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GAMMA I & GAMMA II TRANFORMING PRINTERS

I. PROPOSAL DIGEST

INTRODUCTION

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[redacted] is pleased to submit the following proposal for the design and manufacture of transforming projection printers in quantities of one or more units.

We propose that the task be performed in two separate phases:

a. Design Plan - Phase I This phase will consist of the thorough investigation and description of design approaches, and the analysis and solution of all the presently indeterminate optical parameters and problems. This phase will be completed in a period not in excess of six (6) weeks from date of contract.

b. Design and Manufacture - Phase II This phase will consist of the design and manufacture of an instrument either Gamma I or II as defined herein in accordance with the design specifications resulting from the Design Plan phase as approved.

If the evaluation and acceptance of the Design Plan is completed in a period of three weeks from day of submittal, the project will be completed nine (9) months from the date of contract.

Phase I

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[redacted] will consider rectification of two general catagories of tilted panoramic photography and all investigation in studies performed under this phase. These two catagories of photography, designated Gamma I and Gamma II photography respectively, have the following characteristics.

Input Specifications

		Gamma I	Gamma II
a.	Input focal length	24 inches	36 inches
b.	Input film format	70mm (58mm format)	168mm (155mm format)
c.	Input film length	500 feet	500 feet
d.	Scan angle	70°	70°
e.	Primary pitch	15°	11.7°
f.	Pitch range	Primary pitch $\pm 5^\circ$	Primary pitch $\pm 5^\circ$
g.	Maximum input resolution	200 l/mm	200 l/mm
h.	Pitch and roll	$\pm 5^\circ$	$\pm 5^\circ$
i.	Altitude	Variable	Variable

The studies and investigations shall be based on producing outputs having the following characteristics:

a.	Format size	full format (not segmented)
b.	Output scale (at center of format)	approximately 1.875X (Gamma I) 1.25X (Gamma II)
c.	Resolution design goal	80 l/mm at nadir - no point on format less than 50 l/mm measured at negative scale and printed on high resolution film.
d.	Auxiliary data to be recorded	Data block contained on film
	Roll	corrected as given
	Yaw	not given
e.	Earth curvature	compensated (for either of two nominal flight altitudes)
f.	Pitch and roll	compensated
g.	Panoramic sweep	compensated
h.	Overall system accuracy	The design will be such that a grid constructed in accordance with the input parameters shall be rectified such that no point is displaced from its computed true position by more than .01" using a nominal altitude.

The design parameters mentioned are to be considered as the basic requirements of the printer. In addition to these requirements, the following conditions will be considered in the design plan.

a. Provide variable magnification (± .5%) with minimum resolution degradation.

b. Provision for accommodating pitch angles from -5° to 20° (Gamma I only).

c. Providing automatic determination of exposure requirements for exposure control.

d. Providing maximum reliability, ease of maintenance and construction economy through design simplicity (including use of one easel).

e. Automatic film transport for both processed film and copy film.

II. TECHNICAL CONSIDERATIONS

The technical considerations discussed in the following paragraphs delineate the general parameters which influence or control the design of the proposed rectifying printer, and include factual descriptions of those designs, components, and techniques utilized in the [redacted] 9005 and 8075 which will be included in the proposed instrument.

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DESIGN CONSIDERATIONS

Assume that a vehicle using a panoramic sweep camera is flown over a rectangular pattern on the ground with no compensation made for "image motion" due to vehicle velocity and altitude. As the rectangular pattern on the ground is recorded on the film, the pattern image is distorted. The distorted pattern reflects the change in X and Y scale as the scan approaches the horizon in addition to the scale changes resulting from tipped photography.

The most effective means of removing the distortions is to reinstate the basic camera motions and geometry in the transforming projection printer so that the original photography, with its inherent distortions, will be photographically transformed into a central projection, which is near a vertical photograph of the ground.

The basic geometrical concepts of tipped sweep photography are followed throughout transforming printer optics. However, the instrument must deal with finite image and object distances, a requirement which imposes the following three conditions:

1. The lens system must remain centered at the center of projection in order to maintain the proper ratio of

longitudinal and transverse scale.

2. An axial element at any position must remain focused at the corresponding position in the projection plane during the scanning process. This is accomplished by scanning the optical axis of the projection lens as a function of the actual scan angle thus using the field of the lens to obtain the image and conjugate distances required to fulfill the Newtonian equation.

3. In order to focus a complete line, such as that formed primarily by the projection of a slit length on the easel, and secondly by the slit width itself, the Scheimpflug condition must be fulfilled.

