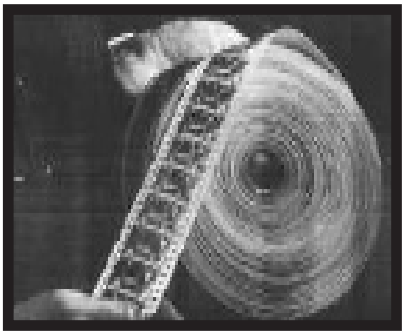
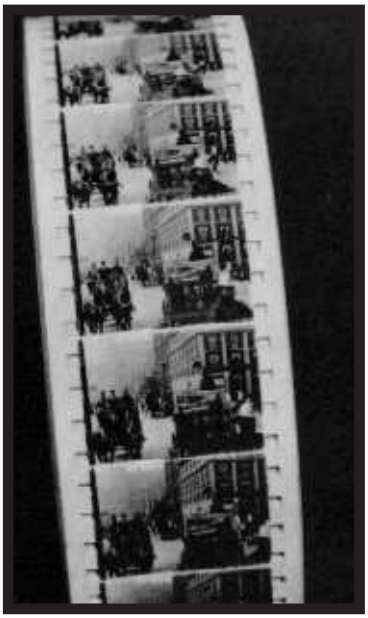
Preserving Early Motion Picture History with the Kinetta Archival Scanner

The Paper Print Collection at the Library of Congress is at once a monumental historic repository of early cinema and an anomaly - literally the only collection of its kind that exists anywhere in the world. It came into being almost by accident. In 1894, United States copyright law had provisions for still photography, but none that covered motion pictures, a nascent art form. Thanks to Thomas Edison, a man famed for going to extreme lengths to protect his intellectual property, film producers realized that if they transformed their motion pictures into "photographs" by printing on paper instead of film, their paper print would qualify for a copyright. A neat trick of entrepreneurs later became a preservationist's dream. Because nearly all 35mm motion pictures produced before 1950 were shot and printed on nitrate-based film, which deteriorates quickly when improperly stored, paper prints now held by the Library of Congress are in many cases the sole existing versions of films made between 1894 and 1915.



The quality of the paper prints did not matter to the producers. Paper prints were made to take advantage of a legal loophole, and there was no expectation that anyone would ever actually look at these prints. In fact, they were forgotten until the late 1930s, when Howard Walls of the U.S. Copyright Office rediscovered the collection under a staircase at the Library of Congress, and began to catalog it.



Over the years, there have been many attempts to copy the collection onto motion picture film, using traditional photographic methods. Kemp Niver did pioneering work in the 1940s and 1950s, for which he won an Academy Award. Don Malkames continued those efforts in the 1960s. Still rephotographing the paper prints frame by frame, he utilized a crude system that copied the prints onto 16mm motion picture film.

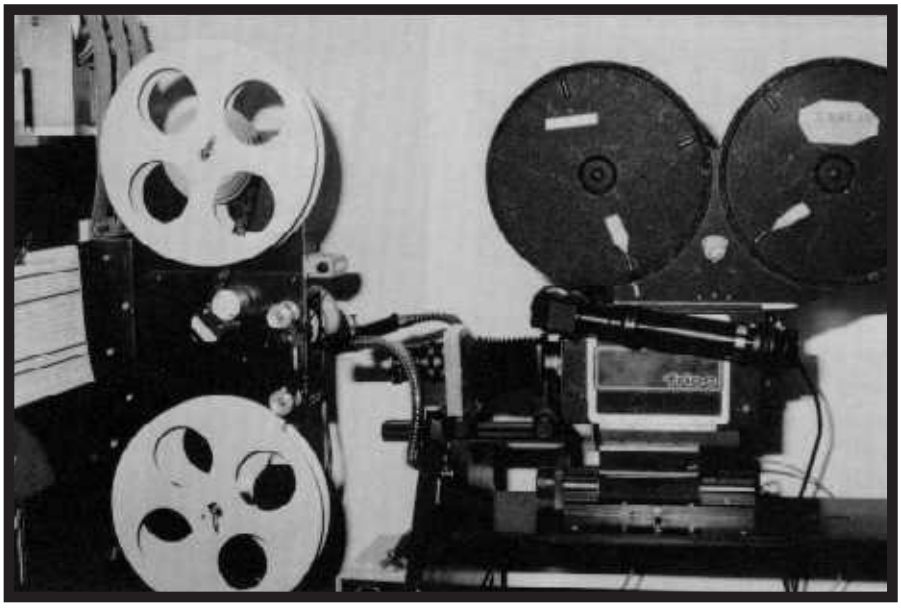
Turning paper into movies was a novel idea, and it let the world look at movies that had sometimes gone unseen for over sixty years. But transformation was an inherently slow and tedious process. And, given how difficult it was to re-register each frame accurately by hand, there often was jitter in the image.

