenated" for at least a few passes by applying Krytox to the oxide surface. This can be done by running the tape over a pad soaked in less than 1% solution of Krytox and about 99% freon TF.

5. Print-through
To minimize print-through, the following is recommended:
Store the tape at low temperature;
use the thickest tape possible;
keep the tape away from magnetic fields;
rewind the tape every year or two;
ship tape in an insulated container to minimize temperature effects;
ship audio master tapes in a steel container (film can) to eliminate the effects of any stray magnetic fields.

Note: When possible, do not copy a tape with a print-through problem, because that will transfer the problem permanently.

Video Tape Formats

Ampex introduced the first commercially practical videotape recorder in 1956. Ampex trademarked the name videotape and patented the helical tape recorder that same year. The video tape recorder field is strewn with about 40 different formats which were not commercially successful. Currently, there are 10 videotape formats in common use. All of these formats have been or are being standardized by SMPTE[1] or EBU[2]. This does not include the five different VHS formats or the five different Beta formats.

A tape recorder designed for professional use has many special features and is also much more rugged than one designed primarily for the consumer market.

Special Consumer Format Video Tape Archival Problems

Low cost videotape recorder formats have several possible archival problems:
1. Cleaning
Cassette recorders are more difficult to clean than open-reel recorders. If the heads and guides are not accessible, the only way to clean them is to use a cleaning cassette. Clean about every 100 hours of use.

2. Thin Tape
It is preferable not to use thin tape in a tape recorder designed for thicker tape. Beta L750 and VHS T160 are thin tapes.

3. Rewind before Recording
Shuttle the tape to the end and back before recording. The purpose of this is to relieve stresses which may be in the tape.

4. Use the Fastest Speed
Record at the fastest tape speed, which is SP for VHS and Type I for Beta. This reduces the packing density of the data on the tape which makes it easier to recover.

5. Leave on Take-up Side
Leave the tape on the take-up hub for long-term storage. The tape packs much better in play or record.

The Main Archival Factors

No matter what tape is being archived, the manner in which the tape was wound before storage and the environment in which it is stored, remain as the two main archival factors.

1. The Environment
As all archivists know, temperature and humidity must be controlled to preserve archival information. Tape is no exception. Tape should be stored in a cool environment: 15 to 20°C (59–68°F) is recommended. The desired humidity is 20–40% RH. Since humidity is usually expensive to control, an alternative is to store each tape in an airtight container or a thick plastic freezer bag. The plastic bags should be self-sealing and made of a heavy-gauge plastic. A metalized coating is superior because a metal thickness of at least 10 micro-meters will act as a vapor barrier. Before sealing a tape into its own environment, it is very important to expose it for a few days to a dry environment of about 30% RH. This should also be at the same temperature at which the tape is stored.

2. The Tape Pack
Many tape problems can be traced to how the tape was rewound before being stored or recorded. The machine used to wind tapes must pack the tape at the correct tension and it must be kept clean.
Every few years, the tape should be rewound. Tape winding is best accomplished on a special machine designed for winding and cleaning tapes.

New Formats

So, we know how to archive the common analog formats but what about the new "high tech" formats. The big news is that digital recording is finally available for both audio and video. For the archivist, the advantages of digital over analog are:
no quality degradation when making copies;
no video dropouts;
no audio print-through.

1. DASH and PD
In professional audio, the DASH format is the most popular digital format. DASH stands for Digital Audio-Stationary Heads. PD (Professional Digital) is another audio format but PD does not have the broad acceptance that DASH commands.

2. PCM
There is also a third form of digital audio which has no standard format. This low-cost digital audio is called PCM (Pulse Code Modulation). PCM is actually only an adapter box which is connected to the input and output of a VHS, Beta or U-matic VCR. The VCR can then record digital audio in place of the video information normally recorded. Most of these PCM adapters are marketed by Sony and there are several different types of encoding schemes. Some of these have a simple error-correction technique which fail to correct for some of the problems common to the VHS and Beta formats. The PCM adapters with the more sophisticated error-correction have become popular among high-fidelity enthusiasts as well as some professionals.

3. RDAT
The consumer audio field will be revolutionized when RDAT (Rotary Digital Audio Tape) is made available to the public this summer. RDAT is a miniature helical tape recorder which uses a tiny cassette capable of recording two or six hours of high quality audio.

Because of its small size and high quality, the RDAT format should be a good archive format. I recommend the 2-hour mode since RDAT records more redundant information than in the 6-hour mode so high quality audio can be maintained even with a degraded signal.

Audio Summary
To summarize the current audio tape recorder situation, the RDAT format will likely take over the consumer audio market and DASH will likely dominate the professional audio market.

4. VHS-Beta-8 mm
In consumer videotape recording there are three basic low-costs formats: VHS, Beta, 8 mm. The VHS is presently the dominant format and it is doubtful that the 8 mm format will replace it. None of the present low-cost formats are really good archival formats, but this year new VHS and Beta formats will be introduced which *may* be archival. These are the s-VHS (s for super) and ED-Beta (ED for extended definition). Both of these formats will be component video requiring two video cables and they will cost around $ 2,000.

The low-cost formats have the advantage of size as well as cost. A VHS cassette takes 1/6 the shelf volume of a type C tape for a 1½ hour recording. The disadvantages are the poor quality of video when copied and the question of interchangeability after several years of storage. Tape damage is also more likely on a low-cost VCR – especially with the thinner, long-play tapes.

5. Analog Video
In professional videotape recording, the analog video, 1″ C format still dominates the market and will for several more years. The high quality of C format allows 10–15 good copy generations when state-of-the-art equipment like the Ampex VPR-3 and Zeus are used to make the copies.

The newer ½″ and 19 mm formats reflect improvements made in integrated circuitry, video head design and computer encoding techniques. They also take advantage of breakthroughs in developments in metal particle tape. The magnetics of metal particle tape are more than twice as great as the common iron-oxide tapes. This means that the amount of information stored on the tape can be greatly increased and the cassette can be made smaller.

There are four challengers to the C format dominance. The ½″ challengers are the M-II and the Betacam-SP. They are small in size and are used in the field as well as in the studio. They are based on the VHS and Beta cassettes but will not interchange with the low cost VHS and Betamax VCRs.

Both formats retain high quality video even after about five copy generations. Both record 90 minutes per cassette and take ⅓ to ½ the shelf volume of a C format tape. The M II and Betacam-SP units sell for $ 20,000 – $ 40,000 so the market is restricted to the high-end user.

6. Digital Video
The long-awaited digital video recorder has finally arrived but it is in two different forms. One is component digital and uses 19 mm wide Cobalt-doped iron-oxide tape. The other is composite digital and uses 19 mm wide metal particle tape. Both use the same SMPTE standard D1 cassette but they are not interchangeable formats. Incidentally, the SMPTE D1 standard specifies three different cassette sizes.

Component digital has the disadvantage of requiring three separate cables for the three colour signals. This is acceptable in a studio where all the signal processing is done digitally but it is a problem in most other applications. It also requires almost twice the shelf volume as C format.

The composite digital format takes half the shelf volume of a C format tape and requires only one video cable. These advantages will probably make the composite digital format more popular than the component digital.

Conclusion
It is obvious that we are in the middle of a videotape recorder revolution and it is not obvious what the situation will be two years from now. There are clearly four challengers to the professional C format but it is unclear as to whether or not a single format will eventually dominate. It is clear that Sam Kula's Universal High-resolution Storage Medium has not arrived yet.

[1] Society of Motion Picture and Television Engineers (SMPTE)
[2] European Broadcasting Union (EBU)

George Boston:
One thing that concerns me about the RDAT format is the fact that it is a very small cassette, and I am involved in storing material, I feel it is far too small; it is getting to the point where we cannot actually label it. I do feel that we are getting to a point where the data density that we are able to achieve is actually counterproductive for serious use of the media.

Jim Wheeler:
123 different companies and organizations were involved in coming up with the RDAT format – that was not an over-night decision. It has an automatic tracking mechanism, it is a very short scan which is to its favour; against it: it is a very narrow tape which is not good for helical scan. One would have to run some temperature humidity cycles with them, just to see how reliable they are; until we get some transports and actually do some tests, we are not sure. It has good possibilities.

Dietrich Schüller:
Two remarks concerning the paper of Gerhard Welz: due to a study which was made almost 10 years ago, we know that a partial erasure of recorded material

Video Tape Formats

	Professional	Industrial/Educational	Consumer
1956	Ampex 2″ Quad		
1960	Ampex Quad Low-Band Color		
1962	Ampex 2″ (Helical)		
1963	*Ampex Quad High-Band Color	Sony 2″ (Helical)	
1964		Sony 1″	
1965		Ampex 1″ (SMPTE A)	
1968		IVC 1″	
1968		Sony ½″	
1969		EIAJ-I ½″ (SMPTE F)	
1970		Philips ½″ VCR C	
1971	Ampex Quad Super High-Band	*Sony ¾″ U-Matic (SMPTE E) C	
1973	IVC 2″ (Helical)		
1975	*Bosch 1″ (SMPTE B)	*Sony ½″ Betamax C (SMPTE G)	
1976	Sony 1″	*JVC ½″ VHS C (SMPTE H)	
1976	Ampex 1″ (A Format with Slo-mo)		
1978	*Ampex/Sony 1″ (SMPTE C)		
1983	Matsushita ½″ M C (SMPTE M)		
1984	*Sony ½″ Betacam C (SMPTE L)		*8 mm C (MP)
1986	*Matsushita ½″ M-II C (MP)		
1987	*Sony ½″ Betacam-SP C (SMPTE L) (MP)		
1987	19 mm Digital Component C (D-1)		
1988	19 mm Digital Composite C (MP)		

* In common use in 1987. C = Cassette

Notes: 1. The dates are when the product was first publically available.
2. In the years 1961–1975, about 30–40 Industrial/Educational formats (CCTV = closed-circuit TV) came and went. Only the more popular formats are listed here.
3. There may be a popular format or two left off this list. If so, it was not intentional.
4. All formats are helical except when noted as quad.
5. MP indicates that format requires high coercivity metal particle tape.

always takes place when magnetic objects unintentionally are brought in direct contact with magnetic recordings, for example when a microphone is transported in a kangeroo pocket on a tape recorder, or when earphones with 240 Oersted get in direct contact with the recorded tape. As tests have clearly proved, something can get lost. Principally it is correct that we do not have to fear magnetic fields of transformers, motors or other objects; yet such objects that we as sound engineers continually use, like VU meters, dynamic transducers, etc. may lead to losses of level in limited places.

We have noticed, that there may be a risk in transporting recorded and unrecorded tapes in cargo compartments of aeroplanes over long distances into hot and humid climates, as they arrive very cold after a flight of 10 to 12 hours. When the tapes come back from a height of 10.000 m into a temperature of 30°C (86°F) and an air humidity of 99%, they may suffer a shock from which many never recover, and for the rest of their lives suffer from oxide-instabilities. We have observed this in two cases some years ago, but never since.

<u>Jim Wheeler:</u>
I am not at all concerned about earphones. As Gerhard pointed out, it is the size of the device, how far you can get the magnetic part right up against the tape. That is a small field, so I am not concerned about microphones and earphones. I am not concerned about putting a tape on loudspeakers because you have a cabinet. If you have got some tests that shows otherwise, I would be interested in seeing it.
On the subject of environmental condition: I have an altitude chamber in which I can produce any temperature, I can run a temperature humidity test through any extreme in the world within 15 minutes. And we have done the tests and I am not concerned about shock. What you have to do after you have gone through a shock of temperature humidity or altitude, is to let the tapes sit for about 24 hours in a room environment, then rewind the tape. It is a big mistake that people make, to wind the tape before it has been conditioned back at room environment.

Defects in Video and Audio Tape Recording and Their Compensation
Brian Jenkinson

Philippe Poncin:
And now Brian Jenkinson will explain in his paper which defects are possible and how to correct them. Brian is a specialist for video recordings at the BBC.

Videotape defects are complex. Unlike film, the tape requires a sophisticated machine in order to view it. Defects may be caused by the original recording, the tape or the replay machine. The inability to play a tape does not necessarily mean that it is faulty. To determine the cause and whether it can be rectified requires skill and sometimes considerable engineering knowledge. However, the user should be able to recognize problems so that he can call on the special skills when required.

Television is a time dependent signal. Each frame, field, line and cycle of colour sub-carrier occupies a precise period of time. When recorded this time dependent signal is translated, by the scanning video head into a precise space pattern on the tape. The replay process translates space back into time. Any irregularity in physically placing the signal on the tape may invalidate the time relationship of the reconstructed signal, resulting in some visible impairment.

Video, in order to be recorded, is translated into a frequency modulated signal covering a band of frequencies much higher than the original video. Frequency modulation is a robust signal in many respects. However, correct recovery of the signal requires a uniform frequency response and depends upon an intimate head to tape contact. This implies an extremely smooth homogeneous tape surface and constant head to tape pressure. Head to tape spacing losses cause defects. Very small losses contribute to colour noise. Larger losses cause high frequency dropouts, the effect of which is to increase the chrominance level and appears as small white flecks when displayed on a monochrome monitor. Deeper losses, in excess of 16 dB, cause signal losses which cannot be recovered. The majority of video faults are the result of timing and/or spacing losses.

Audio faults are similar to video in that they are due to timing errors and spacing losses. As well as this, because the recorded audio wavelengths are larger than the magnetic coating thickness, audio signals suffer from printing. When stored the signal may magnetically print from one tape layer to the next. The replayed signal appears to have pre and post echo.

Let us now consider the implications of timing errors. The television signal as well as carrying the vision signal also carries synchronizing pulses and colour burst. When recovered from the replayed signal they are used as precise timing markers. The time-base corrector delays the signal about a mean so that the original timing references are correctly reconstructed. Timing errors between line pulses can usually be corrected by the simple assumption that the error is linear. If a timing error between line pulses is recorded in, it cannot be corrected as there is no reference between the line rate pulses.

In the case of helical recording the recorded tracks are long and narrow. The ability to replay them requires very precise mechanical alignment between machines. Although this accuracy is required for editing, when replaying, the recorded track can be accurately scanned by modulating the position of the replay head in order to precisely recover the original signal.

It appears that timing errors can be electronically corrected. But like all correction devices there are limitations on the range of correction and the rate at which it can be applied. Timing correction may be capable of a large overall range but not capable of correcting even small sudden errors. Providing the original recording has accurately converted time into space on the tape, the video track straightness is within the format specification and the tape has not been mechanically damaged or stressed in storage beyond the range of the correction systems, there will be no replay timing problems.

Errors caused by head to tape contact problems depend upon the degree of signal loss. Very small losses for example, those caused by tape asperities, appear as colour noise. Deeper losses appear as short periods of colour bright up. These errors cannot be detected and therefore cannot be compensated. However, complete signal losses, dropouts, can be concealed by replacing the dropout with similar information from the previous television line. The result can be excellent for small rates of dropout. For large numbers or bursts of dropout the result is less perfect.

There are other forms of head to tape spacing loss which cause defects. Scratching has the effect of very small dropouts, but because it follows a fixed pattern it is more disturbing. Many scratches cannot be detected and therefore are not concealed. However, because of their repetition rate their position can be predicted and the dropout compensator deliberately switched on to conceal the defect. Mechanical distortion of the tape and damage, such as creases, can also cause small spacing losses due to the head to tape pressure being reduced. The effect will depend upon the degree of loss.

Some tapes suffer from stress demagnetization, when physical stressing of the tape causes a reduction in remanent magnetization. The effect looks like small spacing losses. Although the effect is permanent on any recording the tape is not permanently damaged and can be recorded over without error.

Audio, like video, suffers from timing errors and spacing losses. The effects are wow and flutter and level variations.

Timing variations are normally due to the tape transport. However, variations in tape drag can also contribute and are difficult to overcome.

Audio printing is due to the magnetic character of the tape. The printed magnetization is unstable and can be reduced by fast spooling the tape. The printed echo can be removed completely by a technique known as partial erase, it will however return after further storage.

Editor's note:
Brian Jenkinson also gave a visual presentation of a variety of faults encountered with video tape recordings and machines and some possible solutions. Because of the nature of the presentation it is not possible to provide a printed version.

Anders Orring, engineer at Swedish Television, Stockholm, presented his paper Current Defects of Tape Recordings. Also because of the nature of the presentation it is not possible to provide a printed version.

The Construction of Cylinder Replay Machines
Franz Lechleitner

Beyond the general problems of reproduction of mechanical carriers (cleaning, choice of pick-up and equalization procedures) the reproduction of phonograph cylinders involves a series of special problems: deformation caused by improper storage, shallow grooves and finally, extreme fragility of many items. This paper introduces a playback mechanism specially designed for the reproduction of all cylinder formats, and describes its advantages and limitations as well as noting that for special cases a conventionally constructed mechanism with fixed pitch feed is indispensable.

George Boston:

The next of our speakers is Franz Lechleitner, from the Österreichische Akademie der Wissenschaften in Vienna, and he presents a paper on the reproduction of phonograph cylinders. The Phonogrammarchiv has been in existence for 88 years which makes it the oldest in the world, and they have a depth of experience. Franz has been in the Akademie for 14 years in the sound archive and has spent the last 5 years specialising in restoration. His paper, together with the following one by Lloyd Stickells will make an interesting pair to see the ways that two different institutions have tackled the same problem of being able to replay cylinders without actually destroying them.

The playback of historical cylinder material is often very difficult because of the different formats. In very few cases a sound archive is equipped with a modern playback unit, which allows playback of the more common two and four minute standard cylinders with 2″ diameter, and also the 5″ diameter concert cylinders, Pathé Saloon cylinders or Dictaphone and Columbia cylinders of 6″ length. But the problems actually begin with the playback of the standard cylinders with 2″ diameters. Cylinders with an inner diameter of less than 1. 7″ do not fit in with the Edison standard mandrel. A perfect reproduction of such cylinders requires modification to the mandrel or to the cylinder by careful reaming, but this in turn implies a certain amount of risk. The not quite concentric shape of some – mainly private – cylinders due to inaccurate or improper storage is another important aspect which should not be underestimated. Historical phonographs which have been fitted with a modern pickup system will in most cases deliver signals which are strongly influenced by the concentricity of the cylinder itself or are not capable of tracking at all.

The greatest difficulties are liable to occur when pushing the cylinder onto the mandrel. The cylinder may become loose and unstable during the reproduction if applied with too little pressure. This causes tracking problems and playback distortion. On the other hand the cylinder will crack if applied with too much pressure. For these reasons it does not seem to be useful to modify a historical phonograph for archival transcription, nor to equip a modern playback machine with a mandrel according to the historical model as the problems still cannot be solved satisfactorily.

In the face of these problems new solutions had to be found. If a new cylinder playback unit had to be developed suitable for all common formats, it had to be equipped with two main features:
1. The inner pressure caused by forcing the cylinder on a mandrel had to be kept to a minimum;
2. The cylinder had to be fixed as concentrically (perfectly round) as possible.

If we assume that only the playback surface of the wax cylinder had been manufactured accurately, the cylinder had to be held in playback position on this surface. Thus inside pressure on the cylinder was simultaneously avoided. For the prototype this was achieved by means of a concentric three-jaws-system at the starting position and of fitting rings at the end of the cylinder respectively. The fitting rings have a suitable profile and can be locked onto the driving shaft.

The three-jaws-system has an error of less than 0.1 mm (0.004″) over the whole radial range, therefore any disturbing eccentricity determined by the design will be kept within negligible limits. The driving shaft is equipped with double sliding bearings with bronze bushings on the driving side. The open end is supported by means of a tailstock with ball bearings which can be turned down (fig. 1).

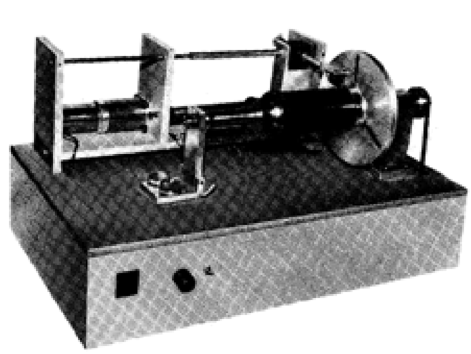


Figure 1

Both the cylinder and the tone-arm are DC-powered and belt-driven by means of two electrically coupled DC motors. The motor driving of the tone-arm is combined with a planetary gearing system having a reduction ratio of 165:1 which can be switched to half speed for 4 minute cylinders. Speed control takes place on the driving shaft and is equipped with a digital read-out. The tangential tone-arm works on the well-known Rabco principle; the main item consists of a Rabco ST7 carriage. For reproduction an AKG P10 pickup system is used which is selected with respect to channel symmetry and low compliance. The low compliance together with a short tone-arm increase the pickup resonance frequency to such a degree that cylinders running off-centre strongly can also be tracked. It also guarantees extra groove contact with big styli. The vertical adjustment of the tone-arm to track the different cylinder sizes is achieved by means of putting spacing blocks under the tone arm drive.

We generally have to deal with three different types of cylinders; commercial products of wax or other materials, private wax originals, and moulded wax copies of private originals.

The playback of the three cylinder types on the new machine showed various handling problems concentrating on the 2″ diameter cylinders only, this being the common format. The manufacture of commercial products was of a high standard. They have a deep groove, high modulation and enough blank space at both ends of the cylinder. Generally, there is no trouble in playing back these cylinders. The blank space is wide enough to place and to lift the needle.
Private originals show similar features, although the groove depth and the modulation is not at the level of commercial cylinders, and often the blank space at the ends of the cylinder is smaller.

In general the moulded wax copies of private originals are of inferior quality. Cylinders moulded from different originals show the same surface properties: hard black wax mouldings with rough surface and uneven wall thickness. The inner and outer cylinder surfaces are sometimes not concentric. This can be compensated for by mounting the cylinder slightly off-axis: a very time consuming procedure. Economic reasons were responsible for making maximum use of cylinder surface from end to end for maximum playing time. These cylinders are fixed between two rubber coated fixing rings, offering the advantage of optimum centering. Most of these moulded copies can be played back without difficulty, but we have to go back to the Edison standard phonograph (equipped with an electro-magnetic pickup) to ensure proper tracking by the lead screw.

For example: With a groove getting more and more shallow the needle will jump out of the groove at a certain point. In other cases a wide crack incompetently repaired by welding the original recording was the reason for mistracking. Another cylinder with a closed groove at the start could also not be tracked. Practical experience confirmed the idea that the cylinder has to be suspended at both ends.

Sometimes there is a considerable error between the centre axis of the playback surface and the centre axis of the inner conus. Under these conditions the new fixing device brings advantages over the traditional suspension employing the Edison standard mandrel. The frequency distortion produced by chatter on the Edison standard mandrel could be minimized. The new suspension will also allow us to playback carefully repaired cracked cylinders, because of the absence of internal pressure in comparison to the suspension on the Edison mandrel.

The auto-controlled tangential tone-arm is a disadvantage in playing back cylinders with major groove deterioration, eg. very shallow grooves, closed grooves, deep or unreliably repaired cracks. Major damage leads to mistracking, which can be prevented by tracking with fixed feed only.

(This is an updated version of a paper presented at the ARSC (Association for Recorded Sound Collections) Conference, New York 1986, published in Phonograph Bulletin No. 45, 1986).

The Construction of Cylinder Replay Machines
Lloyd Stickells

George Boston:
The next paper is presented by Lloyd Stickells, who is the chief engineer of the British National Sound Archive in London, and has been working in sound for quite a few years. I first met Lloyd in 1963, when I was working at the Maida Vale BBC Studios in London, where he had the onerous task of copying commercial films, on to sound tape in something called the Radio Film Unit. It was an interesting opportunity to watch first-run movies in a radio studio. After passing briefly through places like Radio Zambia, the Central Office of Information and the Imperial War Museum, Lloyd has ended up in the National Sound Archive in London, where he works on all forms of restoration, including the construction of cylinder replay machines, and the gathering of the sound from the cylinders. As we will hear later Lloyd also works with the most modern technology using computerised systems to improve the sound, and to get the signal out of the noise and the clicks and the thumps.

There are two basic ways in which Edison cylinders can be rerecorded. One is to play them on the machine on which they were intended to be played, and pick up the sound from the horn with a microphone as if it was a live instrument. The second would be one of the variations of the direct electrical replay method, by replacing the acoustic sound box of the original machine with a modern magnetic pickup.

There are several shortcomings to the first method. Firstly, nowadays suitable machines are no longer readily available. Secondly, it requires an acoustically treated and silent room to record in to eliminate extraneous noise. Thirdly, and probably most importantly, it will not reproduce the full range of frequencies that may have been originally recorded, and the inevitable and unavoidable horn resonances of the replay machine will add further colouration to those already imported by the recording horn, the two being very unlikely to be mutually cancelling. Even so, this method will give a realistic representation of how the listeners of the period may have heard the recordings. Finally, from an archival point of view, the wear caused by the necessarily significant weight of the acoustic soundbox causes unacceptable wear of the grooves.

The second approach is probably the better way to extract the maximum signal information, but is not without its drawbacks. It does nothing about the usually clockwork drive with its tendency to speed instability, or to the noise created by the gear train drive to the lead screw, and the usually sloppy bearings, giving rise to mechanical noise which also tends to be recorded along with the signal. Therefore to get the best possible reproduction calls for a reversion to basic principles.

The requirements are simple or at least simply stated! A mandrel on which to mount the cylinder, running in noiseless bearings. A drive system capable of constant but controllable speed, and a means of tracking the cartridge along the cylinder. Further desirable attributes would be a means of mounting and playing all the various sized cylinders and a revolution counter to show at what speed they are revolving.

The NSA (National Sound Archive) – or BIRS (British Institute of Recorded Sound) as it was at the time – already had a modified machine to play normal cylinders, but due to the shortcomings mentioned already, not least of which was the transmission of mechanical noise from the leadscrew gear train, it was decided to start from scratch to construct a machine to fulfil as many of the requirements as possible and also as simple as possible, since it was myself as archive technician who was going to have to do the machining and construction.

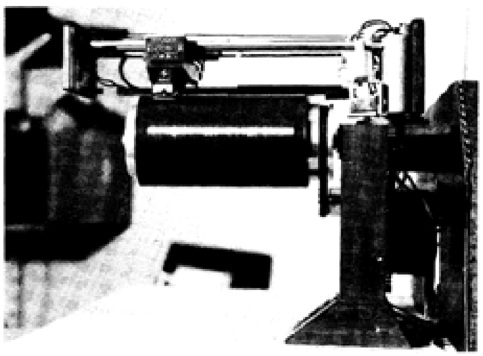
On the face of it, the most difficult part was the pick up arm, since unless the arm was self tracking, the fact that cylinders can have a standard of 100 or 200 grooves per inch (2.54 cm) calls for a tracking mechanism to have a two speed capability and still be locked to the mandrel speed.

A pivoted arm is of course the simplest form of self tracking device, but apart from the theoretically incorrect path it traces, which because of the vertical modulation can be ignored, the necessarily long pivot-to-stylus length can lead to tracking problems when trying to trace out-of-round cylinders – and unfortunately many cylinders warp with the passage of time. This option was therefore discarded and investigation began to make up a tracking mechanism, possibly using a stepping motor to drive the carriage along the cylinder. An initial experiment soon showed that the vibration such motors cause made that impractical.

By this time there were a number of parallel tracking arms on domestic LP players and it seemed that here was an avenue worth exploring. However, probably understandably, most companies seemed reluctant to get involved in supplying spare units for purposes other than those for which they were intended. The Rabco parallel tracking arm seemed to be favourite amongst home constructors, probably by necessity as much as choice, since its relatively massive construction gives it the same or greater inertia problems than a pivoted self tracking arm. Hearing several unfavourable reports on its performance, there was some reluctance to resort to its use. A fortuitous meeting with the local Revox sales manager at an exhibition saved the day. He was quite happy to supply a complete arm and control electronics from a B795 turntable to try. Although these are not cheap, they are far less expensive than the cost of the time taken in making a suitable one.

For those not familiar with the Revox arm, in common with other parallel tracking arms, it has the arm servo driven along sliding runners by a small motor. It differs from most other arms in its length, since the whole assembly sits over the middle of the record and not at the back of the turntable. In fact it has no arm in the accepted sense. The cartridge is fixed into what amounts to a uni-pivot headshell. This makes for a very low inertia cartridge mounting, but does restrict the up and down movement. A way of being able to vary the height between the arm mounting and the mandrel had to be found, and this will be discussed in greater detail later.

The tracking length of the carriage is just enough to cover the groove length of Edison cylinders. The bad news, as anyone who has put more than one cylinder on a mandrel will have discovered, is that the internal diameter can vary significantly between samples, and therefore their position along the mandrel can vary by more than a centimetre or two. The good news is that the arm lends itself to the easiest solution to this problem, lengthening the tracking rods, so the originals were removed and replaced by longer ones. Unfortunately this meant the cover would no longer fit, so until time allows us to make another one, the arm remains in its naked state.


Cylinder replay machine

Another advantage the arm possesses is that the whole assembly can rotate through 90 degrees, a necessary manouevre in its normal LP guide to enable the record to be put on and off the turntable. This feature while not essential in its new role, is a useful attribute in being able to get a cylinder on and off the mandrel without risk of knocking the stylus while doing so. To try out the arm's possibilities, it was decided at first to use a mandrel from an Edison machine which was mounted freely on a spindle and driven round by a leather belt at the larger end. The bearings had however become slack, and it was decided to make another mandrel of a similar design. As a compromise between cost and ease of machining, the mandrel for normal size cylinders was made from a solid bar of aluminium.

Another thing that becomes apparent from a random selection of cylinders is that after the passage of time, which can be anything from 50 to 100 years or so, they do not always retain the prescibed ratio of taper of 1 in 8, or the perfect circularity with which they started - a shortcoming that Franz Lechleitner went to great trouble and expense to find a very elegant answer to, as he describes in his paper. It occurred to me that a simple way of making some allowance for this sort of variation was to cut two grooves round the circumference and sit two strips of sponge that stood slightly proud of the surface of the mandrel, but which would be pushed down level by those that did not fit properly. This had a twofold intention. Firstly to offer some support to cylinders which do not fit snugly on the mandrel and stop them rattling, and also stop them sliding back along it during play. Hindsight and experience suggest that whilst this is quite an effective way of achieving the desired ends, longitudinal grooves would have been even better, although much more difficult to machine on a lathe.