With a tipped oblique photograph, the negative plane and the ground plane (the easel plane in the printer) must intersect. If the plane of the lens is rotated about the projection center of the lens until it too passes through the intersection of the negative and easel planes, the Scheimpflug condition is fulfilled and a sharp image of the negative is projected onto the easel.

Because the easel plane on the proposed instruments is curved to approximate the earth's curvature in scale and because the easel tip angle is variable over a range of from 10-20°, no finite value may be assigned to the Scheimpflug lens angle, instead it must be an infinitely varying quantity over some unknown range to compensate for an infinite number of tip angles and positions on curved easel conditions. In addition, the use of two easel configurations places further variable conditions on the Scheimpflug angle requirements. The solution to this problem requires a fairly substantial amount of computer programming. We propose to perform this task during the Design Plan phase of the contract.

Operationally, both films will remain fixed in position during exposure while the processed film is being scanned by a slit mounted integrally with a projection lamp, diffuser, and condenser lens on an exposure arm. The light will be diffused and projected through the slit and focused at the nodal point of the projection lens. After the image leaves the projection lens it will be reflected from a front surface mirror onto the copy film easel. Scalar distortions introduced by the tipped panoramic photography will be transformed during the reproduction operation; therefore, it will be possible to measure scalar distance directly on the copy film without resorting to scale corrections. The transformation will be

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TABLE OF COMPONENTS

The printer will consist of the following general component sections:

- a. Main Assembly
- b. Processed Film Transport System
- c. Copy Film Transport System
- d. Sweep Mechanism System
- e. Exposure Control System
- f. Optical System
- g. Control Panel
- h. Electrical System
- i. Frame
- j. Skins

DESCRIPTION OF COMPONENTS

Main Assembly

The main assembly will consist of all of the components listed in the preceding paragraph. In addition, a desk type safelight embodying an integral "ON-OFF" switch will be provided for the operator's convenience.

A convenience outlet wired for 115 volts A.C. will be mounted on the base plate for the safelight connection. This outlet will be "live" when the instrument is connected to the line power and will be unaffected by the main power switch.

Processed Film Transport System

The film transport system will be a simplified manual system and will consist of the supply and take-up spindles, two idler rollers, a tension roller, a drag brake on the supply spindle and a hand crank on the take-up and supply spindle. In addition to the above it will include a curved film platen designed to duplicate the relative position and curvature of the Panoramic Sweep Camera.

Copy (9-inch) Film Transport System

The 9-inch film transport will be similar to the processed film transport with the following exceptions:

1. Instead of the film platen, a combination easel will be provided. The easel will have trunnions at the ends of its long axis and have two faces. One face will be shaped to a 91" radius curvature; the other will have a 127' radius. It will be possible to rotate the easel to select either of the two anticipated simulated earth curvatures.

2. The curved easel surfaces will be provided with vacuum grooves to hold the film flat. Each of the two easel faces will have its own vacuum plenum connected to a common vacuum pump and

accumulator. Solenoid valves and switches will be provided so that the vacuum system of the face in use may be activated while the other remains inoperative.

3. The 9-inch film transport system will incorporate a means for metering out the length of copy film required to print the complete format of the negative image. This device will be designed so as to maintain the spacing between copy frames at the minimum distance consistent with prevention of overlapping copy exposures.

4. The take-up spool will be enclosed in a light tight cassette.

Sweep Mechanism System

The sweep system embodies a projection lamp housing, an exposure arm, and a variable speed arm drive. The image distance varies from minimum at the nadir point to maximum at either end of the easel. This causes a light fall-off that increases from the nadir to either end of the easel. This inherent light fall-off is compensated for by varying the angular velocity of the exposure arm and the projection lamp voltage. Two variables are introduced by the driving mechanism to achieve a velocity curve which partially compensates for the light fall-off curve. The arm is driven through its sweep by means of a friction wheel located to give a peripheral drive motion to the arm. A drive motor is connected to the friction wheel in such a manner as to convert rotation to translation. The translation is transmitted to the arm through a sliding linkage which imparts angular velocity to the arm. Because of the sliding linkage, the translation force is applied tangentially at constantly varying arm radii, thus varying the arm's angular velocity so that velocity is minimum at the ends of the sweep and maximum at the nadir position. In addition to the velocity variation induced by the sliding linkage mechanism, another variable is induced by varying the projection lamp voltage. The drive mechanism is coupled mechanically to a variable transformer which is connected to the projection lamp in such a manner that the position of the arm determines the voltage. Voltage (and consequently light intensity) is maximum at the beginning of the sweep and decreases to minimum at the nadir point. Here the transformer references is changed by automatic switching so that the voltage increases to maximum at the end of the sweep. The arm sweeps approximately 70° plus overtravel at each end. The overtravel allows a pre-determined acceleration and deceleration rate before and after the exposure cycle to reduce mechanical transient vibration.

