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BRIEFING NOTES

PG TEAM
AGENDA STATUS REPORT

1 JUNE 1966

Itek

ITEK CORPORATION

LEXINGTON 73, MASSACHUSETTS

[redacted]

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CONTENTS

1. METHOD ORIGINALLY PROPOSED

1.1 INITIAL CALIBRATION THEORY

The objective of the initial calibration is to determine a recoverable relationship between the coordinate system within which the camera lens rotates and translates, and the coordinate system defined by the fiducial holes in the rails.

Essentially, this is the determination of scan angle α and cross angle β for the fiducial images which represent the coordinate relationships in the final image.

1. This is accomplished by including a light projecting collimator in the lens system which will form two image traces on the film during scan. The traces will define the lens coordinate system and the lens movement within this system.
2. Light passing through the fiducial holes in the rails during the same scan will form images defining the rail coordinate system.
3. To isolate distortions caused by film deformations during processing and handling, a calibrated grid will be pre-exposed onto the film to act as a control reference.

1.2 INITIAL CALIBRATION PROCEDURE

To obtain the desired calibration information a sequential 11-point procedure will be followed. This procedure is clearly presented in the Itek proposal [redacted]

2. EXPECTED ACCURACIES

Community Understanding of Design Goals

2.1 RAIL HOLES

a. There will be 73 pairs of holes

b. Each hole 1 centimeter apart with a tolerance of 0.01 inch as referenced from the center hole (hole at center shrinkage marker)

c. Rail hole size shall be 40 microns in diameter and as circular as possible

2.2 IMC COLLIMATOR TRACES

a. There shall be two traces (minimum)
b. These traces shall be 2 degrees apart
c. Each trace shall be 20 to 40 microns wide

2.3 INTERNAL GEOMETRY

The internal geometry of each camera shall be established by appropriate calibration, mensuration, and data reduction procedures to ±4 seconds of arc. (Initially, design goal was 1.5 seconds of arc.)

2.4 IMAGE DENSITY

The density of the image shall be 0.3 above base fog at primary processing levels and fastest instrument cycle rates.

3. MEASURED RESULTS OF PG-1 FORMAT

3.1 PRESHIM, GENERAL NONLIFT CONDITION (Itek)

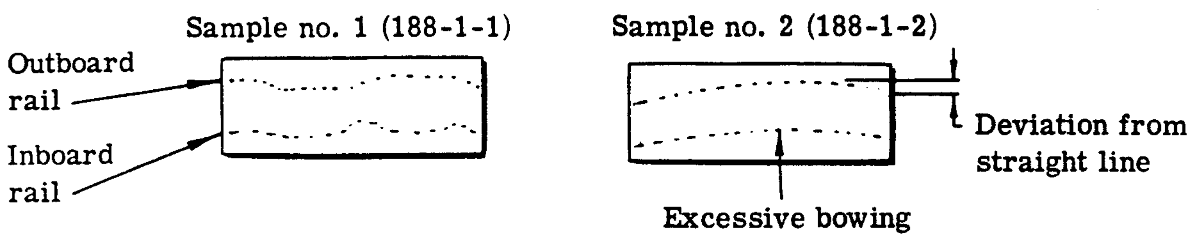
a. Rail holes, general discussion

1) Thick base P/N 188

Rail holes images are not straight (Rail holes were measured as: (1) 50 microns wide statically; and (2) 40 to 80 microns wide when tested at 3.0 seconds per cycle)

Rail holes are not parallel

Rail holes are not precisely repeatable from sample to sample

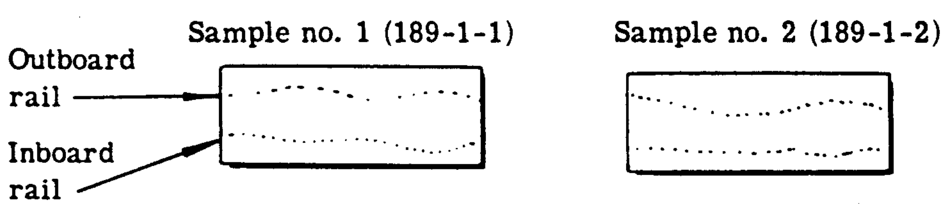


2) Thick base P/N 189

Rail holes are not straight (Rail holes were measured as: (1) 40 microns wide under static test; and (2) 40 to 80 microns wide when tested at 3.0 seconds per cycle)

