The Digital Projection of Archival Films Project: Phase One

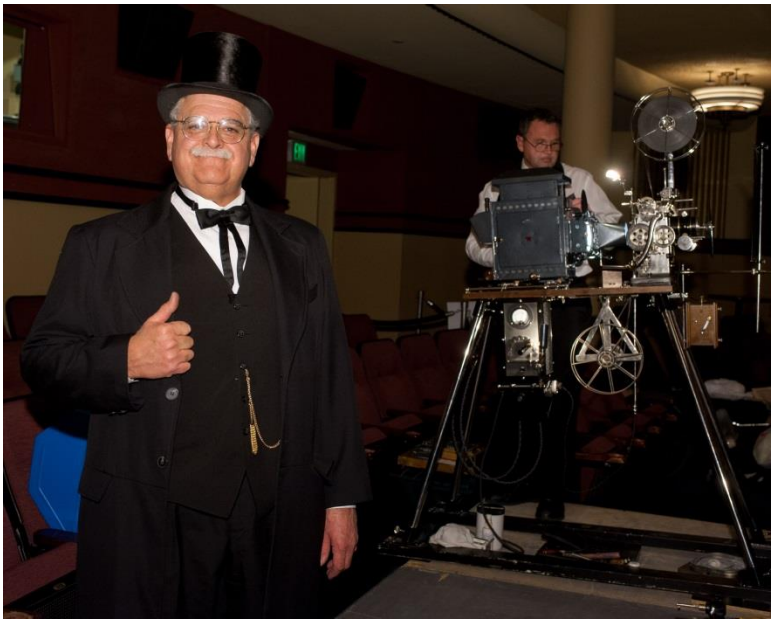
Jonathan Erland, President
Pickfair Institute for Cinematic Studies

Under the aegis of the non-profit Pickfair Institute for Cinematic Studies, the Digital Projection of Archival Films Project is an ad hoc special interest group having the goal of facilitating the digital projection of archive films in their original frame-rates with the inclusion of projector shutter periods. Besides a number of Academicians and industry professionals, participants include such industry institutions as FotoKem, Qube Cinema, the Academy Film Archive and Texas Instruments.

Even before the advent of digital projection, the presentation of silent era films entailed substantial difficulty. Conversion to the conventional sound speed of 24 frames per second produced woefully inadequate results. Simply speeding the projection from the teens to sound speed distorted the cadence or "temporal ambience" of the scene (though this was sometimes precisely what was intended for the original production!) Optical step-printing, while correcting the "pace," introduced visual artifacts.

As Kevin Brownlow observed in, "Silent Films: What Was the Right Speed:"

> They could stretch-print the film – by using an optical printer, they could print every third frame twice to give the equivalent of 16 fps – but this only increased the problem. 16 fps was too slow for most silent films, and the stretching tended to give the action a hiccup effect which was most distracting.

