THIS FILM IS DANGEROUS:
A Celebration of Nitrate Film

Editor: Roger Smither

Associate Editor: Catherine A Surowiec

FIAF
Fédération Internationale des Archives du Film

Published with financial assistance from the Eric Anker-Petersen Charity

First edition, published in 2002 by FIAF.

ISBN: 2-9600296-0-7 ✓

Fédération Internationale des Archives du Film
Rue Defacqz 1, B-1000 Bruxelles, Belgium
Tel: (32 2) 538 3065 Fax: (32 2) 534 4774 Email: info@fiafnet.org

Graphic Design by Julia Mills.
(The front cover design is derived from photographs supplied by the Cinemateca Brasileira, the Imperial War Museum, and Roger Smither; full captions and credits are printed with these images when they are used in the text.)

Printed and bound in the United Kingdom by FiSH Books, London.

The Eric Anker-Petersen Charity is pleased to assist the publication of this book. The Charity promotes the preservation and restoration of archive film held in the UK, and the trustees are happy to consider supporting new projects in this area. Applications should be addressed to the Charity at the following address:

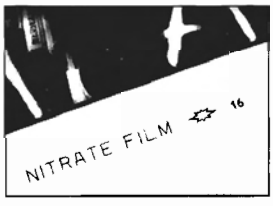
c/o Charles Russell Solicitors, 8 – 10 New Fetter Lane, London EC4A 1RS, UK
(Phone (44 20) 7203 5000; Fax (44 20) 7203 0200; Email enquiry@cr-law.co.uk)

The Film Industry's Conversion from Nitrate to Safety Film in the Late 1940s: A Discussion of the Reasons and Consequences

by Leo Enticknap

Introduction

The use of new technologies within the film industry has traditionally happened in two stages: the research and development of the technology itself, and its subsequent commercial exploitation. In some instances, most notably the introduction of synchronous sound, these two processes were closely connected. Indeed, as a number of historians have pointed out, the financial resources necessary for the development of the Warner Brothers' Vitaphone system to the point of entering mass-production were made available with the expressed intention of commercially exploiting it in an attempt to gain an advantage over their business rivals.[1] The Technicolor corporation, with their beam-splitting camera and dye-transfer printing technique, was another example of the development and commercial exploitation of new technologies taking place in an integrated context.



Edge marking – nitrate film.
East Anglian Film Archive, Norwich.

In other cases, however, these two phases have been separated by significant lapses of time, or were instigated by different individuals and organisations. Single-strip colour, and the technique of dye-coupling which enabled it, were originally invented by the Nazis, but were not used on a global scale until the US and Soviet film industries took over the patents in the late 1940s.[2] Despite the invention and limited use of both 70mm and anamorphic cinematography in the late 1920s, widescreen production did not begin on any significant scale until the mid-1950s, when these two methods were adopted by Todd-AO and Twentieth Century-Fox respectively.[3] Stereo optical sound-on-film, despite having been successfully demonstrated by Alan Blumlein in 1936, was not exploited commercially until Ray Dolby began marketing equipment in 1976. And digitally recorded sound, despite having been on sale to domestic consumers in the form of compact discs since 1983, was not available to film exhibitors until the near-simultaneous launch of three competing formats in 1992.

The technology which I shall consider in this paper differs significantly from the examples given above in that it does not fit into either of these categories quite as easily. The development and commercial introduction of safety film – that is, film stock which is not so highly inflammable, and potentially explosive, that special safety procedures are necessary wherever it is handled – took place gradually over the first half of the 20th century. But the exact form of this technology, which enabled it to supersede cellulose nitrate (inflammable) stock, was developed and launched in a comparatively short time scale, in the decade or so immediately following World War II. I will present a brief historical overview of the conversion process, and consider why the development and adoption of safety film has so few similarities with that of other comparable processes of technological change in the history of the film industry.