AUTOMATIC EXPOSURE DETERMINATION

The exposure control parameters are defined by the requirement to print negatives of varying density to a standard uniform density. Itek has utilized this technique in previous printing instruments, including the Signal Corps EN 71 Rectifying Projector Printer.

The actual control will be accomplished by varying the projection light intensity, the scan velocity, or by a combination of both of these procedures.

The mechanics of the control system will be developed so that the setting of a single dial type control will adjust the light and/or velocity to the level required to print the copy.

A prerequisite for this system is to establish the manner in which control setting information is to be derived. Any particular negative frame may be essentially homogeneous in density or may have a number of areas of different densities. With an homogeneous density negative, the exposure control technique is simply to print it out to the standard density. Negatives with areas of varied density, however, offer the possibility of two techniques:

1.) A representative number of different density areas may be evaluated and these results intergrated to an average negative density. The exposure control may then be set to the average and the printed copy will be printed to an average standard density (if evaluated in the same manner).

2.) A significant area may be selected and evaluated. The exposure control may then be set to the value of the selected area.

The selected significant area of the copy will be printed to the standard density with the remaining area densities varying relatively as on the negative.

Our approach to the method of film evaluation and exposure control setting is governed by the overall philosophy of simplicity and economy. Exotic automatic systems which represent costly and time consuming design and fabrication or involve sophisticated operator techniques have been precluded from consideration.

For the density evaluation operation, we will provide a combination inspection station-light source, positioned to illuminate the frame following the one positioned in the projection platen. The light box will contain fluorescent or incandescent lights arranged to shine through an opal or frosted glass plate. The glass plate will be the same size as the frame format and will be located so that the film lies on it with the backing side in contact with the glass. A Densichron Photometer or equivilent with a Blue Meter Probe will be provided and the probe will be mounted or stored so that the operator may place it over any portion of the film frame. The Densichron unit will be connected to a log scale exposure meter which will be mounted in an area where the operator may read it conveniently while he is probing the negative. The exposure meter will be calibrated so that its scale reading represents the negative density.

Inclusion of the viewing-evaluating station will increase instrument length about ten to twelve inches.

For the exposure control setting operation, a dial type exposure control will be provided, this will be calibrated so that when the exposure meter reading is set on the exposure control, the light intensity and/or scan speed will be adjusted to print a 0.6 density from a negative of the selected density setting. In addition, a dummy exposure control identical to the actual exposure control will be mounted adjacent to the actual. This will be utilized to record the evaluated density and to retain the information until the operator is ready to make the setting.

Optical System

The optical system will consist of a light source, a slit, a film plane, a projection lens, a front surface mirror, and an alternate surface 9" copy film plane. The system will be arranged to give the required magnification of the projected image at the film nadir. The image will be folded, after it passes through the projector lens, by means of the front surface mirror. The folding operation will serve to accommodate the long optical path in a minimum of space.

Control Panel

As the Gamma instruments will be essentially manually operated equipments, controls will be at a minimum. The panel will contain a standby switch for warming up the electronic components, a power switch, an exposure control, an exposure meter, a sweep control switch and a vacuum switch.

Electrical System

The electrical system will consist of the sweep system switching components, the Densichron electronic packages, the projection lamp power source and the associated cables and wiring.

Frame

The frame will be fabricated of aluminum alloy or steel structural shapes to form a rigid unitized support for all of the instruments components.

Skins

The skins will be composed of metal sections with integral fasteners, and will be readily removable from the printer for maintenance or adjustment.

Report

At the completion of the design study and investigation under Phase I, a report summarizing the results will be submitted to the Contracting Officer. The report will present the material in such a manner as to permit the Contracting Offieer to select desired characteristics and, in those instances where options have been investigated, all data including the effect of the various option on cost, accuracy and complexity shall be provided to permit the Contracting Offieer to make valid decisions.

Phase II will consist of the design and manufacture of the equipment according to the technical section approved by the Contracting Officer and based upon the cost estimates of those items approved by the Contracting Officer.

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1 May 1962

Revision of (no 3014)

Gentlemen:

This letter proposal is submitted in reply to Government request to re-evaluate the Gamma I proposal in accordance with the following requirements:

a. Reduce the complexity of the instrument.

b. Incorporate into the Design Study a study of the Delta III B equipment.

c. Submit a budgetary cost for the simultaneous design and manufacture of simplified Gamma I and Delta III B instruments.

For the purposes of this proposal the revised Gamma I instrument shall be designated as Gamma I-R and the modified Delta III B instrument shall be designated Delta III B-Army.