Rail holes are more parallel than P/N 188

Rail holes are not precisely repeatable from sample to sample



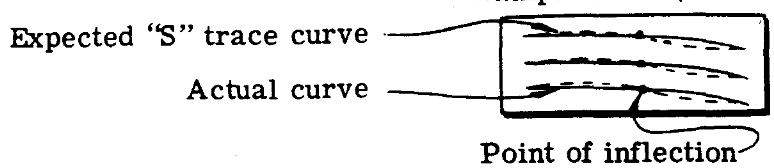
Bowing of inboard rail was not as apparent on P/N 189 as noted on P/N 188.

b. Scan traces, general discussion

1) Thick base P/N 188

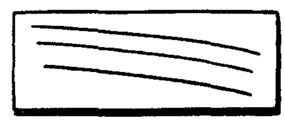
No inflection point (all three scan traces measured 40 to 50 microns wide), curve follows parabolic form (bowed), samples are not repeatable.

Sample no. 1 (188-1-1)



Sample no. 2 (188-1-2)

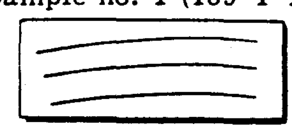
Sample no. 2 curve has different slope than sample no. 1



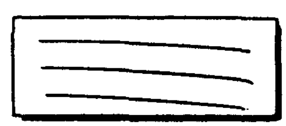
2) Thick base P/N 189

No inflection point (all three scan traces measured 40 to 50 microns wide), curve follows parabolic form (not as bowed as P/N 188), samples not repeatable.

Sample no. 1 (189-1-1)



Sample no. 2 (189-1-2)



NOTE: Present calibration program is based upon point of inflection. Do not have this point on the material. To use present calibration program we would have to use empirical reference point to determine shape of curve.

3.2 POSTSHIM (VISUAL EVALUATION ONLY) AT A/P

Both instruments required shims.

a. Rail holes for both instruments (thick base material):

1) Imagery extremely improved
2) Holes follow same pattern as preshim conditions

b. Scan traces (thick base material):

1) P/N 188, curvature followed same pattern as preshim conditions
2) P/N 189, considerably better curves than preshim conditions

4. CALIBRATION POTENTIAL OF PG-1

4.1 CALIBRATION

a. Present calibration program written mathematically around point of inflection on the scan format trace.

b. There is no point of inflection on PG-1 format. Other calibration methods can be used, but any method selected will result in writing a new program for PG-1.

c. Existing calibration program may be applicable to PG-2 (investigation required and additional PG-2 data necessary).

4.2 ANALYSIS

a. Recommend using PG-1 system as reconnaissance mission, turning on PG lamps only during engineering passes.

b. Use PG information for analysis of "in-flight operation" and not for calibration.

c. "In-flight operation" will give variances in system performance on the format not realizable by ground testing.

d. PG-1 has provided important engineering data to apply to future PG systems (PG-2 and up, and to J3).

e. Areas of instrument manufacturing control are recognizable as in excess of a "J" system requirement.

f. From analysis of available data it is assumed that PG-1 is not calibrated. Present grid lines are also bowed.