Furthermore, the choice of 16mm film was a poor one, since 16mm didn't come close to capturing all the picture information on the paper prints. Fortunately, the paper prints remained intact, to be copied anew.

Bill Ault using the manual Niver Printer at UCLA.

In the 1980s, the Library of Congress contracted with the UCLA Film and Television Archive to re-master some of the collection onto 35mm film. Bill Ault, who had worked with Kemp Niver, did the work, using one of the original Niver Printers. When the contract ended, the Library of Congress decided to do this work in-house at the Motion Picture Conservation Center (MPCC) in Dayton, Ohio.

Over the years, MPCC devised some ingenious methods to improve the duplication of its paper prints. But MPCC's most recent system, the TRIS printer, still required an operator to register by hand every single frame, which led to operator fatigue - and resulted in picture jitter. The process itself remained excruciating – it took more than twenty seconds to copy a single frame. The rough net, per eight hours, was 1440 frames. Put differently: if you're lucky, at the end of the day you've copied about ninety seconds of a silent film.



The manually-operated TRIS printer for paper print restoration at the LOC MPCC.

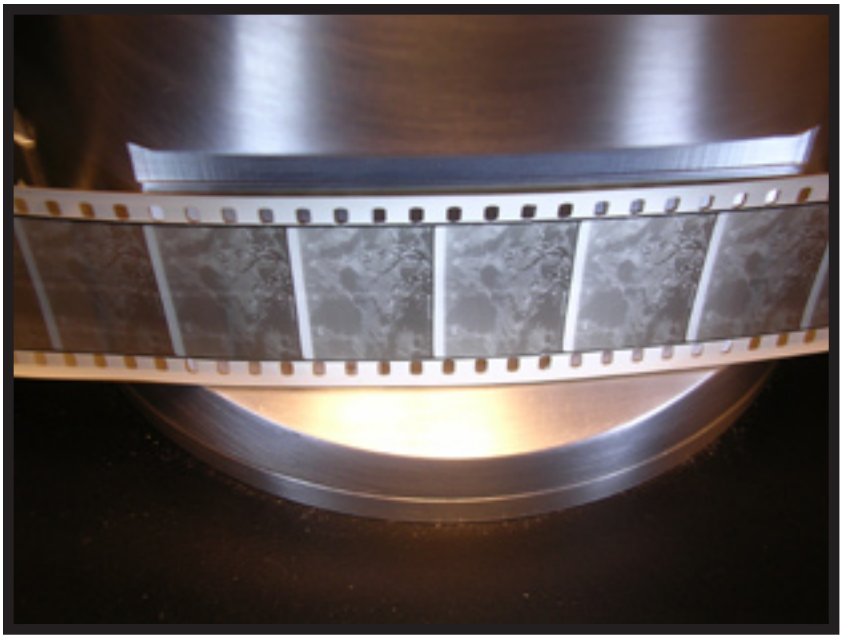
The prototype Kinetta Archival Scanner, at the LOC MPCC.

In 2003, Frank Wylie and Ken Weissman of the LOC MPCC began talks with Jeff Kreines of Kinetta (that's me) about designing a digital replacement for the TRIS printer. The manual printing process was just too slow – at the rate of less than 100 feet of film per day, the paper print restoration project would take dozens of years. Kinetta was in the process of designing an archival telecine, and it was decided that this could be modified to handle paper prints.

