Exploding Teeth, Unbreakable Sheets and Continuous Casting: Nitrocellulose from Gun-cotton to Early Cinema

by Deac Rossell
version: 6 June 2000

[Originally a lecture given at the Congress of the *Fédération International des Archivs du Film*, June 2-7, 2000 during their symposium “And God Created Nitrate....”, at the British Film Institute, London. Then published (with revisions) in *This Film Is Dangerous!*, ed. Roger Smither and Carol Surowiec (Brussels, 2002: International Federation of Film Archives [FIAF]). Text version before FIAF editing for publication.]

I: The Origins of Celluloid

The origins of celluloid lie in the discovery of a method of nitrating cellulose fibres, or, in plain words, soaking cellulose fibres, usually taken from cotton or wood or one of their many products, in nitric acid and adding any one of a number of solvents. This process was first experimentally investigated in the 1830s and 1840s, and led directly to the formation of the field of organic chemistry, the combination of naturally-occurring materials with a solvent or catalyst to produce synthetic materials that do not appear in nature and which have a wide variety of different properties. Two pioneering French scientists conducted experiments in the 1830s which in themselves were only hesitant steps towards the formation of a practical discipline of organic compounds, but which bequeathed the names of their experimental materials to the later history of celluloid manufacture. Henri Bracconot combined nitric acid and potato starch into a material he called “xyloidine” in 1833, and Théophile-Jules Pelouzé used nitric acid and paper to make a material he called “pyroxyline” in 1838.[1]

The first scientist to generate a useful material by combining nitric acid and cellulose, in the form of cotton, was Christian Friedrich Schönbein, a professor at the University of Basle. Distilling sulfuric and nitric acids one day in his kitchen in 1846, his glass bottle broke on the floor, spilling the acids, and in hastily cleaning up the mess Schönbein wiped the floor with his wife’s cotton apron, which he then hung over the oven to dry: instead of drying, it burned up with a smokeless flame.[2]

Schönbein wrote to his colleague Michael Faraday in England on February 27, 1846, that “I have of late also made a little chemical discovery which enables me to change very suddenly, very easily and very cheaply common paper in such a way, as to render that substance exceedingly strong and entirely waterproof”.[3] In a later letter to Faraday written on March 18, 1846, Schönbein included a sample “of a transparent substance which I have prepared out of common paper. This matter is capable of being shaped out into all sorts of things and forms and I have made from it a number of beautiful vessels”.[4]

During this period of intense experimentation with the effects of nitric acid on various forms of cellulose fibres, Schönbein announced, on March 11, 1846, one of his two great discoveries: a powerful new form of explosive that he called nitrocellulose, or guncotton.[5] Quickly patenting his new material in several countries,[6] Schönbein gave exclusive rights for the manufacture of his explosive to John Hall and Sons in Britain, but their factory in Faversham blew up whilst experimenting with Schönbein's new material in July 1847, killing 21 workers, as did factories in France, Russia, and Germany, where experimentation with the militarily valuable new substance was quickly undertaken.[7] As others tried to exploit the explosive power of guncotton, Schönbein continued to experiment with the reaction of acids on nitrated cellulose, and the key reactive solvent that emerged was ethyl alcohol, which produced from a moderately nitrated cellulose a viscous, colourless liquid that, when dried on a flat surface turned into a transparent sheet whose brittleness and strength could be varied according to the proportions of the ingredients in the original mixture. He sent samples of his new material to the eminent chemist J. C. Poggendorf in Germany, who suggested its use as a substitute for window glass, and as a tough and long-wearing replacement for paper in the making of banknotes, evidently forgetting its highly inflammable quality.

By January 1847 Schönbein's flexible, transparent material was proposed as a waterproof and flexible bandage for wounds and for use in medical surgery by the Boston physician J. Parker Maynard. In its liquid form, where it was called collodion,[8] the new material found a significant and lasting use from 1851 as a vehicle for photosensitive emulsions, first suggested by Gustav le Gray, patented by the Boston photographer James A. Cutting,[9] and then developed as a practical medium of photography by Frederick Scott Archer in England in his wet-plate collodion process, or Archerotype.[10] The use of collodion emulsions in photography allowed much shorter exposure times for a photographic subject, an advantage which led directly to the development of "instantaneous" photography and lightweight hand cameras, liberating photography from the confines of the professional portrait studio and allowing photographers to take lifelike pictures in nature. It led as well to the instantaneous series photographs of Eadweard Muybridge, which were made on colliodion wet plates.

As a solid material, nitrocellulose was developed over many years of private experimentation by Alexander Parkes, the son of a brass lock manufacturer in Birmingham, England. He first exhibited his mouldable solid material at the Crystal Palace exhibition of 1862, where he won a bronze medal for the material he called Parkesine;[11] by 1865 he announced publicly that he could make nitrated cellulose into a stable, fully formable material by combining it with any of several plasticizer-solvents. His initial public discussion of Parkesine, at the Society of the Arts in London on December 20, 1865, described his success in "producing a substance partaking in a large degree of the properties of ivory, tortoise-shell, horn, hard wood, india rubber, gutta percha, &c."[12] Parkes then launched a company to mass-produce his new substance in April, 1866, but it was bankrupt by 1868.[13] Again like the initial experimenters thirty years earlier, he left a notable legacy to the subsequent history of celluloid, this time in the form of his works manager, Daniel Spill, who became obsessed with the new material and initiated a lengthy lawsuit against the successful American manufacturers of celluloid lasting from 1876 to 1884, a court action which he lost only when he died of diabetes.[14] From around 1873 Spill was associated with the British Xylonite Company, which had acquired Parkes's patents in 1868 and which ultimately became the sole major British manufacturer of celluloid at the end of the century.

The company that finally found commercial success with the new material was founded in 1870 by John Wesley Hyatt and his brother Isaiah Smith Hyatt in Albany, New York. They called their formable plastic “celluloid”, and incorporated as the Albany Dental Plate Company. Hyatt used a mixture of pyroxyline and camphor in his celluloid, which he saw as a substitute for the hard rubber used by dentists in the false teeth, bridges, and other dental wares of the day.[15] The company struggled until Hyatt, trained as a printer, began to form his teeth (and billiard balls, combs, and other trinkets) under heat and pressure, which created a material that was stable and hard in nearly any shape. Hyatt’s early products used no fillers, and only the “least quantity” of colouring pigments; therefore they were nearly pure gun-cotton, and his billiard balls burned rapidly if touched by a lighted cigar. Hyatt later wrote that “occasionally the violent contact of the balls would produce a mild explosion like a percussion guncap. We had a letter from a billiard saloon proprietor in Colorado, mentioning this fact and saying that he did not care so much about it but that instantly every man in the room pulled a gun.”[16]

When the Hyatt brothers tried to interest a manufacturer of hard rubber goods in their imitation material, and demonstrated their production methods using heat and pressure, the potential customer turned them down with the advice that their new process was so dangerous that they were more than likely to blow themselves up.[17] Recapitalising the business as the Celluloid Manufacturing Company and moving to Newark, New Jersey, in late 1872, the Hyatt brothers worked to continuously improve the manufacturing apparatus for volume production of celluloid, and to explore every avenue of its possible commercial exploitation.[18] John Wesley Hyatt received 61 patents between 1869 and 1891 for various celluloid-related processes,[19] and by 1880 his company had issued licenses to almost two dozen firms engaged in the manufacture of celluloid dental plates, harness trimmings, knife and cutler handles, emery wheels, brushes, shirt cuffs and collars, shoes, piano keys, and a vast range of other items. In both Europe and America, other firms entered the new field that the Hyatts had pioneered, but the manufacture of celluloid, a slight chemical variant of guncotton with fillers added, remained a dangerous and uncertain business, as Hyatt’s record attests: in its first 36 years in Newark, the factory was the site of 39 fires and explosions, which caused at least 9 deaths and 39 injuries.[20]