Modification of the equipments encompasses the following exclusions and revisions:

a. Exclude automatic film transports, exposure controls, integral fabricated skins, leveling jacks, and casters.

b. Reduce the operational complexity in regard to centrally located switches and controls.

c. Reduce the control wiring and capability.

The intent of the aforementioned modifications is to produce a basic laboratory instrument designed for semi-automatic operation by skilled operators.

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This proposal contains the cost of the following three items:

1. Design Study

   A detailed cost analysis submitted on a CPFF basis. This study to be common to Gamma I-R and Delta III B-Army.

2. Design and Manufacture Gamma I-R

   A budgetary cost estimate for the design and manufacture of Gamma I-R equipment.

3. Design and Manufacture Delta III B-Army

   A budgetary cost estimate for the design and manufacture of Delta III B-Army equipment.

I hope that the attached meets with your approval and that we may expect authorization to proceed in the very near future.

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Attachments 4

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Technical Proposal

GAMMA I
TRANSFORMING PRINTER

APRIL 26, 1962

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I. PROPOSAL DIGEST

INTRODUCTION

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[redacted] is pleased to submit the following proposal for the design and manufacture of a transforming projection printer, designated Gamma I, in quantities of one (1) and two (2) units.

We propose that the task be performed in two separate phases:

a. Design Plan - Phase I This phase will consist of the thorough investigation and description of design approaches, and the analysis and solution of all the presently indeterminate optical parameters and problems. It is anticipated that this phase will be completed in a period not in excess of six (6) weeks.

b. Design and Manufacture - Phase II This phase will consist of the design and manufacture of the Gamma I instrument/s in accordance with the design specifications resulting from the Design Plan phase.

The separation of preliminary engineering and scientific investigations from the design and manufacturing phase, and the incorporation of the investigation results into a Design Plan, will insure (especially in the absence of detailed specifications) a "meeting of the minds" between contractor and customer prior to the initiation of actual fabrication, and thus preclude misunderstandings during the performance period. In line with this philosophy, it is desirable that the customer shall evaluate the Design Plan and define all exceptions and objections prior to acceptance.

If the evaluation and acceptance of the Design Plan is completed in a period of three weeks from day of submittal, we feel that the project can be completed nine (9) months from the date of contract.

Phase I

DESIGN PARAMETERS

Input Specifications

a.	Input focal length	24 inches
b.	Input film format	70-mm (58-mm format)
c.	Input film length	500 feet
d.	Scan angle	70°
e.	Primary	15°
f.	Variable	$\pm 5^{\circ}$
g.	Maximum input resolution	200 l/mm
h.	Pitch and roll	given
i.	Yaw	not given

Output Requirements

a.	Rectifier output	full format
b.	Output scale	approximately 1.875X
c.	Isometric magnification	not to exceed 2X
d.	Resolution design goal	80 l/mm at nadir
e.	Data block	Printed
f.	Corrections	
	Tip angle (ϕ)	15°
	Variable tip ($\Delta \phi$)	$\pm 5^{\circ}$
	Roll	corrected as given
	Yaw	not given
	Earth curvature	two position adjustment

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f. Corrections (continued)

Panoramic distortion	sweep compensation
I.M.C.	not compensated
g. Sweep time	variable 15 seconds to 360 seconds
h. Rectification error (based on above parameters)	.01 inch

The above design parameters are to be considered as the basic requirements of the printer. In addition to these requirements, the following conditions will be considered either in this proposal or in the design plan.

a. Variable magnification - Sufficient to bring approximately 10 adjacent frames to the same scale.

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b. Tip angle - from -5° to $+20^{\circ}$ infinitely variable

c. Exposure control

d. Earth curvature - single fixed curve on two-step adjustment

Items (a) Variable magnification and (b) Tip angle are of such a complex nature as to exclude their enclosure within this proposal. These items will be considered in detail in the Design Plan.

Items (c) Exposure control and (d) Earth curvature are included in the technical section of this proposal.

DESIGN OF THE GAMMA I PRINTER

The operating parameters of the Gamma I instrument are similar to those of the [redacted] 9005 Indexing Rectifiers which were completed in 1960 and are presently operational.

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[redacted] proposes to utilize existing designs and mechanisms to the greatest extent possible.

There are two significant differences in operating parameters between the Gamma I and 9005 instruments which will require design changes of appreciable scope.

