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Special Report to the

Color Task Force

28 February 1974

R. A. Koch

Date: 2/28/74

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF TABLES

1.0 FILM MATERIALS

Throughout the following sections, references will be made to film types currently applied in the acquisition and duplication of aerial color photography. Some of these films were not available at the time the last CTF Report was made. Following is a list of the materials now being used and their more important physical characteristics and applications. Resolution and other image quality characteristics are discussed in more detail under color process improvements.

1.1 COLOR ACQUISITION FILMS

a. Aerial Color Film (ESTAR Thin Base) SO-242 and (ESTAR Ultra-Thin Base) SO-255. High-contrast, aerial, color-reversal, Ektachrome films featuring fine-grain and high-resolution. AEI = 2.50 in the current Bridgehead/Grafton modified EKTACHROME process, E-26-8. The photographic properties of these two films are identical. Emulsion layer orientation from top to bottom is: green-sensitive record (magenta image-forming dye layer), red-sensitive record (cyan image-forming dye layer) and blue-sensitive record (yellow image-forming dye layer). These films have been used as the primary camera color originals for high resolution aerial reconnaissance systems since 1969.

b. High Definition Aerochrome Infrared Film (ESTAR Thin Base) SO-131 and (ESTAR Ultra-Thin Base) SO-130. EKTACHROME-type, "false color" reversal emulsions featuring high-contrast, fine-grain and high-resolution. The sensitivity and dye layer orientation consists of: infrared-sensitive record (cyan image-forming dye layer), red-sensitive record (magenta image-forming dye layer) and green-sensitive record (yellow image-forming dye layer), from top to bottom, respectively.

A unique component of these films is the built-in self-filtering capability which prevents short wavelength radiation from reaching the film. In its current Bridgehead/MP^2 modified EKTACHROME process, E-31-1, the AEI is 2.50, which makes it compatible with camera systems that use SO-242/SO-255. Both films were introduced into the reconnaissance community for use in camera systems during mid-1973.

1.2 COLOR DUPLICATING FILMS

a. High Definition EKTACHROME Film (ESTAR Base) SO-356. A high-contrast, color reversal Ektachrome film on 4.0 mil ESTAR Base with emulsion and dye layer orientation identical to Aerial Color Films SO-242/SO-255. These features have made it the principal film employed since 1971, to produce reversal contact color duplicates from aerial color originals.

b. EKTACHROME Aerographic Duplicating Film (ESTAR Base) SO-360. A low contrast, medium fine-grained color reversal aerial duplicating film. This film is color balanced to allow printing by tungsten quality illumination with a color temperature of approximately 3000°K, and appropriate compensating filters. It employs conventional layer orientation of blue-green- and red-sensitive records, thus is not suitable for transferring maximum spatial resolution in contact printing. This film is now used principally in the production of high quality color enlargements (5X - 60X) from Aerial Color (reversal) originals.

c. Color Internegative Film 7271. A low-speed, low-contrast film with good sharpness and excellent granularity. This film is balanced for printing by tungsten illumination with suitable filters. It contains the familiar "orange mask" for improved color rendition when reproducing, (by contact printing), reversal color originals. Emulsion layer orientation from top to bottom is: blue, green and red-sensitive records, respectively. This film is currently used as an intermediate to make subsequent color enlargements onto either EKTACOLOR 37 RC Paper or EKTACOLOR Print Film (4109/6109).

d. Color Print Film 5381/7381. Designed specifically for making contact release transparency prints from either original color negatives, color duplicate negatives, or color internegatives such as Color Internegative Film, Type 7271. This film exhibits excellent sharpness, high resolving power, and the same layer orientation as SO-242/SO-255.

e. Aerial Color Print Film SO-287. This film is a variant of Eastman Color Print Film 5381/7381 (above). It incorporates the same layer order as SO-242/SO-255, and has very high resolving power characteristics. Although designed as a negative working material, it is suitable for special reversal processing. This film was first introduced into the reconnaissance program as the primary color duplication film in November 1973 on Mission 1207-1.

2.0 COLOR ACQUISITION PROCESS STATUS

From the time SO-242/SO-255 Aerial Color Film was first introduced in late 1969, Bridgehead used a modified EKTACHROME ME-4 process (designated E-26-4) to Grafton-process mission color originals thru November 1972. In December 1972, Bridgehead introduced a major change in processing aerial color film by converting to an experimental aerial color process, designated E-26-8, which had evolved as a result of a broad evaluation program conducted under PARs 189S and 197S/R1. This process was first employed on Mission 1204-4, and yielded improvements in the following areas:

a. Sensitometry. The E-26-8 process produces a reversal dual gamma sensitometric aim curve which reduces highlight "blooming" while increasing shadow detail. A sensitometric comparison of the standard E-26-4 versus improved E-26-8 process is shown in Figure 2-1.

b. Tri-Bar Resolution. The E-26-8 process yields increased peak resolution, as well as increased exposure latitude over which maximum resolution occurs. These results are shown in Figure 2-2.

c. Granularity. The E-26-8 process yields greatly reduced granularity in the blue-sensitive record, which permits useful visual analysis at increased magnification (50-80X). The rms-granularity values for each layer are listed in the table below.

TABLE 1

RMS GRANULARITY ANALYSIS

SO-255 Layer	E-26-4 Process	E-26-8 Process
Green Sensitive	.035	.036
Red Sensitive	.042	.039
Blue Sensitive	.158	.053

d. Color Saturation. Increased interimage effects result in greater color saturation, primarily in reds and greens.

e. Edge Sharpness. Increased edge effects are also produced, improving image acuity.

The results of that process change were considered such a positive improvement that Bridgehead has now standardized on the E-26-8 color process for all mission originals. Under PAR 23-3-12S, Bridgehead has continued to evaluate evolving process improvement and development programs in support of mission applications.

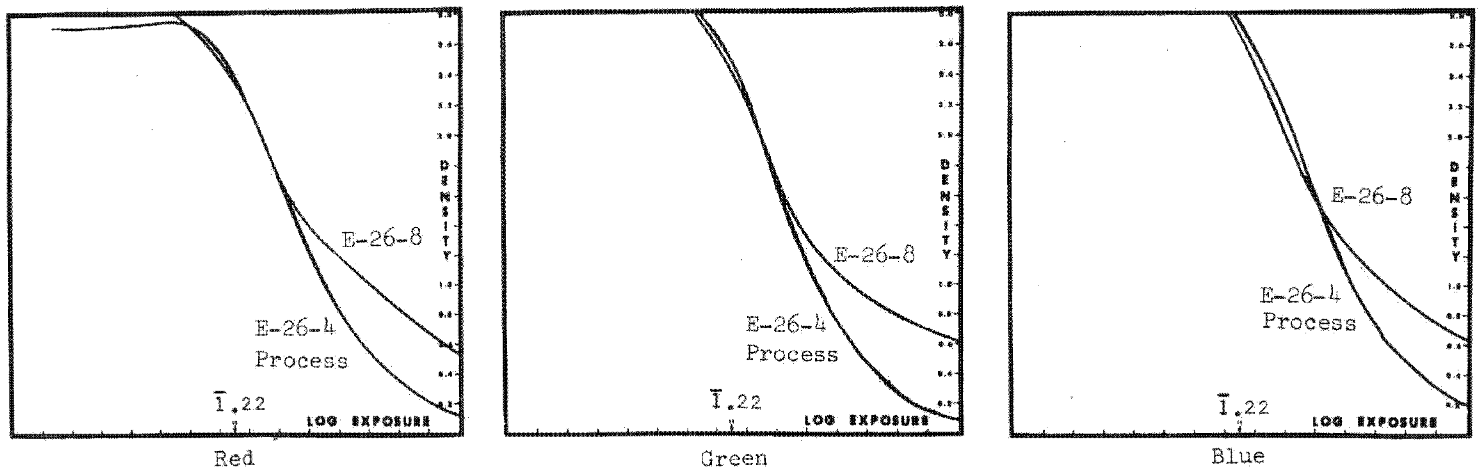

Figure 2-1. Sensitometric Comparison Between the E-26-4 and E-26-8 Processes on SO-255 Film

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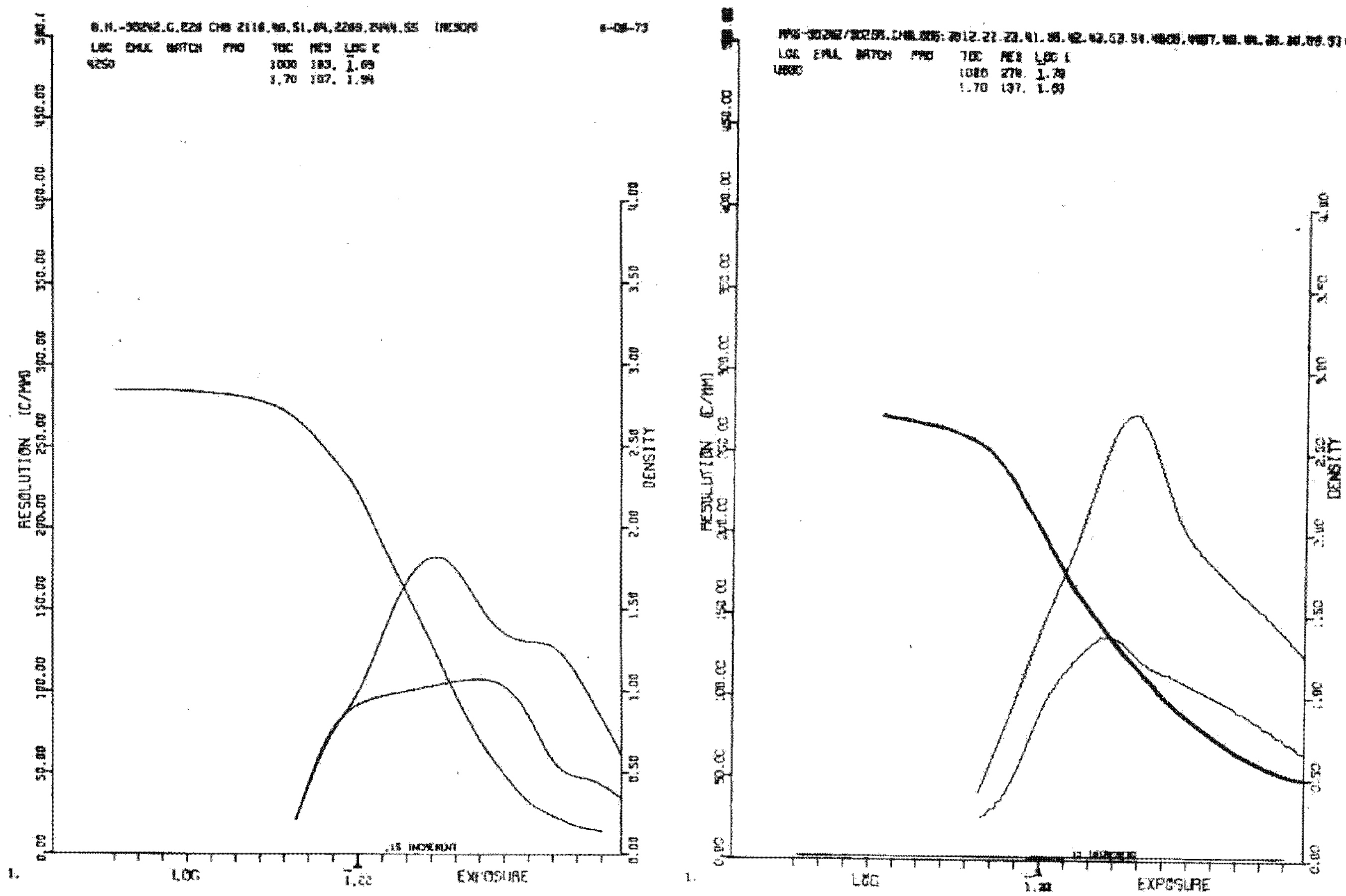

A: E-26-4 Process

B: E-26-8 Process

Figure 2-2. Resolution Versus Exposure Curves for SO-255 Film

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Through processing chemistry, improvements have also been made to the image quality and sensitometry of the infrared acquisition films, SO-130/SO-131. The current process, a modified ME-4 process, designated E-31-1 yields sensitometry conforming quite well to the aerial infrared aim curve established under PAR 24-1-8S. This sensitometry is designed to provide optimum tone reproduction of both highlights and shadows as seen through atmospheric haze and to correct for excessive infrared reflectance of vegetation. The E-31-1 process has been used to process the infrared color originals from Missions 1206 and 4340-2. High- and low-contrast resolving power values in this process are reported at 110 and 50 l/mm, respectively.

3.0 COLOR DUPLICATION FILM/PROCESS STATUS

The experimental SO-242/SO-255 original film process E-26-8 has been further modified to provide additional curve shaping for the SO-356 color duplicate, and has been designated as E-29-8 process. Although the image quality of both SO-255 and SO-356 have demonstrated substantial visual improvements, the total photographic contact duplicating system has been inherently limited by the quality limitations of SO-356 color duplicating film.

Throughout the past two years Bridgehead has sought to identify a slower, finer-grain, higher-quality color print film that might be used to replace SO-356. Eastman Color Print Film (5381/7381) - currently designated SO-287 - together with an experimental reversal process (designated E-87-1), has been selected as the commercial film considered best able to meet the requirements. This film/process combination was first employed in the reproduction of color copies during Mission 1207 in November/December 1973.

Substantial improvements in image quality and resolution transfer achieved since 1971 are shown in Figure 3-1, depicting the following color original and duplicating systems:

- SO-255 (color original - E-26-8 process)
- SO-255 onto SO-287 (current color duplicating system)
- SO-255 onto SO-356 (improved E-26-8/E-29-8 processes)
- SO-255 onto 6451 onto SO-192 (current black-and-white from color system)
- SO-255 onto SO-356 (older E-26-4 and E-29-4 processes used prior to Mission 1204-4)

These curves were generated from a series of laboratory resolution targets derived from a SO-255 (E-26-8 process) color original. The relationship exhibited is the recorded print-through peak tri-bar resolution as a function of input modulation for the three contrast levels evaluated.