In the last quarter of the 19th century, celluloid was identified with cheap goods and imitations of the “real thing”. In this respect, Parkes’s failed attempts at mass production of a substance with an imperfectly understood chemistry was fully in line with the thinking of his peers: celluloid was an inferior substitute for more expensive, more scarce, or more intractable natural materials. Compounding this issue of taste and style, which slowed its acceptance in many areas of manufacture, was celluloid’s never-forgotten origin in Schönbein’s guncotton. As early as 1875, the *New York Times* ran an editorial piece on the subject of “Explosive Teeth.” referring to the propensity of celluloid dentures worn by cigar smokers to ignite.[21] In April, 1892, *Scientific American* reported on the celluloid buttons in a dress bursting into flame after its wearer stood for too long near an open fireplace.[22] Yet along with some specialist items and novelties like key rings and soap dishes, two areas of growth opened the doorway to the gradual acceptance of celluloid as a material with its own advantages: its use in shirt collars and cuffs, and in inexpensive toys. With an increasingly urbanized society after 1875, detachable celluloid shirt collars and cuffs became if not quite fashionable (despite the claims of the best advertising campaigns of the era), then at least both practicable and affordable. Troy, New York, became known as “The Collar City” as more than 100 shirt, collar and cuff manufacturers supplied the growing ranks of clerks and middle managers in an era of rapidly expanding business. Coated with celluloid, these collars and cuffs were waterproof and required less frequent washing. Celluloid also found a place in toy manufacture, particularly for the heads, hands and feet of dolls, due to its easily formable qualities.

In 1893 the French inventor Henri Lioret supplied the renowned toymaker Émile Jumeau with a small celluloid disk recording that provided the voice for a talking doll; in 1897 he used celluloid again in his loud-speaking phonograph, intended for public performances where increased volume was required. His patented process used hot water to temporarily soften the surface of the recording cylinder, which could therefore take grooves of greater amplitude than those it was possible to cut in hard wax cylinders, thereby giving his machine a greater amplification of its recorded sound.[23] His Lioretgraph was frequently used on the Continent to accompany film screenings, where the larger halls demanded greater volume.[24] The exception to these passing fancies, and the major lasting use of celluloid, was in the field of photography.

II: Celluloid in Photography and Early Moving Pictures

The emulsion-coated glass plates used by photographers since the decline of the Daguerreotype had many disadvantages. Heavy and awkward to manipulate in both the camera and the darkroom, they were problematic in the studio, but a genuine burden when travelling in the field. They were breakable, had sharp edges, and required spacious storage facilities. Magic lantern showmen also laboured with the double glass enclosures of their transparencies: several boxes of slides added noticeably to the weight and effort of an evening’s entertainment at the town hall or of instruction at the church hall. When Alexander Parkes took out a provisional patent in 1856 suggesting the use of his flexible, unbreakable Parkesine as a replacement for the glass plates used by photographers, his foresight was remarkable as he proposed “substituting for the sheets of glass a sheet of collodion of sufficient thickness to support the prepared film; a thick layer of collodion may be first formed on the glass, and on this layer the film of prepared collodion may be produced, and the picture taken thereon and suitably varnished or protected; afterwards the whole may be stripped from the glass together.”[25] Daniel Spill also suggested the same use of celluloid at a lecture to the London Photographic Society in 1870, proposing that his xylonite could be “a flexible and structureless substitute for the glass negative supports.”[26] Over the next years, several photographers experimented briefly with the new material, including the Frenchmen David and

Fortier, who in the 1880s formed sheets from liquid celluloid poured onto a heated glass plate which was then coated with a gelatine emulsion.[27] But it was not until November 1888 that celluloid became commercially available as a substitute for glass plates, when John Carbutt of the Keystone Dry Plate Company in Philadelphia announced that he was now making emulsion-coated sheets of celluloid for the photographic trade. Carbutt purchased his celluloid from the Hyatts' Celluloid Manufacturing Company, who formed clear celluloid blocks under pressure that they could then slice accurately to a thinness of up to ten one-thousandths of an inch thick on patented machinery.[28] Carbutt's new plates were widely noted in the photographic press, and were advertised for sale in Europe by mail "without fear of breakage" beginning in 1889.[29]

Within a year, the British suppliers E. G. Wood and William England offered their own celluloid plates, as did others in France, Holland, and Germany, but the photographic profession as a whole was rather slow to adopt them, remaining by the tried and true methods of working on glass. In 1888 Walter Poynter Adams proposed an ingenious celluloid film band for use in the magic lantern, where "Gelatin, Algin Compounds and Celluloid are suitable for this purpose",[30] and E. T. Potter made a similar suggestion proposing a continuous band of celluloid lantern slides moved by a clockwork mechanism.[31] But the real breakthrough for the use of celluloid in photography came with the development of roll-film holders for lightweight and amateur cameras.

As exposure times decreased in the second half of the 19th century through new emulsion chemistry, faster lenses and improved shutters, photographers began to widen their subjects to include pictures of people and animals in natural settings, and the advanced amateur photographer sought ever lighter and more transportable photographic equipment. From around the 1880s, there were a plethora of devices suggested or sold for "automatically" changing photographic plates inside the camera whilst it was being carried as a single independent instrument to the beach, the park, or the party.[32] The lasting solution to the portability of cameras able to take multiple images before being returned to the permanent or travelling darkroom was roll film and the roll film holder, which had been experimentally used since the 1850s but was popularised by Leon Warnerke after 1875.[33] At first, the extremely popular roll film system introduced by George Eastman with his Kodak camera in 1888 used paper backing which was removed from the negative emulsion by soaking in a water or chemical bath and then stripping the negative from its opaque backing before securing it to glass for development of the image; with its success Eastman's developing facilities for this stripping film were overwhelmed, and he immediately began looking for a more efficiently handled substitute for his paper backing. After trying solutions of Irish moss, Japanese isinglass and seaweed, among many other substances,[34] Eastman turned to celluloid, which because of its transparency did not need to be stripped from the emulsion during developing. Production of Eastman's new celluloid-backed roll film began in August 1889, with a viscous celluloid "dope" flowed across twelve glass tables each 3 ½ feet wide and 50 feet long. The celluloid was left to dry and harden overnight, and the next day was coated with photographic emulsion. When again dry, the finished film was cut into sheets of various sizes for plate cameras and into strips for roll holders.[35]

Making a suitably thin celluloid sheet, or strip, that could be tightly wound up around the spool of a roll holder required subtle changes in the chemical composition of the material to increase its flexibility. The appropriate solvent for nitrated cellulose in this case was amyl acetate, patented by the chief chemist of the Celluloid Manufacturing Company, John H. Stevens, in the United States in 1882.[36] The first method of producing a very thin clear sheet for roll holders, as distinct from the sliced sheet made by the Celluloid Manufacturing Company that was the basis of Carbutt's photographic celluloid plates, was to flow viscous celluloid over a long glass table, the method used by Eastman but actually first formally noted by the Reverend Hannibal Goodwin, an Episcopalian preacher in Newark, New Jersey, in May 1887.[37] A further production method was introduced by the Celluloid Manufacturing Company in 1891,[38] when they began flowing the celluloid mix over a slowly rotating heated drum c. 6 feet in diameter, producing a large sheet of celluloid that they could supply either cut or uncut to many secondary manufacturers for coating with proprietary photographic emulsions.

