The Fox Movietone News Preservation Project: The Continuous Motion 35mm Film Transport

By Julian E. Hansen, Daniel C. Lorti, and Roy Thrash

A film transport system was designed and manufactured for the Fox Movietone News Preservation Project. It is a complete system designed to accommodate nitrate-base 35mm film. The film transport was designed with a number of unique features that presented significant technical challenges; among them, the ability to allow for film format differences between silent and sound film, a strobe illumination system for the high-resolution black-and-white charge-coupled device (CCD) camera, and a sound reader. The system also had to incorporate numerous safeguards in the design to secure the integrity of the film. For example, the system had to be concerned with the brittle nature of the film, its combustibility, and poor or broken perforations. Moreover, owing to the tremendous volume of film to be passed through the film transport, the design had to consider mechanical wear and electronic monitoring in order not to place undue stress over time on the film.

Various technical approaches were evaluated for the design. The effort was complicated by the realization that the "best" approach might leave the film vulnerable. Thus, other avenues needed to be included even though they could add complexity and bulk. What evolved through this series of trade-offs is presented in this paper.

The general requirements for the system included "sound" speed, film protection, image quality, sound transfer, and controlled film movement. Although simplistic in nature, the requirements led to a complex set of system specifications that eventually evolved into a state-of-the-art film transport system. The film transport system's final specifications are given in Table 1. Basically, the features could be summarized as follows:

- Constant, low-tension film path between each reel
- Synchronized strobe for temperature control
- Precise, repeatable image frame positioning
- Gentle film handling and manipulation
- Velocity sensitivity for low-noise sound transfer
- Nitrate-base accident precautions

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Description

The film transport configuration is shown in Fig. 1. Illustrated are the roll film transport system and the interface between all major components. This section addresses the various requirements and the considerations that led to this design and implementation.

Speed

The film speed specification had to consider film condition. Conventional film handling, in which the film was moved into the picture area with its perforations and stopped during image capture, was rejected as a viable approach. The age and brittle condition of the film demanded a gentler method.

Accordingly, a prudent 24 frame/sec, continuous movement was selected. This requirement resulted in three motors: two independent torque motors that provide drive to the supply and take-up reels and a third motor that drives the precision film transport.

The servo speed control needed to handle a variety of film conditions includes:

- Cyclic film stretch
- Abrupt changes in film stretch on either side of a splice
- Torn and missing perforations

Under these conditions servo lock and framing had to be maintained with fast recovery to minimize sound quality disturbances.

Constant Tension System

The function of the constant tension system is to maintain a constant but low tension on the film path by regulating the take-up and supply reels' torques. Each of the two torque motors is independently controlled by its own servo (since there is no proportional relationship between the supply and take-up reel diameters for differing quantities of film). As a result, the film

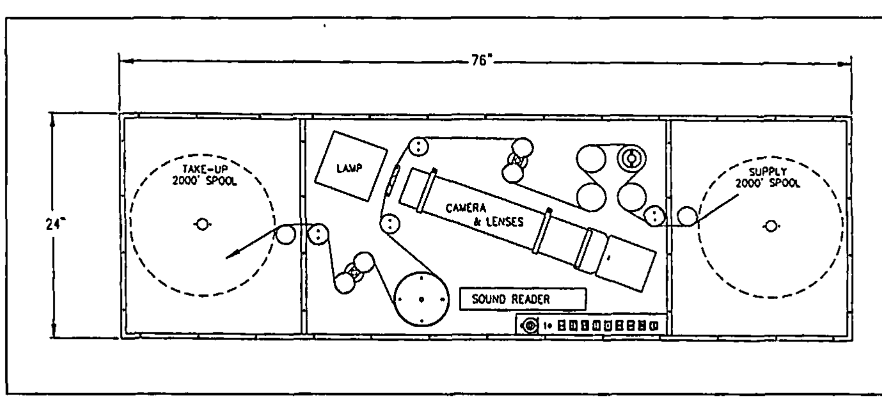

Figure 1. Block diagram of Mekel Model 23200 film transport system.