Of the three contrast ratios presented, the low (1.7:1) contrast ratio may be considered fairly representative of imagery exposed at high altitude. At this contrast ratio, the resolution transfer is significantly improved when using the SO-255/SO-287 system as compared to the improved process SO-255/SO-356 system -- 90 percent compared to 65 percent. The resolution system curves also demonstrate that the image quality transfer of the SO-255/SO-287 system now compares favorably to the quality achieved in the current green record black-and-white from color reproduction system. Thus, the SO-255/SO-287 color duplication system may be considered (at least from an image quality viewpoint), as now offering the potential of eliminating the need for green record black-and-white from color duplicate positives. The overall system improvements accomplished in image quality transfer during

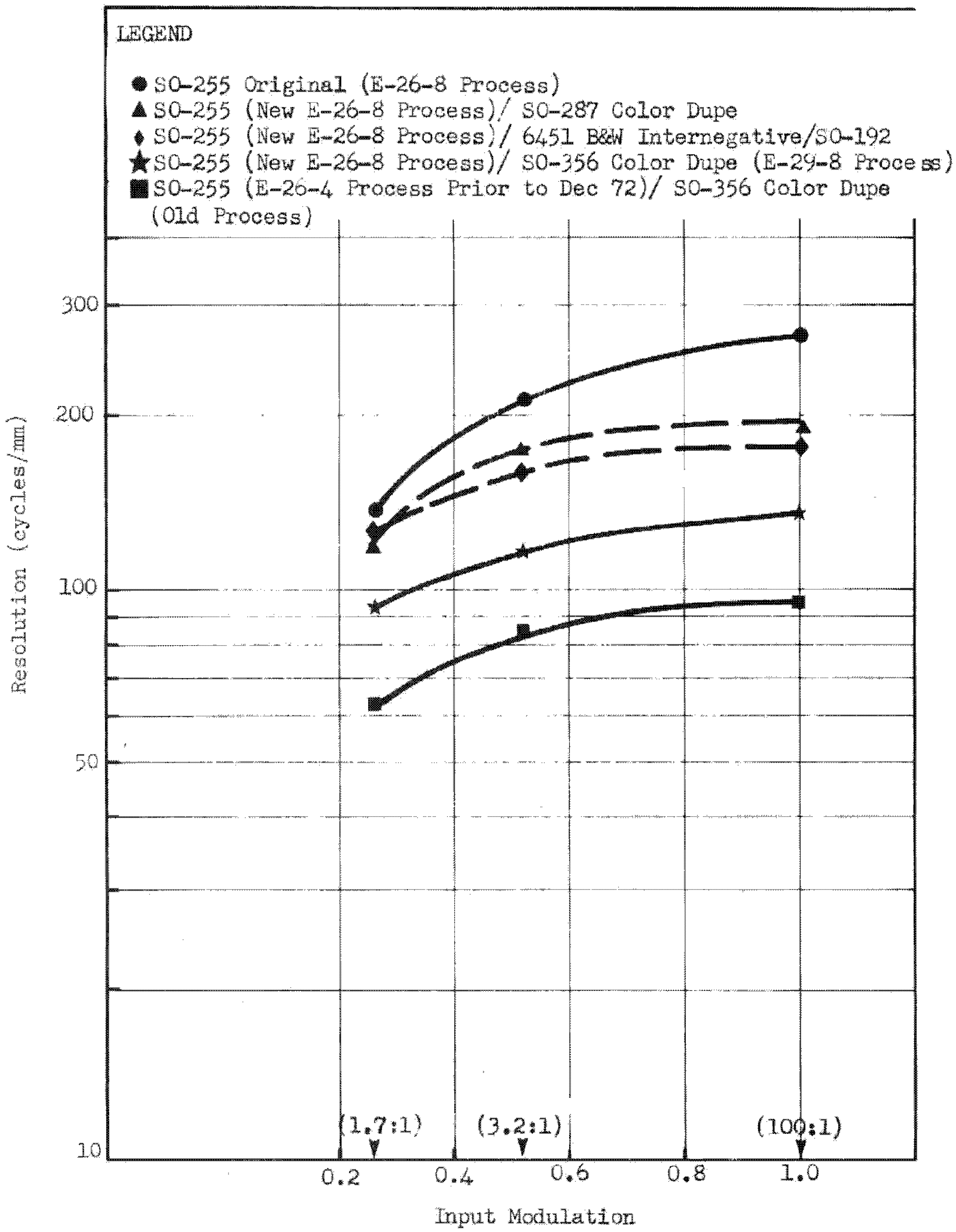

Figure 3-1. Resolution Transfer Curves

the past two-and-one-half years is further demonstrated by comparing the new SO-255/SO-287 system to the older SO-255/SO-356 (E-26-4/E-29-4) system. In this case, the SO-255/SO-287 system resolution transfer shows approximately twofold the image quality capabilities previously obtained.

Although the SO-255/SO-287 color reproduction system first used during Mission 1207-1 yielded substantial improvement in resolution and image quality transfer, overall dynamic tone reproduction suffered due to high contrast and curve shape mismatches as illustrated in Figure 3-2. The color duplicate positive copies prepared using this high contrast sensitometry resulted primarily in producing shadow densities that were judged to be too dark for existing photo exploitation viewing equipment; and secondly, the upper scale individual layer (high green-to-low-blue) contrast mismatches biased the shadow color balance toward magenta-blue. To correct for this upper scale contrast mismatch and overall high contrast characteristic, controlled pre-flashing of the print film was performed on a limited number of copies. This procedure consists of pre-fogging the print film in an additive color printer, prior to printing the color original, with controlled amounts of red, green and blue energy. This effectively lowers the upper scale maximum densities and reduces individual layer contrasts. Representative system reproduction curves reflecting this technique are shown in Figure 3-3.

Selected copies from Mission 1207-1 prepared using this system sensitometry demonstrated major improvement in reducing shadow density and restoring color balance without any apparent loss in image quality. The resulting pre-fogging produces system sensitometry nearly equivalent to the system sensitometry previously achieved in the SO-255/SO-356 system, as shown in Figure 3-4.

Ideal color print film sensitometry for reproduction of aerial color originals should aim for a high blue-to-low red contrast, to correct for the low blue-to-high red contrast mismatch inherent in the color original. Process modifications combined with pre-fogging techniques are currently being evaluated in order to further enhance the color tone reproduction (SO-255/SO-287) system.

Much current interest now centers upon the use of color film for economic intelligence. In this application, color fidelity of duplication may transcend spatial fidelity considerations. Bridgehead is therefore evaluating alternate color reproduction systems aimed at providing greater sensitometric flexibility (curve shaping and color correction) than can be currently achieved with SO-287.

New processes and films introduced and incorporated during the past year's events are listed in Table 2.

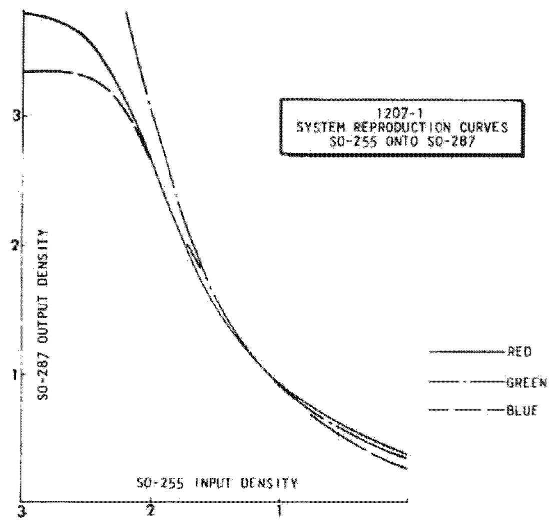

Figure 3-2. 1207-1 System Reproduction Curves, SO-255 onto SO-287

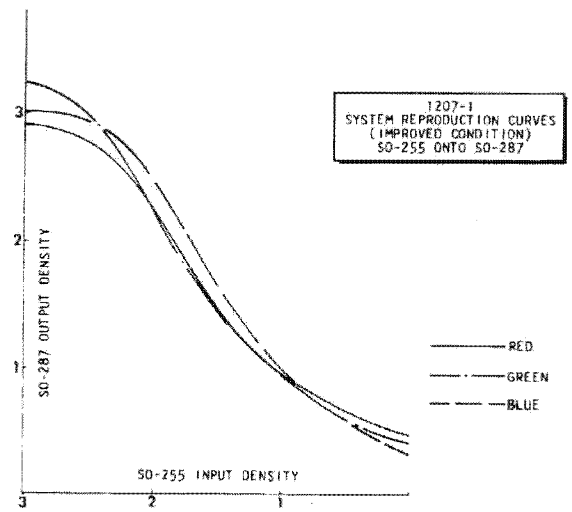

Figure 3-3. 1207-1 System Reproduction Curves, (Improved Conditions) SO-255 onto SO-287

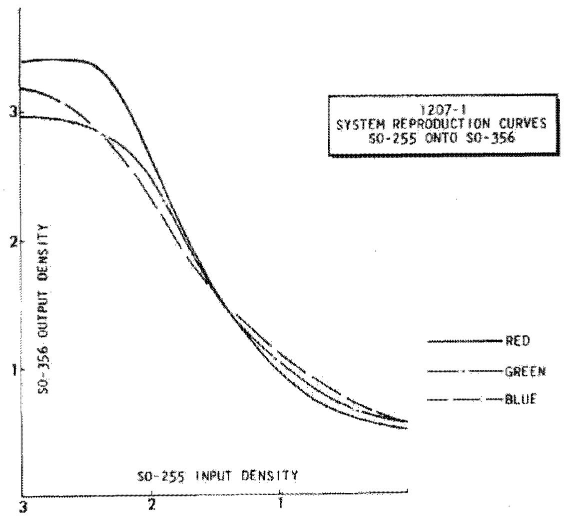

Figure 3-4. 1207-1 System Reproduction Curves, SO-255 onto SO-356

TABLE 2

COLOR FILM/PROCESS IMPROVEMENTS

Mission	Date	Orig. Pos.	Footage	System Change
1204-4	12/19/72	SO-255	9850'	Improved Acquisition (E-26-8) and SO-356 Dupe Processes (E-29-8).
1206-5	8/27/73	SO-131	99'	New Color I.R. Film introduced in S/I System.
1207-1	11/25/73	SO-255	4984'	Introduction of new color duplicating film, Aerial Color Print Film, SO-287, and new process. (Replaced color duplicating film SO-356.)
1207-4	2/21/74	SO-130	500'	First use of U.T.B.* Color I.R. Film and improved original process.

*U.T.B. is ultra thin base

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4.0 BLACK-AND-WHITE FROM COLOR

Black-and-white duplicate positives of color originals have been routinely produced since 1970. Their purpose is threefold, in that they

- provide a unique recording from the high resolution, low graininess layer of the SO-255 color original.

- permit timely delivery of the acquired imagery. This is particularly important for Hexagon mission material since it provides a stereo copy in black-and-white earlier.

- may serve adequately as a lower cost distribution copy if the color duplicate is deemed of no value to the interpreter/analyst.

The current system is the result of several years of experimentation with various film/process combinations, and currently employs a fine-grain, high contrast, high resolution orthochromatic Minicard film 6451, as master black-and-white internegative from the high quality SO-255 green record (magenta image forming layer). High Definition Aerial Duplicating Film SO-192, is then subsequently used to prepare the black-and-white duplicate positives.

4.1 Green Record Internegative

Two important aspects of the duplication system have made it possible to use 6451 as a green-record internegative film. These are printer/film spectral considerations and viscous processing.

a. Printer/film Spectral Considerations

The black-and-white master internegative is made on the Framingham (PAR 184) printer which employs a "white light" 5000-watt Xenon light source. The spectral output of this source when spectrally shaped with a Wratten 16 filter, prevents short wavelength energy from reaching the film.

Minicard Film 6451 is primarily blue-green sensitive; therefore, the remaining unfiltered green sensitivity provides the spectral isolation needed to achieve green record printing. This cascading of source, filter and film sensitivity elements results in an effective quasi-narrow-band spectral isolation and relatively efficient printing system.

b. Viscous Processing. MINICARD film 6451 normally processes to extremely high contrast, approaching sensitometric gammas greater than 6.0. However, lower-contrast processing in this application is accomplished by special viscous chemistry, which makes it possible to use this film and maintain consistent sensitometric control. Sensitometry illustrating the adjusted low-contrast capability provided by viscous developer techniques is shown in Figure 4-1.

Operationally, the major difficulty associated with the use of MINICARD 6451 as a green-separation internegative material is the formation of Newton's Rings (interference fringes) resulting from contact printing. Since MINICARD 6451 has an emulsion surface prone to the occurrence of this artifact, the Framingham printer, which uses a liquid gate assembly, applies a refractive index liquid between the color original/dupe interface matching that of the gelatin surface, thereby eliminating this artifact.

4.2 Sensitometric Flexibility. We have found that sensitometric flexibility must be employed in the second-to-third generation printing from 6451 onto SO-192. Contrast is now adjusted in the printing operation by selectively filtering the ultraviolet energy of the printer source. Printing system components illustrating the variable contrast printing technique are shown in Figure 4-2.

The non-neutrality of low-contrast-processed 6451 acetate-based internegatives, provides the potential for contrast attenuation by selective filtration of the REDONDO (mercury-arc) printer source as shown in Figure 4-2a, b, and c. Contrast control is achieved by varying the intensity of the 313nm low-contrast-producing line relative to the 365nm high-contrast-producing line when printing onto SO-192.

By altering the energy distribution of a REDONDO mercury-source printer in the ultraviolet region with spectral line-attenuating filters, duplication system contrast can be varied to levels that encompass the range of contrast levels provided by the SO-255 color original as shown in Figure 4-3. With this variable-contrast printing capability, it is possible to approach the tone reproduction best suited for each frame or group of frames.

Black-and-white from color printing sensitometry can now be changed on-line during reproduction to off-set variations in tonal transfer resulting from abrupt changes in acquisition conditions; such as haze, solar altitude and exposure. For example, the higher contrast printing condition as shown in Figure 4-3 would be used to reproduce a portion of the color original with a compressed density scale because it was acquired under heavy haze or at a lower solar altitude.

4.3 Image Quality

MINICARD 6451 film is a fine-grain, high-resolution material that yields virtually no loss in image quality and resolution transfer when used as an intermediate to reproduce the SO-255 color original. A third generation SO-192 duplicate positive printed from the 6451 internegative offers spatial quality that is superior to that obtained with SO-255/SO-356 color duplication system. As shown in Figure 3-1 (see Section 3.0), the current black-and-white

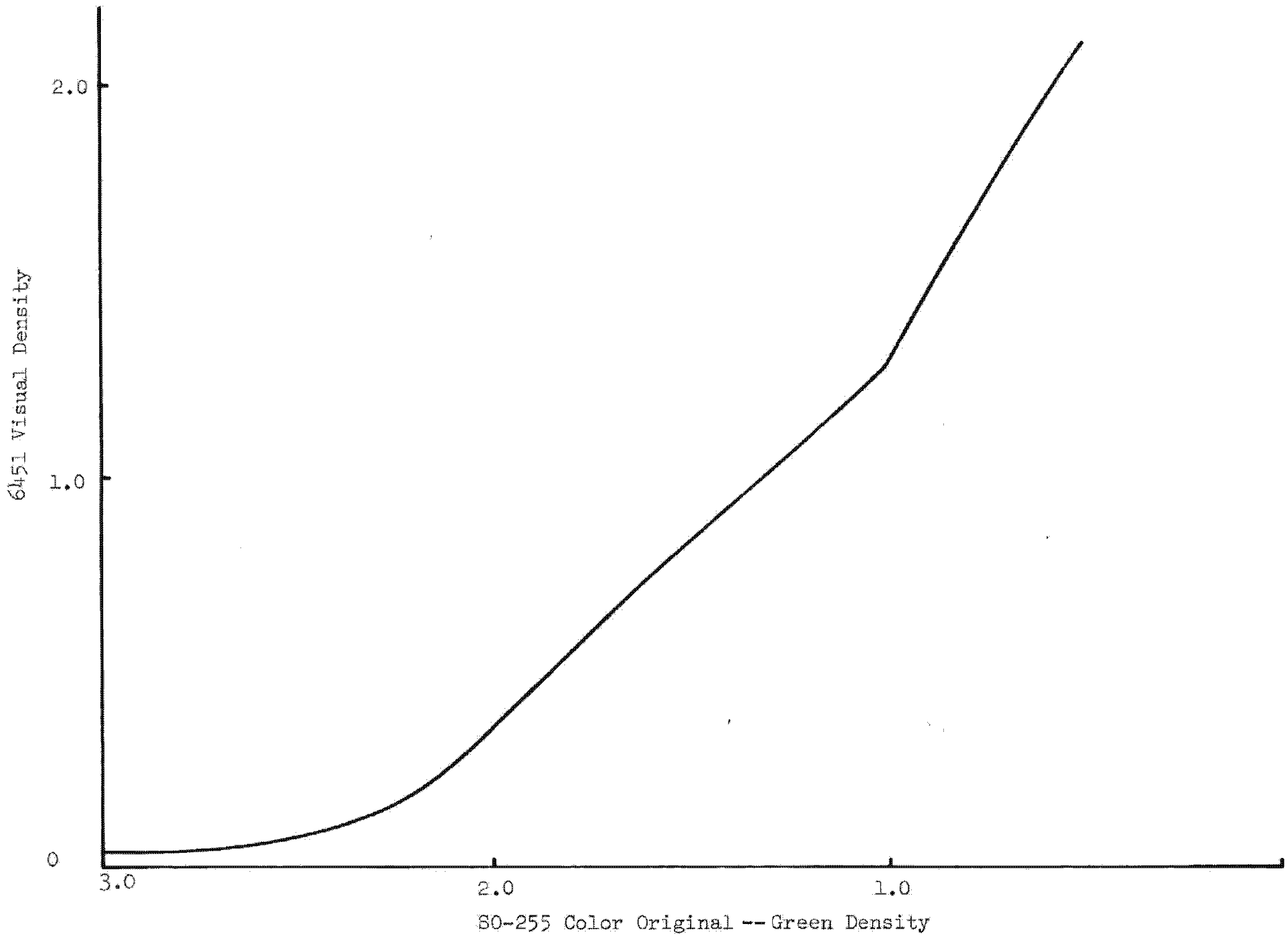

Figure 4-1. System Reproduction Curves for B&W Green Record from Color Original (SO-255→6451)