It was decided at the outset not to attempt to use ballraces as bearings because of the risk of noise, and we used instead plain push-in PTFE lined bearings. The cylinder spindle was mounted in a bracket which also served as a platform for the arm assembly. Initially this was simply done by welding a disk to the spindle to press against one side of the bracket when the threaded stub was pushed through a hole and clamped by a screw on the other side. It did not take long to discover that a fixed relationship in the distance between the mandrel and pick up carriage was inadequate. The head itself has a very limited vertical travel, and the difference between the thickest and the thinnest cylinders soon showed that unless some allowance could be made to vary the distance between mandrel and arm, the stylus could either be barely touching the cylinder surface, or squashed against the body of the stylus. To allow for up-and-down movement, the easiest solution was to make the hole in the bracket for the spindle into a vertical slot. Slackening the screw clamping it then allowed the spindle to be slid up or down the slot to give a desired spacing between any thickness of cylinder and stylus. Extending the slot further down the bracket also allowed the later addition of a mandrel to take the 5″ (13 cm) diameter Edison concert cylinders.

The next problem to be addressed was that of the main drive unit. Again, since one was to hand, the obvious solution seemed to be to use a capstan motor from another Studer product, the Revox tape recorder. This has a normal rotational speed close to that required – we even considered making it a direct drive, but decided that belt drive would ultimately cause fewer constructional problems and so continued on that basis. Initially the motor was mounted under the lid of a wooden box, with the arm assembly and mandrel mounted on top, but this was abandoned for a flat board when it appeared that the box approach gave rise to acoustic feedback when the sound level was above a certain level. In the second version, with everything mounted on top of a board, the motor was mounted in a frame which in turn was mounted on a cushioned spindle allowing the whole assembly to rock to and fro. The idea was that with the spindle mounted off centre, the tendency of the assembly to fall away from the mandrel would apply some tension to the belt.

Although being probably far heftier than is really required for the purpose, the flywheel effect of the outer rotor design goes some way to compensating for the impossibility of adding a flywheel to the mandrel. The speed of the motor is easily adjusted by replacing a fixed restrictor in the control electronics with a variable one to give a range of over two to one. A further advantage is that the application of a positive voltage to one point on the card halves exactly the previous set motorspeed. This can be a very useful feature in cases where the eccentricity of a cylinder is sufficient to cause the pick up to be thrown out of the groove when played at normal speed. In such cases both recording and replay speed are halved which usually allows the cylinder to be tracked without the pickup being thrown out of the groove every revolution. The combination of the half speed facility and the variable capability has given the mandrel drive a speed range of 45 rpm to over 220 rpm. Although the very low end of the range has not been necessary as yet, some cylinders have required from about 80 to over 200 rpm to get them to sound reasonable.

Because the motor has its own servo speed control, determined by pulse derived from the outer rotor, it seemed the obvious thing to utilise these pulses to drive a revolution counter. Using a variable gate time to give a count of 160 pulses when the mandrel is actually rotating at 160 rpm. It is not possible to make strobe for 160 rpm for 50 Hz lighting, so it actually has to be done at 158 or 162, but it makes no difference in principle, and once set, the indicated speed faithfully follows that of the mandrel.

The machine as it stands would not win any prizes for design elegance, and could certainly be improved both in visual appeal and functional capability, but the intended aim of making a machine whose performance would not in any way be the limiting factor in reproduction of the signal engraved in the grooves of Edison cylinders, has been achieved.

<u>William D. Storm:</u>
Have either Stickells or Lechleitner experimented with the standard of longer tone arm, using the stepping motor independent of the tone arm, so that the stepping motor could literally push the mandrel while keeping the tone arm fixed? This is a system which we have been using.
<u>Lloyd Stickells:</u>
That means keeping the tone arm in place and sliding the cylinder underneath it. I have not tried it but it is one approach that could be thought through.
<u>Dietrich Schüller:</u>
Franz Lechleitner's point about the moulded cylinders may need further expansion. This is of interest in connection with Berlin as here they have three institutes which have been active from the beginning of this century. One is the Institut für Lautforschung, the other is the Berliner Phonogramm Archiv and the third is the Institut für Deutsche Musikforschung, which were all active in field recording especially for musicological and linguistic aspects. There was also one freelancer here in this town, called Quadfassel, who worked for all three of the institutes in making copper tube negatives from the cylinders and therefrom all these stearine cylinders which we have been listening to, and others of course, including the famous Hornbostel Collection. About 10,000 cylinders representing early recordings from all over the world have been made and processed in this way. Unfortunately the great part of these copper matrices is now in East Berlin, and is not yet made available for restoration.

Data Density Versus Data Security: Formats Suitable for Archival Purposes

Dietrich Schüller

George Boston:
Our next speaker is in fact Dietrich Schüller, who is from the Phonogrammarchiv in Vienna. He has many years experience in this kind of work. His talk will be on a subject which may appear strange to some of us, but is a plea for more space on our recordings, because it is becoming apparent that many of the older formats which we are dealing with are easy to handle, and the required equipment is far simpler to make than for the more modern systems. Dietrich's paper is a plea for consideration of the problems of the archivist.

Physically the recording of audiovisual material of all kinds (sound records, photographic stills and moving images, videograms) means to store an amount of data which is related to sound pressure-waves, or to emitted or reflected light. The problem common to all kinds of recordings lies in the fact that an enormous amount of data has to be written onto or read from the storage medium – in most cases in real time. The storage medium itself has to keep the data undistorted over a long period of time, ideally to eternity. It should be easy to handle and its size should be practicable.

We should try to discuss our problem by dealing mainly with sound records, taking a glance, however, at electronic processing and storage of images, but leaving aside film and photography for the moment. If we look at the history of av-records we discover two parallel developments: an ever increasing quality, which means an ever increasing amount of data, accompanied by an ever decreasing size of carrier, and an increasing data density. As an example take the bandwidth of sound recordings:

1900: acousto-mechanical	5 kHz
1925: electro-mechanical	10 kHz
1960: magnetic	20 kHz

Parallel to this, space consumption has been reduced drastically if comparison is made between the volume required to store 1 hour of recording in various formats (boxes included):

2 minute cylinders	11 000 cm^3
analog tape (38 cm/s on 26.5 cm spools)	2 665 cm^3
R-DAT (2 hours)	76 cm^3

More recently during the last 15–20 years, together with increasing data density, there is a tendency towards decreasing recording quality in formats aimed at the average consumer, and the compact cassette and the home video formats represent good examples of this tendency. On the digital side we see strong moves towards data reduction techniques which often impair technical quality as well.

Leaving aside these trends towards lower quality standards for the average consumer any development towards data density beyond a certain point unavoidably leads to insecurity of data storage and this shows on the carrier itself and on its readability.

There are several reasons for this:
1. Miniaturization of wave-lengths and recording tracks call for extreme precision of recording and playback equipment and for almost perfect and uniform physical and chemical condition of the recording media. Extreme cleanliness and special environmental conditions are absolutely essential.

2. Thinner carriers, especially tapes, exhibit lower mechanical stability with all its consequences.

3. Magnetic carriers with high packing rates, eg. the high percentage of magnetic oxide, sometimes results in chemical instabilities of the oxidebinder compound, especially

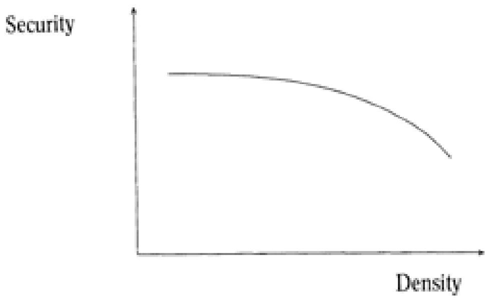


Figure 1

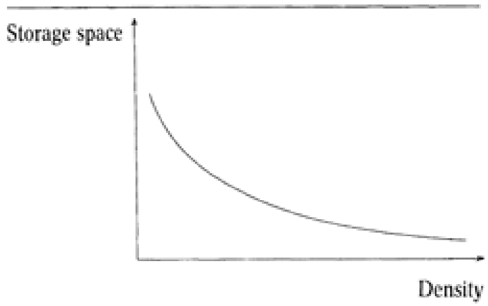


Figure 2

under unfavourable climatic conditions. Beyond a certain point data density is inversely proportional to data security. Data density is dependent on the occupied area (ignoring the fact that all kinds of data storing systems are, strictly speaking, three dimensional): the smaller the area, with constant amount of data – the greater the density and the greater the problems arising therefrom. Furthermore, it appears that this function is a non-linear one (fig. 1).

In using and handling audiovisual carriers, however, access areas and volumes which cannot be used to store information are necessary. For example the area occupied by the label on a record, the hubs, spools or cassettes for magnetic tape, the covers and boxes to house the carriers properly. For obvious reasons, these areas and volumes cannot be reduced beyond a certain point. Record covers should be big enough to accept notes which can be read comfortably. Cassettes occupy a certain volume especially if they have to protect a sensitive carrier. Another factor adds to this complication: a minimum shelf thickness and adequate spaces are required to place the carrier onto the shelf or to remove it. However small a cassette may be designed, there will always be the need for at least an extra 3 cm (one for the shelf and two for the fingers) for handling. Most obviously open shelving in an archive with at least a 60 cm aisle width is sometimes in absurd contradiction to the efforts of miniaturizing data carriers, but moving shelves or other devices for the optimal use of storage areas is extremely costly and prolongs the access time.

Data density and storage space are therefore in non-linear relation to each other (fig. 2).

Additionally, some aspects of practicality and comfort have to be observed. Small carriers are more likely to get lost or stolen than larger ones. Small carriers also suffer from limited space for written information; simply compare the notes on an LP with those of the same contents on a compact cassette in terms of elegance and comfort.

Summary

The unreflecting increase of data density as a goal in itself is senseless. Up to a certain point smaller carriers are practicable and desirable especially by those who are on the production side (such as the ENG people). Beyond a certain point, however, miniaturization becomes questionable. The superficial advantage in terms of storage requirements and the building and maintenance costs involved have to be offset against the costs arising from problems of possible data insecurity. Economists are challenged to calculate the costs of long term preservation including the costs of subsequent transfer of whole archives to new formats. Such a calculation may prove that radical miniaturization may in the end not be the most economic way to store audiovisual material over long periods. This calculation would also have to consider the forthcoming obsolescence of the highly sophisticated equipment necessary for future formats. While it is still feasible to construct replay machines for Edison cylinders with reasonable effort, it is questionable whether future equipment may be rebuilt once mass production has ceased.

Archivists therefore would prefer formats which optimize data security rather than data density. Contrary to general opinion a far higher percentage of all data carriers produced worldwide is retained for at least medium-term storage. This trend is more and more increased by the growing interest in the history of cultural life and science in all spheres. Therefore, in developing new formats, more attention should be paid to the aspects of long-term preservation.

(Revised version of the paper presented at the Joint Technical Symposium)

William D. Storm:
I would like to make a comment as much as anything else. What I am particularly concerned about when we come to data storage and the idea of giving more and less space, is to argue whether material could be packaged in a different way, with a larger area for labelling, but very small actual storage area. People are losing quality because they want to have something that is small and this scares me more than anything else. You get compressed data, and compressed data to my way of thinking is insufficient and very poor data.
Dietrich Schüller:
I quite agree upon the aspect you raise on quality. We have, however, to admit that other factors are obviously pushing development forward, one being the

notorious lack of space of many archives, normally located in the centres of cities. But I think that further miniaturization of recording carriers will only seemingly solve this problem while it introduces others. Therefore we have to calculate storage space into the future and against any financial inputs we have to make for the future care of things. Although I have not calculated it yet, my guess is that storage space is easier to finance than even one extra generation of rerecording. If you can save one generation of rerecording in the next 100, 200 or 400 years then it is cheaper to pay for greater storage area than to leave the troubles to your successors.

Jean-Marc Fontaine:
I would like to contribute with a reflection, Dietrich, as the problems of dimension is a fundamental question now brought about by numerisation of sound. I think we will have to stay calm in the years to come, as we will have a large number of propositions as to the supports for storage. Today we touched on R-DAT, and I would nevertheless like to reflect on Mr. Wheeler's expression concerning storage; this is a product that does not yet exist and we have to assess it, knowing that it is a cassette, a reduced cassette, and analogy has taught us at least to be cautious. Next year we will be talking about CD-ROM, rerecordable disks, and gradually we will get the propositions and have to reflect a lot on these, once again calmly.

Dietrich Schüller:
My paper was intended to be a first voice from the archivists' side against the standards which are imposed on us by industry which does not construct the products for archival purposes. This forum and especially the Unesco Consultation which follows, is very important, because it is a chance for the first time to combine the voices of the archivists who have to pay in the long run for the future care of those products which are on the market now. It will lead to some interesting results.

George Boston:
Shall we ask one of the manufacturers to reply. Jim Wheeler?

Jim Wheeler:
Thank you. Dietrich I will hit you from both sides. Actually I compliment you for taking a stand like this. The Engineering Societies do not hear this kind of a voice, you are right. I think you should be speaking to the Society for Motion Pictures, the Television Engineers Society and the European Broadcasting Union, rather than this group, but I think that some of your assumptions are wrong. One of them is the high packing density: what is happening is, the magnetic heads are being made (I am also a head design engineer, and design tape, heads, the rotary scanner and all this kind of work), anyway in the heads we are making we use very different materials in recent years than before, so we are able to make smaller heads which are much more precise. The metal particle tape allows a much higher packing density, we reckon with a much smaller particle on the tape. Another point you have is on the thin tape. I have been concerned about thin tape, at AMPEX I raised the flag, and was made responsible to make sure that the machines work with thin tape. Provided you use a cracked tension, I do not see that the thickness of the tape is so critical a factor, although the point may be debatable. On getting smaller you are talking about shelf space, but you are not being innovative in thinking of the future when you will have an automated archival system at whatever point you want to enter the system, a cherry-picker, or whatever you call it in Europe. This will pick out the cassettes and deliver them to the person who wants them. With computer control, where no human hands are involved in the system, you have to be thinking differently, not of shelving as you have in the past. On miniaturization however you have a good point to make.

Dietrich Schüller:
Everybody admits that with increasing data density we run into trouble, but we should overcome this trouble. I am not so sceptical as I may have sounded, but we have to calculate what the present and the future costs are. I know of course that we could have automated archives, where materials are retrieved automatically. But all these systems (R-DAT and so on) run into the problem of obsolescence, how do we get these machines in 100 or 400 years time? Today we have seen that we are able to construct cylinder replay machines for an economic input which are far better than machines from the earlier era. It will be virtually impossible economically to construct any of those machines needed to replay all these standards in 500 years time. That is the problem which we have not been discussing, but it is impossible in practical terms to re-make all these alloys or build them up again with discrete elements. There is a second great problem which we have not touched – we should be thinking about a format which is easy to handle. Why does R-DAT run for two hours, why not for one hour? Why is it a .15 inch tape, why is it not an 8 mm tape, if this is available on the market? These are all things which I do not understand: It would cost a little bit more shelf space, but it would be four times more practical – that is the message of the paper.

Jim Wheeler:
What pushes the market here is what sells in TV stations, not what sells to archives. That is the driving force, it is called money. So you should be speaking to the Engineering Societies to make the point that you do need a common format, to settle on a format. I am not sure how you handle that, but some organisation from this meeting should be approaching the Engineering Societies in the world.

William D. Storm:
I have one further comment. There is a very important technical concern here. Archivists are supposed to have to live with what the manufacturers do, but there may be a basic flaw in this type of thinking. If there is a body which shows what they are doing, not what they advertise they are doing, I think you can greatly influence the market as well. Tape, for example: there are many different types of tape that vary tremendously from batch to batch as much as 6 decibels. Thin tape is definitely nowhere near as good as the thicker tapes, and this is very measurable, very qualifiable, however the general market is not aware of that. When the archivists start to become more like scientists and show what is really happening, not the market hype, we can indeed influence what we are given and what we have to work with.

George Boston:
Thank you Bill. I would like to thank Dietrich for a provocative talk which developed into a good discussion.

Technical Staff and Equipment for the Reproduction of Old Video Recordings on 2 Inch Tapes
Denis Frambourt

Philippe Poncin:
Denis Frambourt is my colleague at INA (Institut National de l'Audiovisuel, Paris); he is the engineer in charge of the technical services, especially with regard to archives.

Introduction

The growing interest in the heritage of television, no matter if the broadcasting organizations consider it as a large store of programmes or regard it as a mirror of contemporary civilization, poses a great problem with regard to the preservation and utilization of archives.

The diversity of the preserved physical supports reflects the rapid development of audiovisual technologies. The old video recordings on 2 inch magnetic tapes which got this name due to the width of the tape undoubtedly are the most complicated ones to reuse. Although the first recordings of this type are less than 30 years old, the manufacturers have already stopped producing the machines that are capable of replaying them.

For how many years will the maintenance last of the most sensitive equipment and the supply of services for the consumers when it comes to special components necessary for the maintenance?

Moreover, the same constructors have interrupted the practical training which used to be open for maintenance technicians from broadcasting organizations.

Will future generations regret the disappearance of the largest part of 20 years of magnetic television recordings, as we today realize that more than 80% of the film production from the end of last century has vanished?

Certain national audiovisual archives, like the Institut National de l'Audiovisuel in France (INA), preserve more than 20 000 hours of recording on magnetic 2 inch tapes, tapes which due to economic reasons will not be transferred systematically to modern supports.

The difficulty of undertaking a selective systematic transfer as well as the awareness of their function to preserve the heritage lead the heads of archives to give precedence to maintenance conditions according to technical capacities and the professional expertise necessary for replaying supports.

Equipment for Replaying Recordings on 2 Inch Tapes

History of the 2 Inch Recorders

The quadruplex recorders which are no longer manufactured, were used until the end of the 70s (fig. 1). Cumbersome and not very reliable they were first designed for recording television programmes that were to be broadcast again. The television-makers very quickly understood the benefit they could get from this in the area of recording and editing of teleplays and entertainment programmes.

Figure 1
Quadruplex of the 60s

The first editing was achieved through mechanical cutting of the tape. This mechanical splicing which was possible because of the recording according to transversal tracks on the tape, is no longer employed. Furthermore, the transistorized recorders have been equipped with devices enabling electronic editing of sequences through successive recordings. The impossibility to replay at a lower speed and to stop on a still picture led to the limitation of the editing to an assembly of flat sequences with long duration. Recently the use of remote control and of time code have made it possible to control the video editing process more efficiently. Thanks to technological progress, the performance and reliability of the machinery have been increased. The use of automatic operation has made the handling easier and enabled a better protection of recorded supports, especially during the manipulation of charging and discharging.

The development of the quadruplex recorder, which received its name due to the fact that the replay device of the video picture comprises four heads, has produced three generations of equipment. This process which is connected with the one of electronic components from tubes and transistors to integrated circuits, has led to more reliable machines that are more compact but also less consistent with the imperfections of the recordings produced with the equipment of the previous generations.

Thus the audiovisual archives ought to preserve not only the most modern equipment but also one or several machines of each type existing in the generations between, and to keep them running. According to the technical solutions adapted by the constructors, each type of machine has its own characteristics which might prove advantageous when certain defects are to be compensated.

There are two groups of recorders within the most recent generation:
the recorders mainly aimed at video production,
the recorders mainly aimed at broadcasting (AVR 1 of Ampex).

The recorders of the last type are particularly interesting with regard to replaying old problematic recordings, considering their very short starting time and their larger ability of coping with long instability of the video signal components.

Modern equipment can be connected to the recorders in order to correct the parameters of restored image and sound sequences. The INA has made tests with positive results connecting quadruplex recorders with digital time base correctors (DTBC) designated for recorders of the current formats. Mostly the operation of replaying is followed by a transfer on a modern support for preservation and use.

A further problem which the heads of television archives are confronted with is the choice of support for preservation. How long is the estimated duration of life of the current magnetic supports, and which format should be maintained? One inch? The new format of digital cassettes or a return to the optical film picture? INA has adopted the method of preservation and utilization through transferring on magnetic 1 inch support in order to make restored programmes available at short notice.

The Necessary Technical Staff

The quadruplex recorder that does not have all automatic control mechanisms that the modern recorders have, has to be carefully supervised when put into operation.

The diversity of control signals that have to be supervised and interpreted calls for a good knowledge of the technical functions in operation.

Moreover, each old recording is a special case requiring a special and optimal adjustment of the machine. This leads to the fact that the principal systems of regulation often have to be adjusted.

Due to all these facts the technician operating in this area has to have technical knowledge and capabilities that are no longer required for the technicians in present-day video laboratories.

It would be desirable for the technicians not only to be occupied with the operation but also to ensure the current electronic maintenance of the machinery.

In the case of significant mechanical deformations (edge damages, fissures) reproduction is difficult and involves the risk of completely destroying the tape as well as the video heads.

Here it may be preferable to remove the damaged part and proceed to a new montage of the recording. Finally it seems that the replaying of each old 2 inch recording should be treated as special cases in time. When problems arise, each case should be analyzed and submitted to a special treatment, mostly selected among several possible methods. The operation of quadruplex recorders, considered as the culmination of this technique, in this context of archival treatment shows the skill and the abilities typical of craftsmanship which only can be maintained by the television archives.

Figure 3
Correctors and control before one inch tape mastering

Starting replay:
Before each operation the technician has to verify that the standard regulation of the recorder is suitable for the replaying of the programme in question.

Mostly adjustments have to be made in order to rediscover the conditions of operation that were valid when the recording was made.

A sound knowledge of the technical functions of the machine and a wide experience of the special problems enable the technician to quickly discover and correct the defects listed on the control signal preceding the recorded programme (fig. 3, 4).

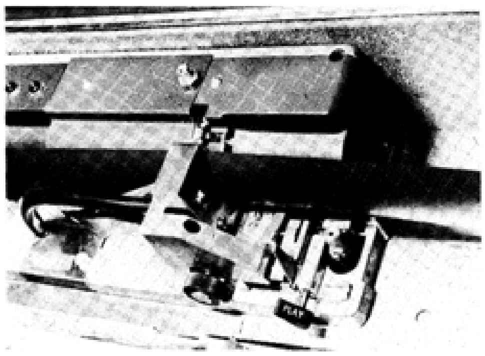


Figure 4
Guide with air pressure in front of the video head

There are two types of regulation:
1. Mechanical ones -
The guide attaching the tape on the video heads should be put correctly into position in order to avoid geometric vertical deformations that influence the picture.

2. Electronic ones -
The technician searches for the points of optimal function which defines the best picture and produces a minimum of noise.

Problems:
When the recorder is properly regulated, the replay of the programme can be carried out. Mostly a transfer to a modern format is made on this occasion.
Most electronic defects are transitory and cannot be discovered during a quick control beforehand. By means of different instruments and control signals, the replay has to be carefully supervised.
A frequently occurring problem of Secam colour recordings is typical of the lack of precision in the video equipment of that period of time and concerns the discontinuous loss of colour in the reproduced pictures. In order to correct this defect, which is often due to an unfavourable position of the colour burst, it is necessary to attach an exterior correction device to the machine. This burst regenerator, developed by the Research Department of Télédiffusion de France remakes and inserts the parts that are missing in the reference signal of the colour.

The first electronic editing in Secam did not always consider the fluctuations of the colour sequences of the coded video signal.
Thanks to a method of transcoding (decoding of the Secam signal followed by recoding), the reproduction of defective colours is avoided. This defect which is not so disturbing for a simple viewing, is inexusable in a copy designated for post-production.
Due to deformation of the support or interferences in the control device of the motor of the heads, instabilities can be observed when the time base corrector of the machine is no longer sufficient for compensation.
Resorting to more tolerant recorders like Ampex AVR 1 leads to a noticeable improvement of the defects.
Another solution is to attach a digital time base corrector to the recorder. This corrector will only be switched on during the disturbed sequences as a slight loss of quality in the image is caused otherwise.

This paper will explain the problems encountered in the area of replaying old recordings (defects due to an inappropriate regulation of the machine or defects due to damages during storage). Finally it should define and initiate the solutions appropriate for the restoration to be made. A sound knowledge of the contemporary methods of video production will make the analysis of the defects and the correction processes to be initiated easier.

Restoration of Old 2 Inch Recordings

The defects encountered when 2 inch tapes are replayed can be divided into two categories:
Electronic defects changing the quality of image and sound, mostly due to the bad recording conditions at the beginning.
Mechanical defects like tape distortion, mostly due to the bad conditions of operation and storage.

Electronic defects:
The video picture recorded on magnetic tape does not grow old in the sense that we talk about the ageing process of films. Actually no perceptible losses of magnetization within that time were noticed, and the accidental cases of erasure are rare. Moreover, the recorded video picture does not suffer from any reduction of the contrast or the colour in the course of time. The electronic recording defects, however, that are due to lack of precision and reliability of the production machinery of that time sometimes prove to be rejected by the recent equipment. This goes especially for the electronic signals accompanying the signal of the image (as is the case in the duration of the colour burst signal in SECAM).

The corrections involve special treatment of the video signal reproduced by means of connecting supplementary electronic equipment with the recorder. However, restoration has got its limits, and it would be illusive to want to give the picture from earlier periods the technical quality of the picture produced by current modern video equipment.

Mechanical defects:
The susceptible dimension of the recorded tracks on the tape, the importance of the pressure to which the support is exposed as well as the high speed at which the heads of video replay machines are rotating, lead to the fact that the least mechanical deformation of the tape has visual consequences for the geometry of the reproduced image and sound and sometimes even, to a certain extent, makes it impossible to replay the images.

According to their increasing degree of significance, the problems encountered in the field of reproduction are as follows:
geometric deformation, scratches in the replayed image;
picture instability;
irreversable damage of the support, fortunately only in exceptional cases.

Before any operation of replay it is advisable to clean the tape in order to avoid the video heads and the mechanical tape guides from becoming dirty. Cleaning machines even detect mechanical splices and tape damages (fig. 2).

Figure 2
Cleaning tape machine

Geometrical deformations of the image generally can be corrected through modifying the regulation of the control position which supports the tape on the video heads.

Picture instability appears when the variations of duration within the video signal cannot be corrected by the time base corrector of the recorder. In some cases it is sufficient to use a machine with a bigger correction window, like the AVR 1, or replace the analog time base corrector by a digital time base corrector.

A recorded signal on the control track is to ensure the exact position of the video heads on the recorded tracks.
Any incidental erasure by using a magnet will lead to losses of information culminating in instability of the picture.
If there is a mechanical splice, the only solution for early editing, this can be the reason of physical damages of the support and lead to problems of replay.
The loss of information during replay causes picture instability again.
After several replaying operations have been made it may happen that the edges of the tape connected by the splice separate and the heads lose contact with the recorded tracks.

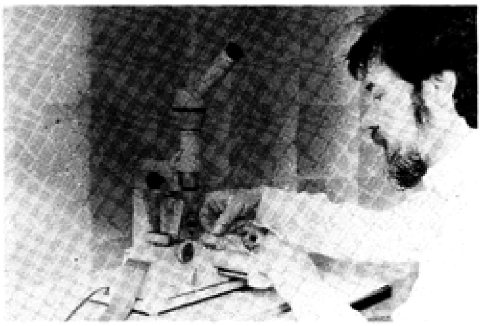


Figure 5
Mechanical splicing

The repair of a mechanical splice is a complicated operation considering the narrow dimension of the interval between two tracks. This leads to the loss of two images and should only be undertaken when absolutely necessary (fig. 5). In order to expose the recorded tracks that are not visible, a solution containing particles of oxide can be applied to the tape, thus making it possible to actually see the frame pulse of the control track and to define the beginning and the end of the recorded frames on the tape.
A microscopic device is necessary in order to put the cutter in the interval of the track which separates two frames and is only 200 μm wide.
Consequently the two edges of the tape are connected with a very resistant adhesive substance with a metal coating.
If the operation has been carefully made, there will be no visible influence on the picture during the replay.
Fortunately it is not often necessary to make a new mechanical splice; the use of a time base corrector is sometimes enough in order to compensate the defect.

Figure 6
Telecine and video recorders for film-to-tape transfers

After storage under unfavourable climatic conditions a partial decay of the binder may lead to oxide deposits on the heads and parts of the tape transport of the machine. This is the reason why a cleaning of the tape is necessary before replay. Fast winding on the machine makes it possible to dry and smooth the tape. This also is the occasion when mechanical splices and possible splits are to be discovered. Other defects may remain, such as the visible streaks on the tape; they lead to loss of information. The compensation of the loss of levels of the machine generally reduces the effects of these defects.
Serious mechanical defects resulting from a long period of storage after an inaccurate winding can make replay impossible. Actually the edges of the tape tend to be creased after the winding process which can lead to splits in the support when they pass the heads during replay. Finally the tape can refuse to follow the tape roller guides of the machine when its edges do not have the same length, a defect made permanent during a long storage (fig. 6).

Equipment Necessary in Audio-Visual Documentation Archives
Fernando Bardon Fernandez

Philippe Poncin:
The next speaker is Fernando Bardon. He works at the Spanish Television (Centro de Documentacio Ente Publico RTVE, Madrid); He is in charge of the technical department. He is also a member of the Technical Committee at FIAT.

The broadcasting corporation RTVE started its work in 1957. Since that date film documents have been preserved, and since 1964 video documents, although the latter existed already in 1953. Due to this fact and considering that RTVE in comparison with other broadcasting corporations of the world is only of medium size, the formats of its documented material vary extensively from videotapes (2", 1", ¾"...) to films in which reversible material was used as negatives and all kinds of sound: separate magnetic sound, optical sound, magnetic sound track, etc.

As soon as the "Ente Publico RTVE" had been created, it was considered necessary to restructure the area of audiovisual documentation into a unit of supervision, documentation and preservation. Thus the Documentation Centre of the "Ente Publico RTVE" was created which deals with the already mentioned requirement and also is of assistance to public, cultural, educational and research institutions.

Due to all this, there is an enormous amount of work to be done and a great responsibility that makes the kind of equipment necessary which will be described in this paper. With the new technology a whole range of problems will appear concerning the modernization of audiovisual archives and primarily with regard to the changes of formats, considering the fact that recorders are the most seriously affected devices.

Bearing this range of problems as well as the every-day technical requirements of a Documentation Centre in mind, we are going to have a look at the smallest amount of equipment that is necessary. In doing this, we have to divide the documents into three groups:

1. Documents on magnetic support
2. Documents on film support
3. Documents on photographic support

1. Documents on magnetic support

In this group we are dealing with two different types:
Recordings on video recorders
Recordings on tape-recorders

As numerous 2" tapes are still existing, it is necessary to preserve the apparatus of this format, even if this will be impossible to carry out in the nearest future, as no more spare parts are being produced and audio and video heads are no longer available. Thus at least four 2" recorders and four 1" recorders will be necessary for a proper preservation in the archive of the RTVE, where the 2" format amounts to a quantity of 42.000 tapes. One recorder of each type should be used for documentation purposes and the others for transferring formats.