5. POSSIBILITY OF PG-1 RETROFIT

5.1 ADVANTAGES

a. Rework and retrofit system for:

1) Better mechanical alignment, rails, trunnion, etc.
2) Install better collimator (2-degree field) and improved prism mounting
3) Install replaceable collimator lamp housings

b. Improve system based on knowledge we have learned on PG-1

c. Total gain should result in an improved system with:

1) Straighter rail hole presentation
2) Cylindrical scan traces, film plane perpendicular to scan plane
3) Straighter grid lines on format

5.2 DISADVANTAGES

a. No guarantee that we can improve PG-1 at all.

b. System has already accumulated in excess of 50,000 cycles. Would require refurbishment of many other parts such as ~~switches, relays~~, lamps, slip-ring, etc.

c. PG-1 system already fitted to its final mount and installed in barrel.

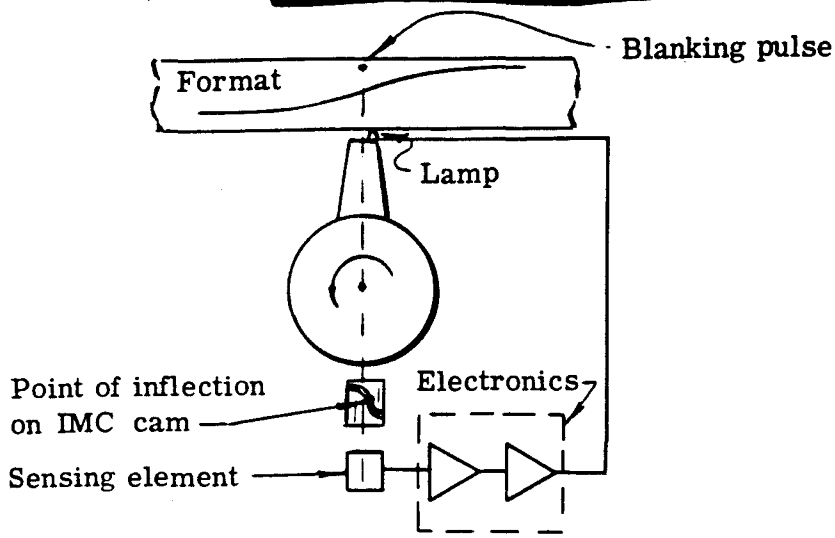
d. System is still an excellent reconnaissance system. It does not seem advisable to break down for retrofit in hopes of getting a better PG display.

5.3 OTHER APPROACHES

This section is devoted to the efforts made to best define the point of inflection (needed for the calibration program) by other than optical presentation. They are as follows:

a. Electromechanical transformation

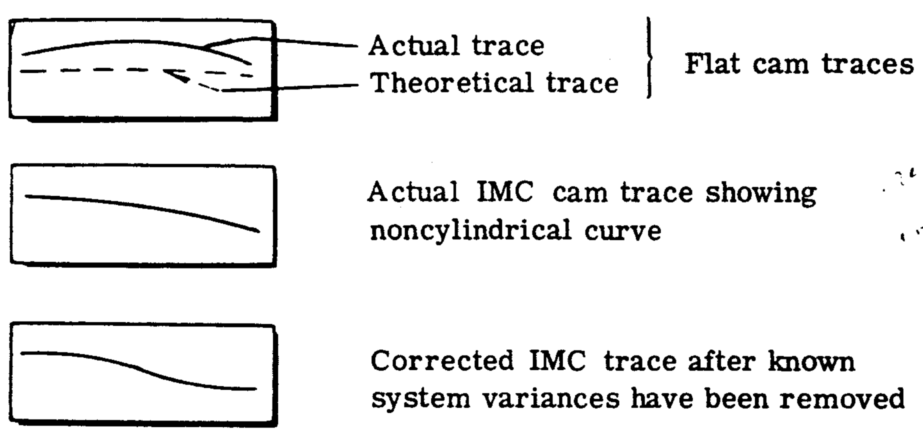
Achieved by coupling film potentiometer to IMC cam aligned to point of inflection inscribed on cam. At this point the pot would send enabling signal to electronics to fire blanking pulse on format. This approach could be used on both thick and thin base film.