Safety Stocks before the Conversion

Although there was no safety film available which equalled the durability and mechanical tolerances of nitrate until the final stage of research and development that led to the industry's wholesale conversion, non-flammable stocks were being marketed a lot earlier. Arguably, the earliest sign of activity in this area was in 1904, when W C Parkin, a French chemist, was granted a patent for a method of inhibiting the flammability of nitrate by adding a soluble metallic salt to the base.[4] Research into inherently non-inflammable cellulose suitable for use as photographic film also took place during this period, as a technical writer noted in an article published in early 1950:

> Much of the literature on cellulose plastics published during the period 1905–1910 contains numerous references to the triacetate of cellulose [the safety base film to which the industry finally converted]. In fact, as early as 1910 the nitrates, acetates, formates, propionates, butyrates, palmitates, stearates, benzoates, acetonitrates, acetopropionates, acetobutyrates, propiono-butyrates, etc., of cellulose had been the subjects of intensive research.[5]

While cellulose acetate stocks did establish a market foothold in some applications, most notably still photography, this research had very little impact on the manufacture of moving image film stocks, which continued to be almost exclusively on nitrate. Consumers of the stock gradually evolved working practices intended to minimise the fire risk, encouraged by various combinations of legislation and industry self-regulation. In Britain, the 1909 Cinematograph Act required all premises where nitrate film was present and to which the public were admitted to be licensed by the local authority, following a number of fatal accidents earlier in the decade.[6] It was this piece of legislation which provided the basis for most aspects of Government regulation of the film industry in Britain, most importantly censorship. This was because the Act gave local authorities the right to grant or withdraw operating licences to cinemas, but did not restrict the criteria for doing so to issues of fire safety.[7] It is interesting to note that this legal situation gave rise to one of the few significant instances of safety stock being used for theatrical film exhibition before the conversion, as the 1909 Act exempted the use of "non-flam" from its provisions. The film society movement, private organisations, and some individuals were thus able to show safety prints on unlicensed premises which had not been approved by the British Board of Film Censors, as such exhibitions could not be subjected to any legal regulation. When a Home Office committee issued a report in August 1939 advising that no such regulation should be imposed, it was welcomed by the liberal press as a cultural safeguard:

> It [the report] is of permanent importance since it establishes the right of societies which may want to study foreign or other films that do not meet with the approval of the British Board of Film Censors to continue to do so if they obtain them in slow-burning form.[8]

Cinema exhibitors, however, took a different view. "Trade Safeguards Ignored" was the headline one industry publication used to describe the report, sarcastically opining that its main recommendation was "obviously based on the false assumption that all such films were educational".[9] The article detailed a number of concerns raised by cinema owners, ranging from unlicensed, unregulated operators undercutting their admission prices and driving them out of business to the unhindered distribution of pornography.

In the US, there was also industry opposition to safety film, although in this case it came from a more specific lobby – the National Projectionists' Union, who feared that their influential position within the industry would be threatened by the abolition of the special handling precautions necessitated by the use of nitrate.[10]

The use of safety film as a way of circumventing the censor was mainly due to a legal anomaly which only affected Britain. The other, more widespread application for this technology prior to the conversion began with the commercial launch of a new film format in 1923, one that was intended for use by amateurs: 16mm. While other "home movie" gauges such as 28mm, 17.5mm, and 9.5mm also went on the market at around the same time, 16mm is especially significant because (a) it was produced exclusively on safety stock (initially on a diacetate base), and (b) it eventually made the transition from an amateur to a professional medium. As I shall argue, it was this process which was partly responsible for safety film making a similar transition, and its eventual use in 35mm stocks. But it was the amateur market which necessitated the use of safety film to begin with; as Brian Winston puts it, "...there was a clear understanding that, for amateurs, nitrate was simply too dangerous."[11] Indeed, George Eastman himself expressed his belief that the use of safety film was essential to any successful amateur gauge. In a letter of June 1912 to the Edison Company, he wrote: "... in our opinion, the furnishing of cellulose nitrate for such a purpose [amateur cinematography] would be wholly indefensible and reprehensible."[12] It would seem that, at the time, his was a minority view. Of 41 amateur film systems sold to the public between 1898 and 1923, only 10 used safety stock.[13] 16mm was certainly the first major film format to be produced exclusively on safety, and aggressively marketed to consumers on that basis.