That said, the production of a clear and flawless sheet of celluloid by any method was something akin to black magic. As one chemist wrote in a thorough study of the celluloid industry in 1894, "We still do not know today to what process the formation of celluloid is to be attributed."[39] All early photographic suppliers were "out of business" for a period in the 1890s when their key personnel (the dope mixer, principally) changed, or when new market demands (for clear instead of translucent films, for example) caused alterations in their manufacturing processes. There were a variety of problems, none easy to solve without causing another problem to spring up as a result of the altered formula. In the first instance, the cellulose mixture had to be impeccably pure with all un-nitrated fibres removed by filtration and a consistent "mating" of the camphor and cellulose from batch to batch. The consistency of the fluid celluloid needed to be precise, just viscous enough that the material would flow evenly on the glass table but not spill off it; yet it needed to be dilute enough so that it did not blister or crack or trap bubbles or show any other imperfection. The photosensitive emulsion was exceedingly difficult to adhere properly to the celluloid base, while the emulsion itself needed to be consistent in its photographic sensitivity; any adjustments or improvements in the photographic qualities of the emulsion also affected its adhesion to the celluloid. In cutting and removing the finished material from the tables, it was also prone to light flares caused by static electricity and other mysterious defects. In use, roll film had a tendency to curl and twist, owing to the different coefficients of expansion between the celluloid backing and the photographic emulsion, posing yet another problem in both its manufacture and its subsequent handling.

In the early 1890s, apart from Eastman's hand-made supply of specially cut strips of celluloid roll film to the Edison laboratory for experiments on the evolving Kinetoscope, all work on celluloid films was intended for the still camera market.[40] Paul Spehr has meticulously documented the process of evolution of Edison's "35mm", or 1 1/4 inch film, and for the first time revealed that for W. K. L. Dickson and Edison's team in West Orange, as well as for Eastman, the issue of the thickness of the film (which bore on its robustness) was co-existent with the issues of its width and its perforation scheme.[41] But by the middle of 1896 there was clearly a second market for roll film in moving picture work, and a rapidly expanding market with good returns for participating manufacturers. Now, in fact, the market was growing swiftly across Europe, and Eastman was not particularly aggressive in serving this new market until he was persuaded of its size and profitability by his British manager, George Dickman, in June 1896.[42] The British pioneer filmmaker Birt Acres, for example, complained to the Amateur Photographer in October 1897, that the Eastman Photographic Materials Co., Ltd., had earlier told him that it would not be worth their while to manufacture cine film.[43] In these early days, several companies began to manufacture celluloid films for moving picture work, although their number was still very limited due to the immense technical (and physical!) problems of dealing with nitrocellulose.

III: Early Suppliers of Moving Picture Film to 1900

In a field torn with strife over priority, fights which hide varying and often arcane definitions of moving pictures, there can be little doubt that the Eastman Company in Rochester, New York, later the Eastman Kodak Company, was the first supplier of moving picture negative and positive film, through their relationship with the experiments carried out in the Edison laboratory on the Kinetoscope and the Kinetograph camera.[44] The other major American supplier of celluloid roll film for still cameras, and therefore a significant pioneer in supplying early moving picture customers, both at their experimental and production stages, was the Blair Camera Company of Boston, Massachusetts. A rapidly assembled agglomeration of small camera, plate, optical and chemical companies that originated in the Blair Tourograph and Dry Plate Company, founded by Thomas Henry Blair in 1881 and that evolved into the Blair Camera Company, this firm was “the only real competition in the American industry for the market Eastman had created” at the end of the 19th century,[45] and with their Hawk-Eye roll camera thought that they had found a separate line of patents that would not infringe the Kodak patents of Eastman. Blair bought their celluloid from the Celluloid Manufacturing Company in Newark, persuading them to make a thinner sheet on their continuous casting apparatus than had been their usual practise. Using this source of celluloid had the additional advantage of avoiding the patent fight between Eastman and Goodwin; Blair coated their purchased celluloid base with their own photographic emulsion at the factory of the Allen & Rowell Company of Boston, a manufacturer of photosensitized materials including celluloid plates, in which Blair bought a controlling interest specifically to obtain roll film production facilities in August 1890, and Blair began commercial production in late 1891.[46] Blair used a different production method from Eastman’s glass tables, instead flowing the emulsion over a large heated drum in a continuous process that was similar to the way their celluloid sheets were made in Newark. The nitrocellulose from the Celluloid Manufacturing Company had a different chemical composition than Eastman’s celluloid that made it slightly translucent; this made Blair film particularly suited for viewing an image by transmitted light, as in the Kinetoscope, and virtually all Kinetoscope positive prints were made on Blair stock from late 1892 through 1895.[47] The Eastman Company provided negative stock for the Kinesigraph camera, although manufacturing troubles between January 1892 and late 1893 meant that Edison had to turn to other sources. Blair’s production technology was first-rate; when Eastman bought the Blair Camera Company in 1899 during a low point in their history after they had lost patent infringement lawsuits he initiated over their Hawk-Eye roll film camera, he acquired the patents on their production apparatus and converted his production facilities to continuous casting in early 1900.[48]

By that time, Thomas Henry Blair had left the company he had founded in a reorganization initiated by his financial backers in early 1893. Blair then immediately went to Britain, where he founded a new company, the European Blair Camera Company, in April 1893, partially based on his own patents and American contacts, as a Memorandum of Agreement between the new company and the Blair Camera Company of Massachusetts set out the terms under which European Blair would acquire “all the right, title and interest of the Blair Camera Company in and to all letters patent in European countries relating to photography or photographic apparatus....”[49] Here, Blair replicated most of his American firm on European soil, and promptly began the manufacture of celluloid roll film at Foot’s Cray, Kent. European Blair supplied raw nitrocellulose film stock, not always exclusively as experimenters tried many sources in searching for the best materials, to the first experiments of the Lumière Brothers in France, to Birt Acres and Robert Paul in England, to Oskar Messter in Germany, and to most of the other pioneer inventors and filmmakers in Britain and on the Continent. During 1895. Lumière enquired about bulk orders, or even the possibility of manufacturing Blair stock under license,[50] and the Blair agent in Paris, George William de Bedts, who founded the first purely cinematographic company in France in February, 1896, was himself a central figure in early cinema work in 1895-1897, in direct contact with virtually all of the French pioneering figures.[51] With the change from slightly translucent film stock useful for the Kinetoscope to perfectly clear film stock suitable for projection, European Blair changed the formulae for their materials, and again ran into serious problems of adhesion between the emulsion and the celluloid base in 1896 and 1897, but they continued to produce cine film until they finally ceased operating in 1903.[52]