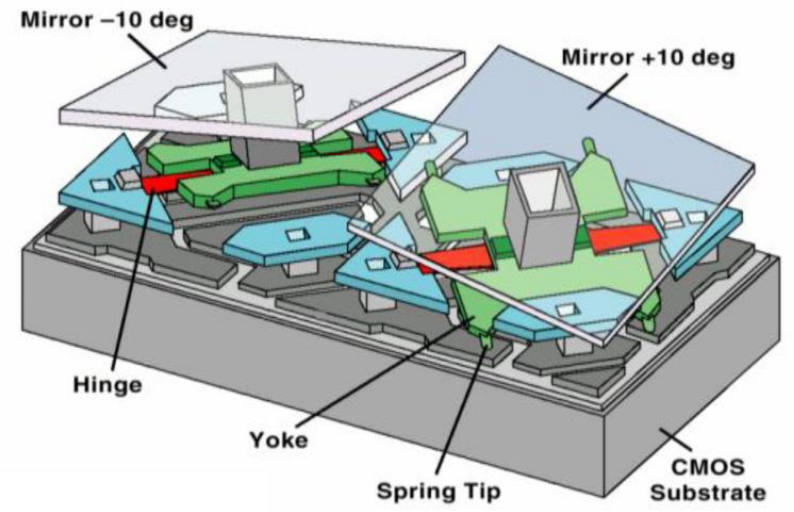


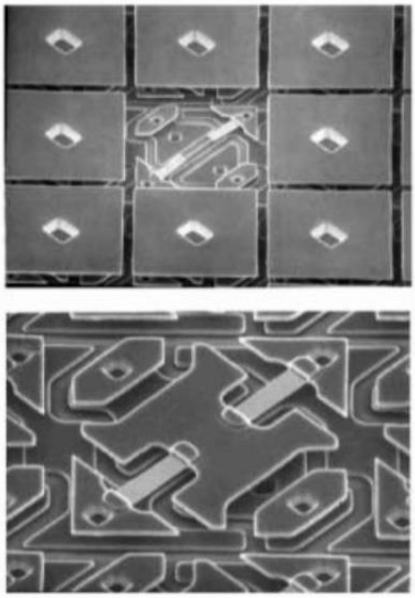
So the practical approach was to project from hand cranked projectors in the tradition of the era. Much success was achieved with this. At the Academy of Motion Picture Arts and Sciences, Randy Haberkamp (Managing Director, Programming, Education and Preservation) has produced many exceptional programs this way, presented on a 1909 hand-cranked Power's Model 6 Cameragraph motion picture

machine restored and cranked by Joe Rinaudo. While nothing can equal the luxury of the performance of Joe Rinaudo and his colleagues, we have to come to grips with the reality of digitally projected archive films.

We applaud the work of Kommer Kleijn and many others who have long championed the cause for establishing SMPTE standards in this area, but we recognize that such standards do not necessarily accommodate the idiosyncratic nature of the medium nor translate into enabling technology. For example, the dominant digital cinema projection system is currently based on the Texas Instruments DLP Cinema® technology.

A very simplistic description of this remarkable device is that it's based on the principle of reflecting light from an array of tiny mirrors. In a 4K chip, there are 8.8 million mirrors, each representing a single pixel of an image. The luminance for each pixel is derived by tilting these mirrors in a rapid fluctuation such that the reflected luminance is modulated from full-on to full-off or any value between.