Present accuracy would be ± 1500 microns (with existing IMC cam). Best possible accuracy attainable by this method would be ± 400 microns (with new IMC cam) on the format. Limiting factor is the ability to find and suitably inscribe the point of inflection on the IMC cam. Vendor estimates ± 0.0005 or ± 0.016 on format or ± 400 microns with a tolerance of ± 200 microns.

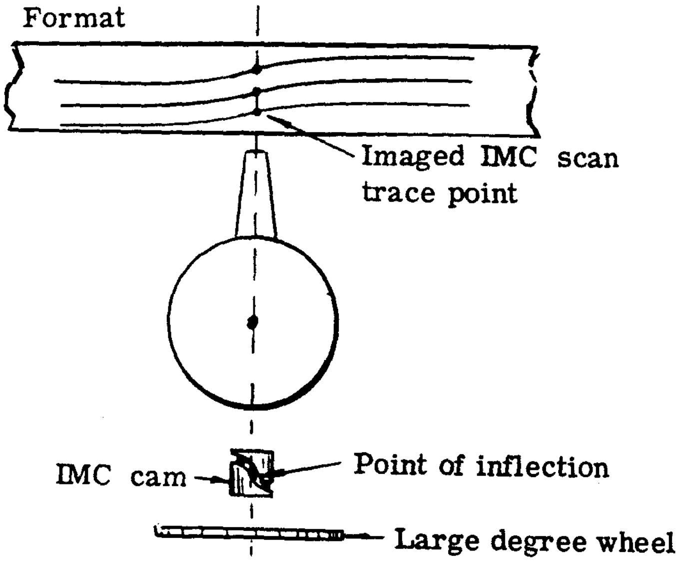
b. Straight function IMC cam

A cam was fabricated without an IMC function and assembled on an instrument. The intent was to theoretically print a straight horizontal trace on the format. If the actual trace differed from the theoretical trace due to system anomalies, the variances could be computed and applied to correct variances in actual IMC traces (applicable to thick base film only).



c. Mechanical transformation

1) A nonoperational static approach was also considered. Hand cycle instrument to known point of inflection on IMC cam. Stop instrument movement at this point of travel. Turn on collimator lamps and image scan traces on format. This is to be done on thick base film only. Accuracy would be ± 1500 microns.



2) Alternate approach

(a) Vendor to place highly accurate hole in cam at point of inflection.

(b) Cam twice as big; therefore, 1/2 angular error for same dimensional error.

(c) New cam follower and pin for locating hole.

(d) Line up scan head lamps over a hole in rail and set pin in cam hole.

(e) Expected accuracy ± 400 microns.

(f) Best possible retrofit would be PG-5.

6. INITIAL RESULTS OF PG-2

6.1 MATERIAL REDUCTION

a. Rail hole presentation

1) Symmetrical, appear parallel, not bowed, straight
2) Repeatability of samples

b. Scan traces

1) Cylindrical pattern, potential "S" trace
2) Mathematical expression feasibility
3) Repeatability of samples
4) Not bowed

c. Grid lines straight and parallel

d. Calibration potential

1) Write a program

(a) "S" traces or other form
(b) May be able to use PG-1 program for PG-2 (investigation required)

6.2 CAUSE OF IMPROVEMENT OVER PG-1

a. Assembly techniques to include tighter tolerances than "J" system.

b. Balanced lens (inertia).

c. Optical alignment methods (thermal calibration).

d. Automatic metering of printer.

1) Better tension control in grid
2) Improved accuracy of metering

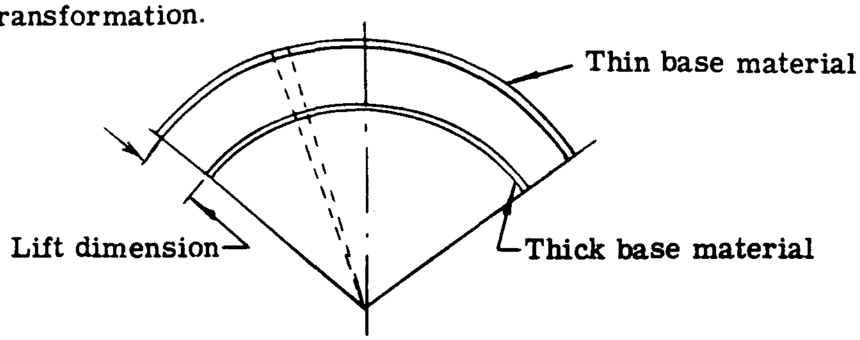
e. Keep thick base material as flat on the rails as possible during exposure.