The use of this format remained primarily in the amateur domain until World War II, when the need to transport films to and show them at temporary locations which could not be equipped for the safe handling of nitrate resulted in the widening use of 16mm. The Allied armed forces decided to adopt 16mm as its standard gauge for the distribution of training and propaganda films, as well as for reduction prints of Hollywood features for entertainment purposes.[14] Other Western government agencies began to use 16mm for civilian applications. This adoption of 16mm in the semi-professional domain was made possible, in part, by further improvements to safety base technology introduced in 1937. The new cellulose acetate-propionate stock used propionic acid as the organic solvent in which the cellulose was dissolved to produce a flexible material (as opposed to acetic or butyric acid),[15] with the result that the new stock was considerably more durable than any existing safety film at the time. The Kodak scientist whose research paved the way for the industry's eventual conversion estimated that acetate-propionate stock "afforded physical qualities midway between cellulose nitrate and the former acetate".[16] Acetate-propionate enabled the widespread use of 16mm release prints that could withstand the occasional worn projector sprocket or less-than-perfect handling, which in turn encouraged the use of the format as an origination medium by field cameramen and the newsreel industry. This led to complaints that its high level of shrinkage made acetate-propionate unusable in the new generation of 16mm cameras which used registration pins in the gate to ensure picture steadiness. One such article concluded:

> But the 16mm medium is no longer confined to amateur use, and has not been for a long time. Being used by professionals for professional purposes in a professional manner, professionals have long been hampered by the shortcomings of this slow-burning base. [...] There is only one solution to this problem, and that is the use of nitrate.[17]

Given the long-established reputation of 16mm as a safety-only gauge, the manufacture of 16mm nitrate was clearly out of the question. And not only did acetate-propionate prove unsatisfactory for use as a 16mm camera negative stock: once again, safety film was ignored by the 35mm market. Brian Winston advances a conspiracy theory, which argues that the systems of legislation and regulation controlling the use of nitrate stock was one of the ways in which the Hollywood film industry exercised commercial control over its output:

> ... nitrate stock was not finally to disappear from the industry until the early 50s, no less than half a century or so after the first patent for the safe alternative. This can be seen as a further elegant, or perhaps extreme, example of industrial conservatism; in effect, the power of suppressive forces inhibiting the introduction of new techniques and materials. [...] The business protection that this provided was worth the odd projection booth conflagration.[18]

If we accept this argument, then it would go some way to explaining why 16mm remained in the amateur domain, despite improvements in emulsion density, until the events of World War II forced a change in policy. Certainly, the production of large numbers of Hollywood features on 16mm enabled them to be shown on a significant scale outside licensed cinemas, and some of these prints ended up in the hands of criminals. In September 1946 five men, including the chief sound engineer of British Paramount News, appeared at the Old Bailey, charged with the theft of 832 reels of 16mm features from the armed forces.[19] A month later, a British newspaper reported the existence of a "big black market in little films". A private investigator hired by the main British distributors found that the 16mm prints had "just vanished, like so many of the Forces' stores did", and claimed to have discovered a number of organised criminal gangs showing them in village halls, workers' clubs, and similar venues.[20] The fears expressed by exhibitors when the 1939 Home Office report encouraging the use of safety film was published appeared to have been realised, and given the existence of such activity it seems reasonable to speculate that the studios and distributors did not want to make 35mm vulnerable to piracy as well. Producing large numbers of 35mm prints on safety stock would certainly have had that effect. Furthermore, they could have been transported without the need for any safety precautions to any one of the hundreds of thousands of cinemas worldwide (i.e., their exhibition would not have been restricted to *ad hoc* venues using portable projectors), where they could then have been shown without the need for any technical modification to the projection and sound equipment.

But if Winston is right, and the resistance to 35mm safety stock was the result of industrial protectionism, why did nitrate cease to be manufactured less than four years after the events described above? One point to bear in mind is that the British film industry's response to the 1939 report did not express hostility to safety film *per se*, but only to the fact that, due to a quirk of the British legal system, its commercial use was unregulated. However, the immediate answer lies more in the technical domain than the political. Cellulose acetate-propionate, though a vast improvement on cellulose diacetate, early forms of cellulose triacetate, and cellulose acetate-butyrate, came nowhere near to matching the performance of nitrate in terms of flexibility, tensile strength, shrinkage, and durability. One series of tests established that an acetate propionate print failed due to perforation damage after 380 projections, whereas a nitrate print run in identical circumstances lasted for 644. In other words, a nitrate print would last almost twice as long as an acetate-propionate one in an average cinema, and therefore double the number of prints would be needed to distribute a title on safety. Moreover, acetate propionate suffered "excessive" focus

drift when projected under a 175-amp high-intensity carbon arc (not an issue with the low-power tungsten lamps used for 16mm projection), and "appreciable" image embossing.[21] For the physical qualities expected of a release print, nitrate remained the state of the art – just as long as it didn't ignite.