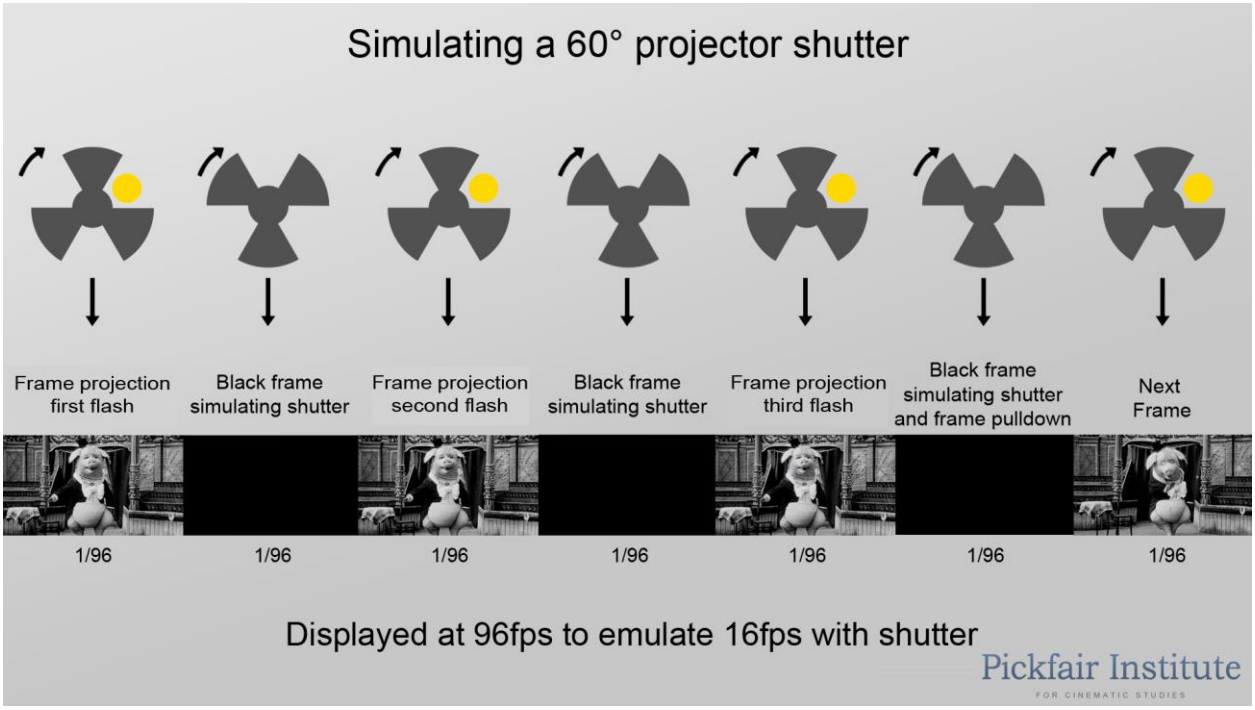


The DLP Cinema system can display new images at a rate up to 120 fps, but it has a minimum frame rate capability of 20 fps. Obviously, many silent era archive films require lower frame rates than that. The mere existence of a standard defining, say, 16 frames per second, doesn't necessarily provide a way to deliver that frame rate. Given the current preoccupation of the motion picture community with the high frame rate (HFR) demands of 3D presentation as voiced by such as Peter Jackson, Doug Trumbull and James Cameron, to name a few, the provision of enabling technology for the "orphan" rates associated with archive films has been given short shrift.

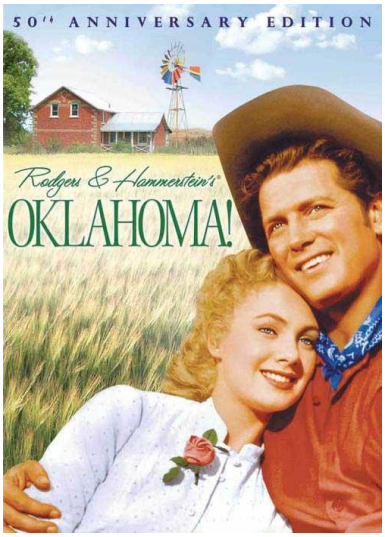
Our project actually seeks to take advantage of the expanding emphasis on high frame rates (HFR) to achieve our goal of providing frame rates below the 20-frame DLP Cinema minimum. We do this by including the shutter blanking intervals as “frames,” or perhaps we should say “pulses.” Thus, a 16-frame film is projected by the digital projector as 96 “pulses” or, three image flashes and three blank pulses for each 16-frame per second image, much as the period projector technology did with the multiple blades of the projector shutter.

Fortunately, and perhaps with some thanks to Peter Jackson, 48-frame 3D films like *The Hobbit* require 96-Hz projection; 48 for each eye.

We can illustrate in this graphic how we are able to project this 1907 film, *The Dancing Pig*.



We project frame one as a discrete frame for ten milliseconds, followed by the projection of ten milliseconds of black, followed by the continued projection of frame one and another similar period of black with yet another projection of frame one and black. We now project frame two and follow the same sequence as before.



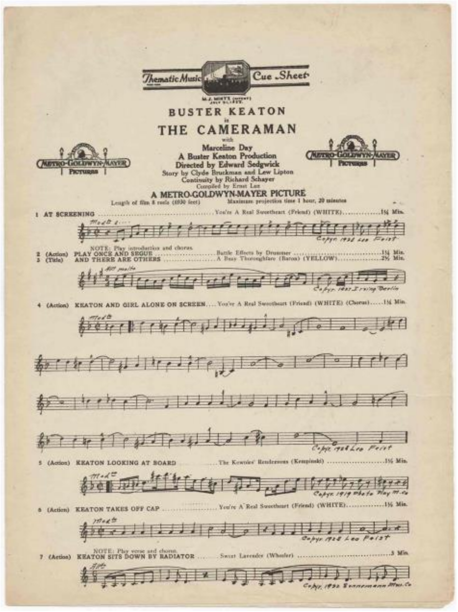
All this has been made possible for us by our teammates in this enterprise: the Academy Film Archive, founded in 1991, is home to one of the most diverse motion picture collections in the world; FotoKem, operating continuously since 1963, remains one of the few laboratories committed to quality celluloid services in a digital media environment; Qube Cinema which manufactures digital cinema servers, integrated media blocks and DCP mastering software. The latter two recently joined forces to achieve a historic digital restoration and screening of the 1955 film *Oklahoma!*.