f. Improved prism mount design to hold thermal reaction to ±15 microns. Based on this improved design it will not be necessary to provide individual thermal calibration curves with each lens.

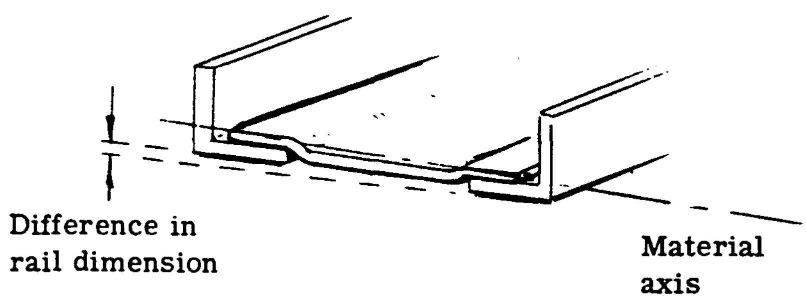
7. SUMMARY OF CALIBRATION FOR: PG-1 AND PG-2

7.1 PG-1

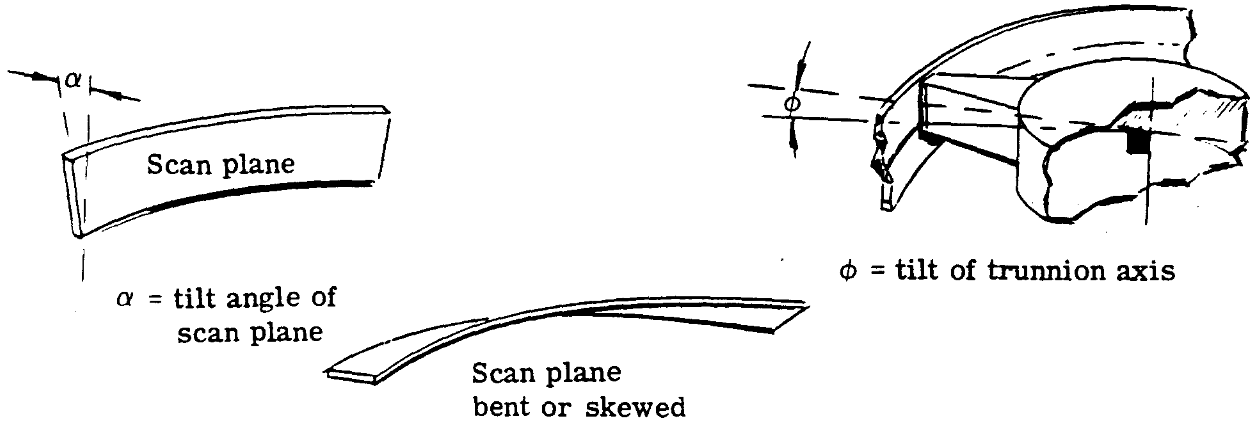
a. Cannot lift material (thin base) and get thick base presentation without going through transformation.



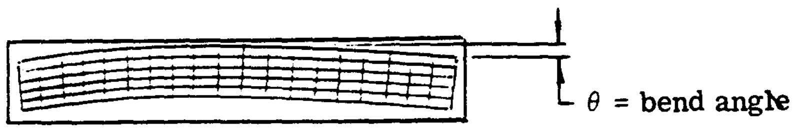
b. Lift results indicate material on an inclined axis. Suspect rails and holes inclined the same amount. Rails and holes could be parallel.