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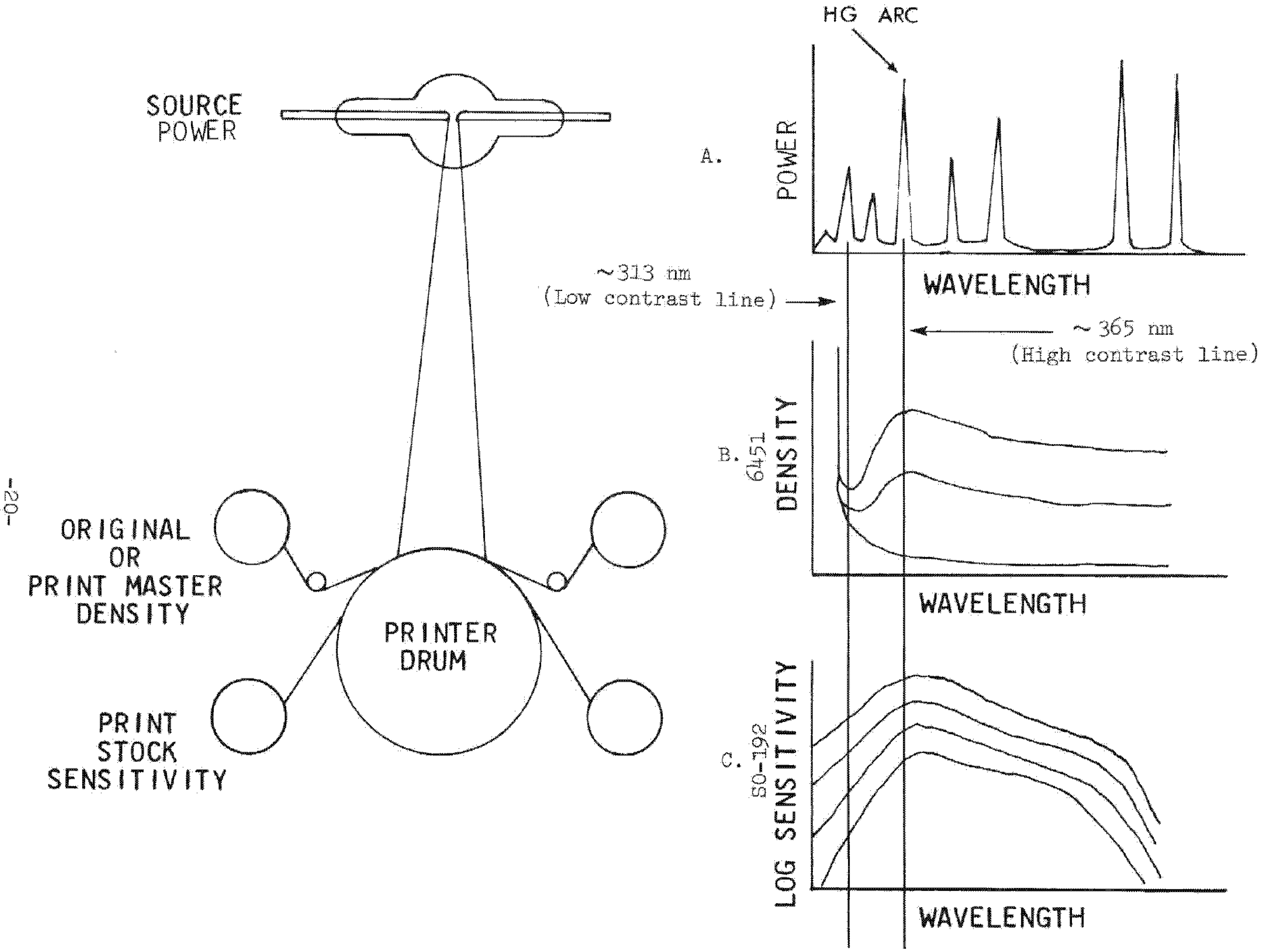

Figure 4-2. Printing System Component Spectral Data

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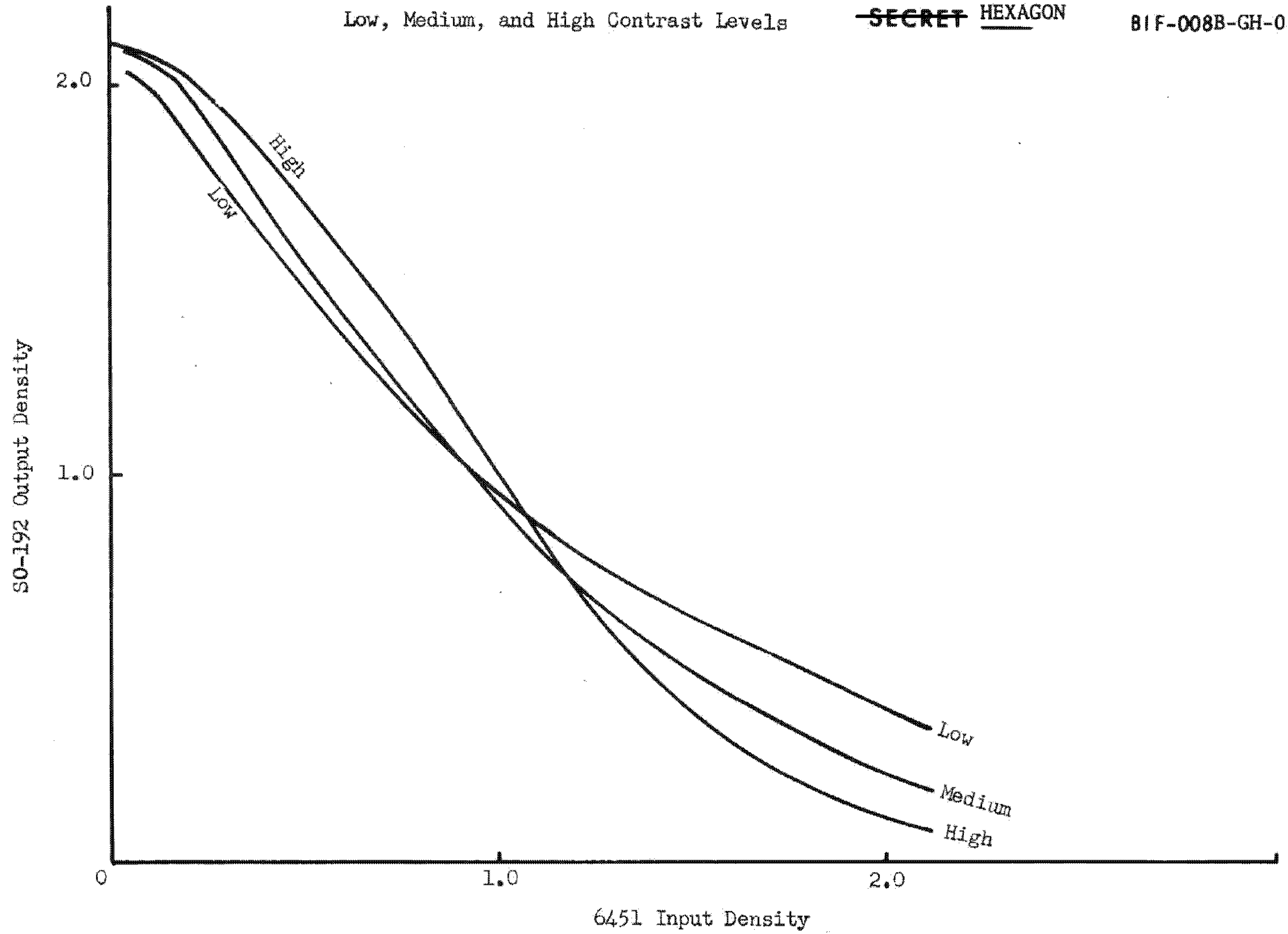

Figure 4-3. System Reproduction Curves for Third-Generation B&W Duplicate Positive (SO-255→6451→SO-192)

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from color duplicate positive system at 1.7:1 contrast ratio, yields 90 percent transfer compared to 65 percent transfer for SO-255/SO-356 (E-26-8/E-29-8 processes).

The new SO-255/SO-287 color duplication system has now closed the spatial quality gap between black-and-white and color duplicates prepared from SO-255 color originals; however, at this time (until the Color Production Processor can become production-viable in early 1976), the black-and-white duplicates still have a delivery time advantage and a cost advantage.

5.0 COLOR REPRODUCTION EQUIPMENT

Operational and under-development printers for reproducing color original films comprise the following:

a. FRAMINGHAM (PAR 184B). The Framingham Printer as shown in Figure 5-1, was developed under PAR 184B and introduced into the production system in May 1972. It is a subtractive, white-light, continuous contact drum printer which employs a 5000-watt modulated Xenon lamp. With computer interface, the printer makes pre-programmed frame-by-frame neutral exposure changes. Color balance corrections can be made by manual changes to the filter pack. The high intensity light source accommodates slower print films, both black-and-white for green record printing and color films. The Framingham is equipped with a liquid-gate assembly in which refractive index matching liquid can be applied continuously between the two webs of film as they pass beneath the exposing aperture in order to eliminate Newton's rings in the printed image. For example, the liquid-gate feature is routinely used in making the green record black-and-white master internegative when 6451 is printed from the SO-255 original. Maximum transport speeds for existing duplicating films are as follows:

Film Type		Speed (Ft./Min.)
SO-356	(Color Reversal Dupe)	100
6451	(B&W Master Inter-Negative)	25
SO-287	(Color Reversal Dupe)	25

b. RAINBOW PRINTER. The printer as shown in Figure 5-2 is a high-resolution, continuous contact printer which has a three-lamp lamphouse for additive color printing. The printer is used in conjunction with a matrix control unit which regulates the light intensities of the three separate lamps. The Rainbow printer is used primarily for contact printing color originals that do not require frame-to-frame exposure changes. Usable printing speeds for printing onto SO-356 is 100 ft/min; and SO-287 is 25 ft/min.

c. PRODUCTION-ORIENTED COLOR ENLARGER (POCE). The POCE is a precision enlarger capable of making high quality prints from color originals (see Figure 5-3). It was developed as an alternative to color contact printing for select targets where maximum transfer of information is required. Projection printing overcomes the transfer losses in contact printing and reduces the spatial frequency loss in information recorded by the print film. Resolution transfer tests from operational color originals have shown virtually no loss when the print is compared with the original.

POCE functions at either of two pre-selected magnifications, 5X or 10X,

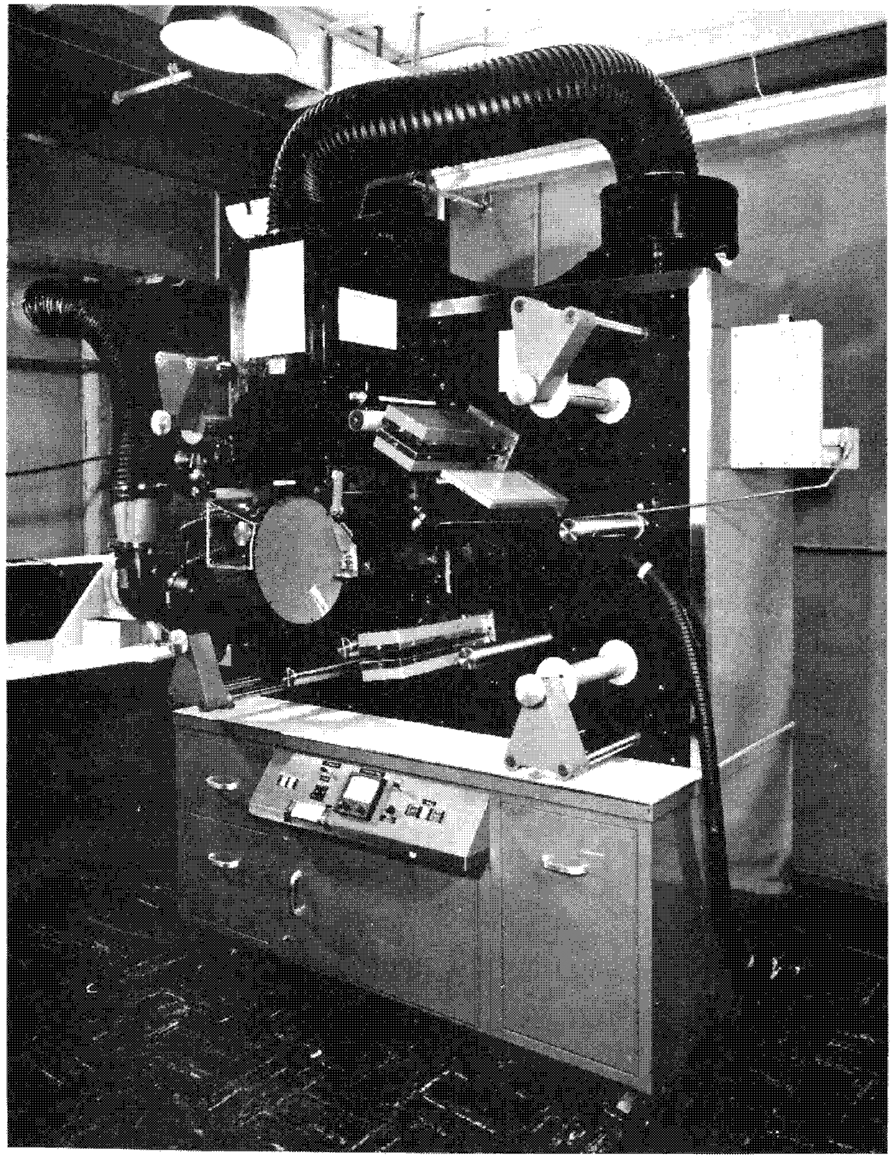

Figure 5-1. Framingham Printer (PAR 184B)