The German Connection

It would take the launch of a new type of acetate stock to come close to matching the performance of nitrate at a comparable cost and thus trigger the conversion. A number of files at the Public Record Office in London provide evidence to suggest that, as with tri-pack colour emulsions, the process of research and development which eventually led to the announcement of this stock by Kodak in 1948 may have had its origins in Nazi Germany.

The manufacture of film base of any sort has never taken place in Britain on any significant scale (even today, the polyester base which is used in most cinema film is imported from the US and Far Eastern countries). During World War II this became a national security issue, as raw stock imports became caught in the Battle of the Atlantic, resulting in the strict rationing of stock for release printing, especially where newsreels were concerned.[22] In mid-1945, the Ministry of Aircraft Production started to investigate the possibility of removing film-base manufacturing plant from Germany in order to establish a facility in Britain. A memo from the Director-General of the Aircraft branch of the Board of Trade sets out the rationale behind this:

> As you will be aware, the production of film base has never been carried on in this country to any appreciable extent and from strategic and economic points of view, it is important that we should no longer have to rely on imports of this commodity.[23]

Attempts to import a plant directly from the US were found to be impossible due to cost:

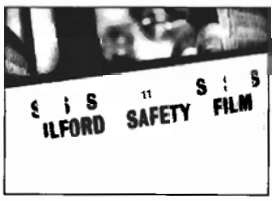
> Demands for industrial equipment of this kind having a very obvious post-war value have been off lend-lease since November 1943. The alternative of a cash purchase would involve expenditure running into millions of dollars.[24]

The Ministry's motivation in this instance was to ensure a safe supply of film for use in aerial photography for Intelligence purposes. However, the supply of raw stock to the cinema industry was also an issue which the Board of Trade had been addressing for some time previously, and its officials were closely interested in the Ministry's project, largely for this reason. Earlier that year they had approached the Eastman Kodak company, which operated a factory in north London for coating emulsion onto imported raw stock, seeking their co-operation in establishing film-base manufacturing plant in Britain. The result was a meeting on 19 April 1945, in which Kodak representatives told the Government that "their own technical knowledge of film casting was not for sale".[25]

A memorandum prepared by the Ministry of Aircraft Production for the War Cabinet Reconstruction Committee, dated 7 April 1945, detailed two key problems that had to be overcome. One was the acquisition of cellulose-casting plant, the other was the chemical composition of the film base. For use on board aircraft, nitrate was clearly not an option, while the manufacture of safety film had thus far been extremely problematic. The memo noted that "... the greatest difficulty has been in obtaining the right type of cellulose acetate: nitrate film has given far less trouble".[26]

That summer a group of British scientists and technicians drawn mainly from Ilford (a British-owned company which operated the second-largest film emulsion coating facility after Kodak), on the advice of eight former employees of the German Agfa company who had been captured as prisoners-of-war and were being held at a converted school in Wimbledon, visited Germany in an attempt to locate film-casting plant and to learn what they could about the chemistry of base manufacture. They discovered that the Americans had got there first, and were keeping the remaining infrastructure of the Nazi film manufacture industry under very close control.

When the delegation attempted to visit the factory of Kalle & Co. in Wiesbaden, they found the premises "under especially close control, with a resident U.S. Army administrator".[27] A year later, British attempts to remove a Koebig band-casting machine (the equipment needed to mould cellulose into 35mm-wide strips) from an Agfa laboratory were systematically blocked by the US authorities. On 1 October 1946 the British Intelligence Objectives Sub-Committee reported that the US Army had decided that the Koebig machine was "obtainable only by reparations" and had refused to issue papers authorising its transport.[28] The following summer, British Rhine Army Intelligence reported that "I have now received advice from our officer in Germany that the Americans have refused to clear this item for procurement either as reparations, booty or by purchase."[29] The US authorities were not the only ones trying their hardest to ensure that no film-base manufacturing plant ever became established in Britain: two months after the British delegation set out, the British embassy in Washington reported that "Kodak do not favour the proposal to establish film base casting capacity in the UK".[30] While Kodak's reluctance to provide infrastructural support to the British government was already clear, the fact that this opposition was also being expressed in Washington raises the question of whether Kodak had anything to do with the US Army's refusal to allow British access to the captured German equipment.



Edge marking – safety film.
East Anglian Film Archive, Norwich.