It is my contention elsewhere[53] that the Lumière experiments in moving pictures were originally intended to bring to the market a kind of inexpensive, adaptable, portable moving picture “Kodak”, based on the business model that George Eastman had found so successful in the late 1880s. If so, then the principal Lumière interest was in providing their customers, on an ongoing basis, with raw film stock and positive prints, after the manner of the Kodak system. The supply of photographic plates and materials was their core business and the source of their profits. As the Lumière brothers experimented with the Cinématographe during 1895, they asked Victor Planchon to prepare some celluloid sheets with their own emulsion. Planchon, a photographic supplier who had established the first French photographic celluloid plate manufacturing facility in Boulogne-sur-Mer, already had the Lumière company as a customer for his photographic chemicals. Planchon, like Eastman, flowed his celluloid onto large glass sheets and then added the Lumière emulsion; the entire glass sheet, still with the completed film unstripped, was then transported to Lyon for the Lumières to test.[54] By late 1895, the Lumières and Planchon were contending with the problems that had faced Eastman a few years earlier: difficulties of adhesion between the emulsion and the celluloid base, difficulties of achieving a constant thickness, and difficulties of achieving a consistent mixture from batch to batch. Lumière carefully analysed the Blair stock, and found that it contained about 12% acetanilid, writing to Planchon that "it might be an idea to adopt this ingredient, since American film is much tougher than your samples."[55] As they developed the production methods and the precise chemical formulae for moving picture film, the Lumières launched a new company to mass produce celluloid films that included Jules Carpentier and others as investors; Planchon moved his business to Lyon and by 1903 was managing the Lumières' fifty-acre photochemical plant at Feyzin just outside Lyon.[56]

Lumière was the only major producer of moving picture celluloid film to enter the market without substantial experience in celluloid still camera roll film. Although a number of other small suppliers were active before 1900, the specialized technology of working with celluloid was a great barrier to entry into the market, and the production of moving picture film stock was then, as now, principally in the hands of a limited number of companies. Like the mechanical technology of the cinema, the chemistry of celluloid was also a newly emerging field in the 1890s, and there were many experiments made at the time, although the history of the supply of film stock to early cinema inventors and practitioners is very largely unresearched. The pioneering firm of John Carbutt in Philadelphia offered cine film from at least 1896 and by November 1897, advertised "standard" width film perforated for either Lumière or Edison apparatus along with "French" 60mm width and "Biograph" 2 3/4 inch width, but no substantial work has been done on his moving picture activities.[57] In Germany, the major chemical company Schering produced moving picture nitrocellulose raw stock in both negative and positive rolls in 1897-8, which had "a somewhat soft base and an irregular cut along the sides....but the Directors of the well known firm were at that time shortsighted, and gave up the manufacture of cine film."[58] Perhaps the most interesting early supplier, but also the most mysterious, since no work has been done on the firm by either photographic or cinematographic historians, is Dr. J. H. Smith & Co. of Zürich. Smith was an Englishman who undertook part of his chemical studies in Zürich, and after working for Mawson & Swan in Newcastle-upon-Tyne, returned to Zürich to open a dry plate manufacturing company in August 1889.[59] He was offering cine film to the market at least as early as late 1896, and advertised in March 1897 that "As the demand for these films is very large, and we have a number of orders on hand, it is advisable to place all Orders without delay."[60] Smith's expertise in working with celluloid must have been outstanding, for George Eastman hired his chief chemist, William G. Stuber, in late 1893 during the period when he was having great troubles in producing consistent celluloid products, and had been "out of business" for over 18 months, running through several chief chemists. Stuber brought with him to Rochester not only the expert knowledge and experience which solved Eastman's production problems, but also, by agreement, Smith's patent for an improved coating machine.[61] Smith and his Continental customers are unresearched, but the firm continued as a respected supplier and moved to Paris in 1908.[62]

Coating, cutting, and sometimes the perforation of prepared celluloid was undertaken by any number of additional firms at this time, for while the price of raw stock fell sharply over the period 1896-1900, it had started from such astronomical levels that it was still an extremely expensive item on an exhibitor's or filmmaker's expense list, and provided good opportunities for prescient manufacturers. Before

1900 many filmmakers used multiple suppliers of raw stock, perhaps out of necessity or perhaps tracking the “good” batches that reached the market from manufacturers who always struggled to produce a consistent product. Film pioneer Guido Seeber recalled buying raw stock in 1897-8 from Oskar Messter (who was selling Kodak stock), from Lumière in Lyon, from Philipp Wolff in Berlin (who was probably selling Lumière stock), from European Blair in London and from Smith in Zürich, along with Schering in Berlin.[63] The secondary market of manufacturers offering purchased celluloid coated with their own proprietary emulsions is also unresearched territory, but a few firms can be mentioned. In Britain alone, apart from European Blair and Eastman (who produced their own celluloid base), the firms of E. H. Fitch & Co., Marion & Co., The Reliance Roller Film & Dry Plate Company and Birt Acres’ Northern Photographic Works were supplying coated cine film in 1897.[64]

Today, celluloid is principally identified in the public mind with moving pictures, as scores of book titles, from *Celluloid Sacrifice* to *Celluloid Weapon* to *Celluloid Dreams*, attest. But physical material itself long ago lost its economic importance and technical distinctiveness; when the word “celluloid” is used today (including references to the cinema) it is only the idea of celluloid that survives, since the material itself is almost never present in the things to which we refer. Archivally preserved nitrate film is one of the few substantial stocks of celluloid that survives, outside a few specialist collections of antique celluloid toys, boxes, and trinkets. Celluloid was the first synthetic plastic, the first practical material from a new chemical industry that with Bakelite in the 1920s and the development of acetate and polymer plastics in the next decades would come to represent, not only for the young Dustin Hoffman, an all-pervasive aspect of the modern world. Not only does celluloid remain an important metaphor for the movies, conjuring up a world of imitations, hopes and aspirations, but nitrate film also remains fixed in the public consciousness as the most dangerous aspect of the first decades of moving pictures.

Appendix: Some Notes on Nitrate and Early Movie Fires

But was nitrate film really so dangerous in the years before 1900? Or is its explosive reputation just an unexamined assumption? Can a study of early nitrate fires help tell us something new about early film history? Can their study help reveal previously unseen dynamics of early cinema?

A few tentative notes drawn from ongoing research suggests that much more work needs to be done on the history of early cinema fires, and suggests as well that there is little empirical foundation for most of the statements made about the dangers of nitrate film in the pioneering years. The highly volatile nature of nitrocellulose based film, and its extreme inflammability, are noted above and are known to all who handle nitrate film. But it is most curious that very few reports of cinema fires are to be found in relation to the large number of reports of film exhibitions between 1896 and 1900. To take a very specific example, in examining the German showman’s magazine *Der Komet* in the late 1890s, only some 6 cinema fires are noted, amongst notes on some 800 film screenings in theatres, markets, festivals and the like. Of these 6 fires, two were caused by arson in the middle of the night, two were caused by exploding lamps, one is only reported as a fire, and one was caused by an electrical short-circuit in the projection apparatus, which had been rented from an established showman by an inexperienced local barkeeper.[65] The fire in Stargard at the end of May 1899, initiated a long debate in *Der Komet*: three booths were burned out and well before the fire, as the Schützenfest was being set up, their proprietors had complained to the local authorities that the booths were too closely situated and that for safety there should be space between them. The local organizers refused to reposition the booths, evidently on the grounds that they could have more rental income from packing in their exhibitors, and *Der Komet* railed against greedy committees that placed maximising their income over the safety of the public (and of the exhibitors).[66] Certainly all of these fires were aided and supported by the inflammable qualities of nitrate film, but only one is (possibly) caused by the nitrate film, and even so, this is relatively a very small count of fires in relation to the number of film exhibitions recorded in *Der Komet* in these years.