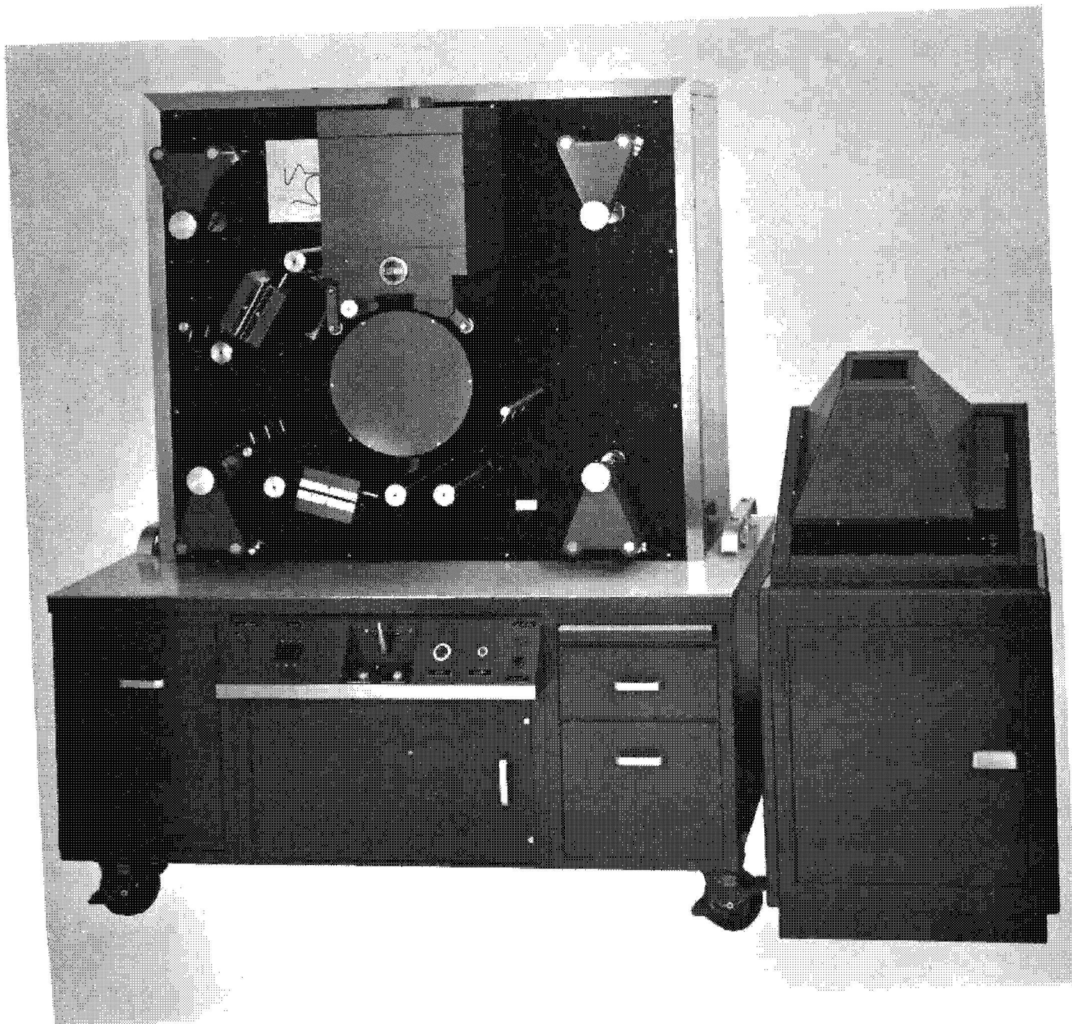

Figure 5-2. Rainbow Printer with Matrix Console

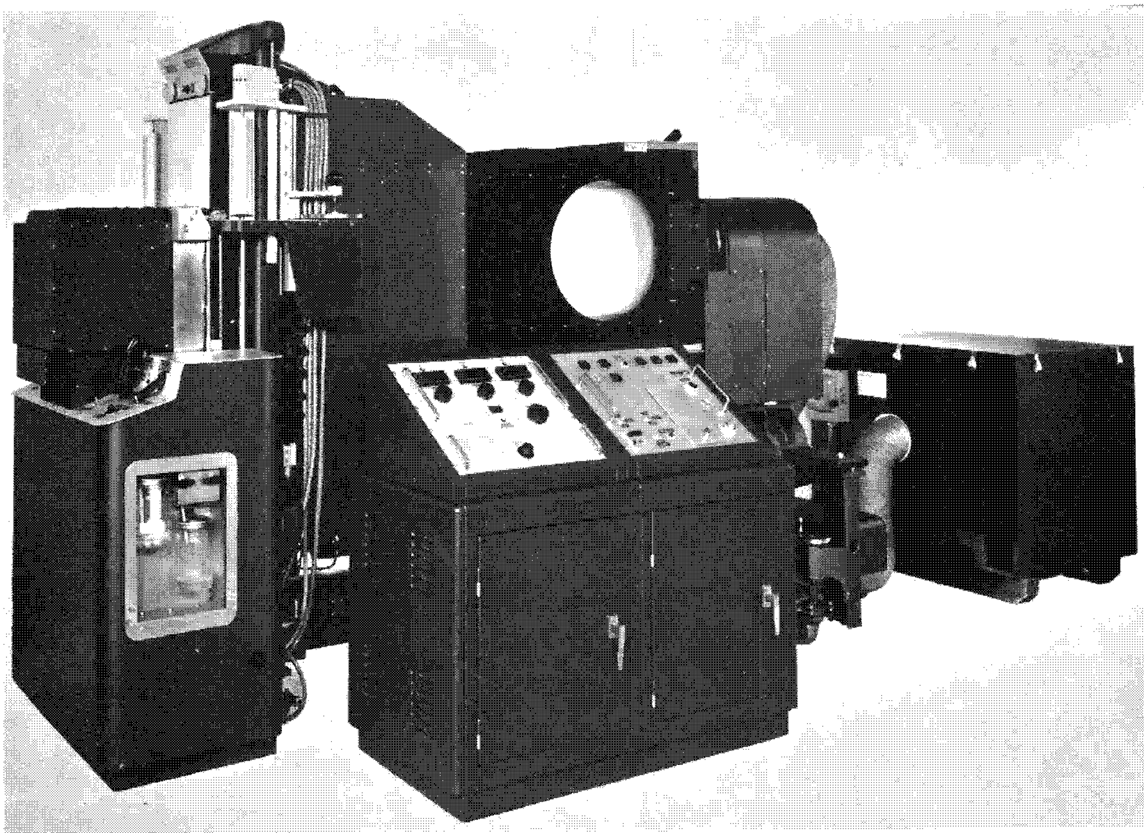

Figure 5-3. Production-Oriented Color Enlarger (POCE)

onto a fixed 9x12-inch format with a contiguous identification frame that is also photographically exposed.

Repeat prints are typically exposed at a rate of 4.8 per minute. The print easel accepts 9.5-inch x 500 ft. roll film (SO-360) which can be processed conveniently in a continuous roll film processor. Subsequently, the prints are cut into 18-inch sections and shipped as stacked flats. Although the production rate cannot compare with that of contact printing, POCE enlargements offer the highest quality color reproductions currently available on a routine production basis. The POCE was developed under PAR 176B and introduced into the color reproduction system in October 1972.

d. MODULATING FLYING SPOT PRINTER. A long-range development program to build a modulated flying-spot, three laser, additive contact printer is currently being pursued under PAR 301S. The printer capability includes two dimensional printing, along and across the film web simultaneously, correcting for density and color balance. The laser flying spot contact printer being developed includes real-time feedback control to accomplish this task. In addition, the printer has the potential for achieving macro-sensitometric curve shape adjustment and a dodging function that produces unsharp masking in the print to enhance the image quality of fine detail.

6.0 COLOR PROCESSORS

Existing and under-development color processors comprise:

a. The Grafton, illustrated in Figure 6-1, is the primary production processor used for both original and duplicate aerial color film processing. Although the process chemistry has been substantially modified over the past two years, the external tank configuration has remained essentially unchanged during that time. As shown in Figure 6-2, the Grafton is now a 32-tank immersion processor -- the result of fifteen years of periodic add-ons and consolidations of deep-tanks from other black-and-white processors no longer in use.

To insure reliability and reduce product risk in processing color original ultra-thin base films, periodic engineering redesign and upgrading of the transport mechanism and roller assemblies have been essential. In 1967, submerged agitation plenums (SAPS) were incorporated to improve process uniformity. This modification resulted in improved chemical recirculation/distribution, and provided the potential for using the improved chemistry (E-26-8) process incorporated in 1972-1973. The Grafton operates at a throughput rate of 7.5 ft/min for current original and duplicate color reversal processes.

b. The Multi-Purpose Modular Processor (MP^2), (see Figure 6-3) was designed to be a flexible testbed processor; primarily aimed at evaluating film/process combinations and, secondarily to serve as a mechanical test fixture upon which design engineers could examine the performance and reliability of equipment components planned for future color production processors.

The processor configuration provides 24 identical modular tank units - each tank having independent recirculation, filtration, tempering and agitation facilities. (This recirculation system was patterned after the submerged agitation plenums (SAPS) presently incorporated into several sections of the Grafton.) The chemical distribution layout of the MP^2 provides for a majority of process tank stages to be configured by means of "quick disconnect" type re-plumbing. The materials of construction of the MP^2 are chemically compatible with all known chemistry constituents to be evaluated -- for example, titanium tanks were employed throughout. Figure 6-4 depicts some of the respective process tank layouts for several processes scheduled for investigation at the time the MP^2 was conceived (1969).

Coincident with completion of the Phase I Color Facility consolidation at Bridgehead, MP^2 installation commenced in June 1972, and the processor was turned over to production in April 1973. This resulted in the acceleration of process evaluation studies including: new or improved processes for color duplication materials (SO-356 and SO-287), and the evaluation of newly developed processes using High Definition Aerochrome Infrared films, SO-130 and SO-131.

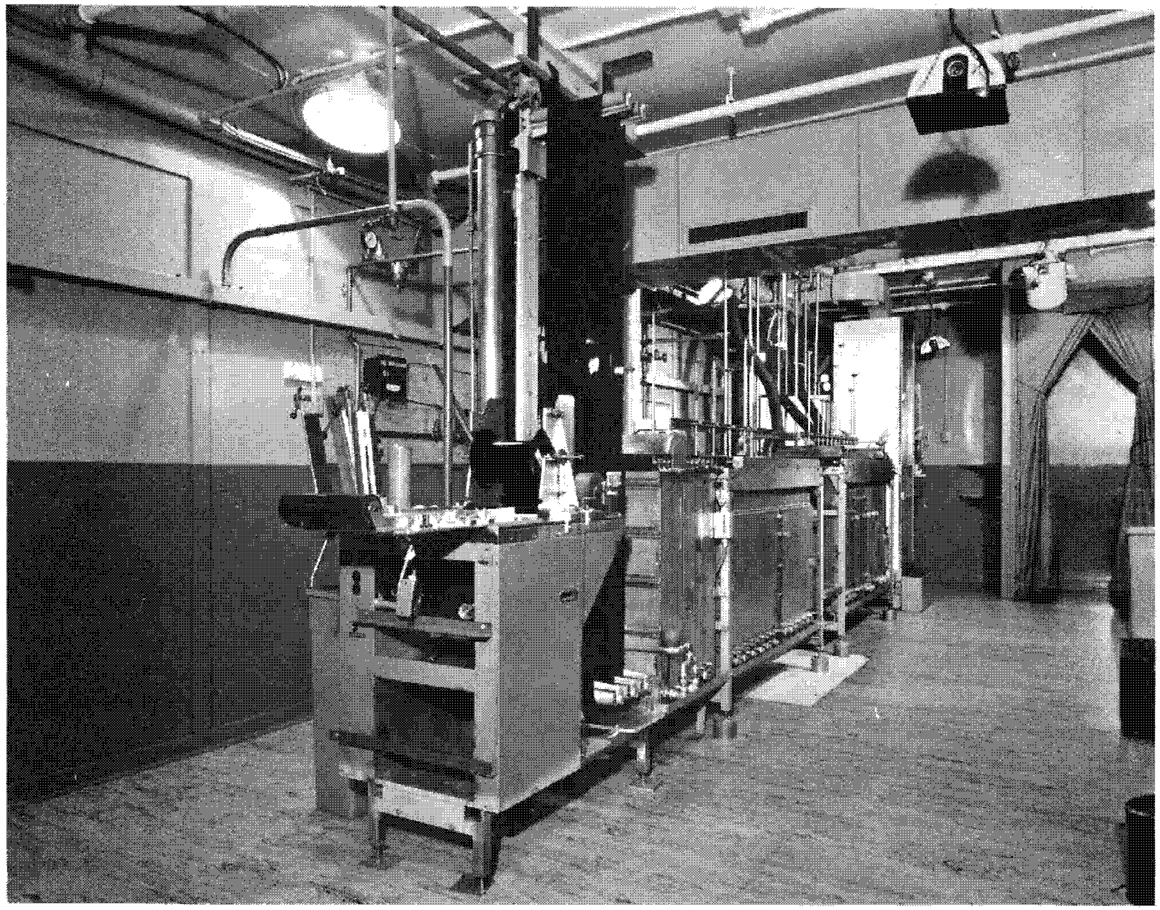

Figure 6-1. Grafton Processor

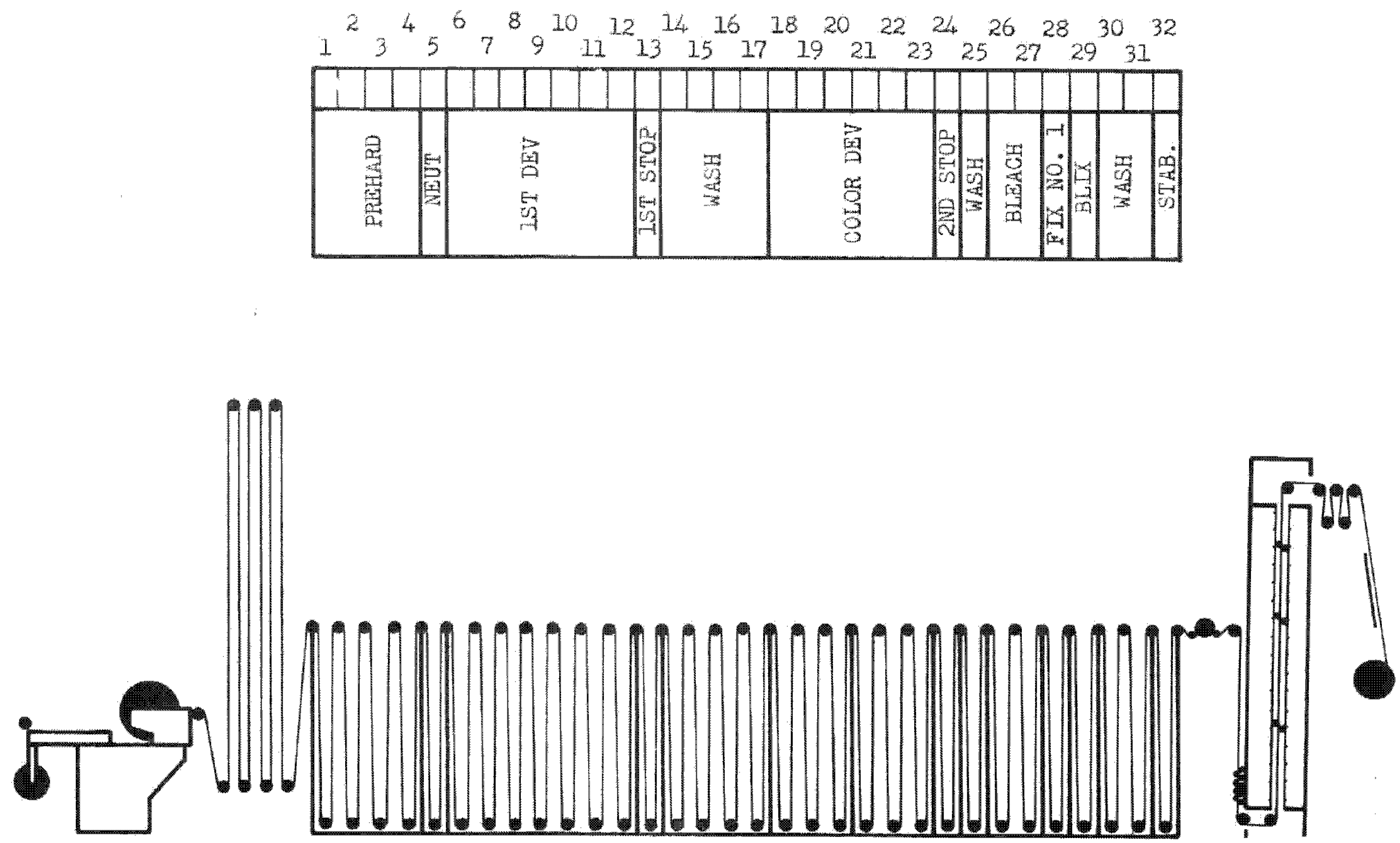

Figure 6-2. Grafton External Tank Configuration

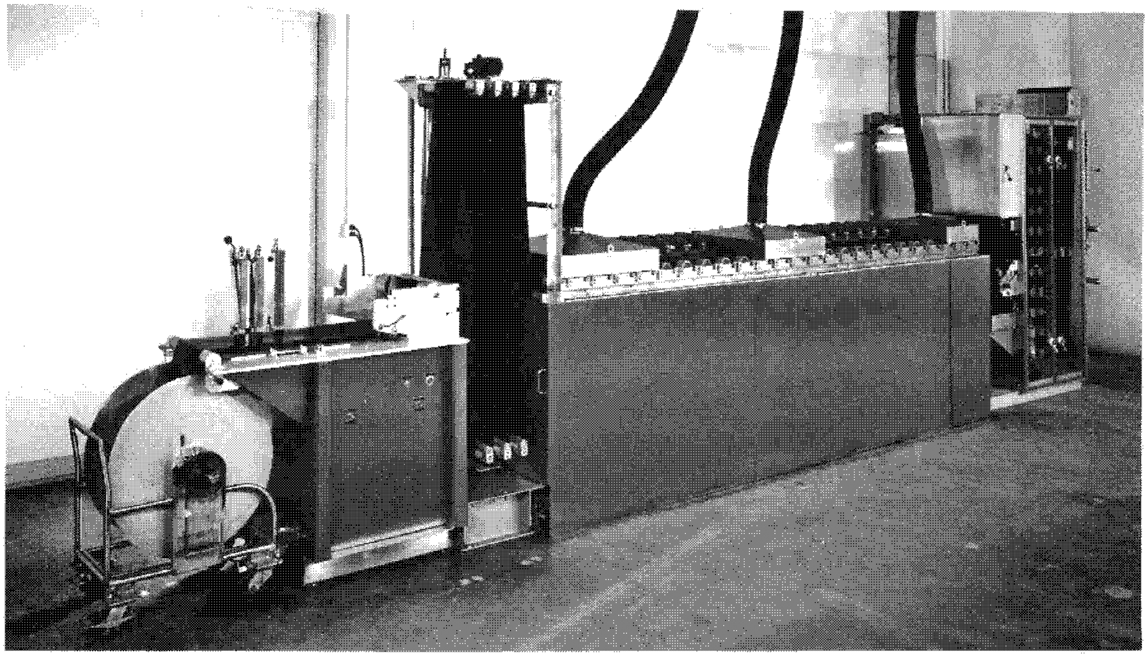

Figure 6-3. Multipurpose Modular Processor (MP^2)