Our calculations show that we need five years in order to transfer the whole material to 1". Due to this fact it is necessary to make a selection in order to exclude less interesting material and to preserve merely programmes of high quality which would reduce the number of tapes to be transferred.

A further problem concerns the tapes lent out by the archives. We think that tapes should not leave the archives because of the possible damage caused by change of climate, transport etc. Thus it would be necessary to have at least two 1″ recorders and one 2″ recorder in order to be able to send copies instead of originals to those who need a special film document.

As far as the documentation work is concerned, a 1″ recorder will be necessary in order to document programmes that are not broadcast daily. Daily programmes can be documented from the programmes recorded by ½″ apparatus. Although their quality is inferior with regard to recording and replay, they are much cheaper to use for this purpose.

The number of apparatus depends on the hours of transmission. Thus, in the case of RTVE, with transmissions on two channels during an average time of 25 hours daily, 14 recorders would be a sufficient number. 12 of those serving the purpose of recording and two recorders for viewings, equipped altogether with 450 tapes of 4 hours each, preserving the recordings for one month.

On the other hand, considering the damages of film material and the costs arising when a film has to be replaced, in many cases there are no financial means available for this purpose. Thus it would be advisable to keep video copies of the broadcasts most in demand, partly for viewing purposes, partly in order to be used as master tapes for the rerecordings of ½″ and even ¾″ material.

In this respect, due to the reduced costs, the ¾″ format can be used, considering that it is possible to perceive damages by using a good time base corrector when transferring tapes to a similar or an inferior format.

The amount of reproduction and recording equipment will depend on the number of performances and should be the object of a preliminary statistical survey.

Thus we can give you a summarized description of the apparatus we may consider necessary:

2″ Recorders - 5
1″ Recorders - 6
¾″ Recorders - this depends on the preliminary study
½″ Recorders - for the recording of programmes and depending on the number of hours to be recorded.
½″ Recorders - 2 for the purpose of documentation.

The second type of magnetic support, sound recordings on tapes, does not imply any serious problems, although the use of the digital disk makes information more easily available, thus reducing the size of the sound archive. The costs of the equipment is a problem, though.

2. Documents on film support

The problem of this type of document is that the transmission prints used as originals when transferred to video material get damaged. In the previous chapter we mentioned a possible solution in order to avoid this kind of risk.

According to the number of demands and the funds available, at least two telecine projectors for 16 mm and 35 mm films would be necessary, each one equipped with their corresponding magnetic read heads.

Documentation work will take place by means of viewing tables and film editing equipment for which two editing tables for 35 mm films and two further ones for 16 mm films will be required.

3. Photographic documentation

As mentioned in the previous chapters, the number of demands and the size of the archive are decisive for the amount of equipment required. In the archives of the Documentation Centre of the RTVE, there are about 500.000 stills, including copies, slides and negatives. At the moment they are set in order and classified.

Even if not yet completed, a study has been undertaken of a computerized system of research and transfer of a different kind of support that does not get damaged during its operation. This could be a material based within the area of image digitalization.

At present, it would be necessary to have at least one analyser of devices and one colour camera in order to be able to transfer photographs to video-tapes.

So far everything that has been previously exposed is related to documentation centres with archives of a certain size. Let us now look at the case of recently created broadcasting companies or smaller ones that have been existing about ten years or less.

In this case, the stored documentation material will not be very extensive, neither will there be many different formats. It would seem normal not to include 2″ video tapes or 35 mm films on 1″, ¾″ (high- or low-band) and in many cases even ½″ and 16 mm films.

In this case the equipment may consist of a couple of 1″ recorders, one for viewings and the other one for rerecordings from ¾″, one for high-band and the other one for low-band, also for ¾″ recordings, two ½″ VHS and two ½″ Betamax as well for rerecordings as for viewings, one 16 mm film scanner with a separate magnetic sound head as well as an editing table for 16 mm films.

A whole range of elements should be added to this equipment, like a T.B.C., a generator of synchronisms, distribution etc., in order to make it operational.

In the corresponding sector of sound, one record-player and two audio cassette recorders would be sufficient.

As film production is being reduced because of initial costs and prints, we can assume that this kind of material will not be too extensive and it should be transferred to video tape.

This seems to be the normal standard; it would, however, be necessary to make a study of each particular case, treating as well the stored material as the way it will be used.

Copying Small Amounts of Non-Standard Film Gauges
Harold G. Brown

Henning Schou:
Harold Brown was the Preservation Officer at the National Film Archive in London for almost 50 years. Harold retired in 1985 and is now a very industrious member of the FIAF Preservation Commission. You may all be familiar with the paper in the FIAF Preservation Commission Technical Manual entitled "Basic Film Handling", written by Harold Brown in collaboration with Kevin Patton.

Most film in archives is 35 mm or 16 mm, and a great deal of printing equipment exists on which it can be copied. There have, however, been a number of other gauges of film during the history of cinema (and I am particularly concerned with those of the early years). Of these only very small amounts have survived; some were only ever experiments of which very little was made.

Apparatus for showing some of these gauges is very rare or no longer exists.

The content of these films can only be made accessible by copying them onto a current standard gauge, e. g. 35 mm or 16 mm. Moreover, they are often in a fragile condition and could not be run at normal viewing speed, even if the machines were available. However, it is possible to copy these fragile films at a very slow speed which they can tolerate.

Usually, film printing equipment is costly. While the high cost of a printing machine is justified for a film size of which there is a large amount to be printed, it is quite impossible for archives to pay a high price for equipment to copy only a very small amount of film. Therefore, simple, inexpensive apparatus for copying these small amounts of non-standard gauges is valuable to archives which are faced with this problem.

What I seek to do here is to demonstrate how it is quite practicable to copy small amounts of such film on the simplest apparatus, sometimes very slowly, and even hand feeding the original film frame by frame. When only a small amount of film has to be copied, it is quite acceptable that it is done slowly.

The National Film Archive (London) has done some work of this kind, and I propose to show something of the ways in which this was achieved.

Our first encounter with this kind of problem was the call, in 1953, to copy some Lumière film with only one perforation on each side of each frame. This had to be done at virtually no cost, and a piece of apparatus was made from various materials which were already to hand; and very slowly some Lumière film was copied. Lumière film is 35 mm wide and the frame size is almost the same as the normal 35 mm silent film frame, so contact printing onto 35 mm film was possible (fig. 1).

Figure 1
Lumière frame of "Heavy Load"

The device on which that film was copied was made of pieces of wood, a child's toy construction set (Meccano), pieces of tin can, strips of velvet ribbon, screws, nails, wire, elastic, an automobile headlamp bulb, a borrowed projector sprocket, a piece of opal glass, and several other odd bits and pieces; and it was put together using only simple carpentry tools and a soldering iron.

The working speed of the machine, at the time that copy was made, was five seconds for each frame; mainly due to the use of a very low-power lamp. The speed was subsequently increased to one second per frame. The machine was also used to copy normal 35 mm silent film and was later motorised, instead of each frame being moved into place by hand-operated lever.

Prestwich 60 mm film with 35 mm reference (fig. 2).

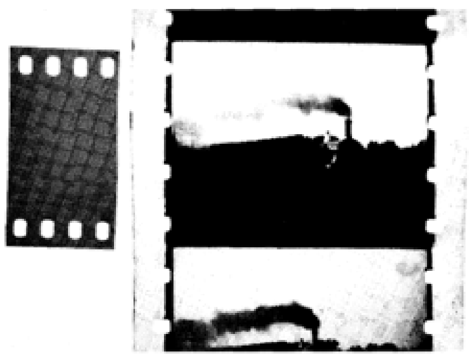


Figure 2
Prestwich 60 mm film with 35 mm reference

When the non-standard film is of quite different size from 35 mm or 16 mm, it is necessary to use optical printing in order to obtain a copy on one of these gauges. This means, basically, a projector, a camera, and a lens to convey the image from the projector to the camera. Many archives acquire apparatus such as projectors and cameras, as well as film, so it is reasonably likely that an archive will have access to a cine camera. If there is no camera, it is possible to use a projector for the purpose (though much less convenient).

The projector head of such a device for small amounts of nonstandard film can be a very simple "home-made" construction. This is the essential part of such a device which we used to copy some 60 mm film made by Prestwich in 1896. Again, it is composed of plywood, metal strips, velvet etc. The light was provided by an ordinary slide lantern, not shown here. The film was raised by hand a frame at a time, and the appropriate perforation set onto a pin which nicely fits the perforation and is fixed in the plywood above the aperture. Between the lantern and the original film, and close to the film, is an opal glass to provide diffusion of the light. This is an effective way to copy the picture, and at the same time to suppress, to some extent, the copying of the fine abrasions on the surfaces of the original film.

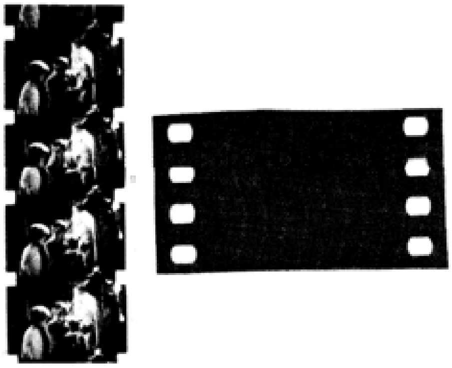


Figure 3
17.5 mm film with 35 mm reference

When Kevin Brownlow made his now-famous reconstruction of Abel Gance's "Napoleon", about 25 minutes of it was derived from a 17.5 mm copy (fig. 3).

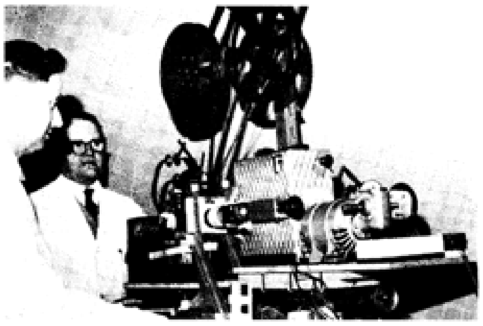


Figure 4
Machine for copying 17.5 to 35 mm

The 17.5 mm copy was enlarged to 35 mm, and this is the machine on which the enlargement was made (fig. 4). In this case, there was a Pathé 17.5 mm projector which could be used. In this case also, abrasion on the surfaces of the 17.5 mm original film were, to a useful extent, suppressed; this time by the use of "liquid" or "wet" printing. The way in which this was done was amazingly crude. The loop of film below the projector gate was passed through a little tin can containing trichloroethylene, and immediately before it entered the bottom of the gate it went between two little pads of velvet which were wedged there. These wiped off any surplus liquid. It was, as I have said, abominably crude, but it was simple, and fairly effective. It could not remove the image of dirt and scratches from earlier stages of copying. I do not think anyone has yet invented a way of doing that. The lack of sharpness of the image reflects the small size of the 17.5 mm frame.

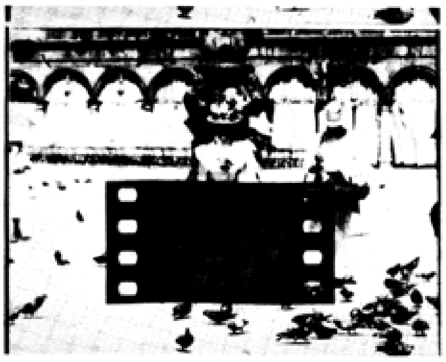


Figure 5
70 mm American Biograph with 35 mm reference

It was most convenient in the cases of the 60 mm film and of "Napoleon" to have the optical axis horizontal. On another occasion, the need was to copy some 70 mm American Biograph film which is unperforated (fig. 5). To do this, it was necessary to move each frame into position by hand, placing the frame line between each frame, against a mark beside an illuminated aperture. Again, the light was provided by a slide lantern, but this time it was easier to have the original film lying horizontal, in a 70 mm wide channel, cut in a sheet of plywood, which also had in it a hole the size of one frame. This hole was lit from beneath, and the lens and camera were mounted above on a stand made of slotted angle iron. Each frame of original film was moved into place by hand and then exposed to the camera using the camera's "one-turn-one-frame" spindle. The steadiness of the resulting 35 mm copy depends partly, of course, upon the steadiness of the original, but also upon the care and accuracy with which the operator places each frame while copying. A member of the Archive staff, retired now for some years, copied eight of the Biograph films in the Archive.

A modification of the same arrangement was used to copy the film of the 1897 championship boxing match between Jim Corbett and Bob Fitzsimmons (fig. 6). This film is 65 mm wide and is perforated, so we made a little mechanism to move the five perforations per frame. This was moved by hand, but the mechanism ensured accuracy of position of each frame.

Figure 6
65 mm sample with 35 mm reference

The same kind of arrangement was used to copy some early Biokam 17.5 mm film with a central perforation. This format was introduced in 1902 (fig. 7). We were appalled at the way the picture jumped up and down. So we made another copy in which the image of the perforations of the 17.5 film were made to show on the screen.

The Biokam film was intended to be used by amateurs, and the whole quality of it is not comparable with what was customary with 35 mm film at that time. And it must be remembered that the steadiness of most cinematography at that time was not comparable with that to which we are now accustomed.

This paper and demonstration does not pretend to show the whole detail of how this work was done. I hope that it has shown some possibilities. If anyone is interested in further detail, I shall be happy to discuss it with them by correspondence.

Finally, do not let anything I have said here deter anyone from striving to get well-engineered equipment whenever possible. The purpose of this demonstration is to encourage those to whom that is not yet possible, and to show that something can be done with a minimum of resources.

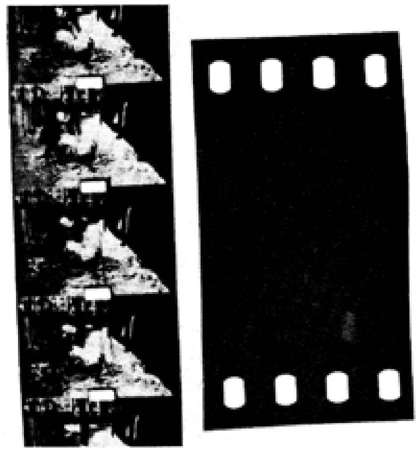


Figure 7
17.5 mm Biokam film with 35 mm reference

Harold Brown:
The colour sequences in "Elstree Calling" were copied on the Mark IV printer at the National Film Archive (London). It also copies 28 mm onto 35 mm film and 9.5 mm onto 16 mm film.

9.5 mm is by no means a rare gauge. There are probably more 9.5 mm projectors in the hands of amateurs than there are 35 mm. I do not know how common the format is outside the UK and France. Certainly it has been very common. In the UK there is sufficient of it around for one or two commercial laboratories to be interested in copying 9.5 mm onto 16 mm or 8 mm film.

Eva Orbanz:
There is a company in France, called S.E.F. (F-8100 Albi), which is still selling 9.5 mm material, cameras and projectors.

Henning Schou:
On behalf of the Preservation Commission, Frantz Schmitt (Service des Archives du Film, Bois d'Arcy) is compiling a list of laboratories, and also archives, which can cope with non-standard gauge formats, with information about the availability of services to external clients.

Photographic Recording of Component Television Signals – The "Cinemac" System
John R. Emmett

George Boston:
May I introduce John Emmett who is from Thames Television in London, which is one of the premier commercial television stations in England. It is responsible for the weekday output in the London area on the commercial network. Dr. Emmett is the research and development laboratory supervisor for Thames Television in London, and his laboratory covers every television subject from factory charges to digital VTRs. But today John will be talking about the techniques that they have devised for storing component video on black-and-white film. It is difficult to see how they manage to cram it all in, but I hope that John can enlighten us.

There exists in the United Kingdom, in common with the city of Berlin, over 50 years of television archives. Some of this is in the form of telerecording film, both 16 and 35 mm, but due to the explosive growth of the television medium in recent years, the majority of the material is on magnetic tape (fig. 1).

Whatever the archive storage qualities of videotape may prove to be, the problem remains of preserving suitable playback machines and viewing equipment. With the combination of the multiplicity of tape formats and the high technology required to maintain video recorders, the prospects appear bleak in this direction.

A curious situation arises from this, in that the earliest film telerecordings are the easiest to handle and should remain so in the future due to the continuing popularity of telecine machines for feature film broadcasting. Note also that the television line standard or colour system does not matter in this case – a fact that we will return to later.

The recommended storage conditions in film (fig. 2) greatly favour monochrome stock on a polyester base. In our own archive facilities 40 metres below ground level in London, such conditions are naturally available without the cost of air-conditioning. To sum up, therefore, the advantages of monochrome telerecordings for television archives are:

Low cost telerecorder, telecine, film stock and processing;

Known archive permanence and relaxed storage conditions compared to colour stock or magnetic tape. Standard film formats are unlikely to become obsolete unlike VTR formats;

Can be edited and viewed as film, and handled worldwide without standards conversion costs using the cinema process, yet they possess the potential high quality and electronic advantages of a component television recording.

In order to record a colour picture on monochrome film, we need either an optical colour separation or an electronic one. The electronic system allows us to take advantage of the next stages in television development, namely the component system and digital coding.

Colour television signals in component form have a number of advantages over those coded in composite (e.g. PAL) form, both for production and for transmission. The advantages can be summarised as follows:

Ease of coding on to any composite system;

Extendable performance compared to a composite signal;

Better compatibility than composite with digital telecine, digital distribution and effects.

The time division multiplex (TDM) form of a component signal is often referred to as a "MAC" signal (fig. 3) although the true MAC forms are intended for satellite transmission. One adaptation of the TDM signal developed at Thames Television and often

UK TELEVISION ARCHIVES

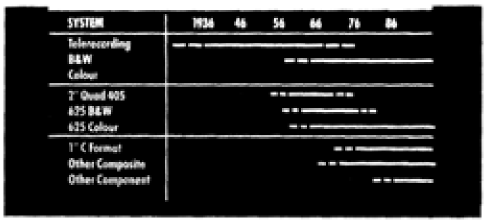


Figure 1

RECOMMENDED MEDIUM TERM STORAGE CONDITIONS FOR MOTION PICTURE FILM (ISO)

FILM TYPE	TEMPERATURE	RELATIVE HUMIDITY
● B&W on cellulose ester base	● 25°C MAXIMUM (77°F)	● 15% – 50%
● B&W on Polyester base	● 25°C MAXIMUM (77°F)	● 30% – 50%
● Colour on cellulose ester base	● 10°C (50°F)	● 15% – 30%
● Colour on polyester base	● 10°C (50°F)	● 25% – 30%

Figure 2

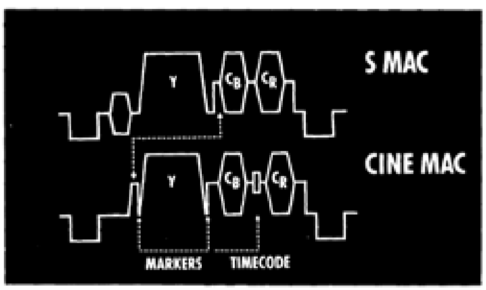


Figure 3

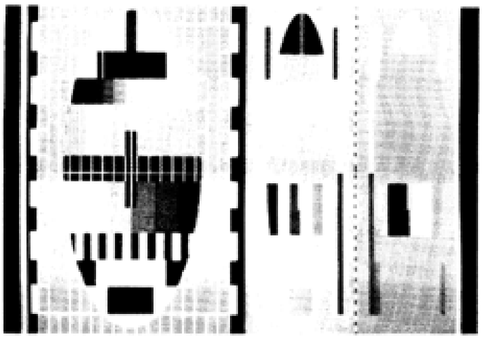


Figure 4

called "CINEMAC" enables colour television to be telerecorded on to monochrome film stock (fig. 4).

There are additional features with the electronic colour separation which may be useful in the future. The start of frame marker and the mid grey "pedestals" before the colour signals allow a correction for gate "wander" and film shrinkage as well as fading of the image. Inserting a vertical band of time code in each frame enables indexing and "labelling" of the material, as well as serving for a sound sync track. It might appear, indeed, that such a marriage of well tried standard film techniques and the latest television electronic developments would have applications well beyond archive applications.

<u>Question:</u>
Do you have any information on the relative costs of the system?
<u>John Emmett:</u>
The actual coders and decoders needed with a black-and-white tv recorder and telecine cost the equivalent of 10,000 pounds at the moment. But of course a colour tv recorder, or a colour telecine would cost many times that value. I am informed by the Chairman that 180,000 pounds is the value of a good colour telecine. And the film stock at the moment is slightly cheaper than colour stock, but of course laboratory charges are very much cheaper. And if I could say, there is no need to produce a positive print, you can work from the negative by inverting the television electronic signals and produce a positive and very good quality print.

The Implementation of Proposed Standards for Copying Audio Recordings
William D. Storm

The purpose of this paper is to acquaint a wider audience with a philosophical standard that has wide implications on re-recording techniques.
One of the most common types of questions we are asked in our laboratory (the Belfer Audio Laboratory of Syracuse University) is, "How do you re-record an old 78?" What about cylinder records, wire recordings, acetate disks etc? Implicit in all of these questions is what is the correct way to do each. The inquirer might easily be satisfied if he limited his questioning to one re-recording specialist. On the other hand, if ten re-recording specialists were questioned, one could easily get ten different responses. The question remains, 'What is correct?' By what standards are re-recordings judged. To answer these questions the purpose of the re-recording must first be understood. For the hobbyist his personal satisfaction is an adequate standard. For the commercial vendor, total sales may well be the standard measure. For the sound archivist the standard is one based on vocational mission - to save history, not rewrite it. This definition of purpose for Sound Archivists was formally agreed to by the International Association of Sound Archives Technical Committee at the committee meeting held in Washington, D.C., USA in 1983[1]. This same statement of mission was also adopted in March 1987 by the Associated Audio Archives[2] (AAA), a committee within the Association for Recorded Sound Collections. Members of AAA represent major sound archives in the United States.

George Boston:
The next paper is from William D. Storm, who is director of the Thomas Alva Edison Rerecording Laboratory at Syracuse University in New York State. I must confess to being rather envious of that title, because of course in the sound world, Edison was one of the great pioneers, and to have that label attached to your laboratory is quite gratifying. Bill is chairman of the Audio Engineering Society's Preservation Committee, and has been a member of the IASA Technical Committee for many years. He works with the preservation of old audio recordings, and has dealt with many formats over the years. Unusually for an archivist, he was also permitted to design his own premises.

Philosophical Standard

This paper will not address itself to the hobbyist or commercial vendor, but will focus on the professional sound archivist who has subscribed to the objective of historical accuracy. For this archivist, saving history, and not rewriting it, becomes a philosophical standard. Implementation of this standard can be very demanding, for while it does not in itself specify standardized procedures, it does restrict the archivist to applying only those techniques which do not in anyway falsify the original sound recordings or the aural content within. But before techniques can be applied a number of factors must be considered.

Factors to Consider

Trying to ascertain what the original sound recording or artists were supposed to sound like is no trivial matter since the industry under study has always thrived on mystifying the public. From the earliest days of the industry, marketing of sound recordings has been governed as much by profit margins and patent rights as the quest for the ultimate in fidelity.

A good early example of this was the advent of the flat disk (fig. 1). The physics of a flat disk using an analog lateral cut groove simply makes little sense from a qualitative viewpoint. The frequency response, from the outermost to the innermost disk diameter, varies continuously. This variance was not true for the first form of commercially available records - the cylinder (fig. 2, 3). Sonically, the cylinder was easily superior to the first disks patented by Emile Berliner in 1887. The best that could be claimed for the flat disk was that it was physically easier to store and more amenable to mass production. Clearly Berliner's success was not in improving the quality of sound recordings. His real success was in securing a patent for an alternative audio recording method, thus posing a marketing threat to Edison, Bell, and Tainter, all of whom, through earlier patents, controlled the cylinder industry.

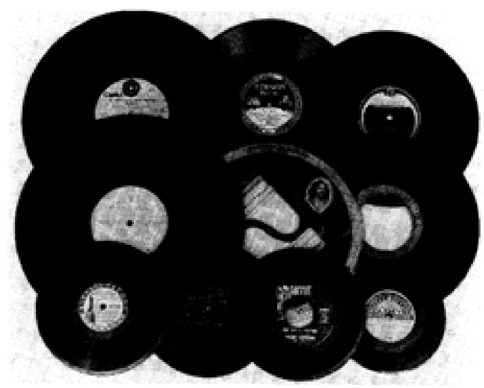


Figure 1
Examples of a variety of flat disks

Figure 2
Cylinder Recordings

The eventual marketing success of the flat disk was an early indicator that non-qualitative factors would strongly influence the fidelity of recordings available to consumers. Changing factors such as playing speed, record length, groove dimension, record composition, physical beauty, size and shape, and etc. have all had an influence on record sales and audio fidelity. Some changes have been responsive to consumer demands. Many have continued to be the result of industry fights to gain control over the market. At various times audio fidelity would both benefit and suffer.

So, an important factor the audio archivist must learn if he hopes to strive for historical accuracy is that recorded sound quality does not follow a chronological path. Blind acceptance of "new must be better" is a major error.

This same message is appropriate for the media that have been employed to record sound. Many different materials have been used: wax, celluloid, shellac, aluminium, acetate, vinyl, tellurium, to mention a few. New materials have not always been improvements over earlier ones. An obvious case was the glass backed acetate disk used extensively in the 1940's, 50's and 60's. The medium's chief advantage was its usefulness as part of a instantaneous recording system. Unfortunately this composition has proved to be more unsuitable for long term storage than most media which preceded it. True, it was not generally intended as a mass distribution medium, but many extremely important recordings made using this medium are now literally falling apart.

Figure 3
Examples of early phonographs

To date there is no proven archival medium for sound recordings. Optical disks, once hailed as "lasting forever", are already suffering from a malady known as "laser rot", resulting in a loss of video and audio signals. The audio engineer in a sound archive simply cannot accept a new medium or technology as suitable for archival work without thorough study independent of manufacturing claims.

Another variable that must be considered is equipment. Sound recordings are 100% dependent on external devices for their reproduction. The number and variety of devices produced since 1877 has been enormous. Unfortunately not all record and reproducing systems were designed with the goal of creating high fidelity. Furthermore, manufacturers continue to intentionally design systems which are intentionally incompatible. Digital audio tape recorders and video cassette recorders are good examples.

Even when a recording can be played on a number of systems, the quality of the systems can vary so greatly that the reproduction can be dramatically different on each. The sonic content is thereby contaminated leaving the listener little or no assurance that the reproduction is as originally intended.

Many more factors could be listed that can have an impact on the sound archivist but none is more difficult to manage than the last to be mentioned – the human mind and spirit.

Figure 4
Turn of the century listening room

A new technology can be so startling that logical and rational appraisal of its attributes and faults is almost impossible. People at the turn of the century were in no position to judge sound recordings – it was too new – too exciting – just to be able to hear recorded sound was satisfaction enough. By 1915, however, people had become accustomed to this new phenomenon and considered themselves a sophisticated audio audience. Proof of audio quality became a competition necessity (fig. 4).

So it was that the Edison Company began conducting its famed Tone-Test Concerts. "Before an invited audience of some 2,500 music lovers and friends of the inventor, Thomas A. Edison exhibited the latest child of his inventive brain in Carnegie Hall, and 2,500 sat enthralled under the spell of the wizardry which reproduced for them a human voice, the subtle shadings of the most delicate violin tones and the blare of a brass band with such fidelity that no one in the audience, hearing also the same music at first hand, could tell which was the real and which the reproduced." - Brooklyn Daily Eagle, April 29, 1916.

These Tone-Tests were conducted numerous times in different auditoria with different artists for different people. The same supportive newspaper reports continued.

By today's technical standards and listening criteria, these early newspaper accounts seem preposterous, yet this same advertising technique of "live versus recorded" sound has continued even into today's markets. The lesson is that regardless of time listeners can be fooled. Judgement and definition of good sound fidelity is relative to a person's experience and education with regard to sound. It is also directly dependent on a person's physical, mental and emotional condition. One of the most difficult things for many people to accept is that listening is not the ultimate or final measure of sound quality. It is only one of the many elements, albeit an important one, to consider. It is therefore incumbent on the sound archivist to recognize that psycho-acoustic factors can tremendously influence peoples' perception of recorded sound and lead to a subjective rather than an objective accounting of the history of sound recordings.

The myriad factors which confront the sound archivist before attempting a re-recording is imposing. From just the few factors previously listed many questions need to be addressed.

What is a realistic assessment of the original sound recording quality?
What objective criteria have the assessment been based on?
Is the proper playback system being used to reproduce the originally intended signal?
Is the playback monitoring system used to judge recordings properly calibrated and neutral in its response?
Is the room in which sound is reproduced designed to be acoustically accurate?
Are filters, equalizers, reverberation and other enhancement devices being employed on a subjective basis?
Are personal preferences and psycho-acoustic phenomena influencing re-recording techniques?
Have all procedures been documented?
Are all procedures, tests and results verifiable?

Implementation

In an ideal world the plethora of questions would all be answered and mankind would be assured that historical accuracy has been maintained in re-recording processes. In the real world all questions cannot be answered, but many practical steps can be taken to minimize our problems in these areas.

Increasing the number of people studying these problems in a cooperative manner is one such step. In recent years, improved communications between sound archives have led to an increased awareness of the engineering goals of sound archivists among themselves, their institutions and countries. This increased awareness coupled with the quest for historical accuracy have provided sound archivists with coherent and rational reasons to seek strong support from administrators, scholars and funding agencies. The results have been tangible and in many cases dramatic.

In the United States alone new facilities were built for the sound archives of the Library of Congress and Syracuse University (fig. 5, 6). New York Public Library and other institutions are also actively pursuing new building programs.

Careful attention to acoustics, calibre of equipment and personnel has improved markedly. Archive engineers who were once fortunate to have a working turntable and tape recorder now have access to equipment competitive with and in some cases superior to that used in professional recording studios.

Figure 5
Front of the Belfer Restoration/Control Room

Figure 6
Rear of the Belfer Restoration/Control Room

Figure 7
Example of acetate disk with water damage

Measuring equipment is now being employed to help separate fact from fiction regarding recording quality and the products that have been used to create and reproduce recordings.
Invention has been prolific. In one example, cylinder restoration, alternative reproducing systems have included magnetic cartridge, fibre optic and laser systems. All were developed within the audio archival engineering community. (Fig. 7)

Re-recording for sound archivists is starting to show signs of becoming a science. Granted, it is a science in its infancy stage, but progress in the past ten years has been significant. Complacency and not learning from the past, however, still remain the greatest nemeses.