The first difference is the requirement to increase the Gamma I magnification to approximately 1.875X as opposed to 1.4X for the 9005 instrument. Three design changes are necessary to meet this demand, they are:

a. The change in magnification necessitates the use of a lens different from that used in the 9005 machines. Inquiry has disclosed that there are no lenses commercially available which will meet the required specifications; therefore, two courses of action are available: First, the [redacted] lens can be scaled up by the 25X1
manufacturer to the specific requirement for a 400-mm f/9 lens. This lens has the advantage of being quite reasonably priced; but, the resolution capability is low, i.e. it approaches 50 l/mm. Due to the requirements of the Gamma I system, this lens will not be considered initially.

STAT Second, [redacted] has the preliminary designs for, and will construct a lens of suitable focal length and field angle. The [redacted] STAT
lens resolution capability will approach 80 l/mm. At present we will consider the construction of this lens as the optimum choice of action. The forecast completion date of the [redacted] lens lies STAT
comfortably within the proposed development period.

b. The change in magnification increases the size of the copy format. To adapt for this change, we will re-design the copy film transport system to increase the easel dimensions to accommodate 9-inch copy film. Concurrent with the design change to adapt for the larger copy film, we will also simplify both the negative and copy film transports to manually operated systems rather than the powered automatic systems of the 9005 instruments.

c. The increase in magnification also requires an increase in the length of the optical path. The configuration and dimensions of the optical path components will be revised to fulfill this requirement.

The second difference in operating parameters is the requirement that the Gamma I instrument have the capability to transform tipped photography distortion.

Whereas the 9005 instrument had the easel mounted in the vertical position and fixed in place, the Gamma I easel will be tipped to a nominal tip angle (ϕ) of 15° with means provided to vary this angle $\pm 5^{\circ}$. The easel will be curved to simulate earth curvature, subsequent evaluation will disclose whether a fixed curvature or two distinct curvatures are required. Should the two shapes be required, we will design either an adjustable face easel or an indexing easel with two film faces.

In addition to the above, it is necessary to tip the lens in order to fulfill the Scheimpflug condition. We will tip the lens approximately 6° at the nadir position and design the focusing cam mechanism so that the Scheimpflug condition is fulfilled at cell points of the sweep for all easel tip angles and for the two easel configurations if these are shown to be required.

Details of the proposed designs and re-designs are included in Section II of this proposal. It is to be understood that all technical statements contained in this proposal are somewhat flexible and are subject to changes occurring from the results of the Design Plan phase.

The accuracy statement is contained in Addendum I to the proposal.

II. TECHNICAL CONSIDERATIONS

The technical considerations discussed in the following paragraphs delineate the general parameters which influence or control the design of the proposed Gamma I rectifying printer, and include factual descriptions of those designs, components, and techniques utilized in the [redacted] 9005 and 8075 which will be included in the Gamma I instrument. STAT

PRINCIPLES OF OPTICAL OPERATION

Assume that a vehicle using a panoramic sweep camera is flown over a rectangular pattern on the ground with no compensation made for "image motion" due to vehicle velocity and altitude. As the rectangular pattern on the ground is recorded on the film, the pattern image is distorted. The distorted pattern reflects the change in X and Y scale as the scan approaches the horizon in addition to the scale changes resulting from tipped photography.

The most effective means of removing the distortions is to reinstate the basic camera motions and geometry in the transforming projection printer so that the original photography, with its inherent distortions, will be photographically transformed into a central projection, which is near a vertical photograph of the ground.

The basic geometrical concepts of tipped sweep photography are followed throughout transforming printer optics. However, the instrument must deal with finite image and object distances, a requirement which imposes the following three conditions:

1. The lens system must remain centered at the center of projection in order to maintain the proper ratio of longitudinal and transverse scale.

2. An axial element at any position must remain focused at the corresponding position in the projection plane during the scanning process. This is accomplished by scanning the optical axis of the projection lens as a function of the actual scan angle thus using the field of the lens to obtain the image and conjugate distances required to fulfill the Neutonion equation.

For Gamma I photography where a projection lens of 400 mm is used, a scan angle of 35^{o} (half of full scan) requires that the lens be used at a maximum field angle of approximately 20.25^{o} along the center line projection. Because the easel and lens are tipped in accordance with the requirements of tipped panoramic photography, the field angle increases to approximately 21.75^{o} for the maximum off-axis element. The above conditions hold for the use of a flat easel; but the Gamma I instrument will incorporate a curved easel adjustable to two distinct radii, 91" and 127". These conditions require that the maximum field angles increase slightly.

3. In order to focus a complete line, such as that formed primarily by the projection of a slit length on the easel, and secondly by the slit width itself, the Scheimpflug condition must be fulfilled.

With a tipped oblique photograph the negative plane and the ground plane (the easel plane in the printer) must intersect. If the plane of the lens is rotated about the projection center of the lens until it too passes through the intersection of the negative and easel planes, the Scheimpflug condition is fulfilled and a sharp image of the negative is projected onto the easel.