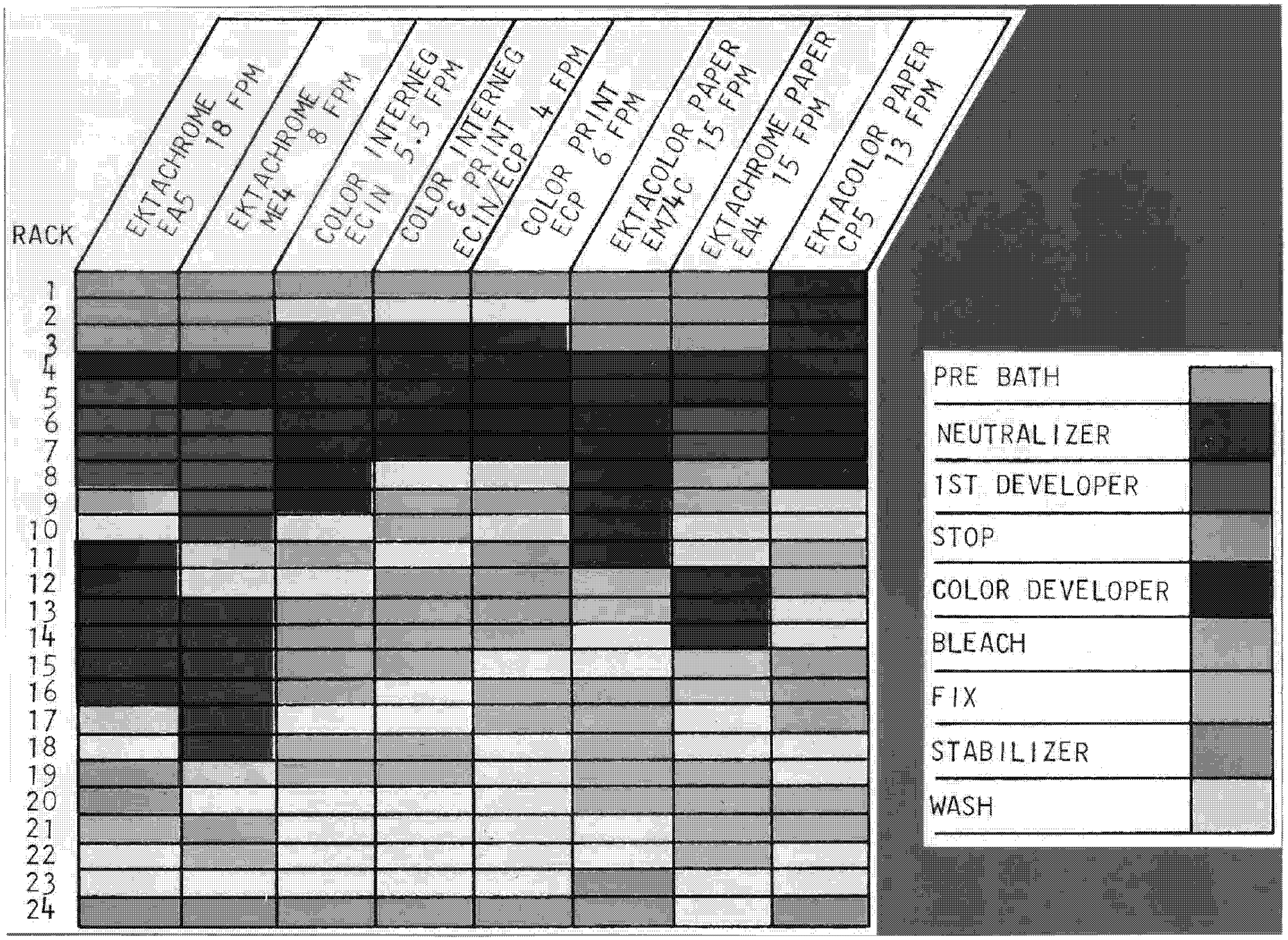

Figure 6-4. Multi-Purpose Modular Processor (MP²)

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The MP^2 has additionally been employed to a limited degree as a production processor, and provides the potential for parallel operation of two color original film processors. This dual capability may be particularly useful when a mission original contains more than one type of color film, such as (SO-255) and infrared color film (SO-130). Current plans for expanding the production application of the MP^2 provide for a gradual division of color duplication processing on future color missions in order to expedite product delivery. In this manner, the MP^2 will serve as a means to initially complement the color duplicating workload with that of the Grafton, and to later act as the "pivot" machine during the phase-down of the Grafton processor and transfer of color production processing to the new color production processor (CP^2), planned to be on-line at Bridgehead in early 1976.

c. The Ragdoll, (Figure 6-5) is a 27-section deep tank immersion processor now used only for the processing of color internegatives (Eastman Color Internegative Film 7271) at 3.6 ft/min. This equipment is of 1940-1950 vintage, having been assembled from various sections of discarded black-and-white processors.

d. Color Production Processor (CP^2). Currently in the final design stages, the CP^2 is to be capable of processing either color reversal or negative materials (original and duplicate) with optimum sensitometry and image quality.

The CP^2 will be the first new processor designed and built during the span of the national reconnaissance program that has been aimed at high volume wide-web color production processing, and is an outgrowth of experience gained through efforts associated over the years with the Grafton and MP^2.

Current designs provide for a nominal through-put rate of 30 ft/min for color original film, and 45 ft/min for color reversal duplicating films.

These through-put rates, in consideration of the square film footage involved, will represent an unprecedented capability for volume processing of wide-web color films while achieving the highest quality consistent with the state-of-the-art.

Figure 6-6 is a plan and elevation view of the current processor design. The machine utilizes tanks 5 ft. in depth. Each tank provides a triple pass for the film and is of modular construction to provide thread path flexibility with minimum machine complexity. Submerged agitation plenums (SAPS) along with ballasted recirculation is to be provided in the critical solutions to control process uniformity. Other tanks containing non-critical solutions will be equipped with turbulators for agitation and to

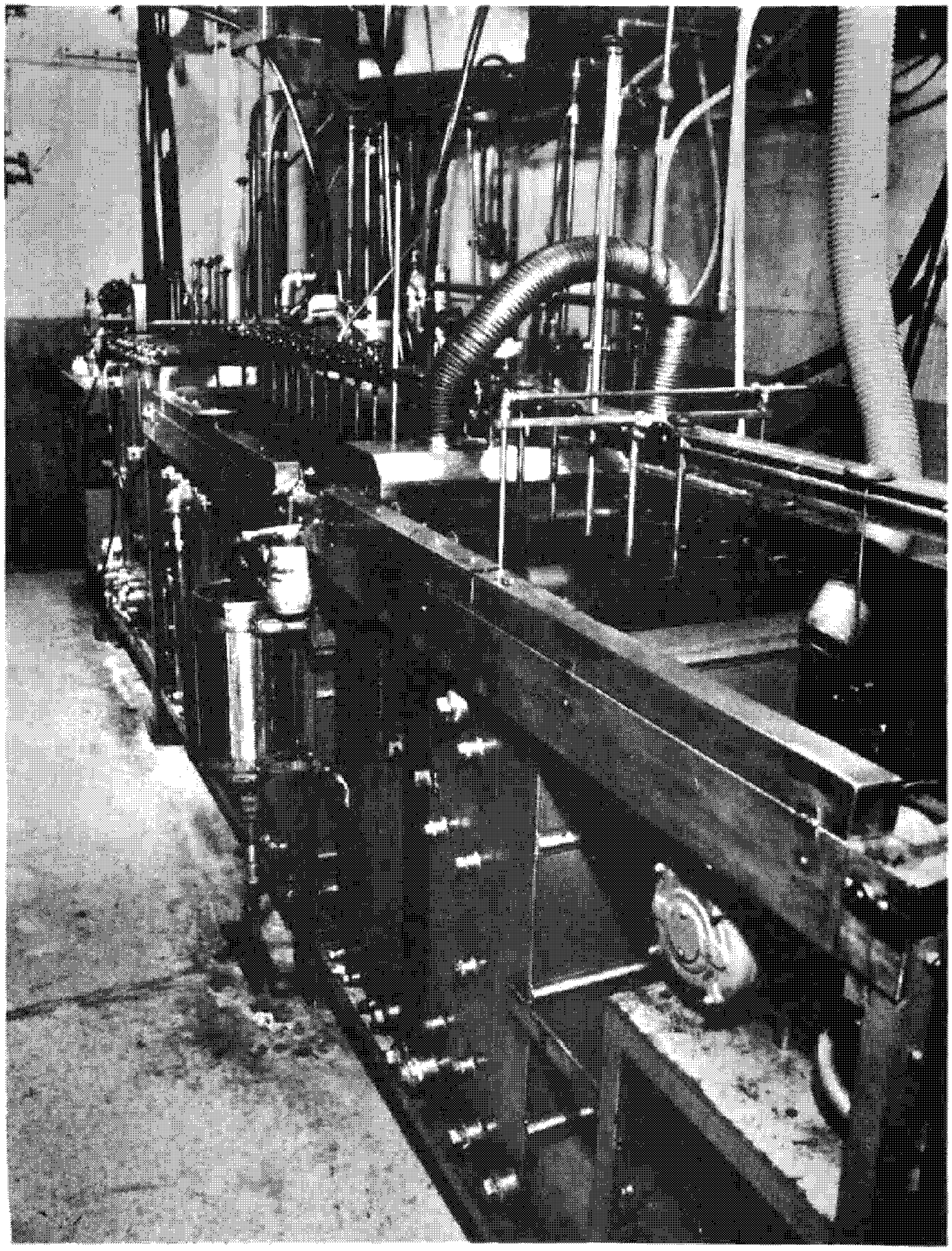

Figure 6-5. Ragdoll Processor

COLOR PRODUCTION PROCESSOR - CP^2

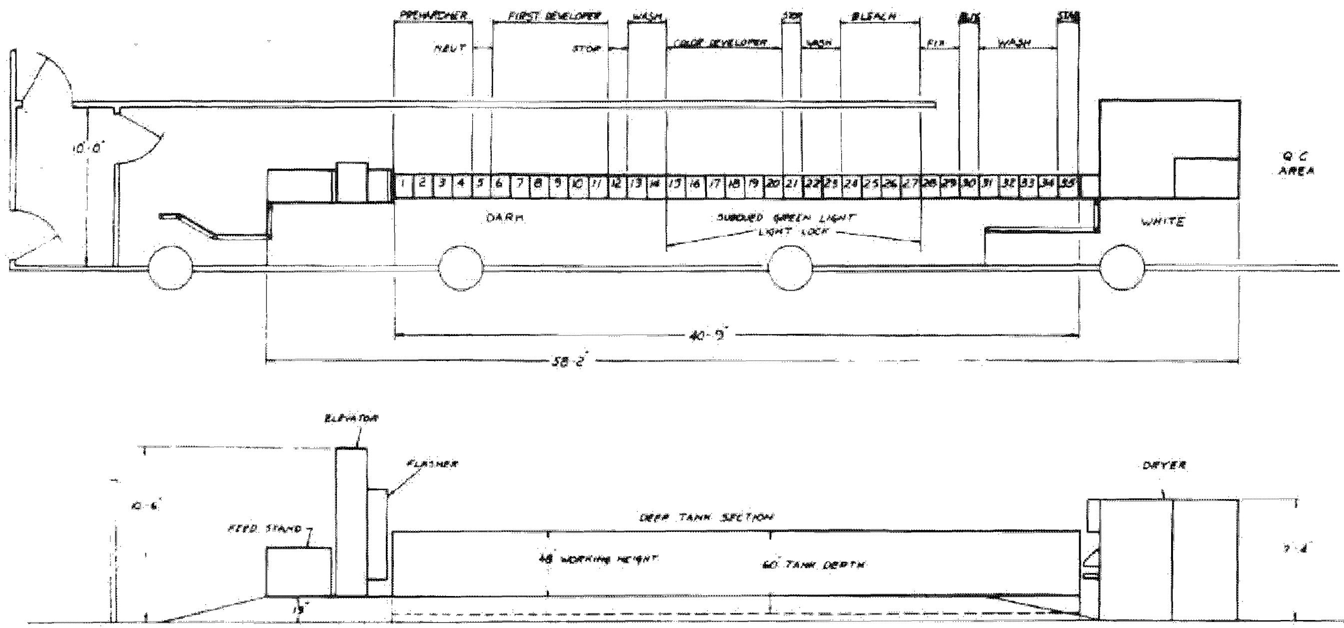

Figure 6-6. Color Production Processor (CP^2)

provide quick tank turnover time. Adjustable depth racks in the tanks will provide means for establishing time in each solution.

An edge flasher is located between the front elevator and the first tank section. Space has been provided to accommodate a detector and edge titler as a retrofit accessory. All the basic mechanical components necessary for the operation of the CP^2 will be located on the floor below. The dryer end of the machine will be located in white light, near the control area, where all functions of the machine such as time, temperature, speed, recirculation, filtration systems, etc. will be monitored and adjusted.

Figure 6-7 shows the CP^2 processor configurations and through-put speeds projected for film/process combination currently in use. In addition, the design flexibility of the CP^2 will enable it to handle virtually any conceivable new or specialized color process chemistry.

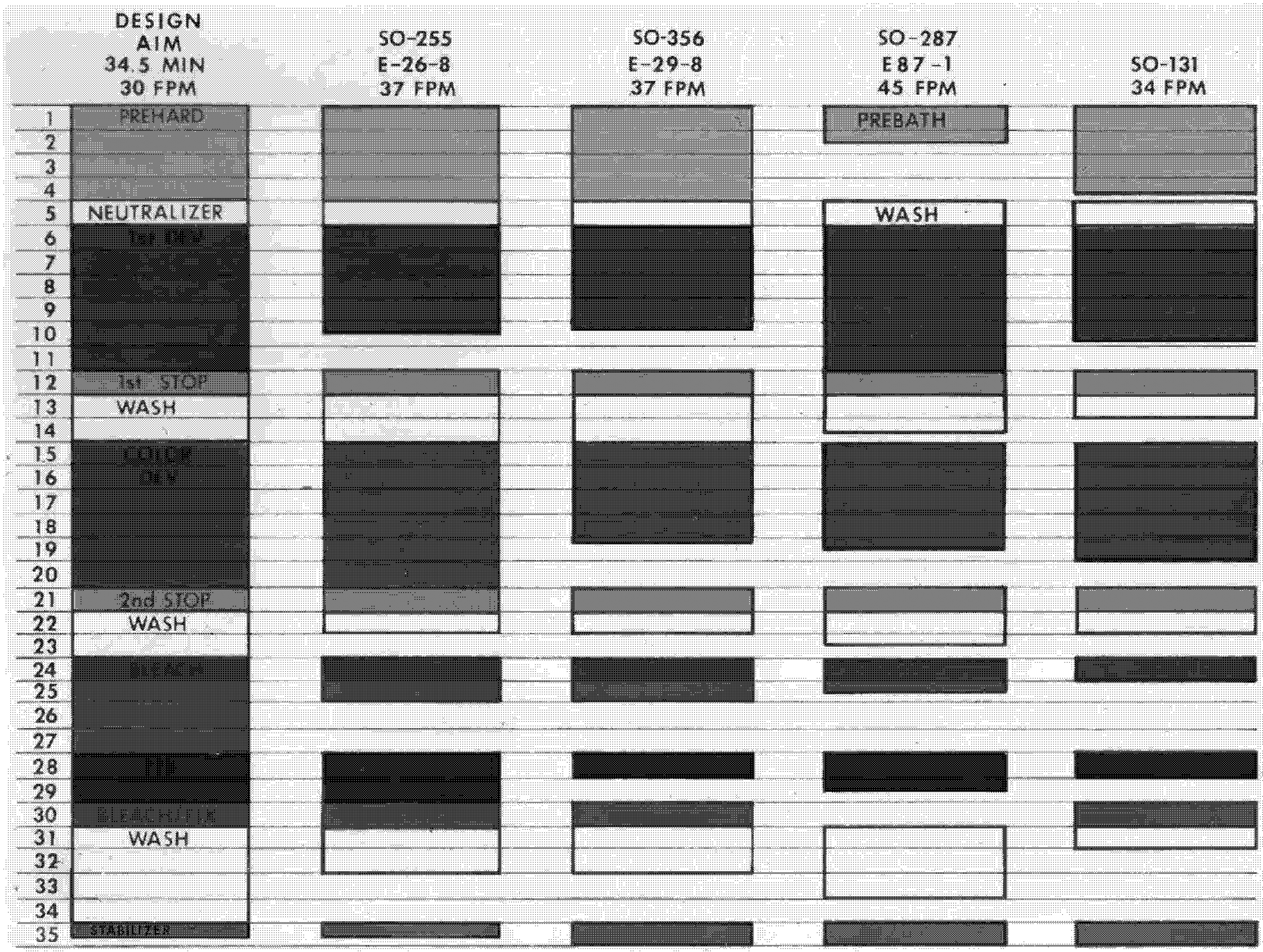

Figure 6-7. Various Processes in the CP^2

7.0 COLOR PROCESSING OPERATIONS

The incorporation and use of new films, processes, and reproduction equipments in today's color reproduction scheme is discussed in the following sections.