There is a likely cultural explanation for this scarcity of cinema fires, especially fires originating from nitrate film: *Der Komet* was a professional journal, and the exhibitors that it noted were almost exclusively professional showmen used to handling exotic materials safely, not least to protect their substantial investments in expennsive and elaborate travelling booths and show apparatus. Most of these exhibitors had long experience with potentially dangerous machinery or materials, from magic lantern projections, which often used the same volatile illuminants, to with portable frying ovens, giant swings, and other inflammable or potentially lethal apparatus. So perhaps their careful treatment of nitrate film was a professional habit that helped reduce the risks of handling inherently volatile nitrate film stock.[67]

At the same time, it is also clear that the new profession of cinema exhibitor, in these early days perhaps better described as travelling cinema exhibitor, offered an opportunity for many inexperienced amateurs to enter showbusiness. As it did in other fields, a new technology, this time that of moving pictures, created a disruption which provided “non-professionals” with access to a previously stable profession. One unexplored theme of early film exhibition is the differential between experienced showmen and this influx of newcomers, not only around the issue of safety but also in the undervalued area of “showmanship”: promotion, advertising, presentation and organization. “The Era of Travelling Exhibition” has for too long been seen as an homogenous period characterized only in relation to “fixed” exhibitions in theatres, nickelodeons and purpose-built facilities; in reality, early travelling exhibitors had an extremely wide range of experience and competence, with the large booths that travelled a circuit of the major fairs, markets, and festivals usually the property of families with generations of experience in entertainment.[68]

Novice film exhibitors were encouraged by many different manufacturers of early cinema apparatus; besides the well-known and partially studied firms like Lumière and Biograph (who did not sell their apparatus at first), or Edison, Messter, Pathé, Paul, Watson, etc., etc., many other firms quickly assembled projection apparatus, which was relatively simple to do mechanically, and offered “complete kits”, which included a projector, a lamp, and five or six films. “Everything you need to make a lot of money fast” was the phrase of one firm’s advertising[69], and others echoed this sentiment, as dozens and dozens of companies jumped into a new market during

1896: Wolff, deBedts, Lubin, Riley Brothers, Roebuck, Foersterling, Amet, Newton, Hesekiel — this list is very, very long. And some firms in the first list also strongly encouraged non-professionals as they sought to expand their sales in a fast-moving business that few expected to last.[70] For many of these new exhibitors who bought a "complete outfit", it was like sending children off to play with nitroglycerine. Some of these newcomers, for reasons of inadequate showmanship or perhaps unrecorded accidents, quickly left the moving picture business, as a large number of advertisements — again from *Der Komet,* and again virtually unresearched by historians — appear from late 1896 and over the next few years offering projection apparatus "complete with six films" that were "only used one week", or "only slightly used."[71]

Was inflammable nitrate film in use on the fairgrounds, in the markets, in church halls, hotels, pubs, and assembly rooms, any more dangerous to the public than many of the cookers, lantern exhibitions, ghost shows, and other amusements of the day?

A closer study of the dynamic between experienced showmen and novice exhibitors, a closer study of the actual occurrences of nitrate fires, a closer study of the targeted advertising of a wide range of manufacturing companies, and a closer study of fires in a variety of entertainment locations – theatre fires, magic lantern fires, cooker fires, steam engine fires, electrical fires — is needed before there is a better understanding of exactly what role the flammability of nitrate film stock played in determining the early course of moving picture exhibition and the social acceptance of the cinema. Of course, to the public at large the cultural associations of nitrocellulose with exploding teeth, burning buttons, and destructive gun-cotton was very present, and the extraordinarily tragic events at the Paris Charity Bazaar were enough to confirm all of their latent suspicions, and to cause the authorities in many cities, states, and countries to act. Only through a better examination of the historical record of early cinema fires, and particularly an examination that places these in the context of 19th century theatrical, magic lantern, and other entertainment fires, can the true impact of the tragic events at the Société Charité Maternelle on May 4, 1897 be properly assessed. As well known as this catastrophic fire is to film historians, its impact on moving picture work, especially in the light of its remarkable world-wide press coverage, has been severely underestimated. The Paris fire was one of those rare cultural events whose impact was far more decisive even than the scale of its tragedy; while the event is noted by most film historians and most describe its "consequences" to the emerging film industry, very little rigorous work has been done on this event, leaving an important element of early cinema reception unexamined and open to widely divergent interpretations and myth-building. Especially given the cultural identity of the nitrocellulose base of moving picture film, there is a real need for accurate research in this area, as well as for a precise study of how, and why, the Paris fire became the rare international media event that it did. This is a decisive case study for the political, social, cultural and popular reception of moving pictures, and without a clear and informed analysis of this event and the context in which it occurred, many of today's questions and debates about moving pictures will remain prone to superficial interpretations.

ACKNOWLEDGMENTS

This work is dedicated to Katharine Stone White, a member of the original staff of the Film Library at the Museum of Modern Art and the founder of film programmes at the Worcerster Art Museum and the Museum of Fine Arts, Boston, where she was my predecessor and mentor for many years. For help with the content of this article I again thank generous colleagues with whom the exchange of information and opinion has been invaluable, including Stephen Bottomore, Thomas Ganz, Colin Harding, Michael Harvey, Stephen Herbert, Martin Loiperdinger, Susan Mossman, and Paul Spehr.

NOTES

1.Pyroxyline came to be a synonym for crude cellulose hexa-nitrate, or guncotton. As a material, it retained the form and appearance of cotton. Xyloidine in later years lost its exact definition, but survived in altered form as Daniel Spill called his material xylonite, which was then used in the name of the major British manufacturer, the British Xylonite Company, Ltd. The name "celluloid" was first applied to pyroxyline plastics by Isaiah Smith Hyatt in the 1870s; the Hyatt brothers trademarked this name in the United States and it was legally used only by their companies, leaving their American competitors to go back to variants of pyroxyline or xyloidine.

2. In some versions of this story, Schönbein had been prohibited by his wife from conducting experiments in her kitchen, and grabbed at the cotton apron in a panic from being discovered. In other versions, he could not find a mop, and used the nearest cloth, the cotton apron. In either case, this was not so much the case of an "accidental discovery", but rather an accident which produced an odd result: the smokelessly burning apron, a result which the good scientist then explored methodically in his laboratory.

3. Georg W. A. Kahlbaum and Francis. V. Darbishire, eds., *The Letters of Faraday and Schönbein* (Basle/London, 1899: Williams & Norgate), p. 153.

4. *ibid*., p. 155.

5. Schönbein's other discovery was the allotropic form of oxygen (0_3), which he discovered again by following his curiosity: this time of the odd smell that lingered around electrical apparatus. He named his discovery after the Greek word for smell (*ozon*), ozone.

6. John Taylor [agent for Christian Frederick Schönbein], *Improvements in the Manufacture of Explosive Compounds*. UK patent 11,407 of 1846; filed October 8, 1846, issued April 8, 1847. Christian Frederick Schönbein, *Improvement in the Preparation of Cotton-Wool and Other Substances as Substitutes for Gun-Powder*. US patent 4,874. Issued December 5, 1846.

7. Schönbein's guncotton was finally tamed by Frederick Abel and James Dewar towards the end of the century, and was in use for many years as cordite, or Poudre B.