The sound engineer in an archive must be reminded not to confuse new technology with suitable or superior technology. Acceptance without testing new technologies and media is a fundamental error. An optical disk that now suffers from "laser rot" is one example. Digital systems that are literally incapable of contending with the full audio spectrum is another. Adoption of digital tape recorders for archival purposes, when no agreed upon standard for this format has been reached, is yet another. None of these are really new problems. They are new demonstrations of old problems - lamination integrity, questionable frequency response, and lack of standardization.

Conclusion

In conclusion, advocacy of the philosophy of "saving and not rewriting history" demands that the re-recording engineer seek an understanding of the many variables that affect the perception and actuation of original sound recordings. Factors such as market competition, original record/reproduce equipment, media formats, acoustics, psycho-acoustics, etc. need to be accounted for.

Implementation of this philosophy is beginning to emerge in sound archives in great part due to improved communications among sound archivists. Questioning each other provides a good system of checks and balances that minimizes subjective rewriting of history. The philosophic standard does not enumerate specific technical procedures, but it definitely does exclude re-recording techniques that can be shown to be subjective and which falsify the original sound recording or the sound of the live artist. Eventually the restrictions imposed by uniform application of this standard could lead to the evolution of universally acceptable re-recording techniques within the archival field. Perhaps then, at least for the archival field, the question "How do you re-record an old 78?" could be answered in one voice.

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[1] International Association of Sound Archives Annual Conference, May 8-14, 1983, Washington, D.C.
[2] Association for Recorded Sound Collections, Associated Audio Archives Committee Meeting, March 1-6, 1987, Ocean City, Maryland.

Digital Signal Processing Methods for the Removal of Scratches and Surface Noise from Gramophone Recordings

F.J.W. Rayner, S.V. Vaseghi, Lloyd Stickells

George Boston:
The next papers are both on the use of digital techniques in the restoration of audio recordings, and we will hear first from Lloyd Stickells of the National Sound Archive in London.

Introduction

Digital signal processing offers many advantages over analogue processing in terms of flexibility and the ease with which complex operations can be implemented. With analogue processing separate equipment is required for operations such as filtering, spectrum analysis, and more specialised operations specific to restoration of recorded material, whereas with digital processing the system can be completely reconfigured under program control from a keyboard.

Many of the more advanced processing techniques are virtually impossible to realise with analogue systems. For example any operation requiring signal delay such as correlation, is difficult to achieve in analogue form, but is a straightforward matter in digital form since signal data can be stored in memory. This paper is concerned with techniques for the removal of large scratches and surface noise from gramophone recordings and the advantages of digital techniques should become clear when we consider these methods.

Scratch Removal

A typical example of the problems to be considered is that of the 78 rpm record which has been broken and the halves stuck together. This produces two 'clicks' per revolution together with the surface noise inherent in a shellac based storage medium. The first processing technique tried was simply passing the signal through a threshold detector with the threshold set above the peak signal level but well below the peak of the click. By examining the clicks, the width was estimated to be no greater than 80 samples. (It should be pointed out here that because of initial hardware limitations, sampling was limited to 20 kHz and resolution to 12 bits). The 80 samples round the click were removed and a linear prediction algorithm was developed to take uncorrupted signal samples from either side of the click and use these samples to interpolate the missing 80 samples. This technique was found to yield satisfactory results for one of the clicks in each revolution but was completely unsatisfactory for the other, in that the click appeared to be replaced by a low frequency 'thump'. Careful examination of the two clicks in any revolution showed the root of the problem (fig. 1, 2).

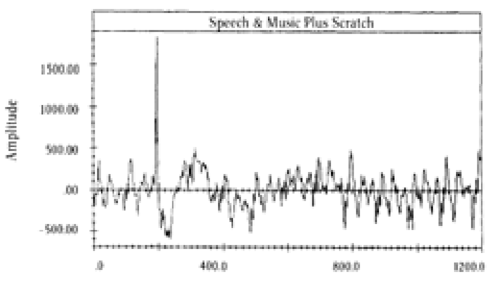

Figure 1

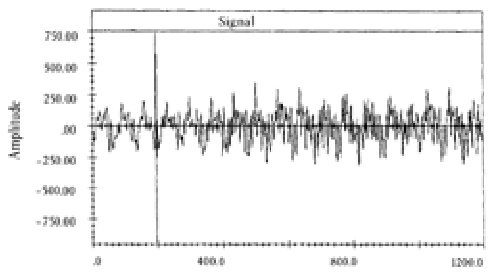

Figure 2

It is clear that one click is of short duration and has no lasting effect whereas the other produces a relatively low frequency decaying sinewave after the click. Observation of the waveform seemed to indicate that although the signal was completely obliterated during the short duration high amplitude click, the low frequency decaying sinewave appeared to be added to the signal, and it should be possible to identify this low frequency sine wave and subtract it to leave only the signal. The short duration click could be dealt with in the manner previously described.

It is conjectured that the low frequency ripple results from the dynamics of the pick-up arm and stylus. Possibly one of the joins corresponds to the pickup having to climb up a vertical wall, whilst in the other the pickup has to drop down. The first case of course produces the low frequency ripple. This is purely conjecture and has no effect on the processing to be applied – the oscillation is there whatever gives rise to it. The problem is to obtain a clean version of the oscillation without signal imposed on it. The method used to obtain this 'scratch template' combines cross-correlation and signal averaging techniques. In essence one scratch is selected to start with, (probably the first one on the

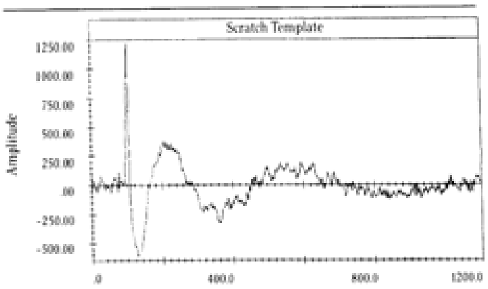

Figure 3

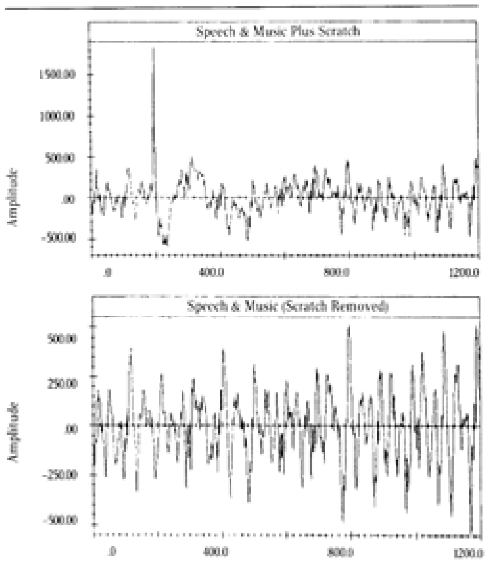

Figure 4

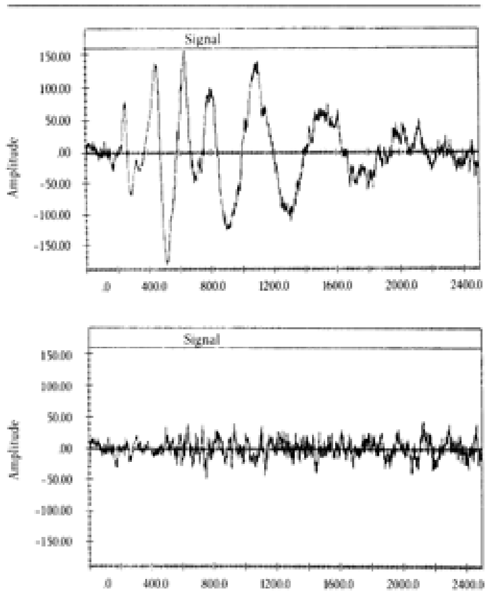

Figure 5

record) and stored as a reference. This reference is cross correlated with the signal in the vicinity of the corresponding scratch in the second revolution: the cross correlation function will show a very sharp peak when the two scratches are added together to produce a new scratch template in which the scratch to signal ratio is improved by about 3 dB, since the signals which are added to the scratches will be uncorrelated. Remember that at this stage we are attempting to produce a good version of the intermodulation frequency signal. This process is repeated about 20 times to produce a reasonably clean version of the scratch template (fig. 3).

Having determined the scratch template the high amplitude spike at the beginning of the template is removed. We are now in a position to attempt the restoration from the beginning of the record as follows. The clicks are detected as before with a simple threshold detector and the samples (80 in this case) containing the clicks, removed. The template is then cross correlated with the signal immediately following the click to precisely align the low frequency ripple and the ripple template. The peak in the cross correlation also indicates the amplitude scaling factor to be used when subtracting the scaled version of the template from the actual signal to give optimal signal to noise ratio. This is particularly convenient since both types of click can be dealt with in the same way; ie. if there is no low frequency ripple following a click, the cross correlation indicates that it is not necessary to subtract the scaled version of the template (fig. 4).

The technique has also been applied to the signal from the optical soundtrack of a film which has been edited between speakers. The transient response of the photo detector produces a transient as shown (fig. 5).

Once the large clicks have been significantly suppressed attention must be given to the problem of impulsive surface noise of the type shown here (fig. 6).

It is clear from this example that it is not possible to detect the noise pulses by means of a simple level detector, as the true signal and noise pulses are of similar amplitude. The technique developed for dealing with this problem is based on the concept of determining an analytical model for the signal which reproduces the signal when driven by a noise signal called the excitation signal. For a speech signal, the model can be considered to be one of the vocal tract and the excitation can be considered as the glottal pulses for voiced speech, or white noise for unvoiced speech. This technique is known in the speech literature as Linear Predictive Coding. The reason for applying this method is that the difference between impulse noise and genuine excitation pulses is much enhanced in the excitation waveform, as can be seen here (fig. 7).

The pulses in the excitation signal which corresponds to the surface noise can now be detected by means of a threshold detector and their time position noted. It is now possible to remove from the original signal a few samples in the vicinity of the surface noise impulse and then use a prediction based on the signal on either side of the discarded samples to fill the gap where samples have been discarded. This produces quite reasonable results but there are two refinements possible. The first of these is to apply matched filtering to the excitation signal to improve the detectability of the surface noise impulses. A matched filter is one whose impulse response is the time reverse of the signal one wishes to detect. Such a filter gives optimal signal to noise ratio for detecting a known waveform in the presence of white noise. In this the waveform is known since it is that function which when applied to the modelling filter will produce the surface noise impulse at the modelling filter output. It is a relatively straightforward matter to calculate the parameters of the modelling filter (fig. 8).

The matched filtered excitation signal can be treated in the manner just described. That is the matched filter signal is passed through a threshold detector which detects the position of the surface noise pulses. Samples in the vicinity of these positions are discarded from the original signal and replaced by predicted values.

The second refinement that can be incorporated is to make the threshold level of the detector dependent on the signal level. In the loud passages the level of the speech/music signal may be comparable with noise pulses even after matched filtering of the excitation signal. However, if the speech level is high it is not important if some of the low level noise pulses are missed. Conversely, in quiet passages the speech level is low and low level noise pulses will be more objectionable. Thus in quiet passages it would be advantageous to use a low threshold level to ensure that the lower level noise pulses are not missed, whilst in high level passages the threshold must be increased to ensure that the speech signal is not mistaken for a noise impulse. In order to achieve this, the threshold level is dynamically varied in accordance with the signal power estimated from a sliding window operating on the previous 600 samples (approximately 30 mS)(fig. 9).

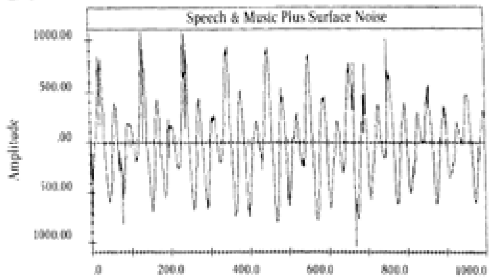

Figure 6

Conclusion

The two digital signal processing techniques have been described in outline and it is hoped that they demonstrate the flexibility of digital techniques. There are many areas yet to be investigated, such as removal of periodic interference with slowly varying frequency, such as frame buzz, echo removal and distortion correction.

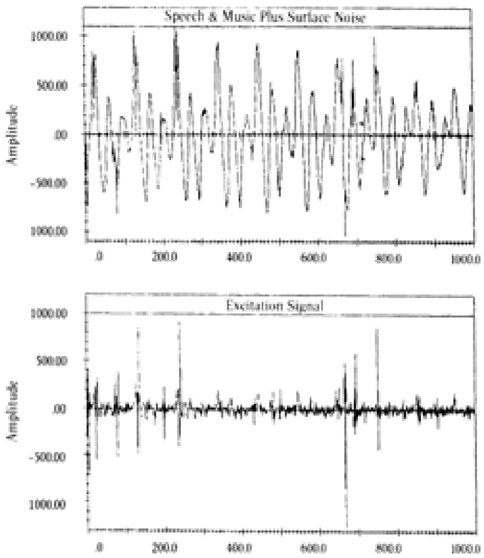

Figure 7

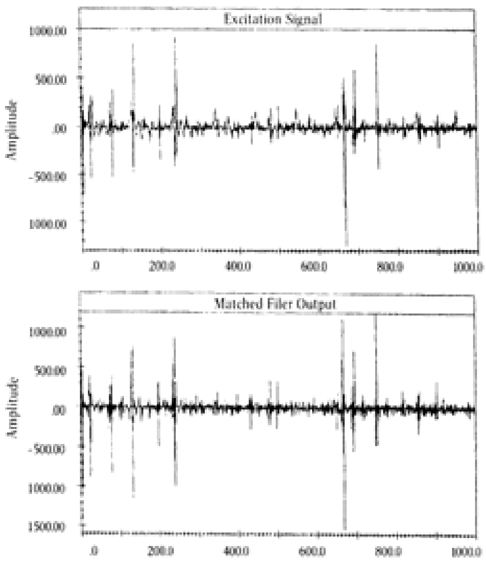

Figure 8

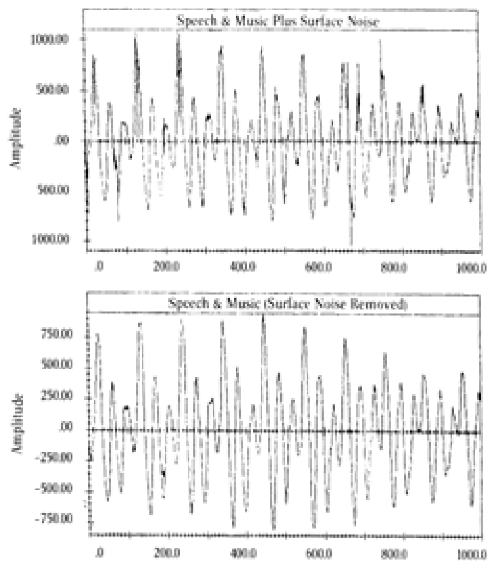

Figure 9

The Restoration of Historical Sound Recordings by Means of Digital Signal Processing: Psychoacoustical Aspects

Werner A. Deutsch, Anton Noll

The purpose of this paper is to present an approach to the common use of digital signal processing when applied to the enhancement of historic sound recordings. The restoration of historical recordings must take into account human perception in general and psychoacoustics in particular, because the listeners are motivated by perceptual and cognitive considerations rather than relying on mathematical models. Starting from the main objective of improving the overall quality of the sound recordings, three kinds of severe signal degradations have to be considered in detail:
1. Transient peaks caused by dirt and damage, scratches and cracks on the original disks or wax cylinders;
2. Unnatural sounds caused by resonances which were present in the original recording equipment;
3. Background hiss and broadband noise due to the imperfections in the recording surfaces of the materials used.

Elimination of Random Impulsive Noise

Time domain signals are first sampled at a sampling rate of F(s) = 16 kHz, quantized to 16 bits and then stored on computer disk. An interactive graphic-acoustic signal editor was developed to locate and label all impulsive distortions, generated by cracks and scratches in the record. Visually and acoustically detectable short term distortions with a duration up to 20 ms have been eliminated by replacing the distorted signal segments with their preceding segments of equal duration. The use of digital signal editing greatly facilitated the selection of zero-crossing segment boundaries. Replacing short distorted signal frames with undistorted, adjacent segments have no unfavourable, audible effects (fig. 1). However one must keep in mind that the statistical characteristics of the signal have been dramatically changed by this replacement operation. Additional processing of the corrected material, eg. autocorrelation etc. could produce undesired side effects at the repeated signal frames.

Trace 1 and 2 (fig. 1) show the digital waveform ($t^1 = 384$ ms, $t^2 = 45$ ms) of an historical recording from 1903. A sharp peak can be seen (and heard) approximately at the centre of the first line. The zooming of the waveform in line 2 helps to determine the extension of the undesired transient as well as to select an appropriate replacement material. Trace 2 and 3 show the result of the acoustic-graphic editing process: the transient has been removed by overwriting the distorted signal with the replacement material (labelled S1–S2). No, or little phase distortion has been introduced. Perceptually, a smooth jump in a phase or even a small gap in the sound is far less offensive than a sharp click or pop. (Deutsch & Noll, 1984)

Figure 1 shows the elimination of impulsive distortions: localisation, labelling and replacement of distorted signal segments with a duration up to 20 ms by undistorted sound material by means of a digital graphic-acoustic editor.

In practice the process of manually identifying and replacing impulse-like distortions in the time domain, has been proved to be superior to real time descrambling procedures because of the possibility of eliminating individual distortions under visual and auditory control. It may be desirable to automate this procedure by suitable computer programs but considerable difficulties caused by the variability of several distortion products have to be expected. Usually considerable variations of the click waveforms have to be taken into account. These vary from recording to recording and depend on the kind of damage to the surface of the recording medium.

<u>George Boston:</u>
Questions will be taken after the next paper because the two papers are very closely related. I would now like to invite Werner Deutsch to present his second paper on the use of digital techniques in the restoration of audio recordings.

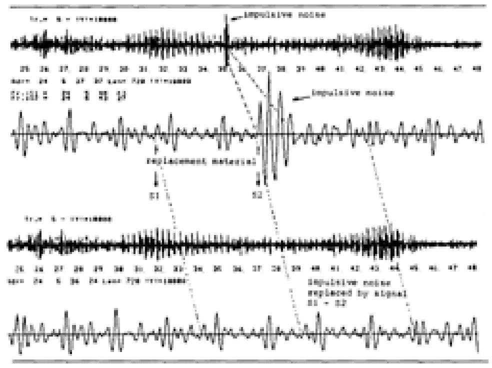

Figure 1:
Elimination of impulsive distortions: localization, labeling and replacement of distorted signal segments with a duration up to 20ms by un-distorted sound material by means of a digital graphic-acoustic editor.

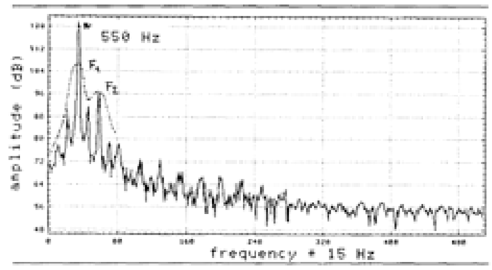

Figure 2:
——— observed and ---- theoretical level of the formant frequencies F1 and F2 of the german vowel /o/. The spectral peak at 550 Hz is assumed to be enlarged due to a sharp recording system resonance.

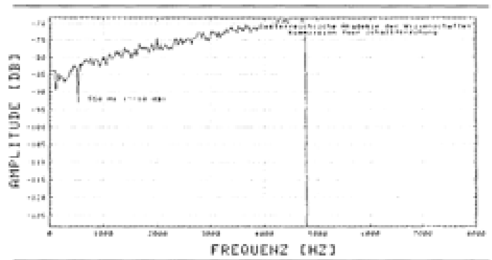

Figure 3:
compensation filter frequency response obtained by inverting the averaged noise spectrum during silent periods of the recording. A notch filter at 550 Hz and a low pass with a cutoff frequency at 4800 Hz have been added.

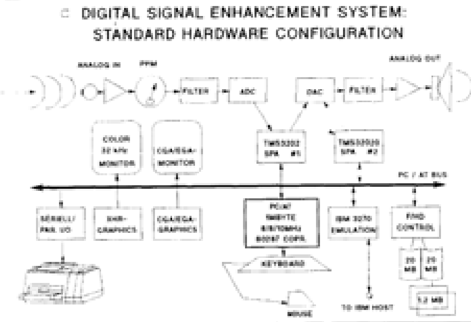

Figure 4

George Boston:
Two very interesting papers on the use of digits to improve all audio recordings.
William D. Storm:
Werner, what was the, what appeared to sound like a phasing sound in your restoration. Was it a phasing or a ringing, filter ringing, because it is not the sound that you ordinarily find on a normal recording.
Werner Deutsch:
This is due to the kind of algorithm we are using. Because of the bad signal noise ratios we are forced to work with a very strong filter, an adaptive filter, which blurs the chronological progress of the signal. There is some smearing, depending on the length of the filter, and using long filters brings this effect. But if you use short filters, you would not get rid of the noise.
Jean-Marc Fontaine:
I address the specialist in psycho-acoustics, we are lucky that one is present here. I would like to ask him, if

Frequency Compensation

The compensation required to remove unpleasant horn and system resonances can be affected by carefully equalizing the recordings with high resolution digital filters. Practically no technical limitations exist with frequency resolution or filter bandwidth. If little or no information is available about the original recording equipment, problems arise because of the difficulties of a reliable estimate of the system transfer function. There have been extensive discussions about how to measure horn and system resonances in combination with the recording media used (e.g. Brock-Nannestad, 1984). In many cases the system transfer functions have to be calculated from unmodulated or silent sections of the recordings, a method which does not rely directly on the physics of the recording equipment. There are some examples which have led us to proceed with caution. Slight errors in the equalization inevitably cause significant deterioration of the whole enhancement process. Certainly it is better to use no equalization instead of introducing a wrong one.

Generally the influence of the nonlinear resonance behaviour of the recording system is to be encountered in the form of sharp frequency response of up to 20 dB. The spectral peaks generate unpleasant amplitude distortions at distinct frequencies when hit by a stationary partial tone of the signal. They can be identified in the long term averaged spectrum due to their invariability over time. For the reasons mentioned above no further theoretical considerations on the transfer function of the recording system have been made, as this more empirical approach seems to be sufficient to compensate for the worst cases. Moreover some practical experience has been gained in extracting resonance frequencies, especially from those parts of the recordings which are characterised by a higher signal to noise ratio. Here it was possible to predict some spectral envelopes on the basis of generally accepted psychoacoustical formant data of comparable undegraded signals, and on the information which can be obtained from the acoustic model of speech production and the theory of timbre of musical instruments.

Figure 2 shows the frequency spectrum of the vowel 'o' of the German utterance 'vorzuführen' taken from the 1903 sound recording of Franz Josef I. According to the acoustic theory of speech production (Fant, 1970), the vowel 'o' has a first formant frequency of about $F1=500$ Hz and a second formant frequency of about $F2=900$ Hz with bandwidths of $B1=54$ Hz and $B2=65$ Hz respectively. Taking into account that there should be a level of difference between F1 and F2 of less than 10 dB, the spectral peak with a magnitude differing as widely from the theoretical formant structure as observed in Figure 2 strongly indicates the presence of a sharp resonance peak as generated by the recording system. In advance of the following noise reduction process, using ensemble averaging and adaptive filtering, it is advisable to prewhite the broadband background noise by adding its inverted spectral magnitude. The frequency spectrum of the background noise can be obtained by averaging silent segments of the signal.

Figure 3 gives the frequency response of a typical compensation filter for a horn resonance at 550 Hz and the broadband noise taken from segments of nonsignal activity; a low pass filter with a cut off frequency of 4800 Hz has been added because no signal energy beyond this frequency is to be expected.

Psychoacoustical Aspects of Noise Reduction

Listeners comments on hearing historical sound materials are characterised by the views that old recordings sound low and dull, that hiss, broadband background noise and cracks are present, the frequency range is very limited and the signal to noise ratio is low. Even 78 rpm disks usually produce a more or less acceptable amount of hiss, representing a historical document.

Modern digital stereo records have a frequency range of almost 20 kHz and a potential dynamic range of more than 80 dB. In addition to the program signal they preserve the room characteristic of the recording studio and in live performances the acoustic environments as accurately as possible, due to the highly sophisticated multichannel recording techniques and stereo mixing used.

Imagine a simple psychoacoustical experiment; first mix continuous background pink noise with a modern recording in order to simulate the signal-to-noise ratio of historical recordings (ie. 10–20 dB). Then we feed this artificially degraded signal into the noise reduction system, and the result will be a clean high fidelity recording with a signal-to-noise ratio almost the same as the original. If we apply the same amount of noise reduction to a historical recording, we will never obtain a higher frequency range than the original had, and expanding the signal to noise ratio of the 'poor' original to the value of a modern record, which is technically possible, will produce a strange unusual sound. It will be clean, completely free of noise, but the dynamic relationships are not correct. Moreover the problem of the limited frequency range of historical recordings (typically 200–4000 Hz) will accentuate the total absence of any high frequency components. This leads to the conclusion that it is undesirable to produce a 'figure' without any background, an experience which is widely documented in the perception of visual information and which is also valid in audio. It is frequently the case that a continuous weak and neutral background sound is better than none at all. Thus the main objective of improving the overall quality of the sound recordings, by reducing the hiss and background noise, can be formulated more exactly from the psychoacoustical point of view: the primary signal has to be enhanced reasonably and the uncorrelated background noise has to be reduced to an extent, in order to achieve acceptable (natural) signal/background conditions.

There are no technical problems in removing the background noise almost completely. But this does not mean that the intelligibility of the speech and the overall quality of the recording can be increased by the same amount. Generally there is a kind of trade-off between 'sound figure' and 'sound background' which depends on the nature of the recording and the noise characteristics. The optimum relation between both has to be determined for each recording individually. Whenever strong signals in the original recording are present the well known psychoacoustical 'masking' effect which increases the subjective hearing threshold of a second tone can be used; ie. whenever strong spectral components of the wanted signal are present, they mask high frequency noise within a certain frequency range (more precisely within one critical band). Applied to the sound samples this resulted in a considerable reduction of the overall noise processing necessary and many portions of the signal were left almost uncorrected. The noise is weakened by the psychoacoustic masking effects.

Conclusion

One main conclusion can be drawn from our experiments: continuous fine tuning of all processing parameters of the adaptive filtering algorithm is needed, including the application of frequency and amplitude dependent rules, to obtain maximum noise reduction when it is necessary from the psychoacoustical point of view and to suppress it when not, without producing the well known 'pumping effects'.

At present the Vienna Digital Signal Enhancement System is implemented on an IBM 3083 main frame computer with an IBM AT personal computer attached as an acoustic and graphic work station. Signals up to a duration of 11 minutes can be processed in a single take. The computing time is about 1:15 to real time.

Currently the development of a (main frame independent) real time system which can be used like a desk top computer is under consideration (fig. 4). Again it will consist of an IBM AT personal computer as graphic-acoustic workstation, the noise reduction algorithms will be processed in a specially built Signal Processor System (SPA) which resides in the host AT. The Signal Processor System is based on the Texas Instruments TMS 32020/25 signal processor family and is capable of being cascaded up to 4 units, computing parallel tasks if necessary. It is expected that this real time machine will

he has done any research concerning the manner in which you listened to old recordings, especially with regard to multiple editions or cumulated ones, and on the listening habits during the development of recordings, and also if he is interested in progressing towards analog or numerical listening?

Werner Deutsch:

There is no corresponding research within the area of psychoacoustics. Yet there is no doubt that our listening habits have changed dramatically during the last decades. If you consider the total loss of dynamic listening, for example, when we listen to the car radio. This is due to the fact that the environment noises have become significantly stronger, and that, especially in the case of pop music, there is a stronger concentration on the variation of tone colours. This is to say, the material and the practised performances of today do not correspond with the historical recordings. In former times you tended to be more prepared to listen to a recording analytically than today. Today the recording has to be attractive, in the full width of its tone colours, which certainly was not the case in the listening habits of former years.

Question:

Do you think it is easier to restore ancient magnetic tape recordings than ancient wax cylinders or records?

Werner Deutsch:

As far as the signal to noise ratio is concerned, they are usually better and you can proceed with much easier methods – that is to say, it is basically much easier.

Question:

The problem of more constant noise, does it not cause any difficulties?

Werner Deutsch:

This is an advantage.

Dietrich Schüller:

In this context, however, I would like to mention that actually the most ancient tape recordings I know are suffering from strong non-linear distortions. These distortions are quite different from those we have been dealing with in our ancient phonogrames so far. It really is the question of an entirely different generation of defects, for which you will have to find new methods.

Werner Deutsch:

Wow and flutter as well as factors of ringing are not easy to remove. Maybe

there are simple solutions for this, I do not know.
<u>*Said Varaghi:*</u>
I do not know what is the optimal criterion in the structure of your adaptive filter, because every adaptive filter has some optimal criteria, and some sort of a structure which could cause the ringing of the filter.
<u>*Werner Deutsch:*</u>
We have left the optimal system in favour of the individual possibility of adjusting the gain of the filter. We do not calculate with an optimum filter solution.

increase the effectiveness of the restoration process significantly. Moreover it will deliver the flexibility and computing power for building an appropriate user interface to continuously tune the filter parameters under visual and auditory control in real time.

(This is an updated version of the paper: Deutsch, Werner and Anton Noll (1986): The Restoration of Historical Sound Recordings by Means of Digital Signal Processing: Psychoacoustical Aspects. In: Phonographic Bulletin, No. 45; p. 36–39.

Bibliography:
Brock-Nannestad, George (1984): Horn Resonances in the Acousto-Mechanical Recording Process and the Measurement and Elimination in the Replay Situation. In: Phonographic Bulletin, No. 38; p. 39–43.
Deutsch, Werner and Noll, Anton (1984): Restoration of Historical Recordings by Means of Digital Signal Processing. Paper presented at the 75th Convention of the Audio Engineering Society, Paris; AES Preprint No. 2092 (H2).

Printing Test: "Drake of England"[1]: A Postscript Report: Hans-Eckart Karnstädt

Within the framework of the Technical Symposium taking place on the occasion of the 43rd FIAF Congress in Berlin (West), a printing comparison test was presented on behalf of the FIAF Preservation Commission. 27 archives participated in this test.

Reference Copy

The National Film Archive in London made duplicate picture and sound negatives from the original nitrate positive and from these they produced a projection print. Subsequently the original (the nitrate positive) was cut into 27 parts and sent to the participating archives together with a questionnaire (copy attached). It was the task of the archives to make duplicate picture and sound negatives from this nitrate positive, and one projection print from the new negatives. These parts and the completed questionnaire were then sent to the Stiftung Deutsche Kinemathek where the film sections were joined into a print.