The issue of cellulose chemistry is especially significant when considering the timing of the final programme of research undertaken by Kodak immediately prior to the launch of their new safety stock in 1948. The British delegation sent samples of two cellulose bases manufactured by I G Farben for Agfa for examination by scientists at Ilford. One, known as "Cellit B", was a compound consisting of 42.5% acetic acid and 16.4% butyric acid; these proportions were similar to the cellulose acetate-butyrate used in 16mm stocks during the 1920s and 30s.[31] None of these would have represented significant improvements on the cellulose acetate-propionate sold by Kodak since 1937. The other I G Farben product, "Cellit F", is described only as "56.3% acetic acid, viscosity 2.6 ost [sic]" (the new American safety stock had an acetyl content of 42.5–44%, without the need for any other organic solvent such as butyric acid), while the British delegation found that several other plants manufacturing cellulose acetates were also still operating: for example, Dr Alexander Wacker-GmbH of Burghausen produced a "photographic cellulose acetate" compound of 55% combined acetic acid.[32] But these files do give the impression that acetate film was far more widely used in Germany than in the West, and, significantly, there is no reference anywhere in these files to the manufacture of nitrate. This could have been because the British delegation were simply interested in film for Intelligence purposes and thus were not looking for anything to do with nitrate (an undated Ministry of Aircraft Production briefing document makes the point that the cinema film industry was the only remaining significant consumer of nitrate film by that stage). However, the systematic opposition by Kodak and the US authorities to the British attempts to benefit from the technological infrastructure of the Nazi film industry, coupled with the fact that Kodak were simultaneously working on a new form of acetate stock that would

become the industry standard within half a decade, seems more than coincidence. As has been shown in the case of colour, Nazi technology was considerably ahead of its time and was eventually adapted and further developed by the American film industry in general, and by Kodak in particular. If the Nazi technology in this case was essentially obsolete, why did the Americans, in the form of the US military authorities, possibly with encouragement from the government and/or the Eastman Kodak corporation, go to so much trouble to prevent the British from obtaining it?

"High-Acetyl Cellulose": The Industry Converts

In a report to shareholders issued on 5 March 1947 (three months before the US Army finally issued a blanket refusal for the British to export the Koebig machine), the Eastman Kodak company announced that it was equipping a large laboratory in Kingsport, Tennessee, "to study the special problems of cellulose esters and their applications, and the work of the company in related fields is being concentrated there",[33] and a later statement by a Kodak spokesman confirmed that the Kingsport facility was being used for the manufacture of acetate film base.[34] Just over a year later, on 17 May 1948, Charles R Fordyce, Kodak's superintendent of manufacturing experiments, told the SMPE annual convention that his company was launching a new "high-acetyl" cellulose acetate, the performance of which almost equalled that of nitrate, and which would be tested as a "possible substitute" for nitrate in the professional motion picture industry. Fordyce explained that Kodak had been working on it "since early in 1946" – a few months after the British technicians had discovered intense American interest in what remained of the Nazi film manufacturing infrastructure.[35]

The essential difference between this new stock and its predecessors was that, in Fordyce's words:

> Cellulose triacetate, the product of complete acetylation of cellulose, is soluble in only a limited number of organic solvents, and would be of doubtful success for motion picture film base because of the difficulty of splicing. Furthermore, casting procedures are difficult with this material, tending to give brittle film. By selecting an intermediate chemical composition, within the range of 42.5 to 44.0 per cent acetyl content, it has been found possible to retain the advantages of high physical strength and at the same time eliminate the problem of proper manufacturing quality and splicing behaviour.[36]

Fordyce's reference both to casting problems and to the use of partially acetylated cellulose raises the possibility of Kodak's research having involved an examination of German casting plant, and the chemical composition of the cellulose esters that were used by the Nazis. The timing of Kodak's research and the American embargo on British access to the Koebig machine would tend to support this speculation. After all, it took 14 years of ongoing research between the launch of Kodak's first mass-produced 16mm safety film in 1923 and its replacement by acetate-propionate in 1937. If Fordyce's statements are correct, the research and development of this revolutionary new base, which finally enabled the film industry to cease using nitrate, happened from start to finish in a little over two years.