Table 1 — Film Transport System Specifications

Function	Specification
Film type	35mm
Film movement	Continuous, manual, forward, reverse, and single perforation phasing for setup
Aperture	0.900/1.000 x 0.735
Film quantity	2000-ft reels
Frame rate	24 frame/sec, continuous movement
Synchronization	Crystal phase-locked
Illumination system	Strobe illumination
Strobe trigger	Multiple perforation sensing
Sound reader system	Laser and photocell pickup
Film cleaner	Built-in Kodak PTR rollers
Input power	115/230 VAC, 50/60 Hz
Enclosure	24-in. standard rack width, 28 in. deep, 87 in. high; supplied with three hinged front doors

tension is maintained at a constant level irrespective of the quantity of film on each of the reels.

Optical sensors mounted on the tension arm shafts provide angular feedback to the torque motor servo. Springs are applied to each tension arm and adjust a predetermined tension on the film when the arm is in its normal operating position.

Film Protection

It was imperative that the film transport emphasize film protection throughout its design. As a consequence, numerous built-in safety measures were incorporated into the construction:

- When the supply spool runs out of film or a film break occurs, the tension arms return to their stops, and the transport operation reverts to a LOAD condition (translation — everything stops).

The transport system contains two fire-resistant film compartments (which hold 2000-ft film reels). Temperature-activated cutters are positioned at the film exit or entrance of each compartment. In the event of the film catching fire, the cutters will isolate the film compartments to prevent the fire from spreading. In addition, the transport mechanism plate is fitted with a front cover for additional fire containment (translation — minimize film vulnerability).

- The transport features fireproof magazines and a fireproof door. A strobe lamp is used for image illumination in place of a constantly on light source. This minimizes any temperature build-up during image capture.
- Film stress is reduced by using rollers with diameters greater than 2 in. The film cleaner rollers, for example, have a 3-in. diameter. Film is transported for image transfer over a hard chrome curved gate having a 24-in. radius to mitigate film damage due to heat and tension during positioning and capture. In addition, the active picture area of the film was protected with the use of two small rollers located on either side of the gate area.

Image Positioning

The position of the film in the gate area is accurately determined by sensing the location of the perforations. Two photosensitive detectors are employed to sense the position of two sequential perforations. This method ensures the accurate determination of the frame position, even when the perforations are damaged. There is a 16-tooth tow-along sprocket with a sensor for maintaining framing. The infrared (IR) perforation sensors detect the dif-

Table 2 — Film Transport System Control Panel Description

Panel	Function
Top RED button	Power on and off
OPERATE/LOAD button	OPERATE (green lamp only). Film tensioned — transport ready to operate. LOAD (red lamp only). Film tension removed — ready to load film.
RUN FWD button	Causes film to move forward (green lamp).
RUN REV button	Causes film to move in the reverse direction (green lamp).
STOP button	Stops film movement, must be pressed prior to reversing film motion (red lamp).
SET 0 button	Marks position, in which film will be returned to when the RETURN TO 0 button is pressed (blue lamp).
RETURN TO 0 button	Causes film to return to position last marked by SET 0 button (blue lamp).
STILL VIEW button	Activates strobe illumination while film is stopped. This function only operates while the button is depressed (blue lamp).
INCHING CONTROL	Causes film to move slowly forward or reverse.
FRAME VALID indicator	Indicates that the transport has obtained valid framing (green lamp).

ference in reflection between the film base and the perforation hole and are placed in front of a mechanical mask so that the background reflective area is blocked except for the small aperture that the film passes over. This enhances the contrast between the film base and the perf and improves the accuracy of the perf sensing.

Sound Transfer

The sound reader provides the drive for the film. The film is tensioned around a precise 5.73-in. drum. To ensure low wow and flutter, the roller is made out of heavy material that allows it to function as a flywheel.

Controlled Film Movement

Precisely controlled film movement between the two reels is accomplished by a synergistic relationship between four major subsystems:

- The capstan drive system
- The central processing unit (CPU)
- The tension control electronics
- The film perforation sensing system

Capstan Drive System

The capstan drive system contains an intelligent motor controller, 12-bit digital-to-analog (D/A) converter, linear drive amplifier, DC permanent magnet motor with integral incremental encoder, and DC tachometer. The system produces the high-gain, well-damped velocity servo system needed by the controller to provide fine control.