The significance of the *Oklahoma!* achievement lies in the fact that it was originally shot in Todd AO on 65mm and at 30 fps, and had to be converted to 4K at 30 fps for digital projection. For this in particular, the Qube Xi Integrated Media Block was essential in handling the higher frame rate and an associated 500 mbps data stream.

The Qube Cinema technology (including the Qube XP-1 server, the Qube Xi 4K IMB and the Qube Master Pro DCP mastering software), therefore, allows us to attain the necessary very high frame rates required to replicate the period projection of silent era films.

With our process, the actual image projection time is approximately 50 percent, with a 48 Hz “flicker” rate, essentially as it was in the original presentation. Of course, we likewise suffer the inevitable loss of half of our projector lumens, but, again, the current drive towards much more powerful lamphouses, e.g. lasers, necessary to address the losses incurred in 3D projection, will in the near future, mitigate this loss.

At this stage, the project is a feasibility study, though it’s sufficiently advanced that we have demonstrated the efficacy of our approach for AMIA in a presentation at the recent “Reel Thing” in Los Angeles. As a result of its enthusiastic reception there, a further presentation is planned for the Hollywood SMPTE Chapter in October. We should note that the ad hoc group has no intention to “productise” this process. Our goal is simply to develop and demonstrate the process. Those wishing to stay abreast of our progress may contact the author at the Pickfair Institute: (jon@pickfairinstitute.org).



While yet more code needs to be written to complete the catalog of silent era frame rates, or rather, their HFR harmonics, we're confident that we shall soon have the majority. We recognize that we still have to address the implication of all this for the sound track, since, as we all know, "silent" films were alive with sound in their actual presentation. The preservation of our "silent" heritage very much involves the preservation of the associated music.

What we have also not yet achieved is the art of film projection exemplified by Rinaudo and his colleagues in their ability to vary the projection speed based upon scene content, a facility that was basic to the "art" of projection in the silent era. The solution to that problem lies some years in the future. But we are working on it, and it will come.

Over the past hundred and twenty years, projector technology has racked up an illustrious history, and that was on top of the equally splendid heritage of the Magic Lantern era that preceded it. But the salient point we'll note here is that, until the electrification and the advent of sound on film, all of this technology was analog and manual.

Both early cine cameras and projectors were manually operated by people who, at some level, understood they were creating art. Basic to that art was their perception that they were masters of time. By the simple expedient of a slight adjustment in the rate at which they cranked the handle of either the camera or the projector or both, they could modify the pace of life itself.

Cinema literature of the period is replete with commentary on that fact:

Thomas J. Mathiesen in "Silent Film Music and the Theatre Organ:"

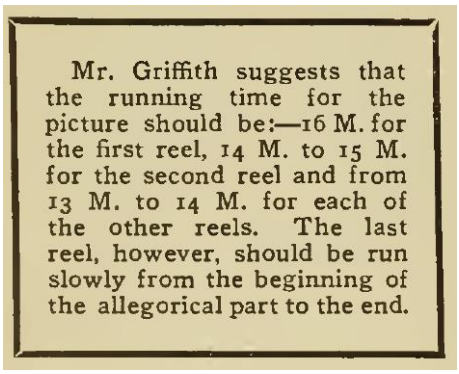
> Certain shows were "first run" and required the fullest resources of the theatre, others were less grand. The projection speed of silent film was not stable at 16-18 frames per second, as is often thought. The conductor's stand in larger theatres was frequently equipped with a rheostat that enabled him to increase or decrease the projection speed in order to