SPECIAL HANDLING

Because the Gamma I easel plane is curved to approximate the earth's curvature in scale and because the easel tip angle is variable over a range of from 10-20°, no finite value may be assigned to the Scheimpflug lens angle, instead it must be an infinitely varying quantity over some unknown range to compensate for an infinite number of tip angle and position on curved easel conditions. In addition, the use of two easel configurations places further variable conditions on the Scheimpflug angle requirements. The solution to this problem requires a fairly substantial amount of computer programming. We propose to perform this task during the Design Plan phase of the contract.

Operationally, both films will remain fixed in position during exposure while the processed film is being scanned by a slit mounted integrally with a projection lamp, diffuser, and condenser lens on an exposure arm. The light will be diffused and projected through the slit and focused at its nodal point of the projection lens. After the image leaves the projection lens it will be reflected from a front surface mirror onto the copy film easel.

The proposed optical system will magnify the image approximately 1.875X and resolve approximately 80 l/mm on the negative at the nadir position.

PURPOSE AND USE

The Gamma I instrument will be a precision optical instrument designed for safelighted darkroon operation.

Photographic information contained on 70 mm panoramic aerial film will be enlarged, and reproduced on 9" copy film. Scalar distortions introduced by the tipped panoramic photography will be transformed during the reproduction operation; therefore, it will be possible to measure scalar distance directly on the copy film without resorting to scale corrections. The transformation will be accomplished by utilizing the [redacted] STAT

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OPERATIONAL CHARACTERISTICS

The Gamma I Printer will be a self-contained instrument utilizing optical, mechanical and electrical components. The majority of the operational functions will be performed manually by the operator; however, the operation of the scan arm will be semi-automatic. The instrument will accommodate 70mm processed film on 500 ft. spools and 9" unprocessed copy film on 500' spools.

There will be separate manual film transport systems for the input and output films.

A means of evaluating input film and controlling exposure will be included.

The instrument will be suited for operation on 115 ± 5V, 60 ± 5 cycle A.C. Power consumption will be approximately 1,000W.

TABLE OF COMPONENTS

The printer will consist of the following general component sections:

a. Main Assembly

b. Processed Film Transport System

c. Copy Film Transport System

d. Sweep Mechanism System

e. Exposure Control System

f. Optical System

g. Control Panel

h. Electrical System

i. Frame

j. Skins

DESCRIPTION OF COMPONENTS

Main Assembly

The main assembly will consist of all of the components listed in the preceding paragraph. In addition, a desk type safelight embodying an integral "ON-OFF" switch will be provided for the operator's convenience.

A convenience outlet wired for 115 volts A.C. will be mounted on the base plate for the safelight connection. This outlet will be "live" when the instrument is connected to the line power and will be unaffected by the main power switch.

Processed Film Transport System

The film transport system will be a simplified manual system and will consist of the supply and take-up spindles, two idler rollers, a tension roller, a drag brake on the supply spindle and a hand crank on the take-up and supply spindle. In addition to the above it will include a curved film platen designed to duplicate the relative position and curvature of the Panoramic Sweep Camera.

Copy (9-inch) Film Transport System

The 9-inch film transport will be similar to the processed film transport with the following exceptions:

1. Instead of the film platen, a combination easel will be provided. The easel will have trunnions at the ends of its long axis and have two faces. One face will be shaped to a 91" radius curvature; the other will have a 127" radius. It will be possible to rotate the easel to select either of the two anticipated simulated earth curvatures.

2. The curved easel surfaces will be provided with vacuum grooves to hold the film flat. Each of the two easel faces will have its own vacuum plenum connected to a common vacuum pump and

accumulator. Solenoid valves and switches will be provided so that the vacuum system of the face in use may be activated while the other remains inoperative.

3. The 9-inch film transport system will incorporate a means for motoring out the length of copy film required to print the complete format of the negative image. This device will be designed so as to maintain the spacing between copy frames at the minimum distance consistent with prevention of overlapping copy exposures.