His data certainly backs up the claim that the new acetate release print stock, designated by Kodak as Type 5302, was comparable to nitrate when subjected to the usage normally inflicted on motion picture film. Tensile strength was almost identical, with a more than 30% improvement over acetate-propionate, while curl and shrinkage during processing were within acceptable limits.[37] Wearing quality

was not quite as good (with failure due to perforation damage after 520 projections, compared to 644 for nitrate), but laboratory projection quality was of a near-identical standard, with the new stock more resistant to frame embossing than even nitrate.[38] Field tests of trial prints used in cinema distribution showed that the new stock was slightly more susceptible to perforation damage, but that the prints had a similar useful life to their nitrate counterparts in all except the most intensive use.[39]

As Brian Winston points out, the film industry had consistently rejected 35mm safety stock for the previous half-century, which makes it all the more surprising (and also undermines his argument that the use of nitrate was deliberately continued as a restrictive practice) that the process of wholesale conversion began almost as soon as the new Kodak stock went on sale. In October 1948 Edward Peck Curtis, Kodak's vice-president, announced that the supply of stock to the Hollywood studios would undergo a "planned immediate switch" to the new acetate.[40] Interestingly, the reason given for this was "pressure put on the producers by the Los Angeles Fire Department as a fire prevention measure".[41] Campaigns against the use of nitrate on the grounds of fire safety were nothing new – for example, the National Fire Protection Association ran major campaigns in 1918–19, and again in 1923[42] – but they had thus far been resisted by the film industry, mainly because the only safety stocks available were fundamentally unsuitable for use in motion picture film transport mechanisms (i.e., cameras, printers, and projectors). The launch of Type 5302 removed this obstacle, and with it the reluctance of the industry to convert. However, the fire issue remained live: in mid-1950, for example, 17 firemen were seriously injured after they inhaled nitrate fumes while fighting a cinema fire in Dallas.[43] To make things worse, research published earlier that year showed that nitrate was even more dangerous than had been previously thought. Two US government scientists investigating a spate of nitrate fires in the New York area following the unusually hot summer of 1949 found that, if stored at temperatures exceeding 100°F for a period of several days, the stuff could spontaneously ignite![44]

DUAL MARKINGS

SAFETY AND NITRATE FILM

It has been reported that there are in circulation a number of black and white prints that are marked "nitrate" film along one edge and "safety" along the other. These films may be either of safety or nitrate base, and this can be determined by the fact that the wording correctly describing the material of which the film base is made is that printed in **black letters on a transparent base.** The white letters on a black base are printed through from the negative and therefore indicate the material of which the negative was made.

Renting organisations are taking steps to remedy the matter but there are a number of films still in circulation which bear this dual, misleading wording.

Dangerous confusion: an announcement from the UK Cinematograph Exhibitors' Association *Film Report* for 17 November 1950.
The Cinema Museum, London.

With this continuing adverse publicity, and no significant performance advantage over the new acetate, it is hardly surprising that the days of nitrate were numbered. In May 1949, Eastman announced that a sixth of all US release prints in circulation were being made on Type 5302, and forecast that the figure would rise to a quarter by September.[45] In July 1950, Kodak reported that they had ceased producing nitrate and that the conversion was 85% complete.[46] Interestingly, it was reported that newsreel producers were continuing to use nitrate (supplied by DuPont, the one other significant film-base manufacturer in the US), as the newsreel distributors felt that the comparatively short life of each release print did not justify the slightly

higher costs of the new safety film.[47] With this level of momentum behind the conversion process, though, it was only a matter of time before nitrate disappeared completely from circulation. It is notable, however, that this final stage of the conversion process did not happen instantly. Projectionist manuals and training publications from the early 1950s continued to stress that, even while tiny numbers of nitrate prints remained in use, full-scale safety precautions had to be maintained in every projection room. One such British publication advises:

> Not until every last foot of nitrate film is out of circulation can the regulations be relaxed. It may indeed be suggested that while there remains the risk that prints mainly on safety base may have leaders, run-outs or reprinted sections on nitrate, there exists an added element of danger. The projectionist will therefore be wise if, for some years to come, he regards every reel of film as potentially inflammable, and exercises the same precautions to which he has in the past been accustomed.[48]

The US insurance industry was equally wary. The National Board of Fire Underwriters refused to classify acetate film as "slow burning" until November 1950, following extensive tests.[49] In order to convince nervous officials in New York City that acetate film was safe, Kodak, in co-operation with a group of cinema owners, invited members of the City authorities to its Rochester plant for a day of demonstrations.[50]

Front cover of a booklet published and circulated by the Cinematograph Exhibitors' Association at the start of 1950. Subscribers to *Film Report* were each sent three copies with the issue of 6 January, and asked "Will you please hand one copy each to your 1st, 2nd and 3rd projectionists. Further copies are available on application...".
The Cinema Museum, London.