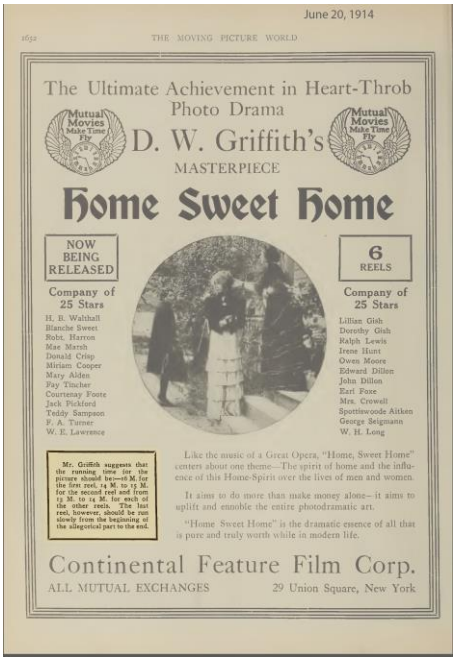
coordinate music and film more closely and, in a sense, to “conduct” the film.

Here is F.H. Richardson in his “Motion Picture Handbook” in 1911:

> Speed is of very very great importance and a comprehension of this fact is absolutely necessary to do really fine projection. The operator “renders” a film, if he is a real operator, exactly as does the musician render a piece of music, in that, within limits, the action of the scene being portrayed depends entirely on his judgment.... Watch the scene closely and by variation of speed bring out everything there is in it. No set rule applies. Only the application of brains to the matter of speed can properly render a film. I have often changed speed half a dozen times on one film of 1000 feet.

In this ad for D.W. Griffith’s “Home Sweet Home” we find very specific instructions on how the film should be projected:


Mr. Griffith suggests that the running time for the picture should be:—16 M. for the first reel, 14 M. to 15 M. for the second reel and from 13 M. to 14 M. for each of the other reels. The last reel, however, should be run slowly from the beginning of the allegorical part to the end.


June 20, 1914

1652 THE MOVING PICTURE WORLD

The Ultimate Achievement in Heart-Throb Photo Drama

Mutual Movies Make Time Fly

D. W. Griffith's MASTERPIECE

Mutual Movies Make Time Fly

Home Sweet Home

NOW BEING RELEASED

6 REELS

Company of 25 Stars

H. B. Walthall
Blanche Sweet
Robt. Harron
Mae Marsh
Donald Crisp
Miriam Cooper
Mary Alden
Fay Tincher
Courtenay Foote
Jack Pickford
Teddy Sampson
F. A. Turner
W. E. Lawrence

Company of 25 Stars

Lillian Gish
Dorothy Gish
Ralph Lewis
Irene Hunt
Owen Moore
Edward Dillon
John Dillon
Earl Fore
Mrs. Crowell
Spottiswoode Aitken
George Seigmann
W. H. Long

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Like the music of a Great Opera, "Home, Sweet Home" centers about one theme—The spirit of home and the influence of this Home-Spirit over the lives of men and women.

It aims to do more than make money alone—it aims to uplift and ennoble the entire photodramatic art.

"Home Sweet Home" is the dramatic essence of all that is pure and truly worth while in modern life.

Continental Feature Film Corp.

ALL MUTUAL EXCHANGES 29 Union Square, New York

> Sixteen minutes for the first reel (19.6 fps); fourteen to fifteen minutes for the second, (17.8 - 19 fps); and thirteen to fourteen for each of the other reels, (19 -29 fps); “The last reel, however, should be run slowly from the beginning of the allegorical part to the end.”

It doesn’t get any more concise than that.

Griffith is quoted as saying, “The projectionist in a large measure is compelled to redirect the photoplay.”

As Brownlow further observes:

The highly inflammable nitrate film had to move slowly past the searing heat of the arc lamp. On most projectors, the fire shutter would descend and cut off the light if they moved below 40 ft. per minute. Projectionists often ignored the 18 minute-per-thousand rule. One might assume that reports that his actors were zipping across the screen would horrify Griffith, and he would increase the speed of his camera to suit the standard projection speed. Not at all. Some sequences of *The Birth of a Nation* are so undercranked that they need to be shown at 12 fps. Griffith, and his cameraman Billy Bitzer, continued to crank slower than average on all the major features they made together. And because Griffith's films are the most frequently revived of all American silent films, film societies religiously switch their projectors to "silent" for Griffith films - and all other silent pictures. The speed is not slow enough for Griffith - and is ruinously slow for other films.