8. Collodion is made from weakly nitrated cellulose (less than 10%) diluted with a 1 to 1 mixture of alcohol and ether.

9. James A. Cutting, *An Improved Process of Taking Photographic Pictures upon Glass, and also of Beautifying and Preserving the Same*. UK patent 1638 of 1854. Filed July 26, 1854.

10. Frederick Scott Archer, *Certain Improvements in Photography*. UK patent 1914 of 1855. Filed August 24, 1855.

11. Parkes's 1862 exhibition materials survive, the oldest known celluloid objects, in the collections of the Science Museum, London. They include buttons, medallions, a letter opener, pill cases and other objects that were either pressed from moulds or hand carved.

12. Robert Friedel, *Pioneer Plastic: The Making and Selling of Celluloid* (Madison, 1983: University of Wisconsin Press), p. 8.

13. While the story of Parkes's failed attempt to exploit Parkesine is noted in several film histories, it is important to point out that Parkes was a prolific inventor who lived entirely from the sale of rights to his more than sixty patents in metallurgy, electroplating, and organic chemistry. He invented a process of desilverizing lead that was widely used long into the twentieth century, as well as methods for making seamless tubes and printing rollers. "More fortunate than many inventors," one biographer wrote, "this life of intellectual adventure never reduced him to penury" (J. B. Goldsmith, *Alexander Parkes, Parkesine, Xylonite and Celluloid*. Manuscript, 1922, British Library, London, p. 36). Parkes was unsuccessful in launching his celluloid plastic as a marketable substance, as he tried to mass-produce the new material using the cheapest cotton remnants available, which contained many impurities, such as husks and pieces of wire. Due to these impurities and Parkes's imprecise understanding of the chemistry of making the new material, the quality of Parkesine varied widely from batch to batch, and he failed in his attempts to make imitation ivory and pearl goods, including knife handles, earrings, piano keys, pens, buttons, combs, and all sorts of inexpensive consumer goods, plus his attempts to develop industrial uses such as insulating material for electrical wires and telegraph poles, gear wheels, and various components of spinning machinery. Parkes returned to the metals industry after 1868, but new research shows that he took up work on Parkesine and celluloid plastics again in 1881, after his original patents had expired, founding the London Celluloid Company with his brother Henry. This second company was also unsuccessful. See S. T. I. Mossman, "Parkesine and Celluloid", in: S. T. I. Mossman and P. J. T. Morris, eds, *The Development of Plastics* (Cambridge, 1994: Royal Society of Chemistry), pp. 9-25.

14. Daniel Spill had originally come to Parkes to negotiate a contract for the use of Parkesine to improve the waterproof properties of textiles produced at his brother's factory. Spill patented many solvents for the nitric acid/cellulose reaction, including the one that turned out to be the most important solvent, camphor, and also re-patented several of Parkes's original solvents and ideas, causing Parkes, at one point in the lengthy American court proceedings, to testify against his former manager. Spill's long court battle most likely dissuaded some potential manufacturers of the new material from entering the field, at least in America, an inhibition on the rapid development of the material that was later parallelled by the long-drawn–out litigation between Hannibal S. Goodwin (and his heirs) and George Eastman over the production of celluloid roll film.

15. Hyatt's original experiments were encouraged by a prize of $10,000 offered by the Phelan & Collender company in New York for patent rights in any suitable substitute for ivory in the manufacture of billiard balls, and his first celluloid-related patent was for a collodion/celluloid billiard ball (John W. Hyatt, Jr., Improved Method of Making Solid Collodion. US patent 91,341. Issued June 15, 1869.). Parkes had taken out a British patent for billiard balls made of Parkesine in 1868.

16. John Wesley Hyatt, speech on accepting the Perkin Medal, In: *Journal of Industrial and Engineering Chemistry,* Vol. 6 (1914), pp. 158-9.

17. Friedel, *op. cit.*, p. 15.

18. There is a curious compliment to the commercial success of the Hyatts in a note made by Alexander Parkes in 1881: "I believe that the American Celluloid company [*sic.*] have greatly extended and forced this manufacture, and by their spirit and Ability have created a large and Profitable business in the United States, " Parkes wrote, continuing "but this manufacture only commenced long after I established the original works in London about the year 1864 or 5...." See S. T. I. Mossman, "Parkesine and Celluloid", *op. cit.* (n. 12), p. 21. I am indebted to Susan Mossman for referring me to this article.

19. Friedel, *op. cit.,* p. 56-58.

20. *ibid.*, p. 96. A number of other companies began to manufacture celluloid in the 1870s and 1880s, but by 1890 the only serious competitor to the Celluloid Manufacturing Company in the American market was the Arlington Manufacturing Company of Arlington, New Jersey, making a product they called “pyralin”. Arlington was prominent in supplying celluloid collars and cuffs, and was taken over in 1915 by E. I. du Pont de Nemours and Company. See Friedel, *op. cit.*, pp. 68-70.

21. *The New York Times,* September 16, 1875, p. 4. Stories of cigar smokers casually igniting celluloid must have been widespread as an urban legend at the time, for its physical possibility is hotly denied in Fr. Böckmann’s 1894 *Das Celluloid, seine Rohmaterialien, Fabrikation, Eigenschaften und technische Verwendung* (Zweite, gänzlich umgearbeitete Auflage; Wien/Pest/Leipzig, 1894: A.. Hartleben’s Verlag), pp. 5-6.

22. *Scientific American* 66 (1892), p. 208.

23. V. K. Chew, *Talking Machines* (London, 1981: Her Majesty’s Stationery Office [Science Museum, London]), p. 61-2.

24. Many early film showings were either accompanied by gramophone performances or were combined with them, with the gramophone playing between films whilst the operator changed pictures. Although patented by Thomas Alva Edison in 1877, his phonograph (and those of other inventors) only went into widespread public use in 1895-6 after the failure of attempts to rent it to business customers as a dictating machine. So recorded sound reproduced by the phonograph was a public entertainment novelty just as moving pictures were born, and the combination of the two new devices was a common entertainment presentation. Sufficient amplification of sound for these performances was always a problem, and several manufacturers introduced special models for use in public exhibitions: Edison produced a duplex phonograph in 1896 using two large horns, the Columbia Phonograph Company issued an instrument with three horns and soundboxes in 1900, and with four of each in 1904. For brief descriptions, see V. K. Chew, *op. cit.*, pp. 62-6.

25. Alexander Parkes, Provisional UK patent 1123 of 1856. Not issued. Parkes abandoned the patent. The suggestion of Parkes is not so far away from the famous stripping film of George Eastman that made a success of his Kodak camera system.

26. Friedel, *op. cit.*, p. 91.

27. Colin Harding, “Celluloid and Photography: Part One — Celluloid as a Substitute for Glass”“, In: *Photographica World* 75 (December 1995), p. 23.

28. John W. Hyatt, Jr., *Method of and Means for Holding Celluloid and Dividing It into Sheets*. US patent 301,995. Filed on June 10, 1884. The cutting process inevitably left minuscule grooves in the surface of the celluloid, which as a result was not perfectly clear and degraded slightly its photographic quality in relation to glass.

29. Advertisement, *British Journal Photographic Almanac*, 1889, p. 845.

30. Walter Poynter Adams, *Improvements in Magic Lantern Slides and Apparatus in Connection therewith*. UK patent 16,785 of 1888. Filed November 19, 1888.