Conclusion

The film industry's conversion from nitrate to acetate did not follow any of the established patterns of widespread technological change in the film industry. As with sound, the conversion happened as soon as a product became available which fulfilled certain technical and economic criteria. Unlike sound, however, attempts had been going on to produce such a product for decades before it finally materialised. These attempts were unsuccessful – it was not a case, as with widescreen and as argued by Brian Winston in the case of safety film, that a satisfactory product was available but was rejected by potential consumers. Acetate-propionate was a lot more expensive than nitrate, and its performance was demonstrably inferior.

If my interpretation of the German connection is correct, then the Nazis had, at the very least, made some progress in developing a more durable safety stock. The fact that (a) Kodak continually opposed the establishment of a British film-base manufacturing facility, (b) the US authorities assisted them in preventing the British from doing so, and (c) Kodak were developing their new acetate stock over an astonishingly short time scale during the same period, would strongly suggest that these events were in some way related.

The widespread use of cellulose acetate-propionate for 16mm illustrated the potential advantages of safety stock, and also the potential drawbacks, such as piracy. But at a time when the film industry was still largely vertically integrated, a 35mm safety base which came close to matching the performance of nitrate offered the possibility for reduced overheads and increased flexibility in the distribution and exhibition sectors, just as the emerging technology of digital projection today offers the possibility of eliminating print manufacture and transport costs. Although, to a certain extent, Winston is right, and the safety precautions associated with nitrate helped Hollywood to regulate the circulation of its films, the

reduction in overheads offered by safety film more than offset any disadvantages in this regard.

References

1. Cricks, R Howard, "Problems of Safety Stock", *Technical Information for Projectionists* (a series of pamphlets issued by the Gaumont-British Kalee corporation, copies available in the BFI National Library), no.6 (1950).
2. Cummins, James W, et al., "Spontaneous Ignition of Decomposing Cellulose Nitrate Film", *Journal of the SMPE*, v.54 (March 1950), pp. 268–274.
3. Fordyce, Charles R, "Improved Safety Motion Picture Film Support", *Journal of the SMPE*, v.51 (October 1948), pp. 331–350.
4. Mees, C E Kenneth, "History of Professional Black-and-White Motion Picture Film", *Journal of the SMPE*, v.63 (October 1954), pp. 125–140.
5. Mitchell, Robert A, "The Film Base: Nitrate and Triacetate Stock", *International Projectionist*, v.25, no.2 (February 1950), pp. 7–9, 32, 34.
6. Pickard, R W, and D Hird, "A Test to Measure the Flammability of Kinematograph Safety Film", *British Kinematography*, v.21, no.3 (September 1952).
7. Pierce, David, "The Legion of the Condemned – Why American Silent Films Perished", reprinted in this volume, previously published in *Film History*, v.9, no.1 (1997), pp. 5–22.
8. Simmons, Norwood L, "Kodak: Innovator Behind-the-Scenes in the Motion Picture Industry", *Communications*, no.70 (April 1970), pp. 9–10.
9. Thiesen, Earl, "The History of Nitrocellulose as a Film Base", *Journal of the SMPE*, v.20 (March 1933), pp. 259–262.
10. "Questions and Answers on Safety Film", *International Projectionist*, v.24, no.8 (September 1949), p. 14.
11. Winston, Brian, *Technologies of Seeing* (London, BFI Publishing, 1998).