The advent of sound recorded on film forced the adoption of the 24 fps standard as the sound engineers determined that it required 18 inches of film to pass over the sound head per second to achieve sufficient bandwidth for adequate sound reproduction.

12
important
features...
of the
Western Electric
Reproducer Set

THE Western Electric reproducer set is built to weather the shocks and jars of many years of constant use. It stands four-square on one base—no auxiliary pedestal to jar out of line. It combines highest quality sound reproduction with projection room requirements of durability, dependability and ease of operation.

These 12 points explain the world-wide popularity of the Western Electric reproducer set with exhibitors and projectionists:

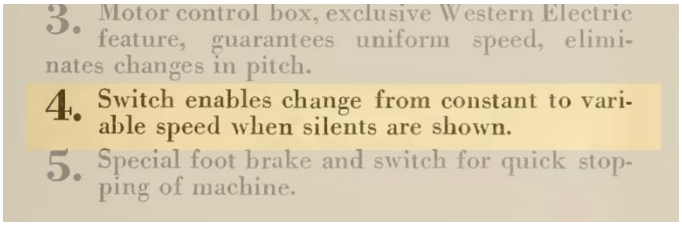
1. All mechanical drives, no belts.
2. Highest quality reproducer; scientifically balanced to provide proper tracking.
3. Motor control box, exclusive Western Electric feature, guarantees uniform speed, eliminates changes in pitch.
4. Switch enables change from constant to variable speed when silents are shown.
5. Special foot brake and switch for quick stopping of machine.
6. Machine rests on ball joints, insures good mounting.
7. Rubber cushions eliminate shocks and jars from turntable.
8. Permits easy adjustment of machine to all projection angles.
9. Photoelectric cell amplifier, rubber cushioned and suspended on springs to eliminate noises caused by jars and vibrations.
10. Film-disc transfer switch enables projectionist to prepare machine for film or disc at time of threading rather than at moment of changeover.
11. Specially designed lower magazine, including a scientifically adjusted ball-bitch sprocket, eliminates "flutter" often caused by uneven film pull.
12. Scientifically designed mechanical filter system in turntable drive eliminates all noise due to action of gears.

A Guarantee of Film and Disc Quality Reproduction

Western Electric
SOUND SYSTEM
THE VOICE OF ACTION

Distributed by
Electrical Research Products Inc.
250 West 57th Street, New York, N.Y.

But for a time, during the transition from silent to sound, the technology accommodated variable speed projection as this Western Electric sound system ad shows.



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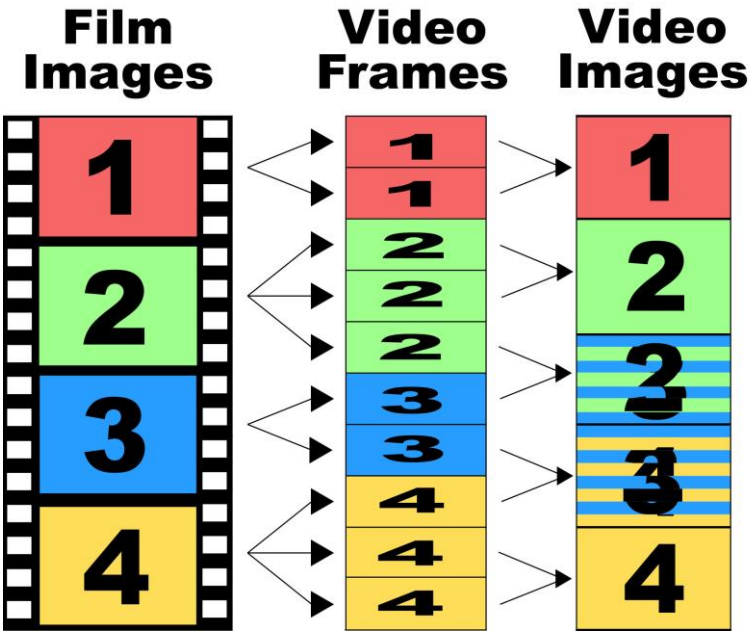
5. Special foot brake and switch for quick stopping of machine.