7.1 Production Work Flow

The basic production steps from the receipt of exposed color film at Bridgehead to the shipment of processed original and duplicate copies, are shown in Figure 7-1.

7.2 Production Schedules

Timelines for the typical color production operations for Gambit and Hexagon recovery vehicles* are shown in Figure 7-2. Color film loads of 1,000 feet for Gambit and 5,000 feet for Hexagon were selected as "typical". These timelines represent average (late 1972 and 1973) production schedules and assume the use of only two production processors - the Grafton, at a throughput rate for both color reversal camera original and duplicating materials at 7.5 ft/min, and the Ragdoll, for color internegative film (7271), at 3.6 ft/min. These timelines also illustrate the overlapping operations performed during the reproduction phases.

7.3 Gambit Color Production

Typical Gambit color reproduction schedules for 500 feet and 1,000 feet of Gambit color photography are charted in Figure 7-3 to produce 30 color duplicates (SO-356 or SO-287) and 4 color internegatives (7271). The requirement to produce a green-record black-and-white master internegative during the early part of the production cycle adds approximately 24 hours to the delivery schedule for Gambit color duplicates.

Within this time, specialized enlargements on the POCE and Beacon

* The nature of the photography of most winged-vehicle acquisition systems, (i.e., slower trend exposure variations as opposed to larger frame-to-frame exposure changes) is similar to that encountered in Hexagon. For this reason, timelines indicative o the Hexagon system can also be considered representative of the general handling times for such missions modified by the number of copies required.

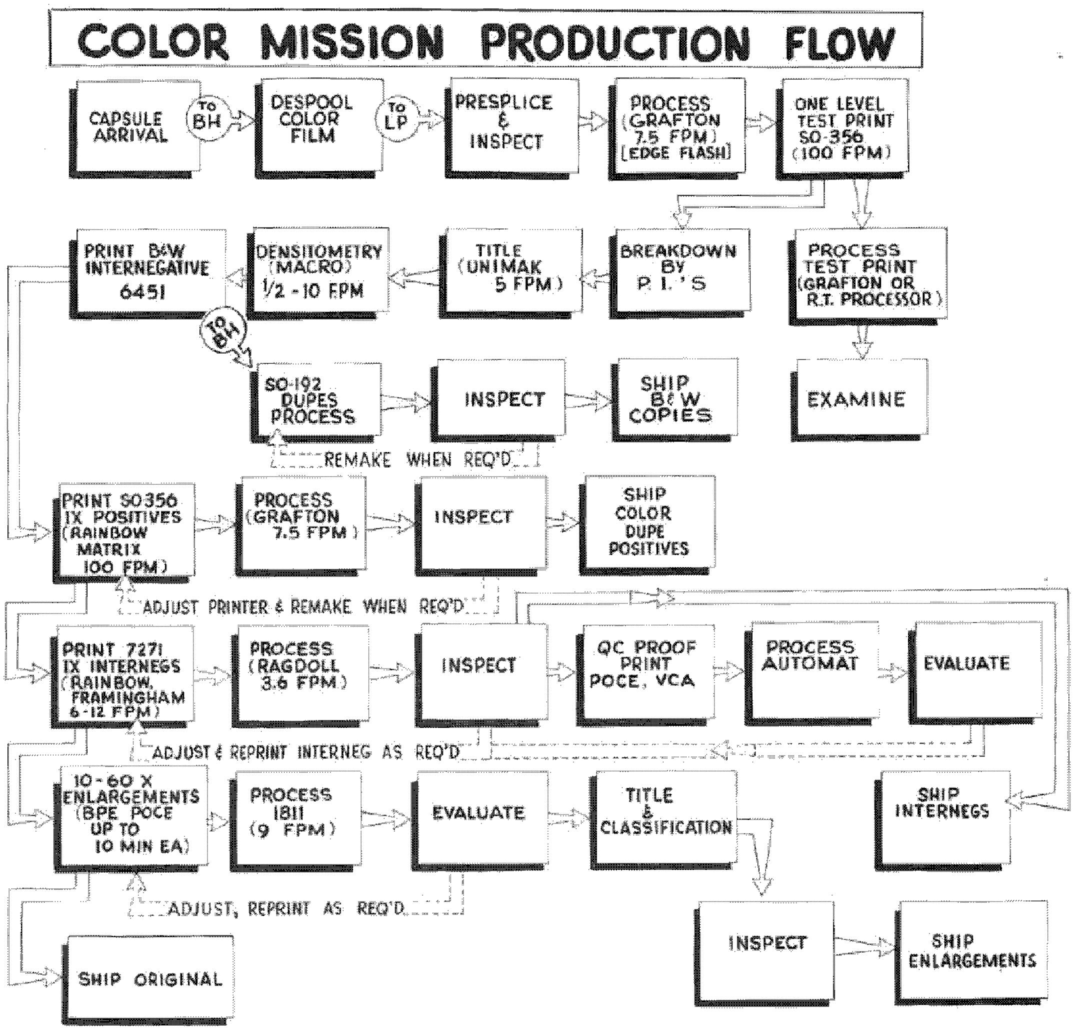

Figure 7-1. Color Mission Production Flow

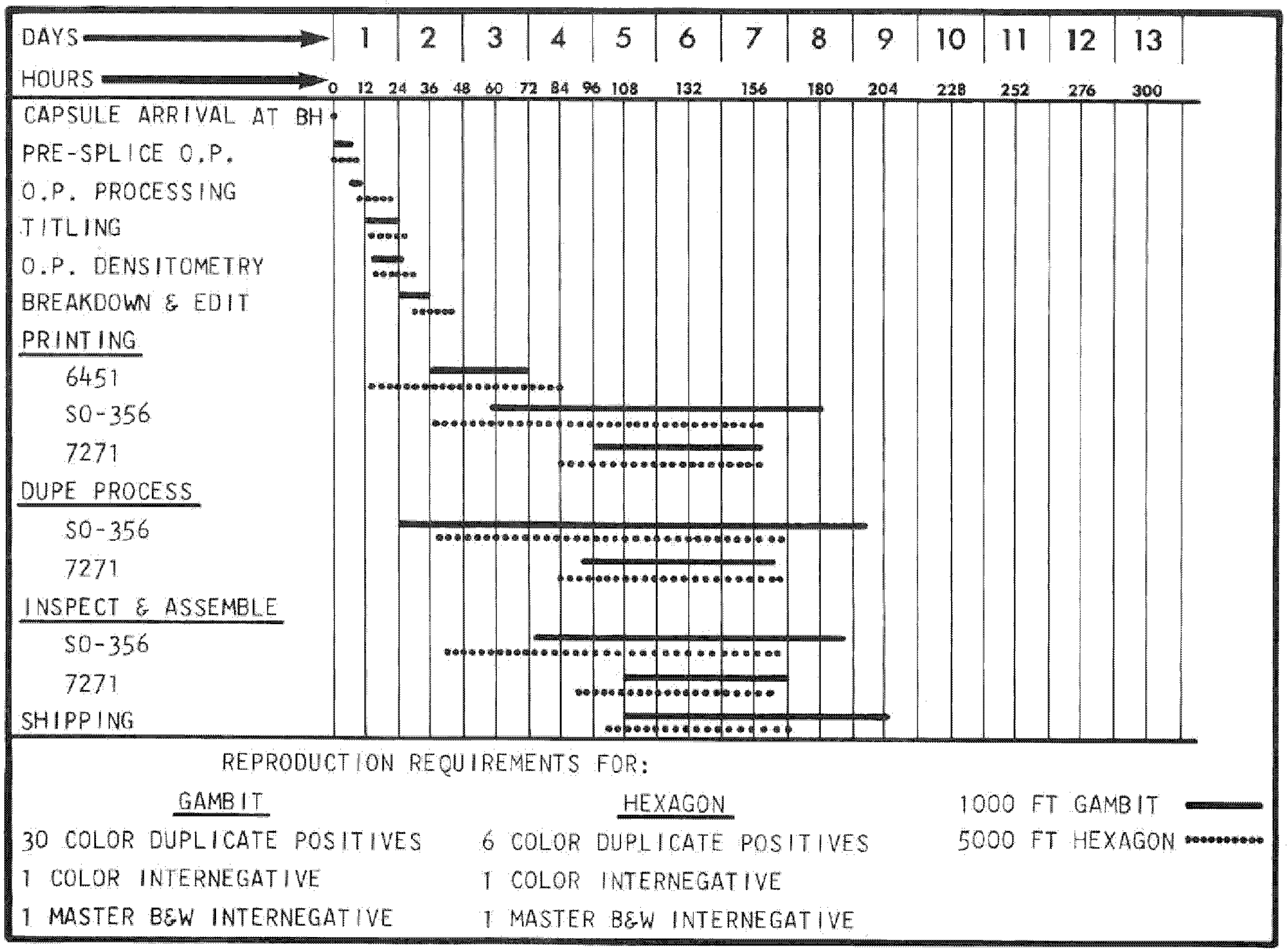

Figure 7-2. Color Production Operation Timelines for Hexagon and Gambit

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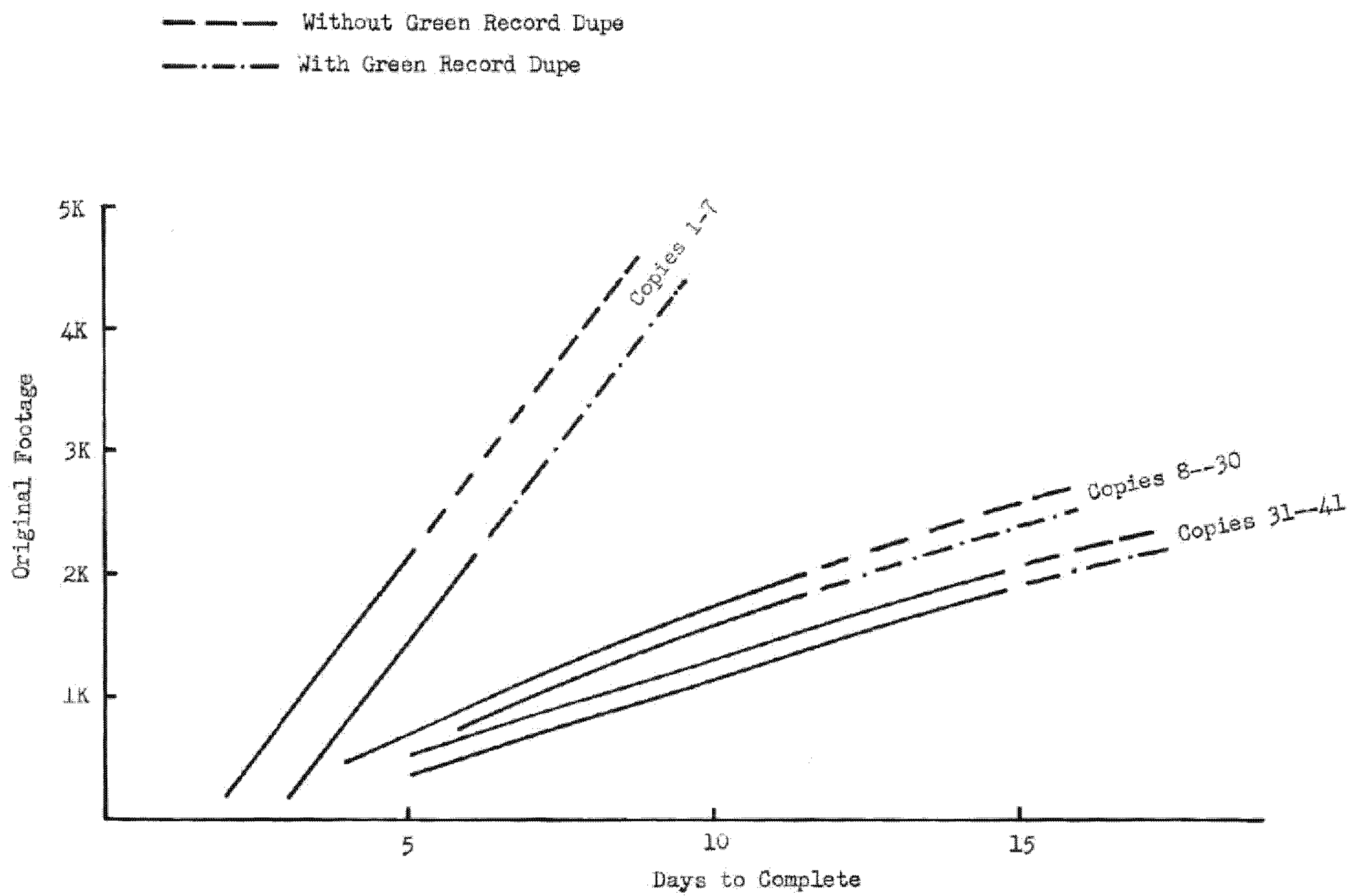

Figure 7-3. Current BH Gambit Color Duplication Capabilities

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Precision Enlarger (BPE) can also be produced and shipped.* Typical enlargement output within this time would be on the order of four to five transparency prints each, from 75 to 100 targets (5X or 10X) produced on the POCE, and approximately 36 assorted paper or transparency prints (3X to 150X) produced on the BPE.

Prior to the construction of the Framingham (PAR 184B) printer, Gambit duplication was performed on Rainbow printers, which have no ability to make density adjustments on a frame-by-frame basis. Gambit photography frequently produces adjacent frames requiring density correction in duplication; therefore the production technique employed required that the color original be cut and composited according to density levels. After the composited rolls were printed on the Rainbow printers, each duplicate copy had to be reassembled, frame-by-frame, into the original sequential order.

With the introduction of the Framingham Printer, pre-programmed on-the-fly density correction is made. This eliminates the need to cut and composite the original positive and results in substantial reduction in the duplication timeline. The Framingham (subtractive) printer has no ability to adjust automatically, or on-the-fly, for color balance variations. Color correction filters must be inserted manually for part-by-part color balance adjustment, when necessary. Color balance changes are generally required only of scene acquisitions which exhibit excessive amount of haze radiance, or are made at low solar altitudes.

The current color production system is nominally paced by the throughput speed of the Grafton dupe process (at 7.5 ft/min). Full production capacity is achieved only after piloting is complete, green record internegative made, and when a sufficient number of printed color duplicates are available to be continuously supplied to the Grafton processor. This steady state production is seldom achieved until after the first 70 hours of Gambit mission operation.

