FINAL PROJECT REPORT

PROTOTYPE FILM TRANSPORT SYSTEM
CONTRACT NAS 8-11627

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D. B. MILLIKEN COMPANY

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PROJECT OBJECTIVE

To design and fabricate a prototype multiple film take-up system by which film exposed in four remote cameras in a launch vehicle can be collected in a single recovery capsule. To this extent a contract for this development program was issued to the D. B. Milliken Company with the generalized goals to be as follows:

(1) Remove the single camera containing 100 feet of film from the recovery capsule.

(2) Design and fabricate a completely new internal take-up assembly incorporating four 400 foot capacity reels, clutch system for each reel and take-up power for the reels.

The capsule design was to provide ports on its side so as to allow film coming from four remotely located cameras to be fed into a manifold on the side of the capsule and on to the four take-up reels. The manifold was to include means of cutting the film before separation of the capsule from the manifold. The port design was to incorporate pressure seals which would be actuated after take-up operations were completed. The major advantages of this program would be:

a. To increase the capsule film capacity of the recovery capsule from 100 feet to 1600 feet of film.

b. To provide for simultaneously photographing four remote activities and collecting all of the film into a single recovery capsule.

BRIEF HISTORY OF PROJECT PROGRESS

The contract was received on May 6, 1964. After a preliminary study of the technical parameters of the proposed system, on June 25, 1964 two D. B. Milliken Co. engineers informally met with the NASA engineers on this program for the purpose of more clearly defining the system requirements. As a result of the meeting, D. B. Milliken Co. felt that a number of modifications and extensions of the program should be considered before proceeding with the detailed design effort. A study of these factors was made and a report outlining recommended changes in scope was issued to NASA on October 30, 1964. NASA, in turn, after reviewing the report decided that the requirements should remain as stated in the initial contract. D. B. Milliken Co. then proceeded with the design during the period from November 1964 through July 1965. The major areas of effort fell into the following categories:

1. Laboratory Model Single Film Design

A single film take-up unit design was accomplished on an engineering sketch basis.

2. Laboratory Model Single Film Unit - Fabrication and Test

The single film take-up unit was fabricated in order to prove in all design factors and components. This single unit was tested extensively with one DBM-5 camera supplying film which in turn was fed through a 20 foot length of Titeflex tubing and on to the single take-up reel. This single film system incorporated a film tension sensing arm which controlled the take-up reel torque through an associated clutch. In so doing, the film tension could be limited so that breakage of the film would not occur.

Great difficulty was encountered when this system was first set up for testing in that the film initially passed freely through the tubing but after approximately 300 feet had passed through the tension would build up in the film and cause film breakage. As the slip level of the take-up clutch was lowered on subsequent passes the film tension built up within the tubing causing the take-up clutch to slip excessively and the film would stop moving. Both conditions were failures in that the film as exposed by the camera could not be taken up by the capsule take-up reel. This situation was investigated repeatedly and, subsequently, successful operation was achieved. It was found that the initial static tension of the film in the tube was of vital importance and that it could not exceed a certain level (approximately 1 lb.). In addition, the tension limiting clutch was to be set to slip at 4 lbs. maximum film tension during dynamic operation. When the film tension exceeded these levels, it would deform within the tube, hugging the inside walls at points of tube curvature. The resulting friction required greater tension for the film to be pulled through the tube and in so doing caused greater friction and higher film tension. In short, it was a self-defeating system. Therefore, the initial static tension of the film had to be limited to these levels in order to allow the complete 400 feet of film from the camera to pass through the tube on to the take-up reel.

Under these conditions the system transported film reliably, even with multiple turns in the tubing or single turns exceeding 360°.

The four pound tension on each film strip at four hundred frames per second determined the motor power requirements. This power requirement is 0.3 horsepower. With power losses in gear trains and clutches the motor rating chosen was one-half horsepower.

A laboratory model of the film port with seal was fabricated, tested and proven successful. The seal was tested with a differential 10.4 psig and in a 48 hour period the pressure loss was only .1 psig. This negligible loss was considered satisfactory and was adopted for the system film port seals.

A laboratory model film cutter was also designed and proven successful by test. This cutter design was incorporated in the tube manifold assembly design. It operated satisfactorily with the film stationary and at film speeds up to the 400 FPS maximum.

3. Prototype System Design

Upon successful operation of the single track system, a four-track system was designated for the prototype capsule, using the knowledge gained on the single track system. This design effort included the design of a new capsule incorporating side film entrance, ports with pressure seals, transport tube manifold incorporating four film cutters, take-up motor and gear head system incorporating a magnetic particle clutch for the single take-up drive shaft, and four individual film tension limiting clutches for each take-up reel.

This design effort proceeded on the following basis:

A. System layout drawings.
B. Part detail drawings.
C. Sub-assembly and assembly drawings.

All layout drawings were completed along with all detail drawings of individual parts. As soon as part details were completed they were released and part fabrication initiated. The sub-assembly and assembly drawings were in progress at the time that the contract funding was expended.

4. G.F.E. Camera Modification

The DBM-3A camera supplied to the D. B. Milliken Co. by NASA was modified for the purpose of using this camera in the prototype system test program. The specific changes to this camera included housing modification to (1) allow the film to pass out a port at the top of the camera and (2) allow the transport tube to be fastened to the housing. Internal changes included:

a. Removal of take-up reel and shortening take-up spindle.
b. Mounting a plate over the supply reel which incorporated film guide rollers. These guide rollers routed the film from the last sprocket of the climbing loop to the housing exit port.

5. Prototype System Fabrication

All parts for the take-up system drive were fabricated or purchased. This system was assembled but funding was expended before operating adjustments could be made. Thus, no operating tests of the take-up system could be made.

The capsule housing and manifold assembly parts were in a state of fabrication when work effort was stopped because funding was expended. New funding was not provided; therefore, per instructions from NASA, all test hardware and prototype hardware were packaged for shipment and sent to NASA Huntsville on April 1, 1966.

CONCLUSION

The overall major goals of this contract were attained in that the engineering effort of design and development of a prototype system was achieved. However, system testing was not conducted because of depletion of available funds. The major milestones achieved on the contract were as follows:

1. The system design configuration was proven successful on a single film system.

2. A four-track system take-up was designed and packaged within acceptable capsule size limitations.

3. Successful capsule film port seals were fabricated, tested and proven successful.

4. A film cutting system was designed, fabricated, tested and proven successful.

5. The G.F.E. camera was modified, tested and proven successful.

6. The system operation of the NASA DBM-3 Camera operating through the transport tube onto the single film take-up system was successfully demonstrated to the NASA Cognizant Engineer on the project on July 22, 1965. Also, successful operation of the film cutter was demonstrated to the NASA Cognizant Engineer.

7. The system design development was reviewed for any new technology and a rough draft report was written. A new technology review meeting was held on April 19. It was concluded that no reportable new technology was developed under this contract. The idea of transporting film through Titeflex tubing was generated by NASA.

Should NASA's interest in this system continue the D. B. Milliken Co. system hardware provided in this contract can be instrumental in system study and testing by NASA.

RECOMMENDATIONS

It is believed that this multiple reel take-up system which has been designed by the D. B. Milliken Co. can be successfully adapted for launch rocket photographic instrumentation purposes. Therefore, it is recommended that before any flight hardware

be contracted, the four-track system as designed and built by the D. B. Milliken Co. be used for evaluation and testing as a system to determine the practicality and/or limitations thereof.

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