During the Symposium the reference print made in England was projected simultaneously with the compilation of the sections from FIAF archives.

The evaluation of the questionnaires is a difficult task, as they contain information of very differing quality or no details at all, e.g., because of trade secrets.

Summary of Information From the Questionnaires:

Cleaning

30% manual cleaning
11% cleaning by machines
22% manual and ultrasonic cleaning
37% ultrasonic cleaning

In 30% of the cases, the original was treated with water. 18% of the archives polished the original before duplication.

Printing of the original

78% step contact printer
15% printer
48% contact printer
37% optical contact printer
37% used wet printing

Three archives (11%) flashed the duplicate negative.

Raw stocks (Duplicate negative material)

Agfa 464 (11%)
Kodak 5234 (52%)
Orwo DN 1/DN 2 (30%)

[1] GB 1935; Dir: Arthur Woods

Henning Schou:
We are now going to discuss certain aspects of film preservation. As is well known, the only economic way of preserving nitrate film is to transfer the visual and sonic content onto a more stable film base. Because the nitrate film will eventually self-destruct, it is imperative for the archive to ensure that the highest possible quality duplicate master is obtained. Quality assessment is difficult, so as an exercise and demonstration of this difficulty, 27 archives agreed to participate in a printing test.

We realise that the amount of information (27 image tests and 27 sound tests) is too much to absorb in one viewing, so we will also show (in the form of slides) 5–6 examples of:
a) a film printed on optical printers compared with one printed on a contact printer;
b) an example of a print made from a low contrast (flashed) negative compared with a print from a non-flashed negative, etc.

We have also compiled a list with a summary of various treatments (cleaning, washing) and printing methods (step, continuous, contact, optical, wet).

Two people in particular, besides the staff of Stiftung Deutsche Kinemathek, have been involved in the assessment of the printing test, and these two people are Harold Brown of the Preservation Commission, and the Head of the East-European Preservation Subcommission, Mr. Hans Karnstädt from Staatliches Filmarchiv der DDR. Hans Karnstädt will give an introduction to the test.

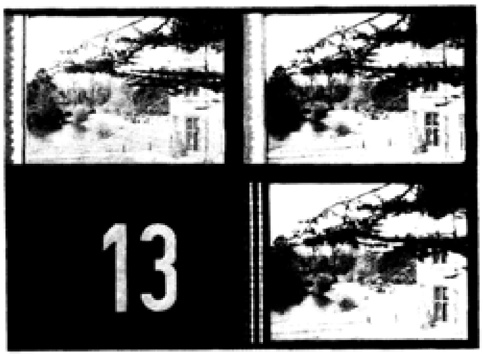

Figure 1

Printing of the projection print

48% step contact printer
44% continuous contact printer

No archive used an optical printer.

Release print stocks

Agfa 561 (44%)
Kodak (22%)
Orwo PF 2 (30%)

In two cases, material from the Soviet Union and India was used.

Sound processing

18% made a combined duplicate negative
22% made a separate sound negative
33% made a sound recording using magnetic tape or magnetic film
26% made a sound recording directly from the film using an optical sound camera.

During the recording procedures, tape limits and absorptions were applied.

Further statistical information is contained in the summary. The evaluation can only be correct to a certain extent, as the nitrate original was not used during the assessment. Neither was there any detailed information as to the steadiness of the printed image. Thus no exact statements can be made in this context; (the parameters of an older step contact printer can be worse than those of a new optical printer!).

Assessment Summary

a) Cleaning made no perceivable difference to the end result.
b) Washing of the original proved to have a positive effect with regard to removal of scratches because of the swelling of the film emulsion.
c) Optical printing caused an increase of contrast. This was compensated for by flashing the duplicate negative.
d) Archives nos. 11 and 25 achieved very good results using optical wet printing with flashed duplicate negatives.
e) In some positives, correction of density would have been necessary.
f) The contrasts of the positives are very different (e. g., the contrast is too high in test film no. 4, and the contrast is too low in test film no. 15). The reason for this is that the duplicate negative and positive were probably not developed to an optimal gamma.
g) During the sound processing, the best results were achieved when the sound was recorded on magnetic material. The corrections, however, were partly carried out in such a way, that the sound atmosphere of the film was also lost (e. g., in test no. 11). This is a controversial subject. For example, should one neglect the noise atmosphere of a film in order to achieve a better understanding of the language?
h) Finally, it is interesting to note that it is only in tests nos. 3–7 of the new positive that the image as well as the sound is of very good quality. In many parts only one component (image or sound) is good.

Acknowledgements

We thank all film archives participating in this test. Our special thanks go to the National Film Archive in London which put the original and acetate positive of the film at our disposal, as well as the Stiftung Deutsche Kinemathek in Berlin (West), which joined all the parts into a print. While doing this, they produced three series of 6 × 6 cm slides. These can be borrowed from the FIAF Secretariat in Brussels. The slides show:

Henning Schou:
When we first planned this test about a year ago, we were looking for a suitable print, and I was very grateful that David Francis and his staff at the National Film Archive (London) were able to come up with a surplus print we could actually chop up into 200-foot lengths. When I received a telex about the technical condition of it, I got the impression that there were hardly any perforations left on the film. However, when we screened the nitrate print in the Staatliches Filmarchiv, we realised that the film was more or less in mint condition. It was then too late to find a scratched print, which would have made it possible to a greater degree, to distinguish between a rejuvenated film and a film without such scratch diminution treatment. We would also have liked to use a film with a variable density soundtrack, so that it would have been possible to compare the results of rerecording the

Nitrate original (left top) – Reference print from London (right top) – New positive from various archives (right bottom) (fig. 1).

Participating Archives

Amsterdam	Nederlands Filmmuseum
Berlin (BRD)	Stiftung Deutsche Kinemathek
Berlin (DDR)	Staatliches Filmarchiv der DDR
Bois d'Arcy	Service des Archives du Film
Budapest	Magyar Filmintezet – Filmarchivum
Canberra	National Film and Sound Archive
Habana	Cinemateca de Cuba
Helsinki	Suomen Elokuva-Arkisto
Koblenz	Bundesarchiv – Filmarchiv
København	Det Danske Filmmuseum
Lisboa	Cinemateca Portuguesa
London	National Film Archive
Mexico	Filmoteca de la UNAM
Montevideo	Archivo Nacional de la Imagen
Moskva	Gosfilmofond
New York	The Museum of Modern Art – Dept. of Film
Oslo	Norsk Filminstitutt
Ottawa	Moving Image and Sound Archives
Poona	National Film Archive of India
Roma	Cineteca Nazionale
São Paulo	Cinemateca Brasileira
Stockholm	Svenska Filminstitutet – Cinemateket
Warszawa	Filmoteka Polska
Washington	Motion Picture, Broadcasting and Recorded Sound Division – Library of Congress
Wellington	The New Zealand Film Archive
Wien	Österreichisches Filmarchiv
Wien	Österreichisches Filmmuseum

soundtrack with duplication of the track (that is, making another optical soundtrack through duplication). In that way we would have had a greater variety of examples. Nevertheless, I think, as a first exercise, this has been very exciting. We have discussed the possibility of having this kind of big technical conference, say, every four years, so hopefully there will be another one in 1991. I think on that occasion it would be good to repeat the exercise and then make it more difficult by using a damaged print with missing perforations.

Peter Konlechner:
I would like to point out that we were in the unfortunate position of not being able to compare the original nitrate print with the first generation duplicate. In terms of listening to the sound, we compared a bad soundtrack which was badly duped by contact printing, with a rerecorded track, which you may have noticed had a better signal-to-noise ratio. The duplication could have lost a lot of treble because of the lack of focus and graininess and so on. I wish that we could repeat the same test and screen the original nitrate with it, because otherwise we cannot truly judge what we have lost. So I hope we will have a congress once in a country where we could gain permission to screen the nitrate original.

Harald Brandes:
I wish the colleagues from the 27 archives would now be able to have a discussion for 2 or three hours. I think we have offered almost anything that can be expected from a printing laboratory.
If this test is to be repeated, a test film referring to the image and to the sound should be inserted before each example. Something that attracted my attention was the extremely varying and partly very grainy character of the prints.

Henning Schou:
I had hoped that it would have been possible to cut a resolution chart into each 200-foot reel sent to various archives, so that under microscope we could have assessed how much resolution (in line pairs per millimetre) was lost in the duplication process. It would also have been good to have a short cross-modulation test in the beginning of each reel so we could have assessed

the quality of the sound more objectively. After having a closer look at the various tests, the Preservation Commission intends to write a detailed report which will be circulated.
Sam Kula:
How was the sound transferred from the nitrate print to the check print?
Harold Brown:
That soundtrack was made by printing, not by rerecording. The soundtrack negative was separate to the picture negative.
Philippe Poncin:
The quality of work in the various archives certainly is striking, especially when you think of how these results could be used. It also made me think of certain cleaning products, like for example Tornade Blanche, a fabulous product that cleans really dirty and even extremely damaged surfaces. Even if a comparison with the original could have been more interesting, I think that the quality as a whole is splendid. I would like to ask you a somewhat more practical question, however, referring to the comparison of work. Was it also possible to ask each archive how much time it spent on restoring each sample they were given?
Harold Brown:
The time which a task takes and the financial cost which it may involve are both very serious factors in what is practicable. Perhaps if we have this future test, these questions could be asked.
Paul Spehr:
This is a general comment on the methodology of doing the test, which I think, is new to most of us here. I found that the process of examining all these rolls of films was fascinating, but it was very difficult to record the details. I am frustrated by the fact that we cannot go through them again, and that all of this information on the charts could not be summarised somewhat before each sequence was shown. It is very difficult to concentrate on all of the different elements that you need to evaluate the different prints. I would be very interested in hearing the comments of the Preservation Commission on the different pieces, but I am not sure that I will remember what number 10 or number 11 had in comparison when I read the report some months from now.

Summary of the Answers to the Technical Questionnaire

	Cleaning			Washing	Base	Printing			Dup. - Negative				Film-stock
	hand	machine	ultras		treatment	step	contin	contact	optic.	wet	G Neg	speed m/min	
1		■		■		■			■	■	0,72	17	Ko 5234
2	■				■	■		■				11	Or DN 2
3	■		■	■	■	■		■			0,53	13,7	Or DN 1
4			■	■		■		■			0,58		Or DN 1
5													
6	■					■							Ko 5234
7	■						■	■			0,88	14	Or DN 2
8						■					0,50		Ko 5234
9			■				■	■			0,47	33	Or DN 1
10			■	■		■		■			0,50	11	Or DN 1
11		■	■			■	flashed		■	■	0,54	11	Ko 5234
12	■		■			■		■			0,60	11	Ko 5234
13			■			■			■	■	0,55	3	Ko 5234
14	■					■	flashed		■	■		5	Ko 5234
15	■		■	■	■	■						9	Ko 5234
17			■	■	■	■		■			0,60	18	Ko 5234
18	■		■	■		■		■				15	Ag 464
19	■					■			■			5	Ag 464
20			■				■	■				60	Ko 5234
21	■					■			■	■			Ko 5234
22		■		■	■	■			■	■		14	Or DN 1
23			■				■		■	■	0,65	33	Ag 464
24	■		■					■		■			Ko 5234
25	■		■			■	flashed	■			0,55	9	Ko 5234
26			■			■			■	■		4	Ko
27			■			■			■	■		5	Ko 5234
28	■					■		■			0,70	20	Or DN 2

Summary of the Answers to the Technical Questionnaire

		Sound				Film-stock		Final print			Film-stock
	printed	separate	combined	via-magn.	dir. to opt.		step	contin	speed m/min	G Pos.	
1				■		Ag ST 8		■	50	2,35	Ag 561
2	■		■			Or DN 2	■		14		Or PF 2
3					■	Sv ZT 8	■		13,7	2,4	Sv MZ 3
4					■	Or Tf 8	■			2,9	Or PF 2
5				■		Ag ST 8					Ko 5302
6	■	■				Ag ST 8					Ko 5302
7	■		■					■	14	2,34	Or PF 2
8					■	Ko 5373		■		2,1	Ag 561
9					■	Or Tf 8		■	33	2,14	Or PF 2
10				■		Or TF 8	■		14	2,35	Or PF 2
11				■		Ag ST 8	■		15	2,16	Ag 561
12	■	■				Ko 5234		■	55	1,6	Ko 5302
13				■		Ko 5373		■	55		Ag 561
14					■	Ag ST 8		■	54		Ag 561
15					■	Ag ST 8	■		9		Ag 561
17	■	■						■	55	1,6	Ko 5302
18	■		■			Ag 464	■				Ag 561
19				■		Ag ST 8	■				Ag 561
20	■		■					■	60		Ag 561
21	■	■				Ko 5373	■		10		Or PF 2
22				■		Ko 5373		■	30		Or PF 3
23	■		■				■		10	2,55	Ag 561
24	■	■				Ko 5373		■	60		Ko 5302
25				■		Ko 5373	■		18		Ag 561
26				■		Ko 5373	■		34		Ko 5302
27					■	Ag ST 8		■	60		Ag 561
28	■	■				Indu	■		20	2,2	Indu

And I am also a little mistrustful of the slides without knowing how they were made. This is not meant as a criticism. I think that this technique is extremely good, and I would encourage doing it more frequently in some venue, maybe not at every FIAF Congress, but there must be some way that we can get together more often than every 4 years to do this kind of thing.

Henning Schou:

Every year, in connection with the FIAF Congress, the Head of the Preservation Commission must present a report to the General Assembly. Back in 1984 I tried to present it in an audiovisual form, showing on the screen the test we had done. I was somewhat criticised afterwards for trapping directors and curators, who felt they should not be forced to sit in on things like that. A statement I somewhat disagree with, because directors and curators who have to argue for the money for preservation ought to know why it is so difficult and expensive to preserve films. Perhaps we could consider in future conferences having a session during the evening after the General Assembly, say, for an hour or two hours, where the work of the Preservation Commission could be presented visually. An example would be the screening of Frantz Schmitt's multiple printing tests, using black-and-white and colour stocks. I would assume that quite a number of you would be interested in seeing those. At the moment only the 7 members of the Preservation Commission benefit from looking at those tests. I shall certainly discuss this proposal with the organisers of future conferences, and ask for a time slot, during which we could screen similar tests. We must remember that it requires special facilities – like here, we have the possibility of screening images side by side; not all archives would have that.

Hans Karnstädt:

The slides were not framed by the individual archives, but one image was cut off from the original negative here in Berlin, and also from the first print. Then the same image was cut off from the new print, and thus the slides were created here in Berlin.

George Boston:

The discussion of the last speaker from the floor was very much in the line of

this being repeated at FIAF events in the future. As a sound specialist I would hate to feel that the expertise, that has been demonstrated in some of the earlier sessions in terms of sound restoration, was going to be restricted exclusively to FIAF. We would like the opportunity to see this sort of event, because they are very interesting to us as well.
Henning Schou:
Thank you very much, George, for that suggestion. We should certainly keep that in mind. Actually Dietrich Schüller asked yesterday, whether we are going to consider digitising soundtracks, and try to clean them up that way. In the National Film and Sound Archive in Canberra, we have recently been involved with cleaning up the original soundtrack for one of the first sound features made in the country. The track was pretty terrible (noisy, inaudible, and so on). We used quite a number of techniques commonly used in sound archives, such as the Packburn audio noise suppressor. We halved the soundtrack into two monotracks by using a Dolby unit, and then sent the signal through a Packburn Model 323. In this way, we eliminated pops introduced through dirt on the sound negative.
Carlos Arnaldo:
I would strongly recommend all possible follow-up to this project. The sets of those slides should be accompanied by a technical card, which gives the condition of the film and how each archive tried to restore the particular defects, and the machines they used for it. This will assist the new archives in selecting suitable machines for their laboratories.

Secondly, I think the archives should participate actively in the Commission's evaluation of the study and the eventual publication of a report on this. I think IASA should be involved in the evaluation of the sound tests, because there have been very successful experiments in IASA.

Finally I would like to ask a question which is rather subjective. In the ethics of restoration of these films we try to restore them to the original intentions of the author. When we view a nitrate film with our naked eye, any film that we have seen in the last 20 years, we are not necessarily viewing that film from

Technical Questionnaire

Pre-Treatment of Original Film
Cleaning

By hand
1. Which solvent was used?
2. What kind of applicator material was used?

By machine
3. Using brushes
4. Using buffers (of what material?)
5. Ultrasonic
6. Other (please give details)
7. Which solvent was used?

Washing

Please state
8. What apparatus was used
9. What liquid was used (plain water, chemical solution; please specify)
10. Duration of immersion
11. Conditions of drying

Treatments to the base

12. Matting (using what solvent?)
13. Polishing (using what solvent?)
15. Coating (using what chemicals: wax, varnish, ...?)
16. Other (please describe the treatment)

Treatments applied to the whole film to decrease shrinkage or increase flexibility

17. Describe equipment, method and materials used
18. State percent shrinkage achieved after any deshrinking treatment

Other treatments

19. Please describe any other treatment applied to the original film

Duplication
Picture

Type of printer
20. Step
21. Continuous (rotary)
22. Contact
23. Optical
24. Dry
25. Wet (liquid; please state which liquid)
    a. Pre-wet
    b. Wet cell gate (aquarium gate)
    c. Total immersion
26. Illumination
    a. Specular
    b. Diffuse
27. Direction of printing
    a. Starting from the head
    b. Starting from the foot/tail

28. Speed of printing.
 a. Metres per minute, or
 b. Frames per second
29. Please state any special modifications to printer, e. g., special sprockets, transport pins etc.
30. Any other information

Film stock
31. Please state type, description and manufacturer's type number of the stock used for the picture duplicate negative.

Processing
32. Type of developer used
33. Please describe as fully as possible any special procedures, such as flashing of stock, adjustment of developing time to obtain particular gamma, etc.
34. Please supply any sensitometric strip(s) used to determine the characteristics of your result.

Sound

Photographic printing from the sound preprint
 Type of printer
 35. Contact
 36. Optical
 37. Dry
 38. Wet (liquid; please state which liquid)
  a. Pre-wet
  b. Wet cell gate (aquarium gate)
  c. Total immersion
 39. Illumination
  a. Specular
  b. Diffuse
 40. Direction of printing
  a. Starting from the head
  b. Starting from the foot/tail
 41. Speed of printing
  Metres per minute or frames

 Film stock
 42. Please state type, description and manufacturer's type number of stock used for sound negative.

 Processing
 43. Type of developer used
 44. Please describe as fully as possible any special procedures, such as flashing of stock, adjustment of developing time to obtain particular gamma, etc.
 45. Please supply any sensitometric strip(s) used to determine the characteristics of your result.

Re-recording (dubbing, transfer) from (original) print
 46. Please state whether direct to optical sound negative or via magnetic.
 47. Please state type, description and manufacturer's type number of magnetic and optical materials used.
 48. Please give any information you can about the sound head used for playing the original nitrate sound track, e. g., tight loop, pull-through, etc.
 49. Please give any possible information on any electronic modification of the signal, by way of enhancement, attenuation, equalisation and/or noise suppression.

the intent of the author, but from the way we see this nitrate film now projected, 30, 40, 50 years later. For example, I think you will notice in the nitrate films, there is a very, very wide grey scale. There may be less contrast, because of the kinds of emulsions used at that time, but the grey scales in the nitrate films are very, very strong, and you can even sometimes see within that grey scale a very strong contrast, depending on how the cinematographer made his pictures.

When these films are now restored, with whatever method, and with the intent to restore the contrast and bring out the lights and the clears and the darks to be darker, have we restored this now according to our norms of the cinematography today, or according to what we think were the norms of the cinematographer at that time. Thirdly, how will we appreciate it with the naked eye – appreciate the softness, the haziness, the depths of a nitrate film which, when you see it on a TV screen or on a film screen with a different contrast, gives quite a different impression. You will notice the haloes, the back lighting of the original film. However, when you look at the contrasted new version, the film is clean, the lights are lighter, the darks are darker, but there is something missing. I wonder if the comparison can be made between those of you who appreciate good wines: a Beaujolais and a 20-year old Bordeaux. Beaujolais cannot be a Bordeaux.

Harold Brown:
Yes, I think it is very true that it is virtually impossible to make a copy which is identical in every respect to an original copy of a film and its presentation 50 years ago. The materials which we have to use are different; the machinery on which it is shown is different; the light sources by which the images are projected onto the screen are different (we no longer use arc lamps, but xenon lamps); the screen surface which we have to use is different; the people who are viewing it are different people with different personal histories and backgrounds and coming from a different society, so the meaning of the film, at the time it was created, is again different to us from what it was to its audience of the time it was made. There are not

only technical factors in this copying, but other less tangible factors, so that I feel that the aim in every case should be to produce a new copy which is as near as we can achieve to the original achievement of the maker. Many people have been saying to the original intention of the maker, however, that is at least a matter for doubt. I would say to this, that we should aim to match the original achievement every time. How nearly we can approach that depends upon our means and our skill.

<u>*Hans Karnstädt:*</u>

I think this screening really showed the differences: the standard density of the new prints is significantly higher than the case was as "Drake of England" was made.

<u>*Tony Lewis:*</u>

I would like to make a very impertinent comment in my field, as my job is to look at prints on the screen, and be able to say from what has been achieved on the screen whether a master negative is satisfactory. The problem with the test has been that I have looked at 27 comparisons and, if I were in my own theatre, looking at my own laboratory's work, I would be able to say, yes, that was a fine bit or an unfortunate bit of duplication. Unfortunately, with 27 different laboratories' productions, it is unfair for me to say I like this, I did not like that. They were probably all in their own right relatively good. It is the master negative that is the important thing, the prints vary so much.

<u>*A Delegate:*</u>

We are approaching the question I wanted to ask, although I am dealing with sound rather than with film. What makes such an experiment so difficult is exactly the human factor. We have compared materials, each one with a human signature and each time with a very large degree of freedom. I simply wanted to mention this aspect.

<u>*Henning Schou:*</u>

I wish to thank David Francis and his colleagues for providing the reference print; Eva Orbanz and her colleagues for getting all the clips and slides together; the projectionist for a fine presentation; Hans Karnstädt and Harold Brown for assessing the quality of the clips; and each member of FIAF who has participated in this exercise, which certainly has not been inexpensive.

Processing

50. Type of developer used
51. Please describe as fully as possible any special procedures, such as flashing of stock, adjustment of developing time to obtain particular gamma, etc.
52. Please supply any sensitometric strip(s) used to determine the characteristics of your results.

Final Print

Type of printer

Printer used for picture

53. Step
54. Continuous (rotary)
55. Contact
56. Optical
57. Dry
58. Wet (liquid; please state which liquid)
    a. Pre-wet
    b. Wet cell gate
    c. Total immersion
59. Illumination
    a. Specular
    b. Diffuse
60. Please state any special modifications to printer, e. g., special sprockets or transport pins etc.
61. Any other information

Printer used for sound track

62. Contact
63. Optical
64. Dry
65. Wet (liquid; please state which liquid)
    a. Pre-wet
    b. Wet cell gate (aquarium gate)
    c. Total immersion
66. Illumination
67. Direction of printing
    a. Starting from the head
    b. Starting from the foot/tail
68. Speed of printing
    Metres per minute

Film stock

69. Please state type, description and manufacturer's type number of the stock used

Processing

70. Type of developer used
71. Please describe as fully as possible any special procedures such as, flashing of stock, adjustment of developing time to obtain particular gamma, etc.
72. Please supply any sensitometric strip(s) used to determine the characteristics of your result.

Experiences With the Processing of Sound Recordings During the Printing of Nitrate Film Onto Acetate Film

Hans-Eckart Karnstädt

For many years, the Staatliches Filmarchiv der DDR has been duplicating nitrate film onto acetate stock. For this purpose, a printing laboratory was established in our film archive. However, it did not have a sound rerecording unit of its own so the sound recordings could only be reproduced through the process of contact printing. In the past, however, this method was only used in the case of variable-area recording, because they are easier to print and process than variable density soundtracks. Nitrate copies with variable-area recording or variable density soundtracks, where different densities existed within a reel, were sent to a commercial printing laboratory. There the optical sound was played back and directly transferred to an optical sound camera. Thus few possibilities for correction existed.

Because the commercial laboratory discontinued their services regarding duplication of nitrate film, and because we were not satisfied with the quality of their products anyway, we decided to construct a sound unit of our own. The construction of this unit is not yet finished. However, our experiences over more than one year show results which surpass those of the commercial printing laboratory.

I will now describe a few methods which we have created to improve the sound quality and to eliminate existing faults.

Mechanical-Optical Enhancement

As the old nitrate films can suffer from a high degree of shrinkage and also from mechanical damage, there is a danger that optical reading (scanning) of the soundtrack will take place outside the soundtrack, that is, of perforations and frame lines. Moreover, damage to the film, especially to the soundtrack, caused by scratches or marks from gear rims, is not exceptional.

To eliminate these defects, we change the width of the light beam used for scanning the track. It is possible to change the width of the sound gap from the side of the perforation as well as from the side of the image. The light beam can be brought into any area of the track position, by varying the width from the standard value to zero. In doing this, not only can we fade out periodical noise but we can also reduce the noise spectrum in the lower wave band through the removal of the track areas that are scratched or damaged in other ways.

The old nitrate materials in our archive have mainly optical sound recordings of the variable density type. As the sound recording covers the total width of the gap, no particular decrease in other quality parameters occurs through the reductions of the scanning width. A progressive fading-out of damaged tracks in multiple variable-area recordings is also possible.

Electronic Enhancement

Level corrections can be made through a sound mixer. This makes it possible to equalize density gaps in the copy. These often occur in restored materials if sections from different prints are used.

To modify the frequency response, we have two equalisers – the universal equaliser UE-100 (Siemens) and the special equaliser W-308 (Barth) as well as a universal filter KF-103 from the company Labortechnik (Dresden). These equalisers allow the

<u>Henning Schou:</u>
Hans Karnstädt is the Senior Technician in charge at the Staatliches Filmarchiv der DDR. He is a member of the FIAF Preservation Commission and also the Chairman of the East-European Preservation Subcommission.

<u>Stellan Norrlander:</u>
I would like to put a question concerning the enhancement of the sound from an optical track which is damaged by a scratch. You do it by narrowing the scanning area with a good result, I think. How do you do it when the scratch moves across the total area of the optical sound? Can you scan the soundtrack until the beam picks up a scratch, and then stop and move the equipment to another scanning area to have it free from the scratch again, and then piece the sound on the film together? Or is it necessary to do it in one run?

<u>Hans Karnstädt:</u>
We are only capable of carrying out this gap dislocation manually. This means, the film reel is checked before in order to see if the soundtrack is damaged. Then the head gap is adjusted in such a way that the damage is no longer scanned. In very extreme cases the damaged part is recorded additionally on magnetic film.

<u>Dietrich Schüller:</u>
For me as a sound specialist it is interesting to hear that there are certain parallels. Especially in the case of mechanical sound carriers we first try to optimize the scanning. As your are dealing with distortions, scratches, etc., it might be profitable to use digital methods of restoration – that is means of digital image enhancement as known in the area of satellite photography. I could imagine that you could reach very good initial products in this way, which you do not have to refinish correspondingly as sound.

Hans Karnstädt:
Basically I agree with you, but we are not that far in our technical development yet. Our sound department is still being constructed, it is only one and a half years old. We have the intention, however, of stressing optical scanning.
Paul Spehr:
Two questions. The first one is whether or not, as a practice, you make a photographic copy of the nitrate soundtrack before you make any rerecording of the track? And secondly, whether you have any experience with wet-gate printing [Editor: full immersion printing] reducing some of the clarity of sound?
Hans Karnstädt:
At the moment we generally record the sound on magnetic film and from the magnetic film on optical sound when we print nitrate material on acetate material; we do not print the sound recording optically.

We do not have any experience with full immersion printing. Once we tested it in the laboratory and discovered that there are better results.
Paul Spehr:
The reason I asked the question about the wet-gating is because on the "Drake of England" test, we tried both wet-gating and non-wet-gating the track on it. The general opinion of our laboratory people was that the non-wet-gated track was actually a little bit better, because apparently there was some change in the optics that tended to middle the recording a little bit more. Since it was not a particularly good track originally, we went with the non-wet-gated track.
Henning Schou:
I think that "wet rerecording" is a very good idea, Hans. It should be fairly simple to install a kind of applicator on your sound playback unit, so you could smear a thin film of perchloroethylene on the track. This would act like liquid film and fill in all the scratches on your print. Otherwise, once you have done the sound transfer, picking up all the noise introduced by the scratches, there is absolutely no way you can filter that out, because the noise could be in any part of the sound spectrum. So I think that wet rerecording is something that all archives should consider.

alternative modification of selected frequency ranges in the total band area, and the universal filter enables cutoff at the ends of the frequency bands or at the limit frequencies.

This way of modifying the frequency response makes it possible to improve the tone quality, e.g., improve the intelligibility of the spoken language.

Moreover, interference frequencies, resonances and excessive increase of the noise spectrum occurring in certain frequency ranges, can be filtered out. Thus perforation and frame-line frequencies which already have been printed in a copy can be filtered out to a certain degree.

Band limitations are primarily used to reduce noise interference in the upper frequency range.

With all the possibilities mentioned here, improvement of the sound quality can be achieved to a certain extent when the sound is rerecorded from optical sound to magnetic sound. We will continue our work to find ways of reducing existing defects or interferences in sound recordings. At the moment we are dealing with the complex task of reducing noise by means of dynamic system for noise reduction, which are adjusted to sound film. These systems include dynamic compressors, dynamic limiting devices, dynamic expanders, as well as an extension of the efficiency of the equaliser.

A further area which we are going to deal with is the wet rerecording of the sound, that is, reading the soundtrack after coating with the organic liquid used for wet printing. Thus we hope to achieve an essential improvement of the quality exactly as in the case of scatched images, and we would prefer this method to the former polishing of the film material.

Rerecording of Optical Soundtracks

Peter Konlechner

Henning Schou:
I am very pleased that we have a number of papers on preservation of film sound, because sound quite often seems to be the poor cousin. There is a lot of attention paid to the preservation of the image and not so much to the sound, to the extent that many archives combine picture and sound on the same piece of film in order to save money, and do not give the soundtrack the attention it ought to have.

Peter Konlechner, who is a co-director of the Österreichisches Filmmuseum and a member of the Preservation Commission, will talk about some experiments regarding the quality you achieve through sound rerecording compared with duplication.

Since the late twenties our cultural heritage has included soundfilms. While cinematheques and production companies are now and have been very concerned for almost 40 years with the printing of nitrate to acetate stock and recently with keeping the colours in our films, relatively little has been done with respect to the sound on films. The reason may be, that it all looks very easy and no special attention seems necessary.