4. The take-up spool will be enclosed in a light tight cassette.

Sweep Mechanism System

The sweep system embodies a projection lamp housing, an exposure arm, and a variable speed arm drive. The image distance varies from minimum at the nadir point to maximum at either end of the easel. This causes a light fall-off that increases from the nadir to either end of the easel. This inherent light fall-off is compensated for by varying the angular velocity of the exposure arm and the projection lamp voltage. Two variables are introduced by the driving mechanism to achieve a velocity curve which partially compensates for the light fall-off curve. The arm is driven through its sweep by means of a friction wheel located to give a peripheral drive motion to the arm. A drive motor is connected to the friction wheel in such a manner as to convert rotation to translation. The translation is transmitted to the arm through a sliding linkage which imparts angular velocity to the arm. Because of the sliding linkage, the translation force is applied tangentially at constantly varying arm radii, thus varying the arm's angular velocity so that velocity is minimum at the ends of the sweep and maximum at the nadir position. In addition to the velocity variation induced by the sliding linkage mechanism, another variable is induced by varying the projection lamp voltage. The drive mechanism is coupled mechanically to a variable transformer which is connected to the projection lamp in such a manner that the position of the arm determines the voltage. Voltage (and consequently light intensity) is maximum at the beginning of the sweep and decreases to minimum at the nadir point. Here the transformer references is changed by automatic switching so that the voltage increases to maximum at the end of the sweep. The arm sweeps approximately 10° plus overtravel at each end. The overtravel allows a pre-determined acceleration and deceleration rate before and after the exposure cycle to reduce mechanical transient vibration.

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EXPOSURE CONTROL SYSTEM

The exposure control parameters are defined by the requirement to print negatives of varying density to a standard uniform density of 0.6. Itek has utilized this technique in previous printing instruments, including the Signal Corps EN71 ( ) Rectifying Projector Printer.

The actual control will be accomplished by varying the projection light intensity, the scan velocity, or by a combination of both of these procedures.

The mechanics of the control system will be developed so that the setting of a single dial type control will adjust the light and/or velocity to the level required to print the copy to approximately 0.6 density.

A prerequisite for this system is to establish the manner in which control setting information is to be derived. Any particular negative frame may be essentially homogeneous in density or may have a number of areas of different densities. With an homogeneous density negative, the exposure control technique is simply to print it out to the standard density. Negatives with areas of varied density, however, offer the possibility of two techniques:

1.) A representative number of different density areas may be evaluated and these results intergrated to an average negative density. The exposure control may then be set to the average and the printed copy will be printed to an average standard density (if evaluated in the same manner).

2.) A significant area may be selected and evaluated. The exposure control may then be set to the value of the selected area.

The selected significant area of the copy will be printed to the standard density with the remaining area densities varying relatively as on the negative.

Our approach to the method of film evaluation and exposure control setting is governed by the overall philosophy of simplicity and economy. Exotic automatic systems which represent costly and time consuming design and fabrication or involve sophisticated operator techniques have been precluded from consideration.

For the density evaluation operation, we will provide a combination inspection station-light source, positioned to illuminate the frame following the one positioned in the projection platen. The light box will contain fluorescent or incandescent lights arranged to shine through an opal or frosted glass plate. The glass plate will be the same size as the frame format and will be located so that the film lies on it with the backing side in contact with the glass. A Densichron Photometer or equivilent with a Blue Meter probe will be provided and the probe will be mounted or stored so that the operator may place it over any portion of the film frame. The Densichron unit will be connected to a log scale exposure meter which will be mounted in an area where the operator may read it conveniently while he is probing the negative. The exposure meter will be calibrated so that its scale reading represents the negative density.

Inclusion of the viewing-evaluating station will increase instrument length about ten to twelve inches.

For the exposure control setting operation, a dial type exposure control will be provided, this will be calibrated so that when the exposure meter reading is set on the exposure control, the light intensity and/or scan speed will be adjusted to print a 0.6 density from a negative of the selected density setting. In addition, a dummy exposure control identical to the actual exposure control will be mounted adjacent to the actual. This will be utilized to record the evaluated density and to retain the information until the operator is ready to make the setting.

Optical System

The optical system will consist of a light source, a slit, a film plane, a projection lens, a front surface mirror, and an alternate surface 9" copy film plane. The system will be arranged to give the required magnification of the projected image at the film nadir. The image will be folded, after it passes through the projector lens, by means of the front surface mirror. The folding operation will serve to accommodate the long optical path in a minimum of space.

Control Panel

As the Gamma I instrument will be essentially a manually operated equipment controls will be at a minimum. The panel will contain a standby switch for warmingup the electronic components, a power switch, an exposure control, an exposure meter, a sweep control switch and a vacuum switch.

Electrical System

The electrical system will consist of the sweep system switching components, the Densichron electronic packages, the projection lamp power source and the associated cables and wiring.

Frame

The frame will be fabricated of aluminum alloy or steel structural shapes to form a rigid unitized support for all of the instruments components.

Skins

The skins will be composed of metal sections with integral fasteners, and will be readily removable from the printer for maintenance or adjustment.