Commencing with Mission 4342, geographic area breakdown of Gambit photography will be employed. First cut estimates indicate that the total shippable duplicate footage may be reduced by a factor of 35% - this should

*Commercial roller transport processors (two Kodak Ektachrome RT Processors, Model 1811 and one Model 1411 Processor) are utilized for processing color enlargements. The availability of these processors permits the exclusive use of the Grafton for production contact duplicates.

materially shorten the time required to complete Mission requirements. Figure 7-4 represents an extrapolation of the delivery times that may be achieved with geographic area breakdown.*

7.4 Hexagon Color Production

The production capability indicated in Figure 7-5 shows that a 5,000 foot Hexagon mission requires approximately 6 calendar days to complete six duplicate positives. Hexagon production methods differ in three respects from those used with the Gambit system:

a. Due to the normally longer camera original of the Hexagon system, portions of the mission record are removed from the processor and are available for printing prior to the time that the entire original is completely processed. This interim time is consumed by making color dupe pilots and processing these film samples off-line in an Ektachrome RT Processor, Model 1811.

b. Because of the longer color original footage, the production of green-record black-and-white master internegative has little or no effect on the total color delivery time.

c. Because of frame-to-frame exposure continuity, Rainbow printers can be advantageously used on Hexagon missions.

Since the pacing factor on production time is again the speed of the duplicate process (7.5 ft/min in the Grafton), it is essential with the longer Hexagon originals to provide the Grafton processor with printed color duplicates as soon as possible. This normally accounts for an elapse time of 64 hours for a 5K length mission. After that time, the length of the mission and the number of dupe copies determines the production rate and completion time of the mission.

7.5 Color Production, Future Consideration

With SO-356 being printed at speeds up to 100 ft/min on the Rainbow

*The solid line in Figure 7-4 represents current color dupe production capability excluding the black-and-white green record duplicate positive. The current requirement is as follows: Priority one, 7 copies; priority two, 23 copies; priority three, 11 copies.

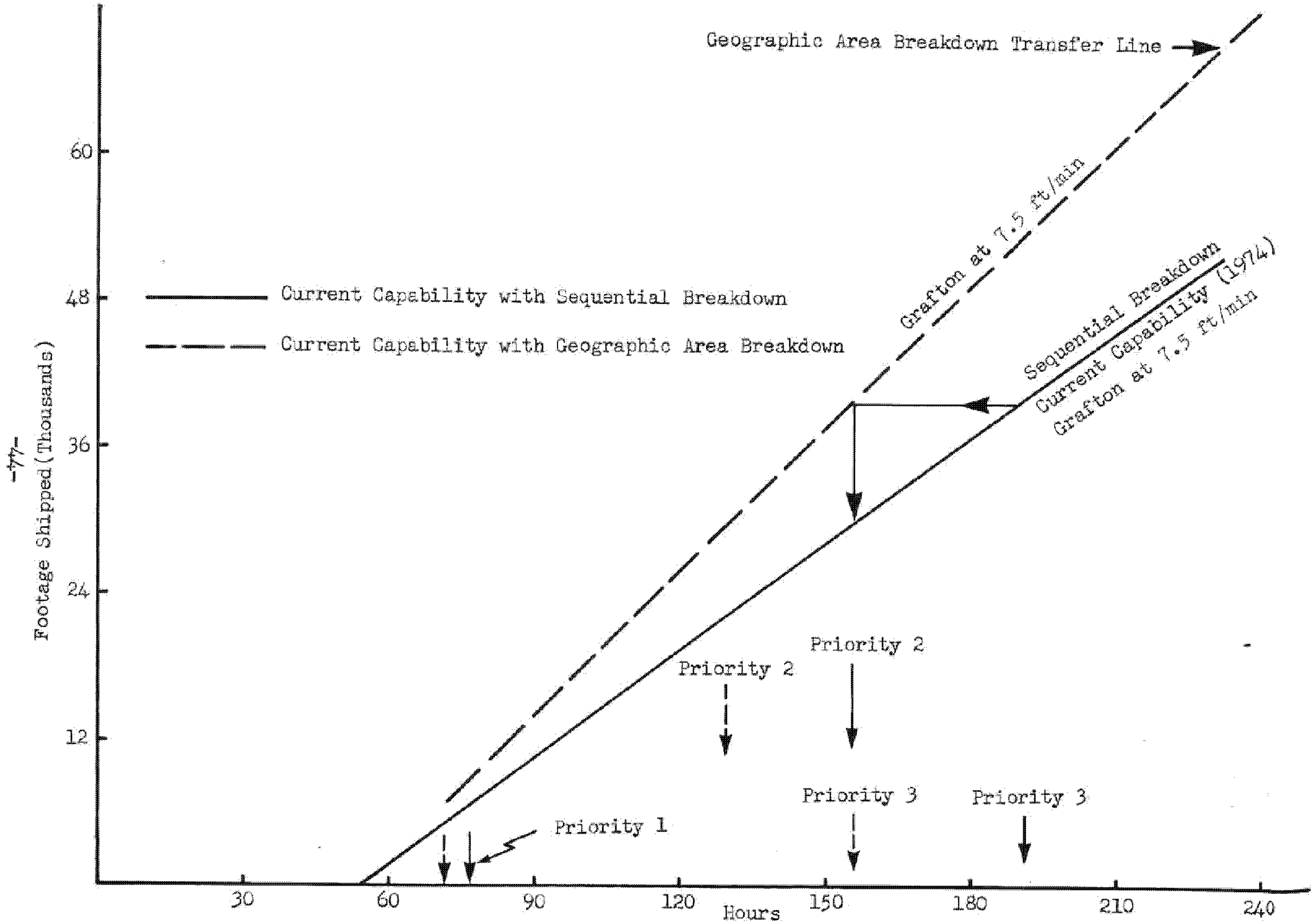

Figure 7-4. Influence of Gambit Geographic Area Breakdown on Production Delivery Schedule (without B&W Green Record DP)

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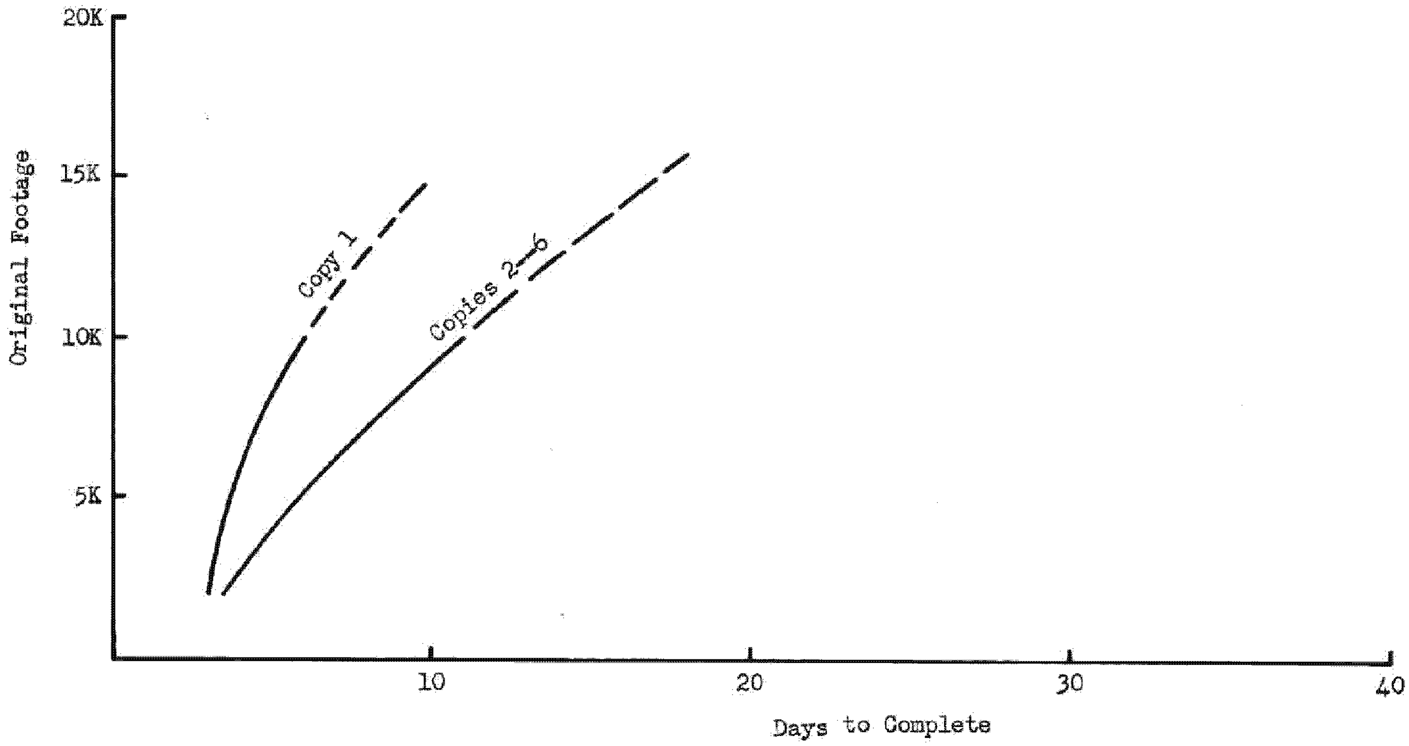

Figure 7-5. Current BH Hexagon Color Duplication Capabilities

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and Framingham printers, there was no problem in being able to continuously supply the Grafton processor with printed film. The recent shift to SO-287 film, requiring slower printing speeds (12 to 25 ft/min), signals a down-stream printer capacity problem which will become out-of-balance when the MP^2 and CP^2 processors are brought on-line, permitting a total dupe process capability of 58 ft/min in 1976.

Future printer designs capable of printing SO-287 at higher printing rates will need to be addressed before that time.

The transition of the color production facility to Bridgehead can begin as early as July 1974; however, significant increases in production capacity will not be achieved at Bridgehead until the CP^2 processor can be brought on-line in early 1976. During the interim period, color duplication processing will be divided between the Grafton at Lincoln Plant and the MP^2 at the color Bridgehead facility to the extent that manpower limitations can support.

With the on-line entry of the CP^2 processor in early 1976, significant reduction in color mission delivery time is anticipated. Assuming that the printer capacity can be increased to continuously feed the CP^2 (at a through-put speed of 45 ft/min), estimated delivery schedules for both Gambit and Hexagon missions reflecting the introduction of the CP^2 processor compared to the Grafton (at 7.5 ft/min) are shown in Figures 7-6 and 7-7. These delivery schedules include the geographic area breakdown for Gambit but do not include the production of green record black-and-white duplicate positive for either system.

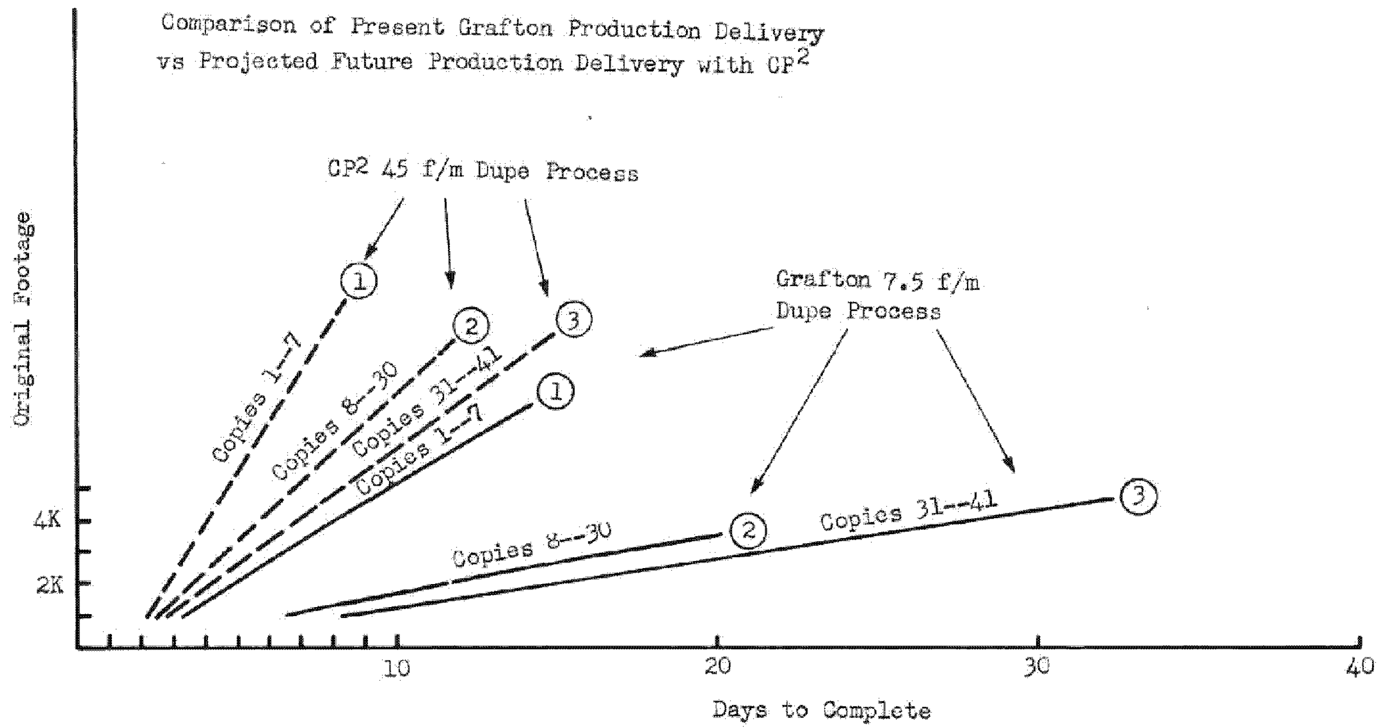

Figure 7-6. GAMBIT Color Duplication Capability at BH

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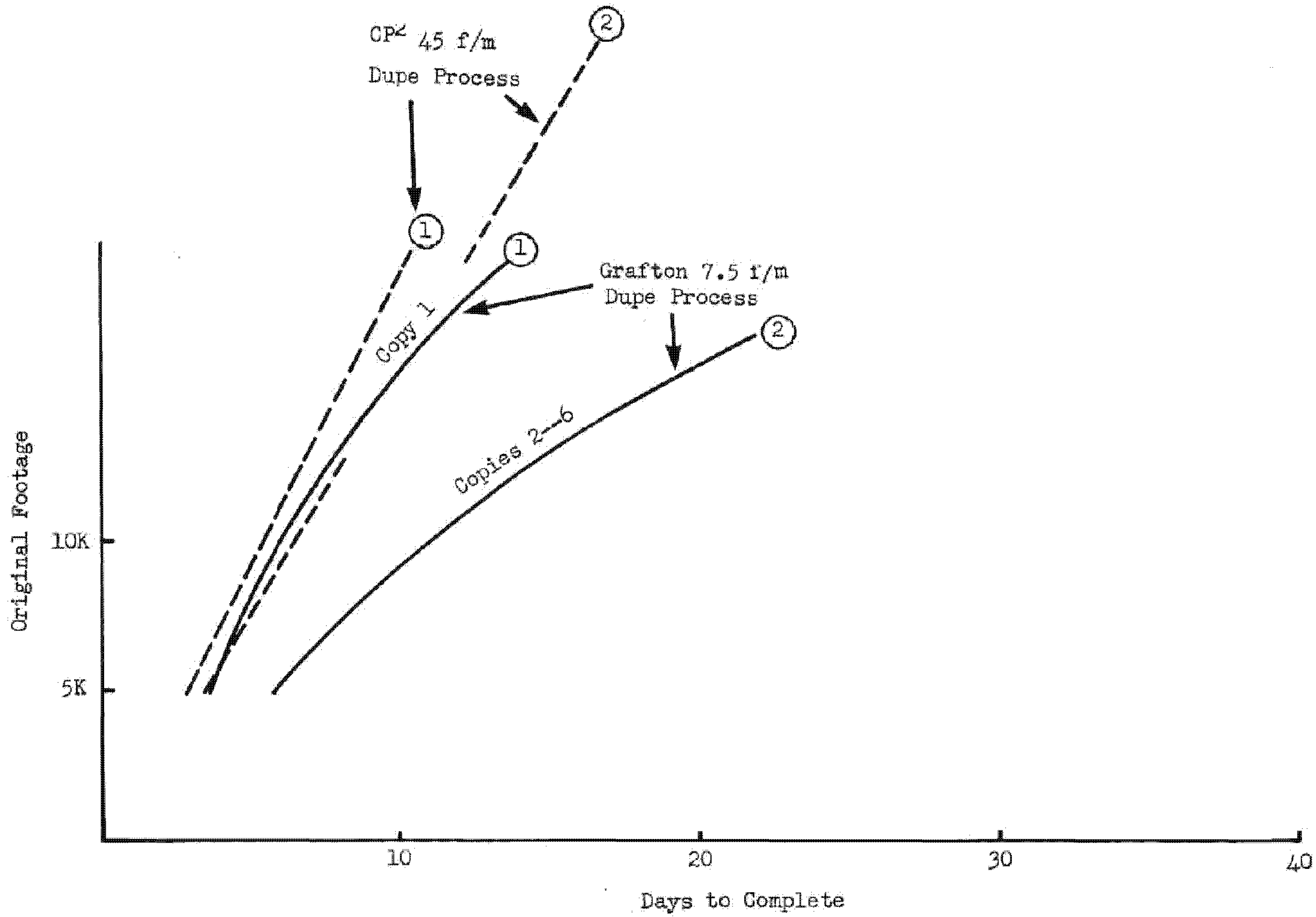

Figure 7-7. Hexagon Color Duplication Capability at BH

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8.0 FACILITY CONSOLIDATION

In 1970, faced with a rapidly growing interest by the National reconnaissance community in the use of color, the contractor proposed a modest facility expansion for color processing and reproduction to be contiguous to and consolidated with the existing Bridgehead facility.