One runs into problems, if there is only a positive print left of a given film, and one tends to save money by making a combined duplicate negative, which means a duplicate negative that contains both image and optical soundtrack on the same strip of film. This inevitably leads to distorted sound, loss of high frequencies and to a smaller dynamic range, the more so if the original soundtrack is of the variable density type.

The distortion comes from a non-linearity of the density-transmission in the positive-negative duplication process. From the early days of optical sound it has been known that the socalled gamma product ought to equal 1, if the transmission process is to be linear and therefore undistorted.

The gamma product means that the product of the gamma (γ_N) of the negative film and the gamma (γ_P) of the positive film should equal 1. ($\gamma_N \times \gamma_P = 1$). The more this product differs from 1, the bigger the distortion. Lichte and Fischer[1] give in their fundamental work a quantitative analysis of the non-linear distortion.

There is no doubt, that considerable harmonic distortion factors of 15% and more are likely to occur during such a process.

The distortion comes mainly from image spread. Image spread can be illustrated as follows. Suppose a tiny, sharply focused variable area soundtrack is recorded on film and the film is processed, the developed image is likely to be larger than the original image on the film, i.e., the valleys "fill in". If one steps up the exposure time, the image on the film will be even larger. This phenomenon is called "image spread". It would be all too simple to believe that one could fight image spread by decreasing the density of a soundtrack. However, decreasing the density of a soundtrack also diminishes its light modulating ability, which means lower output level and signal-to-noise ratio.

The higher the frequencies, the more the valleys are filled in. This leads to an asymmetry which causes considerable distortion and loss of high frequencies.

To obtain a good variable area soundtrack, the laboratory uses a higher density with its larger image spread which will be cancelled by the image spread on the positive (cross cancellation). This process has to be carefully monitored by appropriate test methods (cross-modulation test).

Maximum elimination of image spread (maximum cross cancellation) is essential for a good high frequency response and for the reproduction of clean transients. If large amounts of image spread occur in variable area tracks, the distortion of sibilants is all too well known, especially of the letter "s".

Shrinkage of sound films adds to the problems of restoration. In particular it causes a loss of the highest recorded frequencies. The extent to which this problem can be solved by redimensioning the film by vapour-treatment has already been the subject of an investigation by Henning Schou (refer p.130).

Archives, as well as production companies, tend to save money by making combined duplicate negatives thereby saving the cost of the additional sound negatives. The results are sadly known and sometimes erroneously explained as the poor quality of the laboratory work. In many cases, it is not the laboratory but a physical property of the material which is to blame. A picture negative naturally does not have the same characteristics as a sound negative and must be developed differently. If one has a combined picture negative with a soundtrack, the film has to be developed to the correct density for the picture which differs from the correct density for the soundtrack. Therefore producing separate duplicate sound negatives by a separate printing has been suggested. However, by doing so we do not attain the quality of a new rerecorded sound negative and we do not save any money; the reason being that the reproduction of the optical sound by a good optical sound head and its amplifier can save an almost invisibly bleached-out soundtrack, while a contact-printed negative would be all black without sound information. What applies to old soundtracks is valid for good ones: all details of the soundtrack lose in definition from loss of sharpness, wrong density transmission and image spread. Therefore distortion and loss of high frequencies as well as loss of dynamic range are inevitable, if one does not use rerecording.

Both variable area and variable density soundtracks should also be rerecorded for preservation.

This does not mean going from film to magnetic and only then to the sound camera, rather it suggests going directly from film to a state-of-the-art sound camera like Westrex or RCA. The new sound negative should be carefully developed to the correct density. If one has access to excellent equipment like the Bell & Howell printer 6200CLX using Kodak sound negative stock (5373) or Gevaert ST8, and a laboratory which carefully controls its work by densitometric measurements and cross-modulation tests, the quality losses of the preservation process can be kept to acceptable levels. If the Dolby system (or other frequency related dynamic compression/expansion systems) are used, the quality losses may be minimal. Please note that using such methods as Dolby implies that they will be used in future as well, to ensure a proper reproduction.

Through the help of Schwarz-Filmtechnik AG in Ostermundigen and the Austrian Academy of Sciences[2] some tests have been carried out comparing the recommended way of rerecording with contact printing of a new sound negative from a positive. Figure 1 shows a so-called waterfall diagram of the tests. There are four spectrograms which have been obtained by Fourier transformation of the signal.

We started with a frequency test film from which we made a new sound negative by rerecording and by contact printing.

From these materials we made sound positives which were then used for making a second-generation rerecorded sound negative and a second-generation sound negative by contact printing. The figure gives a good idea of the signal amount available and eventual harmonics indicating distortions.

Already after the first contact printing one recognizes a considerable loss of signal and high frequencies as well as distortion.

This is only a first step in the quantitative analysis of signal and frequency losses and increased distortions in the preservation of optical soundtracks.

In respect of restoration of sound negatives and positives, a lot can be done in addition to normal ultrasonic cleaning and polishing to get rid of the scratches. As long as we have the soundtrack picked up and converted into electronic signals, we have the wide choice of modern sound studio technical equipment like refined noise suppression amplifiers and narrow filters to remove special frequencies without noticeably changing the remaining sound spectrum.

While a lot is possible, my recommendation is, to be very careful with all kinds of restoration not to alter the original work of art. I believe the purists' point of view is here especially advisable. In respect of soundtracks, it seems to me very important not to change the subtle background noise of which the acoustical atmosphere of a picture consists and to filter them away for the sake of a "clean" but dead soundtrack. One should consider, that it will always be possible to make these corrections later in one or the other projection print, where and when one feels compelled to do so, but one should keep the fullest possible original information on the film.

While we are discussing problems of analog technology of soundtracks, the future is to be found in recently described digital optical soundtracks on film. This will not only lead to a) 90 dB of dynamic range (which is almost the range of a big symphony orchestra), and b) to an enlargement of the frequency range up to 20 kilocycles, but will also solve the problems of information losses from duplication. This loss does not exist in a digital process using sophisticated error-correction methods.

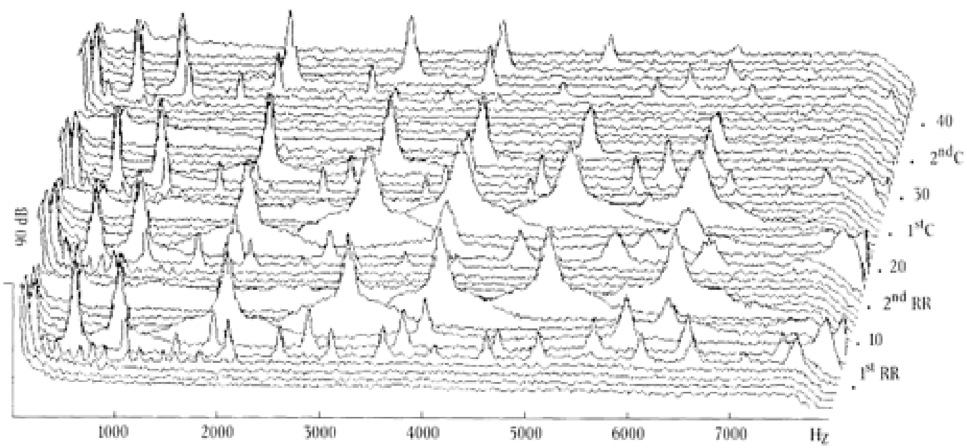

Figure 1
The figure illustrates the difference between running amplitude spectra of four conditions: spectra 1-11: 1st rerecording; spectra 12-22: 2nd rerecording; spectra 23-33: 1st copy; spectra 34-44: 2nd copy. The comparison shows the increasing loss of quality, especially in the high frequency range, and possible distortions.

1) Lichte und Fischer, Tonfilm, Berlin 1931.

2) Grateful thanks are due to Schwarz-Filmtechnik AG and Sonor-Film AG in Ostermundigen, especially to Dr. Rudolf Streit, Hans Künzi and Charles Huser, and to the Austrian Academy of Science: Dr. Werner Deutsch, head of the laboratory of the Kommission für Schallforschung for conducting the Fourier analysis and Dipl. Ing. Franz Lechleitner and Dr. Dietrich Schüller of the Phonogrammarchiv for general assistance.

Henning Schou:
Results of Printing Shrunken Sound Negatives

As described previously by Peter Konlechner, sound prints can be reproduced through rerecording. However, a sound negative must first be printed to eliminate the distortion caused by image spread. And in the duplication process we may encounter problems caused by shrinkage of the sound negative.

Some motion picture film, especially cellulose nitrate and diacetate film, shrinks with time, because the plasticiser contained in the base gradually evaporates. Newly-made nitrate film contains up to 25% camphor which is volatile and will gradually evaporate. As this happens, the film shrinks and you may end up with as much as 5% shrinkage. As far as the preservation of the visual content of the film is concerned, in most cases it can be preserved by making a high-quality duplicate on a step contact printing machine. On such printers, the new raw stock in direct contact (emulsion-to-emulsion) with the nitrate original is advanced frame by frame in the same way as in a film projector. A metal pin (claw) penetrates the perforations of the raw stock and the nitrate film, and advances them one frame at a time. When the films have stopped moving in the printer gate and have become rock steady, the printer shutter opens, lets the light through, and thus exposes the raw stock through the nitrate image in the aperture.

The problem arises when we try to duplicate sound negatives, because these must be copied on continuous printers. If you have a nitrate sound negative with 3% shrinkage, it means that a reel which would originally have been 1000 feet long has shrunk by no less than 30 feet. So your task is now to copy 970 feet of film onto a 1000-foot reel of new sound (release) print stock. The only way you can compensate for the 30-foot difference in length when copying the film continuously is to accept a certain amount of slippage between your nitrate sound negative and the raw stock. Such slippage, which is often discontinuous, will lower the quality of your sound print because high frequencies will be lost in the process.

In collaboration with Colorfilm Laboratories (Sydney, Australia), I wanted to demonstrate the importance of deshrinking the nitrate sound negative before duplication. Because it would be virtually impossible to find a suitable, shrunken test film on nitrate base, this was achieved by reversing the process of shrinkage. I asked Colorfilm to produce three modern sound negatives with different frequencies; one 400 Hz track which was used as a reference, plus a 2,000 and an 8,000 Hz track. From the sound negative carrying the 8,000 Hz track, I extracted plasticiser to varying degrees and ended up with 10-foot test negatives with shrinkage from zero to 1.5%.

Colorfilm then made a sound print from the shrunken sound negative using various continuous sound printers. On playback it became clear that we had lost up to 25 dB at 8,000 Hz. In other words, it sounded like listening to the track wearing earmuffs.

I also asked the Laboratory to make a sound negative of a passage from Wagner's "Ride of the Valkyries" during which high-frequency horns and violins are being played. Again, from this new negative I extracted plasticiser and achieved 1.5% artificial shrinkage. On playback of the print made from this shrunken negative, it was quite possible to hear the loss of high frequencies and the introduction of distortion.

To summarise. If an original negative has shrunk, then high frequencies will be lost in the duplication process through discontinuous slippage between the negative and raw print stock. It is therefore necessary to deshrink the negative through the appropriate vapour treatment before duplication.

Postscript

The details of these experiments are described in my paper „An experimental quality control program for printing archival films" (co-author D. Case) published in the SMPTE Journal, December 1987, pp 1180–1185. Copies can be obtained by writing to the FIAF Secretariat, Coudenberg 70, 1000 Brussels, Belgium.

Experiences With the Preservation and Printing of Three-Colour-Layer Films from the 1940s and 1950s
Hans-Eckart Karnstädt

Henning Schou:
And once again Hans Karnstädt from the Staatliches Filmarchiv der DDR.

On 17 October 1936, Professor Dr. John Eggert presented the new process of Agfa, "Agfacolor – New", as slides to the Berlin press. It was named "New", in order to be distinguished from its predecessors of the same name. Thus a colour-film process, which would be used universally after further development, was presented to the public. It was now possible to produce films according to the reversal process as well as by the negative-positive process.

This new Agfacolor film was a multi-layer colour film with deposited hydrophilic, non-diffusing couplers. The following principles were applied in this film:

a) a multi-layer structure with selective layers sensitive to blue, green and red;
b) a chromogenic development with an N, N-dialkyl-p-phenylenediamine as developing agent;
c) non-diffusing, water-soluble yellow, cyan and magenta couplers, consisting of long-chain alcohol groups.

In 1936, reversible photographic material for amateurs was produced in Wolfen. Three years later, the first cine negative and cine positive films were available. From August 1941, an improved cine negative film for colour feature-length films was produced. The first feature-length film made according to the New Agfacolor process was "Frauen sind doch bessere Diplomaten". The first showing took place on 31 October 1941. Before 1945, a few more feature-length films were produced according to this process, e.g., "Die goldene Stadt" in 1942, "Das Bad auf der Tenne" in 1943, "Baron Münchhausen" and "Immensee" in 1943, "Die große Freiheit Nr. 7" in 1944, and "Die Fledermaus" in 1945. At the time, the great advantage of this process was the relatively simple treatment in the wet process.

The Staatliches Filmarchiv possesses the original negatives of some of these films which were produced on a nitrate base. Contrary to the positive prints, where only the purple colour is left, the negatives still have dyes in all 3 layers. However, the colour density has been reduced by up to 50%.

We decided to use the original negatives as our printing master. Parts of the perforation and the surface of the film were badly damaged. The materials were prepared for printing in a very time-consuming process. A first print was produced from the original negative. Through changing the filter values, the colour densities were corrected. The filter values were changed until a positive with optimal colour densities was achieved. An average of 3 to 4 correction prints had to be produced. Then a colour duplicate positive on Eastman colour duplicating stock (type 5243) was made from this colour-graded original negative. Subsequently, a colour duplicate negative from this was made on the same Eastman-type stock with further minor colour corrections. From this colour duplicate negative a positive print was then made. The sound recording was treated separately. This method of preserving the old colour films is not a cheap one, as an average of 5 positive prints, 2 duplicate masters and a sound negative had to be made in order to produce a new positive that could be screened.

Subtractive step contact printers were used, as the light values of additive printers were not sufficient. In order to change the colour values, gelatin filters in the colours yellow, cyan and magenta were used.

However, it is our opinion that this expenditure for preserving colour films is justified.

Another method, which we have only experimented with in the laboratory, is the process of black-and-white colour separations. However, the results were unacceptable because we had no precision printer which was able to produce black-and-white colour separations of acceptable quality from 1.5–1.8% shrunken negatives, where the quality is determined by the steadiness of the image.

Panchromatic black-and-white colour separations on Kodak stock (type 5235) were made from the original negative. From these a colour duplicate negative was made on Kodak colour duplicate stock type 5243. Producing the positive material took place in the usual way. According to laboratory results, this method would lead to even better results.

Elements for a Diagnosis Before Deciding to Restore a Film: General Remarks on the Facts to be Considered

Frantz Schmitt

Henning Schou:
Our next speaker is Frantz Schmitt, Head of the Service des Archives du Film in Bois d'Arcy, and a member of the Preservation Commission.

The following observations do not aim to be universal. The elements which are essential for an objective diagnosis before deciding to restore a film, are different in the case of a big archive with thousands of nitrate titles to be restored as compared to a small archive that has just been established and possesses fewer than one hundred artefacts or documents to be preserved.

The situation is different if no particular financial problems exist, or if there is no delay in carrying out the work, or if on the contrary the budget is limited implying a preselection.

My reflections are made from the perspective of a big archive with thousands of nitrate titles to be preserved; one that has to plan its actions according to criteria that are as objective as possible, and with the viewpoint of saving as much as possible over the medium term.

The directors responsible for film archives know that, no matter how much they know about cinematography and the history of film, nobody will ever grasp the totality of the threatened films. I have calculated that I would need about 5 years viewing films for 24 hours a day, at a speed of 24 frames per second to see only a small part of the whole amount of nitrate films stored at the Services des Archives du Film since 1969. However, the deciding factor by which the restoration is going to be made frequently implies the comparison of several kinds of material, prints, duplicates, sound, etc.

Yet I have the feeling that sometimes certain decisions in favour of restoration have been delayed in some archives, even if the financial means existed, because the curator or director was occupied by other activities and waited to find the time to view the threatened titles, thus sometimes intervening too late.

Opposed to this, I have been told that in some more prosperous archives it is sufficient that a film exists on nitrate base to make the immediate decision to have it duplicated, at least if it is the only print. This sometimes leads to disappointment and fragmentary restorations, as the analysis of technical demands and content before the restoration was insufficient.

On the one hand excessive centralism, on the other one anonymous work - both should be equally avoided if not prohibited.

Of course the directors responsible for film archives have to delegate a part of their responsibilities to their colleagues, and specialized committees might be called upon to give their opinion on the priorities. Yet the members of these committees, no matter how competent they are, (and that also applies to the technicians in charge at an archive) will never see all the films for which a working project or a research project ought to be initiated.

By now you will have realized the importance of drawing up an inventory of the documents preserved by an archive, and of the technical, historical or documentation data which ought to be considered in this inventory, especially in the case of important holdings.

Here we are dealing with considerations that I would like to call internal ones, that is, they are connected with the analysis of the film material actually possessed by the archive and according to which restoration work and duplication can be initiated. Other considerations, which for the sake of simplicity I would like to call external ones, might come into action when restoration programs are drawn up.

In this short paper, I cannot give a detailed description of what the index card of a given document should ideally contain. However, I would simply like to recall a few general principles and the most indispensable headings that an index ought to contain as a diagnostic instrument to determine whether to start restoration work or not. It should be simple to read, as the person responsible for the decision does not necessarily have the opportunity or the time to see the material which is to be technically restored.

Of course methods differ from one archive to another, and in certain countries national indexing or cataloguing norms may exist. Generally, however, these norms have been created more with regard to books in public libraries than to saving perishable documents. From this point of view cataloguing and indexing should not be mixed up, even if some documentation data also has to be taken into account on the same level as an index.

In a study recently undertaken by the Service des Archives du Film, it seemed that a maximum of about 150 headings in a catalogue of the national production could be taken into account; in the end we did not keep more than 72 for the description of films produced in France.

I am now approaching the crucial point of this matter: which information (apart from particular considerations with regard to the presumed historical or artistic interest of the material) is essential for an index card; to be able to make a responsible decision in favour of restoration without having to examine the material itself? In my opinion the proposed selection should remain open to debate, by providing brief summaries. Yet I have seen so many lists of films, presumed to be worth restoring, and the lists contained only a small amount of information, from which no efficient decisions could be made without examining the material itself. The new film archives, which will need an indexing structure, should ask themselves which data ought to be considered.

My suggestions are as follows - one index card has to be made for each distinct element (or part) of the same title:

General Elements and Techniques of Indexing

1. Reference title of the indexed document: the title which appears in the credits of a film in the available version. If there are no credits or if the title is uncertain, you can use the sign [ ] which stands for doubt.

In order to enable fast reading, the inscription INCOMPLETE could appear after the title, between ( ), if the element is incomplete with regard to the number of reels or to considerable gaps of image or sound in certain reels.

2. Original title, if it differs and is known for certain.

3. Other titles; in this case titles of other versions that are not national ones but known by the archive. (Optional: may be useful for the technical consultation of the card index).

4. The origin of the assigned title: does it result from reading the credits or simply (if the document does not include a title) from the label on the can, from an inscription on the leader strip, or has it been identified by a competent specialist?

5. Exact description of the element, as this indicates the stages and the costs of the work to be undertaken. Is it a print, a duplicate, an intermediate positive, of mixed sound, of an element from a monochromatic selection, etc.

Note:
It should be mentioned that every archive has an interest in maintaining a standardized unchangeable codification with regard to the description of elements.

6. Version of the element.

7. Film base (nitrate, acetate, polyester, others).

8. In the case of a print, the printing number.

9. The exact footage of the images in every reel.

10. The total footage.

11. The total number of reels making up (or which would have made up) the element as a whole.

12. The total number of reels available.

13. The number(s) of the reel(s) missing.

14. Format in mm.

15. Type of framing, silent or sound (if possible with variations).

16. The image and sound mode: black-and-white, stencilling, colour, fixed density, variable density, others.

17. Existing subtitles (for sound films) and the language of those subtitles.

18. In the case of silent movies, the presence or absence of intertitles. Subheadings should indicate if these intertitles are complete or simply marked by photograms, written inscriptions on the leader strip or otherwise.

19. For nitrate films, the most critical point is the chemical analysis, which according to the accelerated age testing method recommended by Kodak, the so-called "alizarin red test" varies between 1 and 4, depending on the state of decay of the base. This is an essential factor for all archives trying to consider operating priorities objectively.

20. A lucid evaluation of the physical condition (image and sound) which might be codified by the letters A to D, for example.

21. Quite a large space on the card for all particular observations made in connection with the examination and which could not be included under the other headings of the technical index (e.g., "censorship card" or "pilot control tape enclosed in the can", etc.)

Documentation Elements in an Index

22. Origin of the material: is it simply stored on deposit, a purchase, a donation, an acquisition, or the result of exchange between archives, etc.?

23. Director.

24. Country of origin.

25. Year of production or release.

26. Principal actors. This heading can only be used if there is a verificateur prior to the complete coverage of the credits.

27. For a newsreel or a documentary, a list of sequences with at least a summarised description of the contents, is absolutely necessary.

28. In the case of a feature film, however, other documentary sources, filmographies, catalogues or specialised files held by the archive, can be used as a supplementary reference at the final stage of deciding if a film is to be restored. They do not have to be considered at the early stage of the index.

Once again I repeat that this is the absolute minimum of data or headings on an index card, in order to be able to decide if a film is to be restored.

Other Technical and Documentation Data

It is obvious that if an archive possesses considerable human and technical resources and it has better possibilities for making analyses, other technical and documentation data can be included in the index card, as for example:

29. the speed in frames per second of silent films (if actually known),

30. the number of splices,

31. the important characteristics and defects, analysed reel by reel (defects of the base, defects of the emulsion, defects of the sides, defects of the perforation, defects of the sound track),

32. the shrinkage, measured in several parts of each reel,

33. the fading of sound or colour,

34. the absence of image and sound (location and duration in each reel),

35. defects of synchronism in case of elements with double tape,

36. original producer and actual copyright owners,

37. genre of the film,

38. other elements of the same film (reference number in the index etc.).

The Service des Archives du Film has created an index card of elements, normally comprising a maximum of 70 technical and documentation headings.

Indexing takes a long time. However, this method has at least the advantage of giving exact information on each title, in a common, standardised language. Thus the restoration programs can be viewed objectively without an additional thorough analysis carried out by the laboratory in charge of the treatment.

I would like to add that, when an archive establishes an index of analysis concerning possible restorations, it is desirable that the pattern of analysis is conceived in such a way that it can easily be adapted for further computer operations. This is relatively easily achieved, for example through numbering the headings in the index. Thus it will be possible to ask questions related to a linked number of index headings (i.e., make Boolean searches), and to adapt the programmes to the available equipment and resources.

For example one could ask as follows: make a list of silent films, 16 frames per second and a pitch (PAS) of 4.730 mm, chemical type 4, suitable for treatment on an optical printer X.

For those of you who have special interest in these questions, I would like to refer to the interesting study which already has been undertaken on this subject in the preliminary document initiated by the Cataloguing and Preservation Commissions of FIAF, and compiled by our colleague Hans Karnstädt under the title "Guidelines for the Description of Technical Data on Film and Video Material in Film Archives."

External Considerations

I will now briefly indicate some of the external considerations that I mentioned before, which are not related to the nature or condition of the available material, and yet have to be considered when deciding to restore a film.

a) First of all the standardised or non-standardised properties of the available material, nationally and internationally. If the material is not standard, the realistic possibility must be assessed of colleagues contributing material that might be in a better condition and suitable for being scientifically compared with the stored material. Here again we encounter the problem of exchange between archives and also of compatible computerised data bases. Financial constraints force us to avoid any "doubling" of restoration work. Sometimes, however, this cannot be avoided; for example, when an element of better quality is discovered later or when an exchange (or a contribution) is impossible. The film, even in an average condition, must be considered particularly important to the archive.

b) The age of the film: it is advisable to make the least known part of the national cinematographic heritage more rapidly available not only for researchers and people interested in cinema, but also to be able to reconsider certain judgements of film historians. Also official financing authorities generally will be more liable to fund bringing these often forgotten early films to light again.

c) The available background information of the film concerned: screenplays, stills, posters, musical scores, for example, of a silent film which is to be subjected to post-scoring.

d) Linking restoration work with a topical event which could make the official authorities especially sensitive towards the role of the archives. For example, in 1989, the 200th anniversary of the French Revolution, the French archives will not fail to restore films dealing with this period of time.

e) The opportunity of employing new equipment or new processes of restoration of a particular restoration which might be used and reproduced again in similar cases. E.g., films processed according to a special method, of the Technicolor or Rouxcolor type, films in obsolete formats on 35 and 16 mm, etc.

f) If a restoration can be carried out swiftly and easily, this will make it possible to save threatened material at any time.

A restoration is a service rendered to persons who deposit films in archives; and this will indirectly lead to new deposits or donations or make the exchange between archives easier.

Finally a more general remark: the work carried out on behalf of third parties (for example production companies wanting to dispose of a print for a television program) might enable the archives to enrich themselves, on the one hand through producing a matrix (duplicate negative) for which they will keep the rights, and on the other hand through financial returns which in some countries will make their activity more credible vis-a-vis the public authorities.

In this respect, the increasing number of broadcasting stations, and communication by means of cable satellites, videodisks and other new technologies, as they create a new demand for programmes, will probably lead to an increasing demand for the material kept in audiovisual archives. Archives in turn might be put under a new pressure, if this is not already the case. However, this new situation might lead to more extended financial aid.

Undoubtedly I have simplified some questions to a large extent, and I did not take historical, artistic or aesthetic considerations into account when describing the elements necessary for a diagnosis before deciding to restore a film, even if they have the same influence on the complicated connection of criteria for deciding priorities.

Ethics of Restoration
Ulrich Gregor

Maxim Gorky
Without knowing the past,
you cannot recognize the true meaning
of the presence and the destinations
of the future.

This discussion is an attempt to start a dialogue between representatives from different fields on questions related to "ethics of restoration". In doing this, we would like to overcome the specialization of individual fields that are only oriented towards themselves.

Which is our starting point today? I will try to give you a few keywords on this subject.

It seems to me, as if we are disposing of more expert knowledge and a different consciousness of the problems in the area of scientific research today in comparison with former times. This also applies to film history. The knowledge of the careers directors make, of the situation of national cinemas, of the problems that may emerge during the production and distribution of films as well as problems related to the screening in cinemas, has become much more extensive, and today we are much better capable in our capacity as film historians of judging our special field of work. We also perceive that it has become larger, more complicated and more differentiated, and that many questions arise that we might not have recognized as questions ten years ago. These are questions that undoubtedly have produced a new situation with regard to techniques or objectives of restoration.

Compared to the situation ten years ago, we have a progressive technology today, highly developed technological procedures of restoration. Thus also a possibility of manipulating sound and image material is created.

And finally a third keyword, which I would like to mention briefly, is the commercial interests that have come increasingly visible during the last years. If there is an interest in introducing sound and image material profitably to the customer and the market, this undoubtedly also leads to strong impulses, even to pressure on the people and the institutions dealing with the old material, who are responsible for this old material.

These are three factors involved in our discussion today: the increased knowledge, the progressive technology and the strong commercial interest of production companies and license holders that also influences the area of film restoration.

The question we ought to ask and the answer of which we are able to approach is: what is the object of restoration? What would you like to achieve, which is your objective, and which procedures should be applied; for whom is this work intended and which is the responsibility of the restorators towards the works of cinema, towards their creators, and towards the audience, the spectators of films?

Ulrich Gregor
Born in Hamburg in 1932. Studied Romance languages and journalism in Hamburg, Paris and Berlin. Since 1955 has been active as a film critic in newspapers, reviews, on radio and television. Contributor to the "Filmkritik" review from 1957 to 1969. Co-founder of the "Freunde der Deutschen Kinemathek" (Friends of the German Cinémathèque) in 1963. Lecturer on film history and film theory at the Deutsche Film- und Fernsehakademie in Berlin, 1966–1972. Since 1971 head of the International Forum of Young Cinema; since 1980 also co-director of the Berlin International Film Festival (with Moritz de Hadeln). Now President of the "Freunde der Deutschen Kinemathek", he's jointly responsible for the programme of the "Arsenal" cinema in Berlin.
Films: "Filmstil und Filmtechnik", parts I–VI (with M. Strauven), 1966.

Publications: "Geschichte des Films" (with Enno Patalas) 1962/82, "Wie sie filmen" 1964, "Der sowjetische Film 1930–1939" (editor) 1966, "Der amerikanische Film 1930–1939" (editor) 1968, "Jean Renoir und seine Filme" (editor) 1970, "Geschichte des Films ab 1970" 1978/82. Editor of the "Kinemathek" newsletters with Erika Gregor, 70 issues since 1963.

Member of the Akademie der Künste since 1984. Was awarded the Käutner-Preis in 1988 (with Hilmar Hoffmann).

The Archivist's Responsibility
William D. Storm

"Casablanca in Color? I'm shocked, I'm shocked!" So reads the title in a Charles Krauthammer essay appearing in Time magazine, January 12, 1987, page 82. The topic, of course, concerns the colorization of old black and white films. Krauthammer quotes – "'Criminal mutilation', says Woody Allen. 'Artistic desecration', says the Directors Guild of America. 'Cultural vandalism', says the Western branch of the Writers Guild of America."

William D. Storm
William D. Storm is the Director of the Belfer Audio Laboratory and Archive, Syracuse University, Syracuse, New York, U.S.A. Storm is also an alumnus of the University with a

Masters in Science in Television, Radio and Film.

Storm's primary interests have been: promoting the establishment of standards for restoration procedures and technologies; promoting scientific methodologies in sound archive engineering; promoting increased communications and cooperation among archives and the audio industry. In keeping with these goals he has been an active Technical Committee member of the International Association of Sound Archives (IASA) since 1979, is the Technical Committee chairman of the Association for Recorded Sound Collections (ARSC), a principal member of that same organization's Associated Audio Archives Committee, and has recently been named chair of the Audio Engineering Society's newly appointed Preservation and Restoration Working Committee. He has made presentations and published papers regarding the concerns and efforts of sound archives and has been a principal investigator on numerous preservation projects and grants.

Krauthammer then proceeds to illustrate how the industry has always done everything it could to sell movies regardless of how contrived, corrupt or debasing. Colorization, in his opinion, is just one more way to market the product. If all of this is not so, he states, "... let the great black and white crusaders stand up and boycott and protect us from other debased and debasing junk in our culture. Otherwise we have a right to conclude that they are not serious, just a bunch of effetes moved by nostalgia, snobbery and fear."