GAMMA I TRANSFORMING PRINTER

ADDENDUM I

Photogrammetric Accuracy

It is indeed difficult, if not impossible, to predict the restitution accuracy of a transformation printer such as the one proposed. Traditionally, photogrammetric instruments have been built to the required mechanical precision to enable them to perform a specific job and to lie within a certain price range. They are then normally classified as first order, second order, or third order instruments. The accuracy then advertised is a result of measurements, tests, and subsequent adjustments. The similar series of instruments are manufactured to the same precision and relative accuracy can then be stated.

Photogrammetric rectifiers, on the other hand, are almost always based upon central projective transformation and therefore the geometric rigidity can only be distorted by the lens distortion and the "unflatness" of the negative and easel planes.

Accuracy of the conventional rectifier is almost wholly dependent upon the settings of the various freedoms or orientation values. Of the eight required freedoms, five govern the geometric projection and three are for sharp imagery.

In the scanning rectifiers or transforming printers, the accuracy of the geometric reprojection is dependant upon the distortions in the optical system, the precision in the orientation settings, how well the easel plane fits the true object plane to scale, and primarily the smoothness of operation of the mechanical scanning components.

The Gamma I printer, as proposed at this time will be limited to three primary orientation settings. The pitch and roll values are given and the most critical freedom is therefore the orientation of the negative in the platen. The magnification is fixed and the lens focusing is cam corrected. The geometric errors in the transformed print due to the combined image motion and image motion compensation are rigidly predictable if the V/H factors and the I.M.C. camera constants are known. The geomotric errors in the transformed print due to an approximate earth curvature correction is rigidly predictable provided that the true curvature for a certain flying height and tip angle can be determined. Earth curvature correction and the errors are being studied in more detail as a full compensation for this error results in complex optical and mechanical solutions.

The proposed projection lens is to be "relatively distortion free" according to the designer, although high resolution and small distortion is not as optically compatible as one would like. Projected lens distortion occurs only in the length of the scanning slit and therefore is not as critical as the mechanical scan as far as the major photographic deformations are concerned.

Film flatness is a problem faced in panoramic cameras as well as transforming printers based on this reprojection principle. Because of this, we have had considerable experience in scan and film positioning components. The problem is considerably less in the printers as the scan speed is much slower.

Film flatness is of great geometric importance when using large optical field angles. For instance a vertical deviation of the film plane where the lens is being used at a field angle of 45^{o} is reflected by an equal magnitude error in image shift. In the scanning printer the lens angle is defined in one direction by the slit width and film unflatness is negligible. In the other direction the lens is being used at a moderate angle due to the optical conditions, but the total angular field only covers the 70-mm film width.

No error studies of the existing printers have been made available and final photogrammetric accuracy can only be predicted using available data.

A recent printer with a total scan of 140° and a magnification of 2X was checked by comparing the grid on a simulated negative to the photographically enlarged print made on the instrument.

The check showed geometric restitution well within the tolerance specified for Gamma I. The magnification differences from one side of the scan to the other and across the film width reflect any errors in film flatness, lens distortion and instrument misalignment.

A summary of the critical measurements follows:

Negative	Print
0° to - 38.2° = 51.323 mm	119.995 mm
0° to + 38.2° = 51.387 mm	119.962 mm

Average magnification over the scan angle was 2.338X and 2.334X for - 38.2° and + 38.2° respectively. The percentage change in magnification is negligible.

Field angle of 9° at $\pm$ 38° scan angle
(with I.M.C. correction)

Negative	Print
+X = 12.024 mm	32.586 mm
-X = 11.902 mm	32.761 mm

Magnification 2.710X and 2.752X showing negligible percentage change.

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April 26, 1962

NPIC ROUTING SLIP

FROM: Chief, TP & DS DATE: 27 Apr 62

	TO	INITIALS	DATE	SIGNATURE	INFORMATION	COMMENTS	APPROVAL	ACTION	SEE ME	FILE	RETURN	SEE REMARKS BELOW
DIR												
DEP/DIR												
EXEC/DIR												
OPS/OFF												
SA												
SA												
✓ CH/AS	Attn: [redacted]											
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SIO/NAVY												
SIO/AF												
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REMARKS:

These two copies of this proposal were handcarried in to us today by one of the [redacted] representatives. It is solicited. Would you please log in and return. [redacted] will be the evaluator.

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This proposal is valid for a period of sixty days, after which [redacted] reserves the right to amend terms and conditions thereof. If required, contractor is perfectly willing to supply contingent fee statement and a certificate of current pricing data.

STAT

We are pleased to have been given a chance to submit this proposal and wish to assure you that we intend to exert our best efforts in the performance of all the work requirements outlined herein.

Should you require any further information regarding this proposal, do not hesitate to call on us. Please direct all inquiries regarding this subject proposal to [redacted]

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