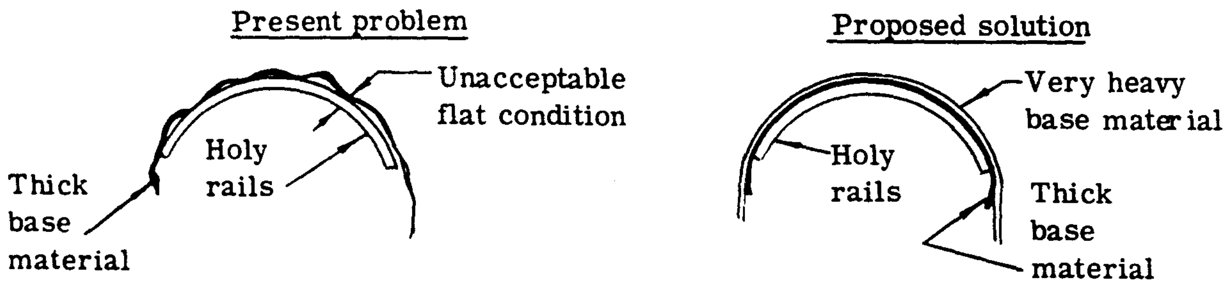
c. Scan plane appears to be bent. Trunnions could be tilted causing lens and stove to swing in arc causing bow. Optical axis perpendicular to scan axis.



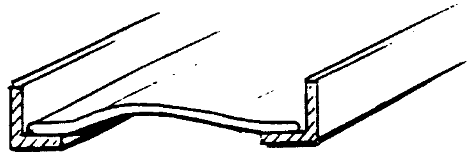
d. Grid lines on thick base material bent on all samples. Not repeatable.



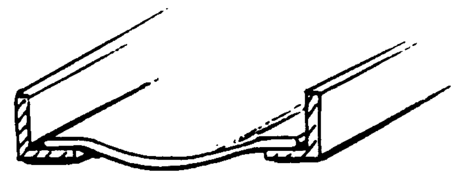
e. Thick base material will not lay flat in the rails. Cannot calibrate material if it will not lay flat. This is our first and foremost problem to resolve.



Thick base material requires a controlled tension to lay flat in the rails within the PG system.



Buckle caused by not enough tension on material in the rails



Sag caused by too much tension on material in the rails

7.2 PG-2 NEW CALIBRATION PROGRAM

The following program is designed to provide sufficient information to calibrate a PG system.

a. Calibration in Boston

1) System constants (determined by Itek and sent to Alexandria)

   (a) True calibrated focal length (mechanical plus dynamic lift)
   (b) Lift measurement every 5 degrees, carefully determined
   (c) Cam constant and cam orientation points within ±1500 microns on the film plane

2) Heavy base material tests

   (a) Heavy base with backing, no tension
   (b) Dr. Aschenbrenner test
   (c) Flat cam with field flattener (10 traces sent to Alexandria)
   (d) IMC traces with field flattener (10 traces sent to Alexandria)
   (e) Test vertical

3) Principal point calibration

   Glass plate

   (a) 0-degree scan and ±15 degrees
   (b) Flat and IMC cams (6 glass plates sent to Alexandria)

4) Thin base material tests

   (a) Dr. Aschenbrenner test for true calibrated focal length

(b) 6-hole and trace measurements for record
(c) No grid

b. Calibration in California, thin base material tests

1) No grid
2) 6-hole and trace measurements (as late as possible)
3) Shim to Boston calibration dolly position (lift) rail holding points
4) Humidity and temperature record

c. Calibration in Alexandria

1) Heavy base material tests

(a) Flat cam measurement
(b) More samples
(c) Otherwise same as now

2) Thin base material tests

(a) 6 points selected (Boston and California)

3) Glass plate material tests

(a) Distance between traces
(b) Principal point relative to holes

4) Plot of: error in "α" scan versus error in "β"

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[redacted]

[redacted]

Retain