The contractor presently occupies and operates a wide-web aerial color film processing and reproduction facility on the fourth floor of Unit 7, Lincoln Plant complex. The entire Lincoln Plant complex is a Navy-owned, Contractor-operated site, located approximately six miles from the primary black-and-white processing and reproduction center at Bridgehead.

This Lincoln Plant facility encompasses approximately 23,000 sq. ft. on the upper two floors of a four story wood-structured/brick-face building built in 1905. Although many of the printing, viewing and analysis equipments within this facility represent near state-of-the-art in film handling and reproduction, the processors and supporting chemical facilities are deemed ill-suited for precision processing operations for the following reasons:

- Precision alignment of processors is virtually impossible. Season-to-season variations in the wooden structural members and floors require periodic realignment.

- Floor loading limitations negate any significant expansion of chemical mix, storage and distribution systems and would severely limit the design and size of future experimental or production processors.

- Present water and sewer lines would require extensive augmentation to accommodate expanded color production capacity.

- Extensive chemical pollution control systems being designed for installation at Bridgehead would have to be essentially duplicated and installed at Lincoln Plant.

- Although Unit 7 is air conditioned, temperature and humidity control within the color facility is inadequate during the months of July and August.

- Current production output is approximately 7-1/2 ft per minute - thus deliveries of color materials to the exploitation community lag appreciably behind black-and-white deliveries.

Accordingly, in 1971, under the aegis of the CCB and National Color Task Force, a three phase program was developed, dedicated to the concept of developing a modern color processing and reproduction facility within the Bridgehead black-and-white facility.

The specific goals of the plan were to:

- develop a responsive state-of-the-art color production center which could provide high quality color duplicates to meet the time-sensitive needs of the photo intelligence community.

- consolidate film breakdown, compositing, off-line titling, inspection and shipping facilities for both black-and-white and color production.

- eliminate a costly satellite facility and attendant security area at Lincoln Plant.

- provide for the installation and checkout of new generation color experimental and production equipment while maintaining production capability on the existing equipments, thus permitting transition to BH without any reduction in support capability.

The status of this three phase facility consolidation program is as follows:

PHASE I - of the consolidation program was started in September 1971 and completed early in 1973. 13,280 sq. ft. of contiguous space was acquired on the first and second floors of Building 12 and the second floor of Building 11 at Bridgehead. (See Figure 8-1.)

Major renovation of the second floor provided installation of the MP^2 processor, printing and viewing rooms, offices, and an equipment room to house necessary utilities for support of the processor and air conditioning requirements. The major portion of the second floor was temporarily used for consolidated storage after being brought inside the security perimeter.

The first floor of Building 12 has been prepared for a color chemistry storage, mixing and distribution facility to support the MP^2 processor. Mezzanines were constructed to hold the 24 pumpstands and recirculation loops for the MP^2 processor, and to support solution recirculation systems for future color production processing machines.

PHASE II - of the consolidation program was initiated in the spring of 1973. It provides for further preparation and improvement of the previously acquired areas in Buildings 11 and 12. This phase (see Figure 8-2) provides for the transfer and operation of virtually all specialized color reproduction and testing operations within the Bridgehead facility. Also included in Phase II facility is the renovation of the temporary storage areas of Phase I to accommodate equipments currently in operation at LP. These improvements include air conditioning, chemical exhausts,

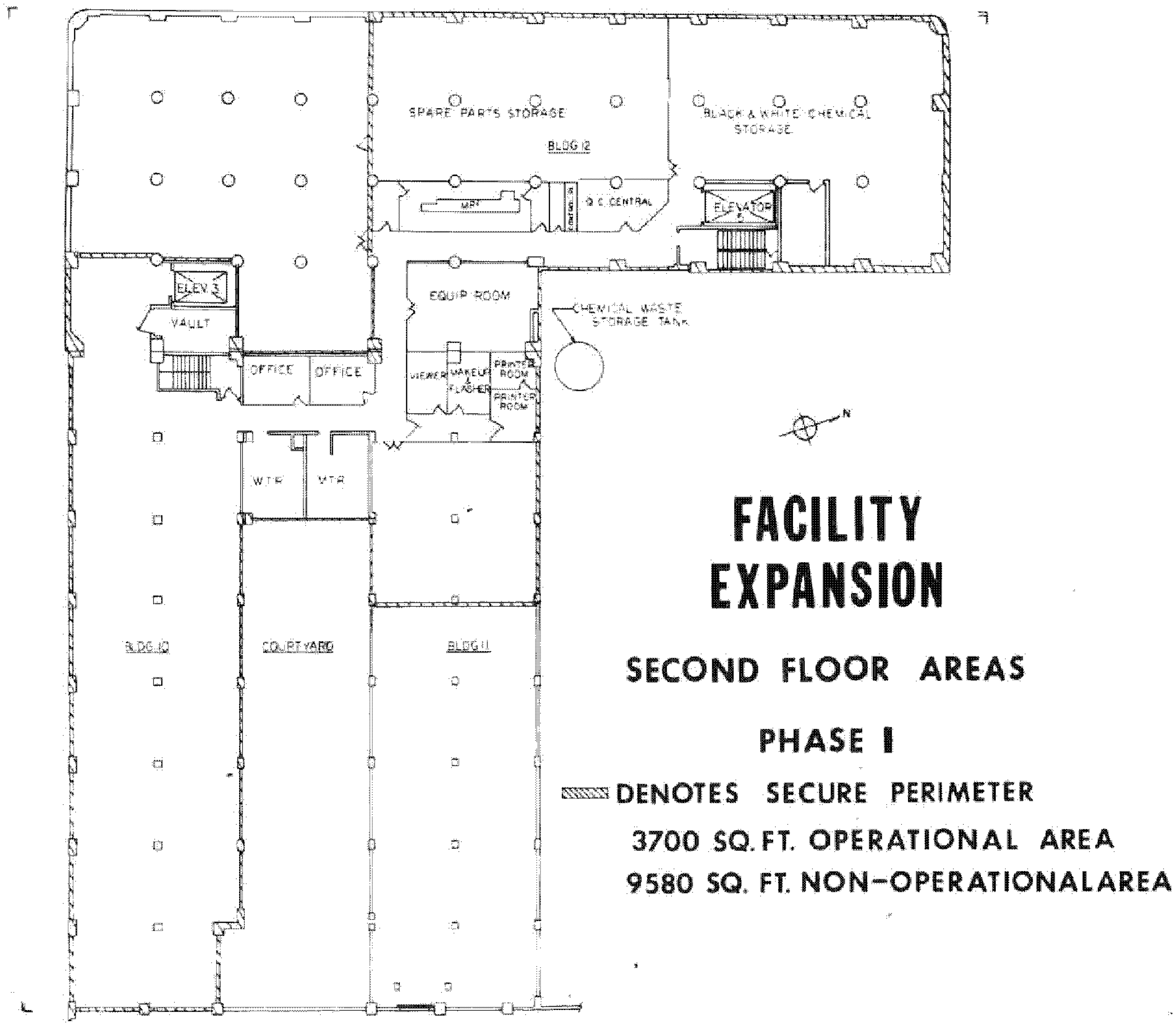

Figure 8-1. Facility Expansion, Phase I

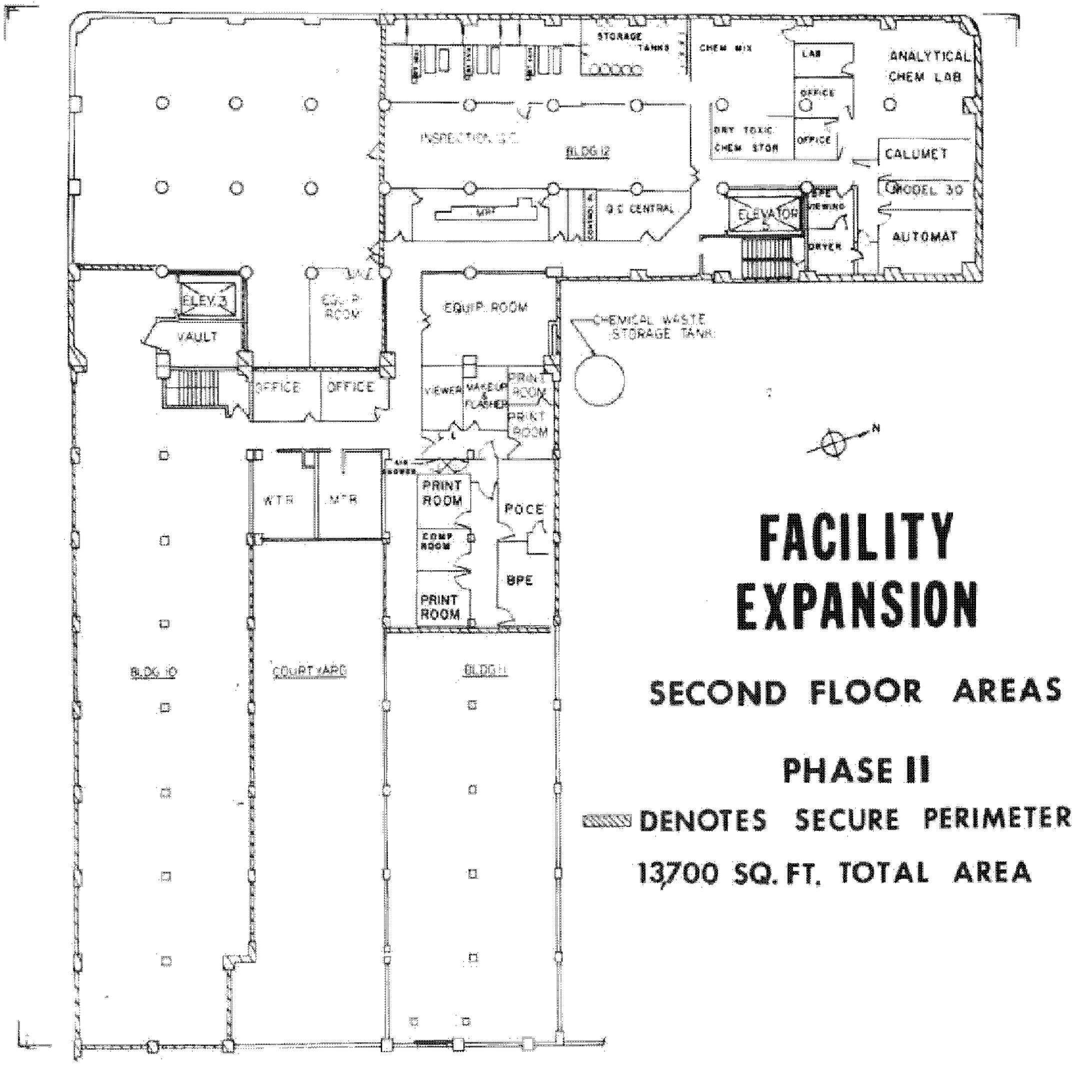

Figure 8-2. Facility Expansion, Phase II

special flooring, drains, water supplies, electrical power, lighting, partitions, and installation of an analytical laboratory. Phase II plan is scheduled for May 1974.

PHASE III - Provides for acquisition of 9,000 sq. ft. of additional space in Building 11 and 12 which will become available in the fall of 1974. It is planned that such space will provide for housing the Color Production Processor (CP^2), additional printing rooms, an equipment room, a film cold storage area, and supporting office, storage and maintenance areas. Conceptual layouts of the Phase III consolidation facility are shown in Figure 8-3.

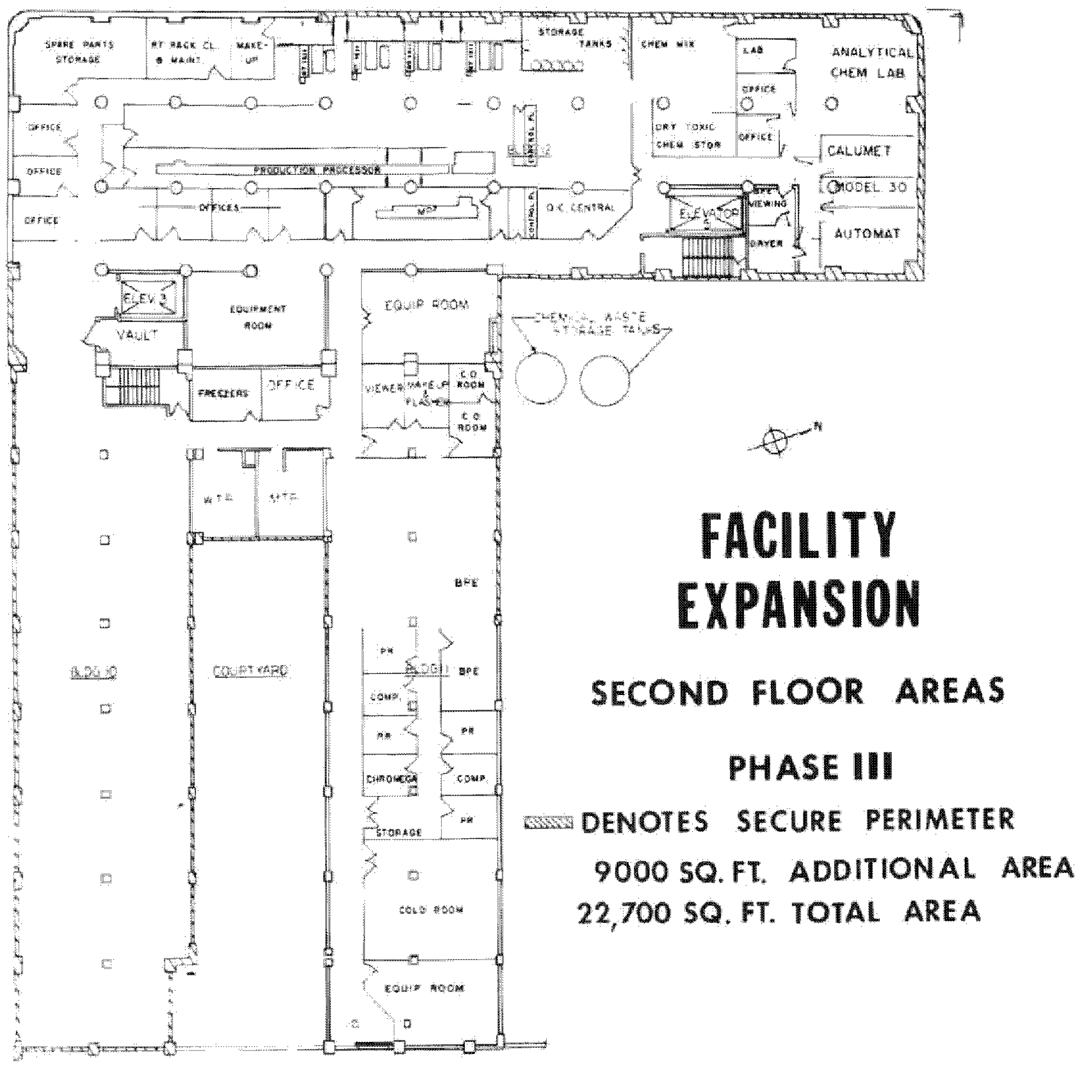

Figure 8-3. Facility Expansion, Phase III