Notes

1. Douglas Gomery, "Warner Bros. and Sound", *Screen*, v.17, no.1 (1976), pp. 40–53; Donald Crafton, *The Talkies: America's Transition to Sound, 1926–1931* (New York: Charles Scribner's Sons, 1997) [v.4 of the series "History of the American Cinema"]; and Scott Eyman, *The Speed of Sound: Hollywood and The Talkie Revolution, 1926–1930* (New York: Simon & Schuster, 1998).
2. See Dudley Andrew, "The Post-War Struggle for Colour", in Stephen Heath and Teresa de Lauretis, eds., *The Cinematic Apparatus* (London: Macmillan, 1980), pp. 61–75.
3. See John Belton, *Widescreen Cinema* (Cambridge: Harvard University Press, 1992), passim.
4. Earl Thiesen, "The History of Nitrocellulose as a Film Base", *Journal of the SMPE*, v.20 (March 1933), p. 259.
5. Robert A Mitchell, "The 35mm Projection Positive Film", *International Projectionist*, v.25, no.5 (February 1950), p. 7.
6. Dorothy Knowles, *The Censor, The Drama and the Film* (London: Allen & Unwin, 1934), p. 169.
7. Neville March Hunnings, *Film Censors and the Law* (London: Allen & Unwin, 1967), pp. 48–54.
8. *Manchester Guardian*, 23 November 1939 (source: cutting from microfiche in BFI National Library).
9. *Kinematograph Weekly*, 10 August 1939, p. 5.
10. David Pierce, "The Legion of the Condemned – Why American Silent Films Perished", reprinted in this volume, previously published in *Film History*, v.9, no.1 (1997) pp. 5–22, passim.
11. Brian Winston, *Technologies of Seeing* (London: BFI Publishing, 1998), p. 60.
12. Quoted in Glenn E Matthews and Raife G Tarkington, "Early History of Amateur Motion-Picture Film", *Journal of the SMPTE*, v.64 (March 1955), reprinted in Raymond Fielding, ed., *A Technological History of Motion Pictures and Television* (Berkeley: University of California Press, 1967), p. 130.

13. Ibid., pp. 130–131.
14. Winston, op. cit., p. 75.
15. J M Calhoun, "The Physical Properties and Dimensional Behaviour of Motion Picture Film", *Journal of the SMPE*, v.43 (October 1944), pp. 227–267.
16. Charles R Fordyce, "Improved Safety Motion Picture Film Support", *Journal of the SMPE*, v.51 (October 1948), p. 331.
17. *International Photographer*, v.18, no.3 (April 1945), p. 22.
18. Winston, op. cit., p. 60.
19. *Evening News* (London), 17 September 1946.
20. *Daily Herald* (London), 4 October 1946.
21. Fordyce, op. cit., p. 342.
22. For more on this, see Leo Enticknap, "The Non-Fiction Film in Britain, 1945–51", unpublished PhD thesis, University of Exeter, 1999, pp. 66–70, 85–90.
23. Public Record Office (PRO), London, BT 64/4497, memo dated 18 October 1945.
24. PRO BT 64/4499, cable from the British Air Commission, Washington, DC, to the Ministry of Aircraft Production, 27 April 1945.
25. PRO BT 64/4499.
26. Ibid., Memorandum by the Ministry of Aircraft Production on the Manufacture of Film Base, 7 April 1945, p. 6.
27. Ibid., cable to the Ministry of Aircraft Production, 13 August 1945.
28. PRO BT 64/4497, cable to the Ministry of Aircraft Production, 1 October 1946.
29. Ibid., cable dated 4 June 1947.
30. Ibid., cable dated 2 October 1945.
31. Ibid., memo from the Chemical Industries Branch of the Board of Trade to the Ministry of Aircraft Production, 12 February 1946.
32. Ibid., memo dated 19 March 1946.
33. Quoted in *International Photographer*, v.19, no.4 (April 1947), p. 29.
34. *International Photographer*, v.20, no.10 (October 1948), p. 18.
35. *International Photographer*, v.20, no.6 (June 1948), p. 20.
36. Fordyce, op. cit., p. 332.
37. Ibid., p. 334.
38. Ibid., p. 342.
39. Ibid., p. 345.
40. *International Photographer*, v.20, no.10 (October 1948), p. 18.
41. Ibid.
42. Pierce, op. cit., passim.
43. Dallas Morning News, 15 June 1950, reported in *International Projectionist*, v.25, no.7 (July 1950), p. 30.
44. James W Cummings, et al., "Spontaneous Ignition of Decomposing Cellulose Nitrate Film", *Journal of the SMPTE*, v.54 (March 1950), p. 271.
45. *International Projectionist*, v.24, no.5 (May 1949), p. 18.
46. *International Projectionist*, v.25, no.7 (July 1950), p. 26.
47. Ibid.
48. R Howard Cricks, "Problems of Safety Stock", *Technical Information for Projectionists* (a series of pamphlets issued by the Gaumont-British Kalee corporation, copies available in the BFI National Library), no.6 (1950). Author's emphasis.
49. International Projectionist, v.25, no.11 (November 1950), p. 9.
50. Variety, 24 February 1954, p. 13.