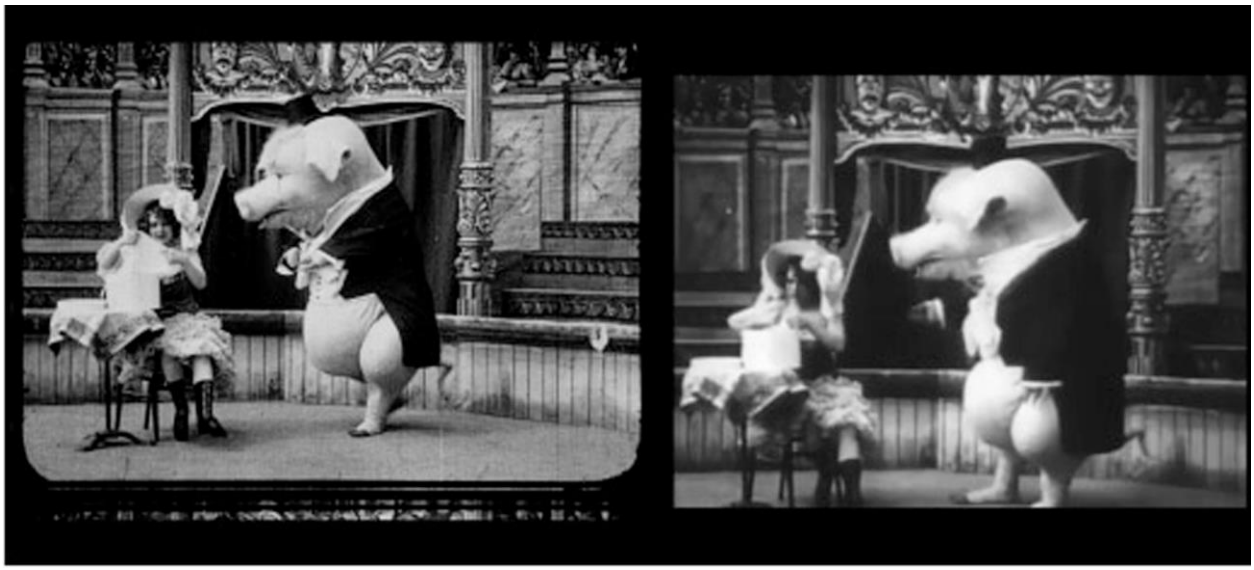
A constraint imposed by the advent of the 24 fps standard is that it compromised our relationship with our history. To be shown in the sound era, these films were, as Kevin Brownlow described, step printed up to the 24 standard (a dis-harmonic transfer) and had sound added to them. Fair enough, there was sound in the original presentation,



but the step up in frame rate introduced artifacts. Worse followed when these same films were transferred to television via the three two pulldown process.

Now we had cascaded two dis-harmonic transfers.

We can show the effect with another illustration from The Dancing Pig. In this example, we show on the left a single discrete image obtained by our process, compared on the right to the same image as seen via the video conversion.



It's a profound relief to be able to begin to redress that with the technology available to us now.

While we have always been able to show silent era films in their original frame rates using the appropriate projectors, it's becoming clear that this will not always be possible. The original elements have already become too valuable, and reprints will eventually become impossible. So a major goal of our project has been to develop ways to project such films digitally, while retaining as much fidelity as possible to the original.

We know the very earliest films were shot at a variety of frame rates, even variable frame rates. Often the actual rate may no longer be known. So we have to employ forensic strategies to try to determine these.

Here's an example of the investigative approach to confirming the frame rate at which William Dickson shot his Sioux Indian "Buffalo Dance" in the Black Maria one hundred and twenty-four years ago.

The Library of Congress records it at 20 fps though we couldn't find that confirmed by Dickson's notes, and he often shot at much higher frame rates. So we made the assumption that, since the dance is still performed today and likely hasn't changed much over the years, we'd simply compare the Dickson version with the current practice. We even produced a split screen version to show what we did. In this way, we determined that Dickson actually shot this particular piece at 18 frames per second.

We believe this work will be a significant achievement in an age in which it will be prohibitive to project actual film prints, and vital for a museum, such as the one the Academy is planning, where the need will be for literally thousands, indeed essentially continuous, presentations.

We hope the work we have undertaken provides some comfort to the archive community.