Central Processing Unit

The CPU is the controller whose purpose is to function as the kernel of the film motion control and compensation system. It is a printed circuit board containing a Z80 microprocessor, memory circuits, RS-232-standard interface circuits, memory mapping and decoding logic, and Z80 super integration interface modules.

Tension Control Electronics

Two spring-loaded tension arms, with positive feedback optical sensor, supply the tension feedback voltage to the analog electronics. Through comparator networks, output signals are routinely routed to the power amplifier assemblies, which in turn, drive the take-up and supply torque motors.

Film Perforation Sensing

The film perforation sensing sprocket contains a sensor wheel that generates a signal used to define a 9-msec window once per frame when the perforation sensor's outputs are valid and can be electronically combined to compensate for torn perforations.

Construction

The film transport mechanism plate is machined from 0.5-in. aluminum gauge plate; all motors, drive shafts, film cleaning rollers, film gate assembly, strobe lamp assembly, sound pickup assembly, and control electronics are bolted to it. This results in a self-contained film transport unit. The transport size is 28 in. wide, 30 in. deep, 80 in. in height, and weighs 300 lb.

Controls

The front panel reflects the user-friendly automatic operation capability of the film transport. It contains nine control buttons and an indicator. Their functions are described in Table 2.

Operation

There are five operating procedures that are used with the film transport system:

- Loading film
- Normal operation
- Framing adjustment
- Sound format change
- Still view and inching

Conclusion

A number of significant technical challenges were presented by the Fox Movietone News Restoration Project that specifically dealt with the handling and manipulation of old nitrate-base 35mm film. The result was a specialized film transport system capable of sustained 24 frame/sec automatic operation. It features continuous and complete film protection while providing high-quality film image capture and minimum distortion sound transfer.

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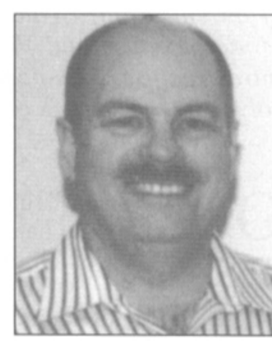

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The Fox Movietone News Preservation Project: Operational and Logistic Aspects

By Rebecca Redshaw and R. Evans Wetmore

The Fox Movietone Newsreel Library consists of approximately 40+ million ft of 35mm film, much of which is on nitrate base. To handle, catalog, and digitize this amount of material required the development of a number of procedures, techniques, and computer systems, as well as the creation of an entire infrastructure. Twentieth Century-Fox contracted with WRS Motion Picture and Video Laboratory in Pittsburgh, Pa., to operate this infrastructure. This paper describes some of the many problems that were solved as part of this massive undertaking.

One of the major issues in this project was how to handle this large amount of film, much of which was flammable, deteriorating cellulose nitrate. Problems included shipping, inspection, preparation for transfer, keeping track of the film, segregating safety and nitrate film, and creating a database that tracked the original paper film records with a new computer database.

WRS Motion Picture and Video Laboratory was selected to operate the two film scanners (Fig. 1) and to prepare the film for transfer. WRS was chosen for its unique video and film expertise, as both disciplines would be needed in handling a project of this size. WRS was also familiar with the handling of nitrate film.

The "Run"

One of the first concerns was how to divide this volume of film into quantities that could easily be digitized without having to constantly change the setup of the film scanners. This meant that the film had to be segregated during the preparation process to allow efficient transfer.

The film existed in every conceivable picture format: camera negative, fine-grain positive, dupe negative, and prints. There were also three aspect ratios to be dealt with: silent full aperture; early sound, which used the height of silent aperture with the width narrowed by the sound track area; and finally, the Academy aperture adopted in 1932. There was the additional problem of many different sound-track types: positive variable density, negative variable density, positive variable area, negative variable area — all types, both single-ended and push-pull. Additionally, some material has a 10-frame offset between track and picture while other material has a 21-frame offset. Finally some material was shot at the silent speed of 16 frames/sec, while most of the library was shot at the standard sound speed of 24 frames/sec.

With the constraint of keeping the film type uniform for a given transfer it was felt that more than a few thousand feet at a time would make assembling the film too time-consuming, and time would be lost searching

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