31. E. T. Potter, Provisional UK patent 14,171 of 1888. Filed October 2, 1888. Abandoned, not issued.

32. See, for example, Arthur S. Newman’s bag changer of 1886 which allowed the hand manipulation of multiple plates without removing the plate holder from the back of the camera; the falling-plate cameras of E. V. Swindon of 1887 and the Lumière “Automatique” camera of 1890, both of which held multiple plates vertically for exposure, which then fell to the bottom of the camera case and stacked horizontally; or Krügener’s Simplex camera of 1893, where cut films interleaved by a zig-zag paper band were drawn around the corner of the camera back after exposure and stacked in the top of its case. Many other types of multiple plate holders and mechanisms were brought to the market; see Brian Coe, *Cameras. From Daguerreotypes to Instant Pictures* (Gothenburg, 1978: Nordbok), Chapter 6.

33. Early roll holders were suggested by Joseph Blakey Spencer and Arthur James Melhuish in 1854, and by Humbert de Molard and J. H. Barr in 1855. Some used strips of calotype paper pasted together, others a silk band or black calico with the sensitive paper pasted to it. For a detailed history of both these early experiments and the introduction of mass market roll holder cameras by Eastman and others, see Brian Coe, *Cameras. From Daguerreotypes to Instant Pictures* (Gothenburg, 1978: Nordbok), Chapters 7 & 8.

34. Jenkins, op. cit., p. 127

35. Demand for celluloid roll film was initially very high, and by June 1891 Eastman had a new facility making film on 12 plate glass tables each 200 feet long. To supply European customers, who initially got one-third of the Rochester production, a new Eastman factory was opened at Wealdstone, just outside London, which made 960 linear feet of film a day on 12 glass tables 80 feet long and 42 inches wide. Good surveys of Eastman's production are in Jenkins, op. cit., pp. 122-133. and Harding, "Celluloid and Photography. Part Two — The Development of Celluloid Rollfilm", in: *Photographica World*, No. 76 (March 1996), pp. 34-36.

36. John H. Stevens, *Manufacture of Compounds of Pyroxyline or Nitro-cellulose*. US patent 269,340. Filed June 12, 1882.

37. When Eastman and his chief chemist Harry M. Reichenbach applied for their two patents on the method and the material, the patent examiner noted that the applications by Eastman and Reichenbach interfered with each other, and that both interfered with Goodwin; the subsequent patent battle lasted from 1889 until 1914, over a decade after Goodwin's death. Goodwin's heirs won the case, aided substantially by the photographic wholesalers Anthony and Scoville (later Ansco), who bought up Goodwin's rights and his small Goodwin Film & Camera Company from his heirs. For the year and a half remaining on Goodwin's patent, Eastman paid GF&CC $5 million for a license; other smaller infringing manufacturers paid just over $300,000. Like Edison's use of his broadly written patents to harass other filmmakers in the same period, this case shaped the later history of the manufacture of celluloid roll film for both still camera and movie use, inhibiting substantial investment in its manufacture by companies not a party to the fight. For the entire story of this case, see Jenkins, op. cit., pp. 125-30, 146-47, 156-58, 248-51, 332-35. The patents are: George Eastman, *Improvements in Flexible Photographic Film*. US patent 306,284. Filed April 9, 1889. Harry M. Reichenbach, *Manufacture of Flexible Photographic Films*. US patent 417,202. Filed April 9, 1889. Hannibal Williston Goodwin, *Photographic Pellicule and Process of Producing Same*. US patent 610,861. Filed May 3, 1887, issued September 13, 1898.

38. J. H. Stevens & M. C. Lefferts, *Process of Manufacturing Pyroxyline Sheets*. US patent 600,824. Issued March 15, 1898. John H. Stevens was the longstanding principal chemist in Newark, and Marshall C. Lefferts was the son of the Celluloid Manufacturing Company's director and later president of the company himself. Although they applied for their patent on an improved continuous casting apparatus in 1891, the conversion of Newark production in that year is very likely the result of the Celluloid Manufacturing Company's purchase of the small American Xylonite Company of North Adams, Massachusetts, formed in 1882 to exploit Daniel Spill's patents in America; they used a continuous casting apparatus designed by Mowbray which considerably reduced the cost of manufacture. See Fr. Böckmann, *Das Celluloid* (n. 21), pp. 36-43.

39. Dr. Fr. Böckmann, *Das Celluloid,* (n. 21) p. 47. Böckmann's book, first published in 1891, was a standard work with at least six editions through 1920, an English translation of the 3rd edition in 1907, and a later English edition in 1921.

40. The hugely increased amateur photography market that followed the introduction of the Kodak system had yet another effect on the manufacture of celluloid, since celluloid covers for photograph albums and standing celluloid photograph frames, often elaborately decorated, became a popular addition to many households. For samples of these, see Joan Van Patten and Elmer & Peggy Williams, *Celluloid Treasures of the Victorian Era* (Paducah, KY, 1999: Collector Books), esp. pp. 64-127.

41. See Paul Spehr, "Unaltered to Date: Developing 35mm Film", In: John Fullerton & Astrid Soderbergh Widding, eds., *Moving Images: From Edison to the Webcam* (Sydney, 2000: John Libby Co.). It is interesting to note that probably no pioneering cinema inventor other than the renowned Thomas Alva Edison had the standing to engage such individual attention from another outstanding and market-leading firm whose supplies, and the alterations in them, were so important to the evolution of his work. Although there were relationships between some inventors and some suppliers, the most prominent being between the Lumières and Victor Planchon, pioneers like William Friese Greene, Robert Paul, Max Skladanowsky, Oskar Messter, Henri Joly, Léon Gaumont, the Lathams or Jenkins & Armat just did not have the standing or the access to technologically leading firms to replicate the kind of remarkable collaboration that Spehr documents between the Edison laboratory and the Eastman factory.

42. I am indebted to Paul Spehr for this comment; Letter (Email) 9 May 2000, Paul Spehr to Deac Rossell. Dickman was evidently passing up orders for moving picture celluloid, especially from France, and pressured Eastman into focussing on this new market. In part, Spehr relates, Eastman also saw a threat that Blair could use his extensive supply of cine film as a lever to begin competing against the Kodak in the at the time more profitable still camera roll film market.

43. Letter of Birt Acres, *The Amateur Photographer*, 1 October 1897, p. 277.

44. Again, I recommend here Paul Spehr's precise account of the work between Edison and Eastman. There was some "pre-cinema" use of celluloid films or transparencies by the chronophotographers. Étienne-Jules Marey began using paper-backed roll film in October 1888, changing over to celluloid strips obtained from Georges Balagny in 1890. Ottomar Anschütz was using celluloid transparencies in his Schnellseher automat manufactured by Siemens & Halske by 1892, which drastically reduced the centrifugal forces on his spinning disk, although he probably used glass plate picture carriers in his earlier models.

45. Jenkins, *op. cit.* p. 134.

46. Jenkins, *op. cit.*, p. 138.

47. Charles Musser, *The Emergence of Cinema. The American Screen to 1907* (New York, 1990: Charles Scribner's Sons), p. 72 & 81. In the Kinetoscope, the moving film was illuminated from underneath the band, with the viewer's eyes above the band, necessitating a slight diffusion of the light across the film frame.

48. Jenkins, *op. cit.*, p. 181.

49. Public Record Office (London), BT31/5568/38433, Ref 6406, *Agreement between Thomas Henry Blair and the European Blair Camera Company*, p. 1.