Krauthammer's depiction of the hypocrisy within the movie industry is not unfounded, but in many respects it is irrelevant. First of all he fails to note an elementary point – that there are many different kinds of people involved. Many of them are not hypocrites and are seriously concerned with the integrity of the original productions. Secondly, he makes statements regarding the quality of many productions. By doing so he has become judgmental and may himself be accused of being effete and snobbish.

In the field of sound recordings we too have a variety of people involved, including those who can be judgmental. Many of these people listen only to certain artists, certain record labels, certain time eras, certain producers, certain equipment, etc. They have every right to make these choices, but they will rarely agree among themselves as to what is best in these categories. At the same time, we too have our "colorizer" – the "man with the golden ears." He can assure you that he really does know what is best.

He can take an original sound recording – re-equalize it, edit it, add the proper ambience, and perform other feats of magic that will guarantee to serve the demands of the public as a whole. He is so blessed that he is immune to the physiological, psychological, and psycho-acoustic effects that plague the rest of us. And his powers don't stop there. He can take an inexpensive cassette machine and external microphone – knowing full well the built in microphone is not quite good enough – and with these tools create a re-recording from an old acoustic phonograph, so marvelous that he is compelled to re-issue this material for the good of mankind. Rumor has it that he may begin using digital techniques. The digital equipment he is considering is incapable of covering the audio spectrum, but with "golden ears" anything can be overcome. And if all of this technical wizardry isn't enough he will also be happy to tell you what your taste in music should be.

The "colorizer" and the "man with the golden ears" will always exist as will artists, producers, companies and writers with different motivations and degrees of competency. In many ways these variations are a strong part of our attraction to film, television and sound.

This is precisely why someone's duty is to objectively document and save original productions; to leave an accurate historical record complete with all that was good, bad or indifferent.

And, contrary to what Krauthammer's essay might lead the general populace to believe, there are people who are serious enough about this matter to make a profession of preserving our cultural heritage – they're called archivists.

The archivist is ethically responsible to maintain historical fidelity. It is with this ethic in mind that any restoration work should be done. Any technique or technology employed must meet this standard of objectivity. They must also be well documented and verifiable in other laboratories. An objective approach to restoration can be time consuming, expensive and difficult. It is plain hard work.

This hard work may never get the plaudits of the popularized work of the "colorizer" or the "man with the golden ears". In fact, the archivist will probably save their productions as yet more examples of the craziness of the industries.

Perhaps someday someone will re-colorize the work of the colorizer - but it won't be the archivist.

The Moral Responsibility
Raymond Borde

Raymond Borde
Born in 1920.
Until 1960 he worked as a film critic for the two journals "Positif" and "Temps Modernes". He has written several books on cinema, including: "Panorama du film noir américain" (1955), "Le néorealisme italien" (1960), "Le jeune cinéma italien" (1963), "Laurel et Hardy" (1965), "Harold Lloyd" (1968), "La Cinémathèque Française, recherche de la vérité" (1977), "Les Cinémathèques" (1983).

Until the death of André Breton he was connected with the group of the surrealists. In this context he made the film "Pierre Molinier" and published the book "L'extricable".

In 1958 he founded the Cinémathèque de Toulouse, and he still is its president.

Film restoration also implies problems of a moral kind, a fact of which archivists have become conscious during the last years and so far treated empirically. FIAF, however, included the subject of "Ethics of Restoration" in its symposium in Canberra (1986), and our meeting in Berlin will go even further, as a proper moral codex is being prepared.

These problems concern the good and bad ways of using restoration techniques. Globally we could put it this way:

1. When an archive reconstructs an old film from negatives or from different prints of the original, how large is the scope of freedom? How far can you go without betraying the original work of art?

2. At what stage does a restoration become misapplied, distorting the intentions of the creator?
Before the Symposium of Canberra, several specialists had already expressed their opinion:
Peter Konlechner of the Österreichisches Filmmuseum and Enno Patalas of the Münchner Stadtmuseum, in conferences and interviews, Vincent Pinel of the Cinémathèque Française in its Bulletin No. 4 published in December 1985.

Konlechner, Patalas and Pinel have dealt with ethics proceeding from their own experiences of precise work at a film editing table. Like many of their colleagues they were doubtful about how to proceed, and these doubts show the need of systematized rules. In Canberra, Ray Edmondson and Henning Schou made concrete recommendations of a moral codex. Discussions showed that there was agreement in a certain number of questions, yet the debate remained largely open. The Preservation Commission of FIAF took an interest in the matter, and in many countries there have been productive studies concerning the ethics of restoration. In the review "Archives" (No. 1, September/Oktober 1986), issued by the Cinémathèque de Toulouse, I tried to make a first synthesis, and it is according to these source materials that I would like to give an up-to-date presentation of the matter.

Restoration or Modernization

The moral idea predominant in all these discussions, and one that everybody agreed upon, is the idea of respect:

- respect for the wishes of the film makers, no matter if film director, director of photography, screenplaywriter or writer of dialogue,

- respect for the artistic product, that is for image and sound such as originally recorded,

- respect for the historical environment and the cultural context in which the film was shot.

This means hostility towards any kind of modernization. Film archivists put it quite clearly: it is not their task to commercialize the products of the past by changing them. On the contrary, it is their task to restore the original version of films, or get as near to it as possible, always considering accidents and irrevocable losses.

This also means the nonprofit thinking due to respect. The recent attempts of modernization, like Giorgio Moroder's version of "Nosferatu", or the much more serious one of "colorization" of black-and-white films, were all commercial endeavours with no other aim than financial exploitation of old products. In Canberra the general feeling was that archival work would have to be pursued according to the traditional scientific criteria of e. g. art museums, without consideration of the commercial market or economic pressure. The conservator of the National Film Archive, David Francis, emphasized very strongly how to regard "exterior manifestations (...) and would-be restorations (...): mostly they are merely exhausting the funds available for daily preservation work, and they leave an increasingly large number of films behind them that fight for their survival".

Choice of Techniques

The respect for the original work determines the choice of techniques when silent films are to be restored.

1. The first problem is the one of tinted prints. Should we continue to make black-and-white prints of silent films, when contemporary prints exist, indicating the colours and tints? For a long time these tints were neglected, as they did not appear at first sight but only subsequently in the laboratory from the positives. However, they serve as a language code: blue for the night, red for violence, sepia for intimate scenes, etc. Theirs was a dramatic function according to the wishes of the film director. In addition they made the image very beautiful. The opinion of archivists in this matter also has developed gradually. Today many of them think that a proper restoration has to respect the original colouring whenever there is reference material available. This implies another rule that could also be included into the moral codex: not to destroy the tinted nitrate prints transferred to black-and-white acetate, but to preserve them for as long as possible, until they are duplicated according to the original.

2. A further ethical problem is the one of stretch printing. Do we have a right to tamper with silent films and reproduce one image of two in order to adjust the speed of shooting (16 frames per second) to the speed of our present projectors (24 frames)? There was a very good intention behind this: to show the audience an equivalent of the original rhythm, to present the classics under the best conditions possible, to introduce silent films in modern cinemas and to revive them for the young generations. Morally speaking, these motivations were irreproachable, and yet they are thwarted by a technical factor: the rhythm of shooting continuously increased since 1920, until in certain cases there were 22 frames per second just before the arrival of sound film. Stretch printing thus had the contrary effect: the film was slowed down, the gestures became jerky and finally the original was betrayed. At the Symposium of Canberra, more complex processes of "stretched printing" were conjured up. Today, however, most experts condemn any work on the film and find that the only solution is to equip the projectors with devices for different speeds.

3. On the other hand, the question of intertitles has not been solved at all. Should they be respected or reduced? We often have the impression that there are too many intertitles and we are annoyed with these useless phrases cutting off the pleasure of the image. In those days, however, the spectators did not yet have our audiovisual faculties. They were only discovering cinema. Their way of viewing films still was awkward. They had to be guided and the intertitle assumed an educational role. Moreover, for a long time distributors lent films to cinemas according to length: a certain fee per meter, which tempted film makers to insert undue intertitles that were cheap but brought a clear profit.

So far, no exact doctrine has been developed by FIAF. There is no doubt about the fact that you have to respect the texts reflecting the personality of the director: Griffith loved philosophizing and Abel Gance was a man of letters. The texts that are necessary for understanding the action have to be left where they are. Yet I think you have the right to omit intertitles cutting of movement, thwarting the gags, having no other reason than making the film longer. This is what we have done at the Cinémathèque de Toulouse, being conscious of the fact that we were dealing with an ethical decision, and Vincent Pinel has dealt with the same problems at the Cinémathèque Française. This is the reason why we believe that a future moral codex has to contain a certain freedom for the restorers in this field.

4. A few words on sound reproduction. Except for exceptional cases where a musical score exists that was written especially for a film (the music by Saint-Saens for "L'Assassinat du Duc de Guise", or by Edmund Meisel for "Berlin. Die Sinfonie der Großstadt"), there is a general feeling that the film should be left intact, that no sound track should be made, and that the film should be accompanied by piano or by an orchestra, just like it used to be originally. Here again we find the moral criterion of respecting the past and endeavouring to remain faithful to the performance of films by restoring all of its magic.

Length

Here we approach the core of the discussion. Which is the real length of a film? Which is the most satisfying version? What is the archivist supposed to do when he has a large amount of different material that is sometimes contradictory, according to which he has to make a master print, that is a continuity of image and sound ensuring the survival of a film? His role is at the same time noble and dreadful, and every decision he makes refers, consciously or not, to a certain kind of ethics of restoration.

There are doubts as to the double and triple negatives from the age of silent film, the manifold foreign language versions from the beginning of sound film, the reconstruction of the same film varying from country to country, disappearances due to censorship, cuts made by producers after festivals and press screenings, the comparison between short versions for the cinema and long versions for television, and the sometimes enigmatic existence of never used parts of a print. At the Symposion of Canberra, professor William Routt saw a parallel between literature and "plural texts" presenting themselves to the interpreters. He said: "I would like to see the word difference inserted as an elementary principle of restoration: difference between prints, between takes, between sound tracks". Which one should be chosen? Which one is the original? This is a question concerning all archivists, and the moral restoration codex should find an answer to it.

Eileen Bowser thinks the criterion ought to be: "the print of the first public release. If the reconstructed version differs from this, the reasons have to be pointed out clearly." P. K. Nair adds: "Any conscious attempt to interfere with the original is dangerous and immoral." Vincent Pinel's opinion is that the version viewed by the public has become a sociological document, and he agrees with Eileen Bowser that the oldest used print should be the criterion.

Some people allow the addition of passages that were submitted to censorship against the wishes of the film makers, in cases where an obvious violation of the artistic creativity has taken place.

On the other hand there is the theory of the longest possible version, including all the available material. This was the suggestion of Ray Edmonson and Henning Schou: the preservation of as many visual elements as possible, to be restored during a limited period of time in order to enable a discovery of new elements.

The debate remains open. I am not going to take the liberty of anticipating the recommendations to be made by FIAF, but only to give my opinion:

I insist on thinking that the wishes of the director, the wishes expressed during the time of shooting, is the decisive criterion in the selection of restored images and the ideal length of a film. This might be a somewhat too artistic point of view, yet the coldness of the philologist claiming "it is neither always possible, neither really desirable to establish a definitive version" seems too mechanistic to me. In order to become acquainted with the wishes of the film maker or his crew you have to surround yourself with witnesses and documents.

If these are lacking, it is the task of the archivist to fight his way through his cultural and historical knowledge, his worries and in short, his sensitivity.

In questionable cases it might be advisable to make two versions, one of which a lighter version for public screening, the other one as long as possible, for researchers. This was not clearly expressed in Canberra, the idea, however, was subliminal.

Finally, the technology of the video disk makes it possible to regroup all different versions in one electronic structure, the whole range of withheld or left out images, all versions, cuts or additions of a film. This was the suggestion of William Routt: "a scientific edition" that can be interpreted in various ways, and according to which no print would have the priority over others and would not hinder the access to differing sequences.

Preliminary Measures

In order to finish this one-sided and fragmentary introduction to the ethics of restoration, I would like to mention a certain number of wishes that have been expressed among us:

1. First of all the wish for transparency and international cooperation. Before the laboratory work is done, the maximum amount of negatives and print ought to be compared to a great extent. This kind of work is too expensive to be made provisionally, and the time during which every archive guarded its treasures jealously, the era marked by the neurosis of secrets, is past. The recasting and acquisitions of the catalogue of silent full-length films made by the Cinémathèque Royale de Belgique, the new edition of the catalogue of short films or "Treasures from Film Archives" (Embryo) made by the Museum of Modern Art in New York, the inventory of foreign sound films from the nitrate period made by the FIAF secretariat, all point in the same direction of transparency, and they are essential instruments of restoration work.

2. A further preliminary measure, expressed by the Film and Sound Archive in Australia, is to preserve the originals strictly and to carry out all the editing work on duplicates. This suggestion makes way for the future and would like to avoid the things happening in the 19th century in painting or in architecture, where elements that had survived so far were disfigured for ever by modernization.

3. Finally, Ray Edmondson wishes a kind of declaration of purpose for every film restoration: a document similar to a pressbook, describing the aims, the material used, and mentioning the degree of accuracy that was reached. He also wishes that restored films (technical restoration) should contain credit titles with the following information: explanatory introduction, dates of work, name of the responsible archive, names of other archives or collectors who have contributed with material, questions of length, tinting, etc...

The Responsibility in Daily Work
Vincent Pinel

Vincent Pinel
Born 1937 in Le Havre.
Diploma of the IDHEC.

It is difficult to treat a problem like the ethics of restoration within a few minutes. This is the reason why I am only going to outline one particular question, that is the original form of a film.

The ethics suppose that there is a choice between several possibilities, and that there is a good and a bad choice. And to restore a film means to reconstruct it as closely as possible to its original form, more exactly as closely as possible to the way it was perceived by the spectators of that time. As you know, there are some nuances possible here, sometimes technical changes are necessary, a reconstructed film is not always absolutely identical with the original film. In the case of silent movies it is often difficult to find the original form again. Generally the negative was not on the bobbin as in the case of present-day sound films, but due to a number of reasons like the laboratory work during the first period of cinema it was fixed on a frame.

Also because of the colour effects, toning, tinting, etc. and due to the intertitles, the film was classified into small bobbins and put into boxes according to criteria of order, a somewhat complex procedure. Thus the film montage is not carried out on the level of negatives, but on the level of prints, which is always risky if you want to establish a final version of a film, an original form.

On the other hand, the silent image was not yet dependent on the sound track, and consequently it was extremely easy to make changes, transpositions, cuts in a print. Not even very famous film-makers refrained from doing this, it is a well-known fact that Griffith accompanied the projection of "Birth of a Nation" from town to town, and that he did not hesitate to cut an image here and there, to change the order of a sequence, before each projection. It is known that Gance worked on his "Napoleon" all his life, changing and varying forms, thus remaking it continually. Other film-makers also have worked like that. This means that the original form has become an extremely difficult matter that is complicated to define, when you want to restore a film in 1987. I would like to mention other intervening factors very briefly, like the production companies, of course, which did not always agree with the film-makers. The versions made for abroad very often were different from the versions of the original country, often shorter, made on different material, using other takings. Finally there are the versions made for family audiences with their changes caused by distributors or even by the cinema owners, as well as the censorship which also varied.

Thus there is a countless number of changes in a film, and the problem is to know what we are going to reconstruct. Should the film be reconstructed that was viewed by the public? This is an important argument, as this is the way the film was known and appreciated during that time. Or is the film as its creator wanted it the significant idea? This is the principal opinion of the archivists, as they love cinema, and yet it contains some risks and dangers, above all on the level of interpretation. Finally there is the sociological point of view, the artistic point of view, the historical point of view. There are a large amount of choices, and this is where the ethics begin, in making a choice.

There is a further problem that is particularly interesting with regard to silent movies. Often there are only fragments of the positive left, sometimes there is no positive at all, in cases where negative material still exists. This negative material usually was labelled, containing numbers of order which enables the restorator to set up a chronological order that is more or less correct. Sometimes, however, the instructions are incomplete, not absolutely assuring the authenticity, as it is a certain fact that the girls setting the positives in those days disposed of a guide-line determining the final order such as the director or the production company wanted it. And we know that the director was not necessarily the one with the greatest authority on this level.

In the case where we find negative material with no absolute certainty as to the order as it was when the film was made, we are not only faced with a problem of restoration, but also with the problem of the chronological order of the reconstruction, which is a different problem altogether. Here it becomes necessary to refer to other sources, like scenarios. Still a scenario may be changed during shooting, and there may be variations due to the frenzy of a story-teller or due to commercial reasons.

Chief editor, director of several short films and one feature film. Journalist. Among his publications on cinema are "Louis Lumière" (1974), "Techniques du Cinéma" (1981), "Filmographie des longs métrages sonores du cinéma français" (1985).

For 20 years he inspired the L'Unité Cinéma of the Maison de la culture in Le Havre.

Since 1983 curator for films at the Cinémathèque Française.

Chevalier dans l'Ordre des Arts et Lettres.

There are of course serious sources like the musical score that allows us to reconstitute an order with a certain accuracy and also indicates the intertitles. Especially in Germany, there are the censorship cards, sometimes allowing us to reconstruct titles and intertitles quite correctly, as these intertitles very often have disappeared. They were not always on the film but on cardboard that sometimes was filmed during the montage of a film.

Finally we of course appeal to the witnesses from this time. You know, however, that this is a disputable matter as it is a question of interpreting, a very difficult task. Especially this is the case with the directors who often have a very faulty memory of their films. This is a surprising fact, but somebody who has been working on a film for more than a year has kept a modified impression of it, especially if he has not seen it again, and he remembers things that did not actually exist in the original, things he wanted to do, tending to mix up his artistic desires with the reality of the work he actually made.

Thus the restorator has an absolutely essential part within the frame of reconstruction. He also needs a good deal of altruism as it is significant to avoid making one's own film from the images of another person, in order to reconstruct the work of this other person in a somewhat subjective way that, however, endeavours to be as objective as possible. I think that the signature of the organization or the person carrying out the restoration is absolutely essential.

In the case of sound films these modifications will generally be more superficial, the difference between sound track and image making them problematic and difficult. Thus it is very difficult to modify a sound film without having recourse to the negatives. In addition to these formal difficulties there is the law on artistic property, issued in France in 1957, according to which the original version of a film is defined as the first standard print. This is a relatively precise frame, and yet problems may arise when for example the film-maker and the producer disagreed, and we have the choice between two versions, although generally it is the version of the producer that exists. One might, however, try to reconstruct the version of the film-maker.

We have the particular problem of multiple versions from the beginning of the sound film era, and also in this case it is desirable, if possible, to reconstruct the different versions that were differently interpreted. There is also the important problem of dubbing: what should be done with the dubbed versions? It seems to me that they should be preserved, even if only the sound track is preserved, without making special dubbed prints.

The last problem, finally, is the problem of co-productions, which have increased enormously in Europe since the 50s. Which version should be preserved in this case? For example, "Carosse d'or" by Jean Renoir is a French-Italian co-production with British participation. The director is French, thus one would find it important to keep the French version, but the majority of the distribution shares are English, and English was the language principally used during the shooting. Consequently it seems that for this film, the English version seems to be closest to the intentions of the film-maker, and still it remains a complicated question which has to be solved with some subjectivity.

The Responsibility of Television
Jürgen Labenski

Jürgen Labenski
Born 1940 in Wiesbaden.
Trained to be a newspaper editor.
Since 1968 editor at the Zweites Deutsches Fernsehen (ZDF), occupied with history of cinema.

I work as an editor at a television station and purely accidentally came across film restoration. This started with my participation in the prize awarding ceremony of the Bundesfilmpreis in 1969. Among other films a part of a silent movie with Curt Bois was screened, and Volker Schlöndorff, who was sitting next to me, protested against this screening, as Curt Bois, because of the wrong projection speed, "jittered" over the screen in the shown sequence.

Our television station (Zweites Deutsches Fernsehen, ZDF) had bought a package with about 10 films from the years 1922 to 1928. These films were to be shown in the usual manner, that is untreated, with the wrong projecting speed, without the full silent frame, etc. Now I suggested to change something here and began tinkering together with the operator.

In the meantime we have developed a good technical standard, having solved these problems by means of our technical possibilities. We are able to show different image formats on the screen, we are able to project different speeds, in infinitely variable forms but also according to single steps, and we show the early sound films in the correct format (in the first screening of "Der blaue Engel" heads and feet were cut off).

I would, however, like to point out that the Zweites Deutsches Fernsehen was not the first station to show silent movies in the technically correct way. Hans Brecht from the Norddeutscher Rundfunk Hamburg founded the film club 26 years ago: "Die Hose" (1927, d: Hans Behrendt) was the first film he projected there.

Thus we possessed these 10 films and started working. For example music for the films had to be found, which was a big problem: should there be new music? should there be old music? records? (As an example can be mentioned that we obtained Buster Keaton films from the USA with disk recordings. There the record ends abruptly with the end of the act, even if the scene continues in the following act. For this part a new record begins.) We commissioned new compositions, and yet always wanted to get closer to the original. Later we were able to get information about film music in the 20s by the bandleader, cinema and orchestral conductor Werner Schmidt-Bölke. He reconstructed a part of his musical scores for us and gave us a lot of general information.

Besides we asked actors, for example the actress Ilse Trautschold, who lives in Berlin and gave us a detailed description of how Piel Jutzi directed his film "Mutter Krausens Fahrt ins Glück" (1929). She also possessed the "scenario" that helped us a lot during our reconstruction. We also get in touch with directors, as far as they are still alive, or with the cameramen.

We also might get musical scores by means of which we can determine the style of the film. Synchronous points are fixed and intertitles are written correctly. With the aid of the musical score we are able to time the speed of projection and in doing this we can find out where an intertitle belongs.

One problem, however, still exists: we cannot force the archives to reveal their secrets. Thus we appeal to the archives to support the television companies in their work and show them their stored material.

The financial moment is important also for us – we do not have unlimited means for reconstructing a film. Many colleagues in the television companies are very sceptical towards this kind of work, as they really only want to broadcast. For example, a film has been bought from MGM – and now the fact that this print is 300 m shorter than the original and that the most important parts are missing, is of no interest whatsoever. The money is gone, we have obtained the film. And if you actually ask MGM if they still have a few reels colour material of "Ben Hur" from the year 1925, they say: what? colour? that film never was in colour! and send you a review from the year 1931. And then I send them a review from the year 1925, mentioning that the film had colour sequences, after which they start looking for them, finding 7 reels, and in 4 reels there is only white powder. During the last decades, nobody has had a look at these. This is something you can also experience in archives.

We are making an effort to present the films at least partially as they appeared on the screen 50, 60 or 70 years ago. We owe this to the spectator of today, who no longer goes to the cinema but rather stays in front of his television set, expecting to receive some culture there.

Within the frame of this task he is responsible for more than 70 film restorations including the musical score; more than 20 film reconstructions (among others "Ben Hur", 1923/25, "Potomok Tschingis-Chana", 1928, "All Quiet on the Western Front", 1930); more than 400 television programmes (e.g. "Ratschlag für Kinogänger" [Advice for cinema-goers]; about 100 dubbed versions of foreign feature length films (also as a co-writer); film documentaries on Harold Lloyd, the history of the film "All Quiet on the Western Front", and on Jerzy Bossak.

Publications (among others): Biography "Robert Wiene", Reclams Filmführer.

The Responsibility for Publication
Kurt Deggeler

Kurt Deggeler
Born 1947 in Bern.
Studied musicology in Basel.

1969–1982 assistant at the Schola Cantorum Basiliensis, a teaching and research institute for ancient music.

1982–1984 different occupations in the area of record production of classical music. Establishing and setting up the company Tritonus Sound Recordings.

1984 appointment as head of the Schweizerische Landesphonothek with the task of setting up this institution in Lugano before the end of 1987.

Since 1986 (within the frame of the occupation at the Landesphonothek) head of the project "Historical Sound documents in Switzerland: Information, Documentation, Restoration" which is part of the "National Research Programme 16", "Methods of Preserving Cultural Assets", of the Swiss National Funds for promoting scientific research.

I feel a bit uncomfortable with the title of this session. When we are talking about ethics, there is a great danger that we start to build barriers where we should be looking for a dialogue, and a dialogue with those people who are constructing such a foe image of the people making commercial restorations. This may also concern the people working in the broadcasting companies, who according to our opinions do not think about, or want to think about, or are even allowed to think about such ethics. If we isolate ourselves in our archives and develop our own ethical principles, there will always be two worlds, and I fear that the archival ethics will have significantly less authority than the ethics distributing a wonderfully faded and stereophonic recording of Toscanini – that is making a recording from 1939 as pleasant as possible and as close as possible to the audio habits of listeners in 1980.

On the contrary we should impart our principles by cooperating with the commercial restorers. Above all we should make our work public. A beautiful example already exists in a compact disk that was produced by the Phonothéque Nationale. This disk contains restored recordings, but unfortunately it has been a commercial failure abroad.

It always seems to me that an ethical problem appears in sound archives where there is incredibly expensive equipment for restoring sound documents, but no good rooms for storage. When there is a temperature of + 20°C in the archive, with a relative humidity of 80% you can practically see the fungi growing on the documents. Preservation policies should have first priority. If we do not care about preservation, it is senseless to begin any restoration work at all.

The Responsibility to Make Decisions
Philippe Poncin

Philippe Poncin
Born in Paris in 1948.
Civil engineer for telecommunication in 1973.

Working in INA (Institut National de l'Audiovisuel) since 1977, at first as head of the technical department, and then as deputy Director of the audiovisual archives' Direction.

Responsible for planning of specific buildings for storage and technical services (sound, film, video).

Modernizing the technical equipments for transfers and preservation.

Responsible for the computerized inventory of the audiovisual carriers (actually 450.000 TV and 250.000 radio references).

I would like to make a brief presentation, using extracts from articles or interviews with film-makers who have been especially involved in television, in order to illustrate three questions that could be asked with regard to restoration and the problem of reusing films on television.

1
The first extract comes from Carlos de los Lanos, who made a film series based on archives, "Rue des archives", in 1979 and who talks about the rules he set himself for this compilation. I think this kind of rule could also be applied by people like us who supply the archives. He said:
"I think that our use of archives is an extremely honourable one. The matter is an exercise of style with several fundamental ideas: First of all there is a certain closeness to the intrinsic value of the document; secondly there is the closeness to the era; thirdly the closeness to what television was."

2
The second topic I would suggest has been approached by another film-maker, Philippe Colin, who talks about the problem of production, which, however, can also be applied as well to moving images and sound – in short, to our work of preservation and restoration. In a very brief manner he says:
"The worst cheating trickery is the time reduction, the time value."

With such a synthetic sentence in mind, I think we can find a lot of examples of deception with regard to time, duration. I will give you two examples connected with television:

The first one we saw in Fernando Bardon's short presentation on restoration work, on mechanical splices of video tapes, requiring the cutting of some images, sometimes even only two; yet the question concerns the reduction of the final montage in order to eliminate the defects.

Management of the different branches for preserving and providing programs or extracts to public and private customers.

The second problem is rather one of imperfection in television. Television trifles a lot with time, as far as the compilation of programmes is concerned. I will give you a typical example: last month two channels of the French television acquired the rights of a certain programme, some features with Laurel and Hardy. And just to fit with their own schedules, some films of more than one hour duration have been shortened to less than half an hour. - Broadcasts are often mutilated according to the need of programme planning. This is a clear example of deception with regard to the problem of duration.

Conduct of international engineering and head of the European Technical Commission of FIAT.

For neither technical nor economical reasons can we afford to change the time value.

3
The third topic is maybe even more critical and more difficult to outline, that is the relations not only between the archivists and the film-makers or the producers, but also with regard to those who want to gain access to the archives in order to reuse their documents, people who want to make money out of the archives and tend to exploit them in a most anachronistic manner. There are two very concrete examples on this: A recording from 1939, which has been faked in order to give it more colour or more atmosphere under a commercial pretext (the supposed taste of the present audience); another example, just as striking, is the broadcasting of films without respecting the original format, when the broadcasters want to make what they call a "full frame" (that is broadcasting on the whole television screen). Here again the argument is a specious one, as the broadcasters will tell you that their audiences do not tolerate black stripes on both sides of the image. In my opinion this is totally unacceptable. It is a question of a purely economic argument, as the broadcasters do not want to take the risk of reducing their audiences.

One last problem that is also connected with money and not with ethic is the problem of colorization of old black-and-white films. Here is a very short extract from the "Figaro" of January 6, 1987, where the correspondent in Washington talks about "The Maltese Falcon", produced by John Huston in 1941, which has recently been colorized and distributed:
"On the one hand, great film-makers like Woody Allen, John Houston, Billy Wilder or Stephen Spielberg, famous actors like James Stewart, Jack Lemmon or Charlton Heston, the American Film Institute, the Guild of American Film Directors call it a scandal, a sacrilege, a mutilation and an artistic violation. There are petitions circulating in Hollywood and New York, and as always in the United States, barristers and lawyers present their arguments. On the other hand, the heads of television channels, with Ted Turner in the lead, the distributors of video cassettes, the laboratories specialized in colorization, and - apparently - the general public approve of this new procedure making an end of feature length films that would not have found an audience again, if they remained black-and-white ones."

Our work is part of the struggle between such distant points of view.

The Responsibility to Preserve
Peter Kubelka

I would like to talk here not only in my capacity as an archivist, but also as a film-maker. I refer to the tremendous shock I have been forced to live with as a film-maker since I discovered that 20 or even 15 years after I have made a colour film, this film is disappearing.

Peter Kubelka
Born March 23, 1934 in Vienna.
Filmmaker since 1952.

Co-founder with Peter Konlechner of Österreichisches Filmmuseum in 1964.

If we compare the existing expressions of human beings from the past with the memory of an individual, then there is the appalling conclusion that the life span of documented human articulations continues to become shorter since pre-historic time. The Holy Books of all religions, that were passed on by oral tradition and never materially laid down, have the longest life. Then there are the objects made of stone, those made of wood, subsequently those on canvas, that is painting, and finally paper. And today we are confronting a situation that never before existed in the history of mankind: a situation where the creators lose their work already during their lifetime. Not even at the end of their lives, but as soon as a work has been created, it disappears! And mankind does not seem to get a better memory the older it gets, neither the possibility, the urgently needed possibility, of dealing with the past in order to be able to cope with the future. On the contrary, mankind is losing its memory.