Rather than advance the paper print frame-by-frame and attempt to align it perfectly, it was decided to stick with far gentler continuous film movement, and use a pair of diffused pulsed-xenon lamps, triggered by optical sensors, to freeze the image of the moving paper print for capture by a 2K x 2K monochrome digital camera. This data was captured as a 12-bit log image, and stored onto hard drives.

Delivery deadlines made it necessary to build this system using off-the-shelf machine vision components, including an Imperx MDC-2048 camera and an IO Industries DVR Express capture card with Video Savant capture software. Future versions will use a Kinetta 2K or 4K camera head, and capture directly to hard drives without requiring a computer, greatly simplifying the process.

An important design parameter was the ability to handle extremely damaged material without requiring major repairs to that material before scanning. The film path is designed to operate at extremely low tension. The film path is short and simple – the film



Paper print in prototype scanner gate

wraps around six 3" particle transfer rollers (PTRs – which remove dirt and dust) and over the film gate. The gate is curved, so that even warped prints will lie flat with minimal tension on the film.

The motor control system, designed by Henry Morton, uses his patented dancer-arm control system that maintains film tension perfectly. The position of the dancer arm is read by a Hall-effect sensor that tracks the position of a magnet mounted at the pivot-point of the dancer arm.

Rather than provide back-tension to the feed platter, the system actually advances the film forward to the gate, so accurately that the dancer arms barely move. Two of the PTRs, at either side of the gate, serve as drive rollers, and advance the film.

Prints can be scanned at speeds up to 8 frames per second. This is a limitation of the current camera and data-capture system; near-realtime scanning will be possible in future versions.

Once the film is captured digitally, it's restored using MTI's CORRECT software for dirt, dust, and scratch removal, and Adobe After Effects for stabilization and grading, as well as any image repositioning that might be required.

It was originally thought that most of the footage would require digital stabilization, but, to the surprise of all, the registration of the scanner is excellent, and only footage with registration problems in the print have required digital stabilization. (This is a big time-saver, as digital stabilization is quite slow.)

After the film is cleaned up digitally, it is recorded back to 35mm film using a Kinetta 4K Film Recorder. Normally, this is a color system, but a special monochrome version optimized for 1:1.33 aspect ratio imagery was built for the LOC. Output speed, depending on film stock, is between 1 and 3 frames-per-second.

Kinetta 4K Film Recorder

While the scanner was built specifically for paper prints, we decided to add the ability to scan film, both 16mm and 35mm. To this end, we built the camera and lens system in a configuration similar to an optical printer, so that the image could easily be repositioned, cropped, rotated, etc.

The gate is designed to be multi-format – you simply rotate the outer sleeve of the gate to the appropriate film aperture. (The sleeves are interchangeable for paper or film prints, or for other formats, including 8mm/S8/16/S16/17.5/22/28/35mm.)

We designed the film illumination system around our telecine gate, with a large integrating cylinder behind the film. This provides an extremely diffuse light source, which eliminates most scratches that aren't already printed into the material.

We weren't really sure how much use the film gates would get until we delivered the system to the LOC. Someone had just donated seven reels of unique WW I footage of the Battle of Liege. The prints were nitrate, and in extremely poor condition. The Library had done tests to see if they could be printed them on their highly modified optical and contact printers, but the prints were so fragile that they crumbled when wrapped around any rollers.

Because of this, the extreme perforation damage hadn't been repaired, as would have been required for conventional printing. This can take weeks – a skilled restoration artist repairs the film with clear tape and an X-Acto knife, cutting each perforation out by hand, since shrunken film can't be repaired with conventional splicers or perforation repair tape.

Needless to say, no one had much hope that the film would make it through the scanner. But with little to lose, we threaded up a reel, and hit the run button.

We waited. After a minute or two, the film kept running smoothly through the scanner, without a hitch, and we started looking at (and capturing to hard disk) material that was thought to be lost forever. (The film has since deteriorated seriously – it's turning into goo. Fortunately, it was digitized before that happened.)

The Library is also finishing restoration of two Chaplin shorts -- "Gentlemen of Nerve" and "Dough and Dynamite" -- the best versions of which existed as paper prints. Details to follow at kinetta.com.

Thanks to Buckey Grimm for some of the history of paper print restoration.
See http://members.tripod.com/~cinefan/ppart1.htm for details.