50. Letter of Louis Lumière to Fuerst Brothers, London, 19 November 1895, In: Jacques Rittaud-Hutinet, ed., *Letters. August and Louis Lumière* (London/Boston, 1995: Faber & Faber), p. 47-8.

51. On the interesting career of de Bedts, see Laurent Mannoni, "George William de Bedts et la commercialisation de la chronophotographie", In: Lagny, Marie, Gili & Pinel, eds, *Les vingt premières années du cinéma Français* (1995: AFRHC).

52. From c. 1900 Charles Urban was a shareholder of the European Blair Camera Company, and it is likely that he used European Blair as a major source of film stock for his expanding filmmaking and distribution business. When European Blair closed in July 1903, the Whetstone Photographic Works of Birt Acres, his successor firm to the Northern Photographic Works, picked up some of the European Blair customers, including that of Maguire & Baucus, Ltd.

53. See Deac Rossell, *Living Pictures. The Origins of the Movies* (Albany, 1998: State University of New York Press), pp. 133-39, or Deac Rossell, "Die soziale Konstruktion früher technischer Systeme der Filmprojektion", In: *KINtop* 8 (1999), pp. 53-82, esp. pp. 71-5.

54. Rittaud-Hutinet, *op. cit.*, p. 39-43.

55. Rittaud-Hutinet, *op. cit.*, p. 86-87.

56. It is my view that the very late public demonstration of the Cinématographe, on December 28, 1895, which happened as is well known at the urging of Antoine Lumière, is a consequence of the difficulties of achieving production of celluloid film stock: Auguste and Louis wanted to have the complete commercial system ready before they publicly demonstrated their hardware.

57. Advertisement in *The Phonogram*, November 1897, p. 9. “Standard” width film sold for 5 cents per foot unperforated, the Demenÿ “French” 60mm width for 9 cents per foot, and the Biograph 10 cents. Perforated film was one cent per foot more. I am indebted to Paul Spehr for this information. The inclusion of “Biograph width” stock is particularly interesting, since at this time the Biograph apparatus was not for sale but was installed under contract in leading variety theatres. It is a fair assumption that the American Mutoscope and Biograph Company was one of Carbutt’s customers, and that this advertisement was just written up without really thinking through that no potential customer could order raw film for a Biograph camera other than AM&B itself. By exclusively using still camera roll film, which was cheaper than “cine” film (and which Eastman complained about bitterly, trying to get Biograph to order their special moving picture film), Biograph ensured that its supply of raw stock could come from several manufacturers, and not be cut off as a consequence of their patent fights with Edison. See Deac Rossell, “The Biograph Large-format Technology”, In: Luke Mckernan and Mark van den Tempel, eds., *Griffithiana* (special issue), forthcoming, Pordenone 2000.

58. Guido Seeber, “Die ersten Jahre...”, In: *Filmtechnik*, Nr. 18 (1927), p. 329. The firm Actien-Gesellschaft für Anilin-Fabrikation (Agfa) only began making celluloid film for moving pictures in 1906.

59. René Perret, *Frappante Ähnlichkeit* (Brugg, 1991: BEA & Poly-Verlags Ag), p. 100. My thanks to Thomas Ganz for this reference.

60. *The Photographic Dealer*, March 1897, p. ix. My thanks to Colin Harding for this information.

61. Jenkins, *op. cit.*, p. 154.

62. Perret, *op. cit.*, p. 100. Smith’s high reputation was particularly in the field of quality dry plates and photographic paper; he also experimented at length with colour photographic processes.

63. Guido Seeber, *op. cit.*, p. 329.

64. John Barnes, *The Rise of the Cinema in Great Britain* (London, 1983: Bishopsgate Press), p. 25. Fitch & Co. were described in 1897 as “the well-known pioneers of celluloid films in this country” and may have been making their own celluloid. Additionally, Philipp Wolff had an office in London to supply the British market, as did Dr. J. H. Smith, while Lumière was represented by Fuerst Brothers and had as their customers Robert Paul, Cecil Hepworth, George Cricks, and Charles Urban. See Colin Harding, “Celluloid and Photography. Part Three – The Beginnings of Cinema”, In *Photographica World*, No. 77 (June 1996), p. 11.

65. Briefly, the fires were: at the Schützenfest in Stargard, where a lamp exploded during the last showing and burned out three entertainment booths, severely damaging Hartkopf’s Museum, Kleeberg’s Panorama, and Schuster’s Kinematograph (*Der Komet*, Nr. 741, 3.6.99, p. 6); at the Georgmarkt in Saarunion, where the explosion of a lamp burned out the booth of Mr. Huff (*Der Komet*, Nr. 736, 29.4.99, p. 8); at Neuilly where fire broke out at 3 am two hours after the show was closed and turned out to be a case of arson (*Der Komet*, Nr. 746, 8.7.99, p. 3); at Utrecht, where Hermann Fey’s booth was destroyed by arson in the middle of the night (*Der Komet*, Nr. 749, 29.7.99), at the Markt in Offenburg, where Herr Bantleon’s booth burned completely *(Der Komet*, Nr. 809, 22.9.00, p. 6), and at Retsal, where an electrical short in the projector burned out the booth of C. Leilich which had been rented by an inexperienced operator, a local publican (*Der Komet*, Nr. 816, 10.11.00, p. 8). Another reported fire burned out a Mutoscope exhibition in Hamburg at the Weinachtsbazaar, when an arc lamp in the adjoining photographer’s booth ignited his cloth backdrops (*Der Komet*, Nr. 821, 15.12.00, p. 7).

66. See *Der Komet*, Nr. 741, 3.6.99, p. 6; *Der Komet*, Nr. 745, 1.7.99, pp. 2-3; *Der Komet*, Nr. 746, 8.7.99, p. 3.

67. For a strikingly similar British example, with an equal scarcity of nitrate fires in professional travelling shows from the period 1908-1913, see Vanessa Toulmin's contribution to this volume.

68. For a preliminary discussion of various types of travelling exhibitors, and an overview of international bibliography on the subject, see Deac Rossell, "A Slippery Job: Travelling Exhibitors in Early Cinema", In. Vanessa Toulmin and Simon Popple, eds, *Visual Delights: The Popular and Projected Image in the Nineteenth Century* (forthcoming, Autumn 2000: Flicks Books, Trowbridge).

69. Advertisment for projection apparatus made by the H. O. Foersterling & Co. in Berlin, from *Der Komet*, 25 July 1896.

70. Oskar Messter, for example, offered in 1898 and 1899 a wide range of apparatus at various prices, including Model 97 "for families" at 150 Marks; a portable travelling Kinetograph "for public exhibitions" at 300 Marks, and an Amateur Kinetograph "for taking and projecting Living Pictures" at 200 Marks. Experienced professional exhibitors used his new Thaumatograph sold at 686 Marks, or the Kinetograph-Messter System "Apollo", which sold for 622 Marks. Data from Ed. Messter, *Berlin, Special-Catalog über Projections- und Aufnahme-Apparate für Lebende Photographie (Special-Catalog No. 32)*, Berlin, 1898 (Reprint edition, 1995: Stroemfeld/Roter Stern, Frankfurt am Main/Basel. =KINtop Schriften 3), pp. 15-26.

71. See, for example, anonymous advertisements in *Der Komet*, Nos. 617 (16.1.1897), 715 (3.12.1898), and 774 (20.1.1900).