Of course FIAF, and other archivists are experiencing this shock by realizing that everything is slipping through their fingers. For many years FIAF put – and still is putting – its faith into materials of the future, e. g. the transfer to the electronic or the digital medium that finally would put an end to all worries. But if we consider the existing experiences with the electronic and the digital media, then we would be leaving our house to seek shelter in the rain: These media are even more ephemeral than ours! The television director loses his creation faster than the maker of films.

The only way to answer future questions is to preserve the original as an original, with one's full strength, until it slips through our fingers as a white powder, and then to keep this in a box.

For an example: Compare Kristina Söderbaum with Jane Russell. These two actresses illustrate and represent different ideologies. But these ideologies were not in the person of Kristina Söderbaum, nor in the person of Jane Russell, but in Söderbaum on Agfa-Color and Russell on Technicolor. Here the pastel colours, the cleanliness of the German petty bourgeoisie – and there the roaring colours of Jane Russell. If you put the real people side by side, they would look quite similar – two human beings, two women. We clearly see: IT IS NOT THE CONTENT we preserve, we are preserving film reels, material. And we cannot transfer any content on another material, not even from Agfa-Color on Technicolor, without losing significant meaning.

Another Example: The effort of restoring "River of No Return" is wonderful, and Mr. Labenski really ought to be working in a film archive. But television can never be the home of films. A film like "River of No Return" would never have been produced like that for television purposes, as its most significant feature is the need for a screen of at least 40 m. If you bring Cinemascope into television, we have a film presentation comparable to a live performance of Beethoven's 9th Symphony replayed by a small cassette recorder. We must not transfer our content on digital and think that everything has been taken care of. A whole century has created a large part of its significant expressions on this material FILM. And as FILM they are existing. If we give up this idea, then FIAF no longer exists, then cinema no longer exist. And if it would be a fact, that cinema goes out of business, then this would oblige the film archives also to preserve the film EVENT. We are not only obliged to preserve film strips but also to build or preserve cinemas, we have to preserve the machinery, we have to have printing laboratories, we have to carry on the whole industry, so to speak. Our governments will be obliged to help us in this undertaking. Mankind cannot afford to lose one hundred years of its memory inscribed on film.

Statement

The International Federation of Film Archives (FIAF) meeting in Berlin, 18 May 1987, affirming the principle that film, as works of art and culture, should be preserved and presented in the form that most closely approximates the film-makers' original intent, condemns the colourization of Black and White films.

AB Film-Teknik

FICA®

Product

FICA Box
(Film Conditioning Apparatus)

The FICA-Method eliminates the difficulties in controlling the humidity at low temperatures and thus the high costs involved in having a dehumidifying plant in combination with a refrigeration plant for cold storage. This is made possible by conditioning and sealing of the films before storage.
(from the company prospect)

Address

Box 1328
S-17126 Solna, Sweden
phone (46-8) 27.28.20
telex 12888 filmtek s

Contact

Stephan S. Lund

Wilhelm Albrecht GmbH

Product

Magnetic Sound Equipment

In 1980 the Magnetic Film Recorder/Reproducer MB 51 was introduced to replace the well-known sprocket-driven series MB 21, MB 31 and MB 41. The MB 51 drives the film by means of a capstan and without pinch-roller. The system is controlled by microprocessors. This new system guarantees gentle film handling, easy operation and high operational speed (up to 30times). The electroacoustic performance meets any demand.

The head assembly of the MB 51 is interchangeable, so that any track configuration on magnetic film can be recorded or reproduced. Furthermore optical sound can be reproduced in mono or stereo. For archival purposes the high speed transport version MB 51 allows re-recording with full quality at two-times or four-times speed.

Based on the same capstan system a high speed projector and a film scanner are available. Both are using the Holoscope prism system and deliver a flicker-free image at any speed. With the projector the screen may be up to 2 m wide and the light intensity is 170 Lux.

Address

Maybachufer 48–51
D-1000 Berlin 44, Federal Republic of Germany
phone (49-30) 623.60.39
telex 184 500 mwa d
fax (49-30) 623 10 31

Contact

Gunter Kiess
Peter Stroetzel

Branch & Appleby Ltd.

Product

Branch & Appleby, who are one of the leading makers of sound heads in Europe, manufacture sound heads for the following applications in the area of broadcasting:

- 1/4 inch full track to 2 inch 32 track, including centre track TIMECODE
- 8 mm to 70 mm film and projector heads in standard and extended life versions
- B and C - Format video sound heads and high speed loop bin types for cassette duplication

Branch & Appleby also offer a quick reprofiling service for tape-, film- and VTR-sound-heads, which restores worn heads to good as new conditions.
(Hermann F. K. Roos at the Joint Technical Symposium)

Address

Stonefield Way
Ruislip, Middlesex, HA4 OYL, England
phone (44-1) 864.15.77 or 423.35.97
telex 918582 magsnd g
fax (44-1) 4222949

Agent in the Federal Republic of Germany:
Vertriebsbüro Hermann F. K. Roos
Jahnstraße 49
D-6102 Pfungstadt 2
phone (06157) 85330
telex 4191777 vbmg d
fax (0) 6157-85330

Contact

England: Terry H. A. Summers
Germany: Hermann F. K. Roos

CEDAR

Cambridge Electronic Design Ltd.

Product

CEDAR
(Computer Enhanced Digital Audio Restauration)

"(...) CEDAR houses in effect three bodies:
the National Sound Archive in London, the Cambridge University Department of Engineering, and the Cambridge Electronic Design Ltd.
We have an advanced prototype of the software together with the peripheral supplied by Cambridge Electronic Design, which will enable us to make major advances in sound restoration. It follows from an initiative that we took some 3 or 4 years ago, when we liaised with NEVE Electronics in the production of a digital desk using the Betamax digital PCMs. But from that initial development with Neve, we began to liaise with Cambridge University Department of Engineering, and with them we have produced a software which we hope to place on the market through Cambridge Electronic Design by early 1988 (together with the peripheral circa 4.000 pounds). (...)"
(Christopher Roads at the Joint Technical Symposium)

Address

Science Park, Milton Road
Cambridge, CB4 4FE, England
phone (44-223) 31.61.86
telex 818184 cedrtc

Contact

Said Vasaghi

Debrie International

INTERNATIONAL

Product

Printers, Processing Machines, Sound Equipment, Video Colour Analyser

"(...) We have concentrated on three principal directions: the printing of films, processing machines, and video colour analysers. As for the last product, produced about two years ago, I do not think it has any equivalent on the market, as it is capable of analysing and grading films at the same time as it is supplying film programmes and video cassettes. This machine is able to work directly according to negatives or positives or dupes.

Our firm is one of the few film equipment firms to have an integrated research division, allowing us to develop material and keep an evolutive aspect of what we are producing. Our equipment develops within the course of years and thanks to the permanent contacts with international laboratories.

With regard to archives, we have developed a printer in cooperation with the Bundesarchiv. It has now been operating for four years, and I think it is one of the most high-performing machines as far as the reproduction of old films is concerned. Here of course the technique of total immersion and the numerous advantages of eliminating scratches and dust is called for. Especially in black-and-white films, the nuances of the contrast are essential, and only total immersion can ensure a satisfactory image in this respect. Our firm especially stresses the importance of maintenance service. This is the reason why we are offering a guarantee of two years and further visits to the laboratories during 5 years, in order to ensure that the operators are fully informed about the use of the equipment. This has been a very successful innovation (...)"
(Jean-Vincent de Saint-Phalle at the Joint Technical Symposium)

Address

2, rue des Aérostiers
Z.I. des Richardets
F-93160 Noisy le Grand, France
phone (33-1), 45.92.19.40
telex 231763 f

Contact

Jean-Vincent de Saint-Phalle
Jean-Pierre Blauwblomme

L'Equipment Integral

Product

Film Processors, Film Cleaning Machines

"For more than 30 years we have been producing film processors. The supple drive of this equipment completed the range of traditional products in film laboratories. This is a machine that reconditions the emulsion by passing it into a bath, removing scratches.

On the other hand, we also have added a film cleaning machine to our products which has been well received by archives as well as broadcasting companies. This machine is characterized by three very dynamic cleaning rolls of film transport. A complete drying process has been considered, as well as all other operations necessary in this respect. Thirdly, the use of this machine is very simple. In addition, this type of equipment is very low-priced and suitable for noncommercial budgets."
(Pierre Faucheur at the Joint Technical Symposium)

Address

95, Route de Versailles-Champlan
F-91160 Longjumeau, France
phone (33-1) 64.48.84.76
telex 600 748 f

Contact

Pierre Faucheur

Filmowy Ośrodek Badawczo-Rozwojowy "Techfilm"

Product

Film Regeneration Machines, Film Cleaning Machines, Rewinding Tables, Sensitometer, Silver Extraction Devices, Film Editing and Viewing Tables

"(...) "Techfilm" is dealing with research and development work in the area of film technology. Room acoustics, photochemistry, treatment, protection and preservation of film material as well as development of measuring and preservation instruments are areas belonging to this research. The same goes for the applied optics, test methods and measuring instruments of recording, precision objectives, development of the optical systems for film equipment; lighting technology in the areas of film and television, measuring instruments for lighting.

The film regeneration machine is suitable for regenerating the carrier and emulsion layer of film prints as well as for the coating of silicone lacquer (in order to reduce the coefficient of friction). The ultrasound cleaning machine (for 16 or 35 mm) operates in a totally closed circuit with an ultrasound generator (ecologically very beneficial).

"Techfilm" produces also the cleaning machines without ultrasound generator; these machines work mechanically only.

All products from "Techfilm" have been operating in quite a large number in socialist as well as in Western countries for a couple of years."
(W. Pierzchlewski at the Joint Technical Symposium)

Address

ul. Dominikánska 9
02-738 Warszawa, Polska
phone (48-22) 43.00.81-5
telex 817169 fobr pl

Contact

W. Pierzchlewski

Lipsner Smith Co Ltd
RTI (Research Technology International Ltd)
Zenon GmbH

Product

Ultrasonic film cleaning machines (Lipsner Smith)
High speed automatic film inspection/cleaning machines (RTI)
High speed automatic videotape cleaning/evaluating machines (RTI)

Research Technology International of Illinois, U.S.A. manufacture a range of high speed automatic equipment for the quality control and cleaning of motion picture film and professional videotape. Its Lipsner Smith subsidiary is classed as the world's leading manufacturer of ultrasonic film cleaning equipment. The top of the range is the model CF3000 – this not only ultrasonically cleans and dries in the Academy Award winning Lipsner Smith fashion, but also incorporates a built-in solvent and vapour recovery unit to ensure that at least 85% of all film cleaning solvent used is recovered. This provides the user with significant solvent economy and allows the user to comply with forthcoming anti-pollution and health and safety regulations concerning the exhaust of chlorinated solvent to atmosphere. Lipsner Smith has also recently developed a further modification which can improve the performance of its existing ultrasonic film cleaning machines in the field. Currently the film cleaners use ultrasonic cavitation only and some users have found that this may not be adequate for extremely dirty or contaminated prints. Lipsner Smith can provide a modification which would combine ultrasonic cavitation and immersed rotary buffers. The combination of buffers and ultrasonics produce the most efficient film cleaning available, while maintaining the usual high standards of safety users come to expect from Lipsner Smith.

From RTI there is a range of high speed automatic videotape cleaning and evaluating machines – and the most popular use so far is to allow broadcasters to recycle their 1", ¾ " U-Matic or Betacam cassettes. The machine cleans the videotape using 2 advancing tissues which remove loose oxide, dust and other contamination. The most important aspect however of improving the play back quality is the incorporation of a set of burnishing blades which allow the tape to be cleaned of irregularities which cause poor quality viewing and dropouts to be visible on the screen. The unit is available for 1" tape, 3/4" U-Matic, Beta/Betacam and VHS/M format. All units also incorporate optical detection which allows the tape to be checked for physical damage without erasure of pre-recorded material. The results of the evaluation, the date of the cleaning etc. can be displayed on a screen or taken as a hard copy printout.

Finally RTI is also the world leading manufacturer of high speed automatic film inspection machines for both 16 and 35 mm film – these units check for perforation defects, sound edge faults and bad splices and operate at speeds up to 400 metres/min. (Jonathan Banks at the Joint Technical Symposium).

Address

RTI –
4700 Chase
Lincolnwood, Illinois 60646, USA
phone (1-800) 323.75.20
telex 28-9414 lcwd
Zenon (for the Federal Republic of Germany):
Carl-Benz-Strasse 16, D-7608 Willstätt

European office & plant:
7 Cowley Mill Trading Estate
Long Bridge Way
Uxbridge UB8 2YG, Middlesex, England
phone (44-895) 521.91

Contact

RTI Europe: Jonathan Banks
Zenon (FRG): Mr. Meyer

Precikino

Product

Optical Film Printers (G.M.F.)
Digital Electronic Lamphouse,
Sensitometer

"(...) We have developed a special archive printer in collaboration with the French archives in Bois d'Arcy. We have achieved special wetgate projectors for all the existing film formats such as 8.5, 16, 17.5, 22, 25, 28 mm and Lumière formats. In our development we were taking special care of the two major problems in archive film printing: shrinkage and bad condition of the film material. To solve the first point we modified our sprockets so that they can overcome the worst shrinkages.

The step size is also adjustable to the shrinkage so that no perforation can be damaged and steadiness is brought to an optimum. To solve the problem of scratches in the film, we have developed a fool-proof wetgate system. We have also solved the speed problem: some films were shot at the speed of 16 or 18 f.p.s. Now every projector is projecting at the speed of 24 f.p.s. Therefore we are using a cadence changing device which is printing every second or third frame two times so that we are filling up the gap between 18 and 20 f.p.s. This freeze-frame device we are using for this cadence changing device is also used for the 9.5 film titling which we can freeze as long as it is necessary.

The film printer can work in daylight, is equipped with a Digital Electronic light house from Italy or on request with our own subtractive light house. Through the flexible build-up system of our printer we can adapt it to everybody's particular needs. (...)"
(Ferdinand Mees at the Joint Technical Symposium).

Address

Kortrijkse steenweg 301
B-9830 St. Martens-Latem, Belgium
phone (32-91) 82.74.12
telex 12210

Contact

Ferdinand Mees

W. Steenbeck & Co.

Product

Film and Sound Editing Machines 16/35 mm
Viewing and Controlling Machines
Motor Driven Rewinding Tables
Video Sound Editing Machines 16/35 mm
Studio High Speed Projectors
Studio Magnetic Film Recorder
Film-to-Video Transfer Units

"STEENBECK" presents a Film-to-Video transfer system (flatbed table type) that transfers picture and sound information of 16 or 35 mm motion picture to any type of video tape recorder. COMOPT, COMMAG and even SEPMAG sound can be handled. The picture signal can be inverted and colour corrected to get a video positive out of a film negative. Timecode can be read or generated and inserted into the video. All these features (and more) come in a very handy and compact unit and offer reasonable quality at reasonable expense.

The second exhibit to be mentioned is a newly designed rewinding table with electronically controlled reel motors for constant film tension to take care of valuable materials. In addition the rewinder can be equipped with electronic universal counter, dry cleaning and perforation checking units.

Last but not least we present our film data computer system that helps you store, catalogue, and retrieve important data on floppy disk by means of dedicated software. The system consists of computer, keyboard, monitor, floppy disk drive, and printer.

Address

Hammer Steindamm 27/29
D-2000 Hamburg 76, Federal Republic of Germany
phone (49-40) 20.16.26
telex 212383

Contact

Winfried Bass

FIAF
Fédération International des Archives du Film

The principal aims of the Federation are as follows:
to promote the preservation of the film as art and historical document and to bring together all organisations devoted to this end;
to encourage the collection and preservation of documents and materials relating to the cinema (what is generally called "non-film material");
to help in the creation of new archives in countries where there are none;
to develop cooperation between members and "ensure the international availability of films and documents";
to promote film culture and facilitate historical research.

The International Federation of Film Archives was founded in 1938. It is completely independent and financed totally from members' subscriptions. It is governed by an Executive Committee elected from among the members.

The members are autonomous, non-commercial national film archives which are dedicated to the study of film history and aesthetics and whose collections are accessible to members of the public. Their main object must be the acquisition, restoration, preservation and cataloguing of films and documentation relating to the cinema.

There are three commissions working within FIAF: the Preservation Commission, the Cataloguing Commission and the Documentation Commission. These are groups of experts which meet periodically, set up work programmes, collate the results and prepare publications for FIAF.

The Preservation Commission has as its task to assemble, study and publish the most reliable scientific information relating to storage, preservation, and restoration of audiovisual recordings.

The members of the Cataloguing Commission coordinate and carry forward work on the publication of standards, manuals and studies related to cataloguing and automated data processing for moving image materials held by archives.

The role of the Documentation Commission is to promote the exchange of information, knowledge and expertise among colleagues with a view to standardise working procedures whenever possible, thereby improving and facilitating exchanges at all levels. In 1972, an international "Film and Television Periodical Indexing Project", based in London, started publishing annual volumes with regular updates on microfiche to its subscribers.

The journal of the Federation, the FIAF Bulletin, is published twice a year and sent to all associates. Other publications about special topics related to the work of film archives are available to the general public.

Training of archive personnel takes place at FIAF Summer Schools which have been held several times in Berlin East and also in Copenhagen. These introduce participants to the problems of preservation, cataloguing, documentation and the administration of a film archive.

Important elements of FIAF's work are the annual congresses where professional problems and questions regarding the Federation are discussed in symposia and meetings.

The Federation comprises 78 institutions in 56 countries.

FIAF Secretariat: Coudenberg 70, 1000 Bruxelles, Belgique, phone: (32-2) 511.13.90

FIAT/IFTA
Fédération Internationale des Archives de Télévision International Federation of Television Archives

The principal aims of the Federation are as follows:
to encourage cooperation among its members;
to promote the improvement and compatibility of documentation relative to audio-visual materials as well as documentation exchanges;
the preservation of its collections;
the study of all questions relating to Television Archives;
the evaluation and exploitation of its holdings.

The International Federation of Television Archives was founded 1977 in Rome. It is a non profit making professional Association for the heads of television archives. It is governed by an Executive Council elected by the General Assembly.

Membership of the Federation is open to all television archives. Their main object must be the preservation and cataloguing of television material.

There are three commissions working within FIAT/IFTA: the Technical Commission, the Documentation Commission, the Training Commission.

FIAT/IFTA publishes an information bulletin and organizes research seminars, workshops and international meetings about archive problems.

An important element of the work of the Federation are the General Assemblies, which are held every two years.

The Federation has 56 members in 29 countries.

FIAT/IFTA, President, Anne Hanford, BBC, Head of Film and TV Library, Reynard Mills Industrial Estate, Windmill Road, Middlesex TW8 9NF, England; Treasurer, Jean-Sylvestre Cosandey, RTSR, Chef du Service de Documentation et Archives, Case Postale 234, CH-1211 Geneve 8.

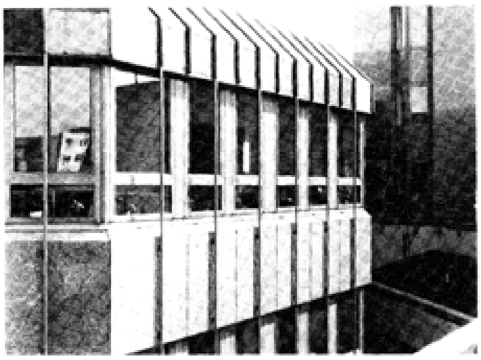

Figure 3

Figure 4

All rooms in which cellulose nitrate film is treated have pressure relief areas in case of a fire. There are also pressure relief areas in the roof constructions of the interior rooms (fig. 2). The windows of the exterior rooms are constructed in such a way that they will be pushed out at a positive pressure exceeding about 0.8 bar. Bars are placed in front of the windows to prevent the panes from being thrown too far away (fig. 3). For safety reasons, the window panes are made of compound glass which consequently does not splinter.

In addition to the monitoring system mentioned earlier, important parts of the building, such as the vaults, the passageways that lead to and from them, and some workrooms, are monitored by movement detectors after normal working hours.

Ventilation

All workrooms are connected to a ventilation system. In order not to expose the staff members to fumes of solvents or other gases, the installation uses purified fresh air only (i.e., no recirculation). The inducted air passes into the ventilation centre through filters. To prevent dust particles, e.g., cellulose nitrate particles, from re-entering the air-conditioning system, there are fine dust filters in front of each waste air outlet. The effectiveness of the large filters attached to the air intake is controlled by means of a residual pressure manometer. The air humidity in the workrooms is kept at levels of about 55% by passing the incoming air through a steam installation. The water, which is necessary for the process of humidification, is obtained from an osmosis installation. In case of a fire, automatic fire safety valves in the ventilation system will isolate workrooms in which nitrate material is treated.

The monitoring of the working environment in each store room is also part of the general work safety in a film archive. A central control unit assumes this task. All important values are controlled by a computer, and regular recording printouts of the climatic values are at our disposal (fig. 4). An area such as the colour film store, in which the required levels of temperature and relative humidity must be strictly adhered to, is supervised by its own monitoring system with a recorder.

Energy Consumption

In addition to staff salaries, the cost of energy consumed by a film archive is an essential factor. This cost ought to be as low as possible. This begins with the construction of the exterior wall which should have optimal qualities of insulation. The construction of the wall from the exterior inwards should be: a 4 cm thick granite slab, then a 8 cm thick insulating layer of rock-wool, ventilation from behind, and finally the walling itself which should be 15 cm thick. In this way, a heat penetration factor (K) of 0.40 is achieved.

The store towers are constructed in the same way. However, the insulation is better there because the interior walls of all stores are made of tubular brick, 49 cm thick. Thus a total heat penetration (K) value of 0.30 is achieved.

In the colour film store, where the temperature is -6°C (21°F) with a relative air humidity of 25%, there is an 11 cm thick insulating cell behind the tubular brick wall. Thus a heat penetration (K) value as low as 0.27 is achieved. In order not to freeze the area surrounding the cooling cells, the air space around the cells is heated to a temperature of +5°C (41°F). Door seals, as well as locks, are secured against freezing through their own heating system. The black-and-white film stores are run at +15°C (59°F) and a relative humidity of 55%.

Running a film archive consumes a great amount of energy. Project planning and realization, including purchase of special equipment, were therefore from the very beginning geared towards achieving the most economic consumption of energy. The heat of waste water and air from exhausts are channelled back into the heating

Peter Konlechner:
When you discussed the structure of the walls, did you mention anything about the vapour barrier?
Harald Brandes:
The wall is constructed like this (from the exterior inwards): granite, ventilation from behind, vapour barrier, insulation, brick wall.
Anna-Lena Wibom:
I understand that you have invented ways of saving water. Have you calculated how much energy you use per square foot or cubic metre to maintain the temperature and the relative humidity you aim for?
Harald Brandes:
There are no theoretical calculations for this on behalf of the planners, and we still have not reached a stage that we

The journal of the Association, the Phonographic Bulletin is published three times a year and sent to all members. Other publications include a Membership List and a Directory of Member Archives, which are periodically revised and a series of Special Publications related to the work of sound archivists.

IASA holds an annual conference which includes a General Assembly to report the business of the Association to the members, working sessions for IASA committees, and sessions on topics of general interest.

The Association has over 400 members, individual and institutional in 43 countries.

IASA Secretary General: Jean Claude Hayoz, DRS, Studio Bern, Phonothek, Schwarztorstrasse 21, CH-3000 Bern 14, Switzerland

The Chairmen/Editors
6 Biographies

George Boston
Chairman IASA

George Boston has been involved with recording sound since joining the BBC to work in the radio drama and music studios in London in 1962. He moved to Manchester in 1967 and worked in the studios and on location for radio and television. In 1975 he was appointed the Assistant Audio Manager to be responsible for the day to day administration of the Manchester Audio Unit.
In 1982 he was appointed Audio Manager at the BBC Open University Production Centre at Milton Keynes where he is responsible for the sound content of the programmes made on film and video for television and on audio tape for radio. In addition to the transmitted programmes, the centre also makes master tapes for audio and video cassettes and video disks, including interactive disks. George Boston has been an active member of the IASA Technical Committee since 1985. He is the Chairman of the Co-Ordinating Committee of the Technical Commissions of the International Federations for Audio, Film and Television Archives.

Helen Harrison
Editor IASA papers

Helen Harrison is a qualified librarian and Fellow of the Library Association (UK) who has worked with audiovisual materials in a variety of library and archive situations. She began her career working with film in the National Film Archive in London and moved to Visnews, a commercial newsfilm agency in 1963. In 1969 Helen joined the Open University in England as Media Librarian dealing with the moving images of video and film, sound recordings and still visuals of slides and photographs.
Helen has been associated with audiovisual librarianship and archivism throughout her career and is the author of several books and papers on the subject. She was responsible for editing and publishing the journal "Audiovisual Librarian" for 5 years in the 1980s. Helen Harrison is currently President of IASA and a member of several committees, including one on Conservation and Preservation of library materials where her principle role is to keep reminding the committee of the existence and special needs of audiovisual materials.

Eva Orbanz
Editor

Born 1942 in Berlin. Worked at the German Film and Television School (Deutsche Film- und Fernsehakademie Berlin) from 1967 to 1972.
Guest student at the Cinémathèque Royale de Belgique, Brussels, and at the British Film Institute, London.
Since 1973 employed by the Stiftung Deutsche Kinemathek; first as a coordinator, since 1985 as head of the Film Department.
Publications: "Wolfgang Staudte" (1977), "Journey to a Legend and Back. The British Realistic Film" (1977), etc.

Philippe Poncin
Chairman/Editor FIAT papers

Born in Paris in 1948. Civil engineer for telecommunication in 1973.
Working in INA (Institut National de l'Audiovisuel) since 1977, at first as head of the technical department, and then as Deputy Director of the audiovisual archives' Direction.
Responsible for planning of specific buildings for storage and technical services (sound, film, video).
Modernizing the technical equipments for transfers and preservation. Responsible for the computerized inventory of the audiovisual carriers (actually 450.000 TV and 250.000 radio references).
Management of the different branches for preserving and providing programs or extracts to public and private customers.
Conduct of international engineering and head of the european technical commission of FIAT.

<u>*Dr. Henning Schou*</u>
Chairman/Editor FIAF papers

Dr. Henning Schou is Head of Film and Television Preservation and Technical Services at the National Film and Sound Archive in Canberra, Australia. He is President of the Preservation Commission of the International Federation of Film Archives (Prescom FIAF) which carries out research and publishes guidelines and recommendations on all aspects of motion picture preservation. Dr. Schou has undertaken research work on deterioration of colour dyes in film stocks and on the decomposition of cellulose nitrate film – two of the major problems facing film archives world wide. He has edited and written numerous patents, technical texts and papers, such as "An Experimental Quality Control Program for Printing Archival Films" (with D. Case) in the Journal of the Society of Motion Picture and Television Engineers. Dr. Schou, an avid film buff, is also an expert in film animation.

<u>*Dr. Dietrich Schüller*</u>
Chairman IASA

Born 1939 in Vienna. Studied physics at the Technical Highschool of Vienna 1957–1959, thereafter ethnomusicology and cultural anthropology at the University of Vienna.
Joined the Phonogrammarchiv of the Austrian Academy of Sciences in 1961, became its Director in 1972.
Actively engaged in the organization of sound archivism on a national and international base:
1975–1978 President of the International Association of Sound Archives (IASA), 1978–1984 Vice-President, 1984–1987 Editor of the Phonographic Bulletin. Chairman IASA Technical Committee since 1975.
Chairman (1976–1985), Secretary General of the AGAVA (Austrian Working Group of AV-Media Archives).
Member of various national and international advisary boards and working groups on av-media. Various consultancies for the formation and organization of av-media-archives, especially in third-world-countries.
Numerous publications on av-media, with emphasis on phonographic field work and problems of storage, preservation and restoration. Editor of the series "Tondokumente aus dem Phonogrammarchiv der Österreichischen Akademie der Wissenschaften".

Acknowledgment

We especially thank the members of the Organizing Committee: George Boston, Harald Brandes, David Francis, Anne Hanford, Wolfgang Klaue, Peter Konlechner, Sam Kula, Fernando Labrada, Philippe Poncin, Henning Schou, Dietrich Schüller, Lloyd Stickells; the colleagues from the Stiftung Deutsche Kinemathek, the staff of Common Filmproduktion and Helmut Wietz, the library of the German Film and Television School as well as Sender Freies Berlin for their support in realizing the Joint Technical Symposion.

Epilogue
April 1988

1

The world is anything but an either-or, anything but a victory at the first attempt. (Ludwig Hohl)

2

Once again in order to remind you:
Berlin, May 20 through May 22, 1987.
The weather of the week: 17°C, sunny, windy, rain showers.
The headlines of the week: US frigate attacked by Iranian aircrafts - the census - Gorbachev criticizes the delay of the disarmament procedure - the Golden Palm of Canne awarded to Sous le soleil de Satan - US dollar below 1.77 DM - Billy Wilder becomes professor honoris causa.
The hit of the week: La isla bonita.
The Berliners' motto of the year: 750 years.

3

Three days in the fully air-conditioned Congress Centre. Documents and last pieces of information at the counter. The escalator to Saal 3. A discussion with the exhibitors - sometimes just an avid glance at the equipment.
Three days of papers, discussions, film and video presentations, sound demonstrations - strange noises, distorted images, double images. Communication via microphones, head-phones; mostly in a foreign language. Quick photocopying in the secretariat, last minute translations; the final program on the blackboard.
Three days with coffee breaks: stimulating discussions, biscuits against the first signs of hunger; queueing for lunch.

4

For some indefatigable delegates the Arsenal in the evenings. Scherben bringen Glück - Der große Trick - Ein jeder hat mal Glück - Cent Films Lumière - L'Assassinat du Duc de Guise - Ihr Unteroffizier - Harakiri - Way Down East - Elstree Calling - L'Hinrondelle et la mesange - Autour d'une cabine - Nummisuutarit - Grunja Kornakova: examples of the practical work in film archives.

5

Only now, compiling and making a montage of the papers, all the details have come to my knowledge. This makes some things, among others, very clear: the wish for co-operation, the curiosity with regard to the work of the colleagues, the need to continue the dialogue.

6

We owe the fact that the Joint Technical Symposium became an important mosaic stone in the efforts of archiving the audio-visual heritage to all participants, not least to the chairmen of the sessions.
Here I would like to express my thanks to Frank Behnke, Ulli Bohling, Ulrike Bothe, Jacques Gagné, Marie Hagen, and Elke Seidler. They were imaginative enough to believe in the success of this event.

Eva Orbanz

ARCHIVING THE AUDIO-VISUAL HERITAGE

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