COR-2370
COPY 2 OF 3

SHC64-9051-24

Copy # 2

16 January 1964

Gentlemen:

STAT STAT [redacted] is pleased to submit this proposal for changes under the basic Contract [redacted] Task Order #6, in accordance with the work statement cited in Section I for the consideration cited in Section II of the attached proposal.

STAT This proposal constitutes [redacted] formal bid for a retrofit system that will adapt the Gamma I Rectifying Printer for automatic electronic dodging, thus expanding the present operational capabilities of the printer.

Our prices do not contain federal, state, or local taxes, as none are believed applicable. Furthermore, the above prices do not contain a price or charge for royalties in excess of [redacted] STAT

Further, the prices found in this proposal are predicated on the following terms, conditions, and contract considerations:

1. The F.O.B. point for all items is [redacted] and costs for delivery, as directed by the contracting officer to points other than the stipulated F.O.B., will be handled in accordance with the Changes Article cited in the contract. STAT

2. That final acceptance testing of instruments will be conducted at contractor's plant; installation costs for equipment at location other than Washington, D.C., which may result at the request of the contracting officer, will be handled under the changes article of the contract.

3. The prices shown in Section II are valid for a period of 45 days, after which time [redacted] reserves the right to amend.

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4. That your activities will issue a CPFF Contract substantially in accordance with ASPR and AFPI provisions as presently cited in the basic Contract [redacted] Task Order No. 6.

STAT

Executed copies of the Contingent Fee Statement and Certificate of Current Pricing will be forwarded at a later date.

Should you require any further information regarding this proposal, do not hesitate to call upon us.

Very truly yours,

[redacted]

STAT

Contracts Manager

HAM/mm

SECTION I

[redacted]

20 November 1963

Proposal 3501.01

Retrofit Gamma I Rectifying Printer with Electronic Dodging

1. Introduction

This proposal presents the combined approach of AMS, [redacted] STAT

STAT [redacted] for the design and fabrication of a retrofit system that will adapt the Gamma I Rectifying Printer for automatic electronic dodging. The purpose of this system is to expand the operational capabilities of the existing rectifying printer.

The proposed electronic dodging system will not eliminate the existing light source but will be in addition to it; that is, each light source will be designed to facilitate assembly to the rectifier and either may be employed according to operator discretion. In this manner, the inherent advantages of both light sources will be preserved. The present means of controlling the light source sweep motion and the function of all controls not pertaining directly to electronic dodging will remain unchanged.

A technical proposal for the electronic components necessary for automatic dodging was submitted to [redacted] STAT

STAT [redacted] It is our intent to sub-contract this

STAT phase of the system to [redacted]ecause of their extensive experience in automatic dodging. This will result in an operational system in the shortest time commensurate with the lowest costs.

STAT [redacted] will be responsible for the mounting of the [redacted] components STAT to the Gamma I instrument, liaison with the sub-contractor to insure compliance with the specifications, and testing and debugging of the integrated system.

2. Description and Operation

2.1 General

Figure 1 illustrates the arrangement of the components to accomplish automatic dodging. The cathode-ray tube and its yoke will be mounted to the scan arm in place of the conventional light source. The illuminated slit will be projected through the projection lens to the front surface of a beamsplitter. The beamsplitter will reflect 90% of the light to the printing plane and allow 10% of the light to pass through the beamsplitter.

A front surface mirror, an opal glass diffuser, and a photomultiplier tube will be affixed to the scan arm so that they will be behind the beamsplitter and the photomultiplier entrance pupil will be coincident with the entrance pupil of the lens and the slit.

The instantaneous value of light transmitted from that portion of the negative illuminated by the flying spot will be sensed by the phototube and the velocity of the spot will be varied proportionately to provide velocity modulation dodging.

A detailed explanation of the principles involved is included in the

STAT [redacted] proposal. (See Appendix)

2.2 Operation

The rectifying printer will be operated in the same manner as with the conventional light source. The initial settings of line speed velocity and end point control will be accomplished on the [redacted] control unit and STAT then the operational controls of the printer will be used to determine total exposure time.

2.3 C-R-T and Yoke Connections

The conventional light source consists of a 500-watt pre-focused projection lamp and a fan for cooling of the lamp. The wires that service these components terminate in a releasable connector and receptacle. When the light source is removed, the connector need only be released and the power source will be dead-ended in the receptacle. This arrangement allows the conventional light source to be re-installed with minimum effort.

The wiring of the power source to feed the cathode-ray tube and the deflection yoke will be installed in a similar manner for ease of installation and removal.

2.4 Beamsplitter

The folding mirror used in the existing design is a front-surface mirror that has been highly polished to a flat surface and over-coated to provide a nearly 100% reflective surface. The rear surface of this mirror is parallel to the front surface, but it has not been polished from the rough ground condition.

It will be necessary to rework this mirror into a beamsplitter. The quality of the glass must be checked for inclusions or defects that could be detrimental. If the quality is satisfactory, we will have the reflective coating stripped and have the rear surface polished flat and parallel to the front surface within close tolerances.

2.5 Photomultiplier Tube Mounting

The photomultiplier tube will be located in a position to the rear of the beamsplitter. In order to accomplish this, it will be necessary to fold the transmitted illumination path by inserting a front surface mirror between the beamsplitter and the phototube. An opal glass diffuser will be mounted between the mirror and the phototube to allow satisfactory sampling.

These components will be rigidly mounted with respect to each other and the sub-assembly will be firmly coupled to the scan arm such that the entrance pupil of the phototube will always be in line with the exposing slit.

2.6 Counterweight

A counterweight is attached to the lower section of the scan arm to balance out the dynamic effect of the moments of inertia of the lamp housing during scan so as to provide a smooth motion. It will be necessary to design another counterweight to act in conjunction with the phototube and the cathode-ray tube to provide the proper balance.

3. Interface Conditions

3.1 Cathode-ray Tube

Consideration must be given to the physical location of the cathode-ray tube with respect to the spacing between the film plane and the faceplate of the tube. [redacted] would like to have the faceplate of the tube spaced approximately .031 inch from the film plane so as to keep the spot size from becoming too small and burning the phosphor of the tube. This would also allow the elimination of a physical slit. STAT

The present mechanical configuration of the printer does not physically allow this close spacing. It will therefore be necessary to:

a. Investigate types and sizes of tubes other than that mentioned in the [redacted] proposal. STAT

b. Investigate the inclusion of condenser optics between the film plane and the CRT.

3.2 Control Console

[redacted] will supply the necessary electronic chassis and power supplies housed within a 18 1/2 by 26 1/2 by 14 1/2 inch cabinet (height, width, depth). The unit will weigh approximately 75 pounds. [redacted] will STAT 25X1 provide the necessary interconnecting wiring and cabling to facilitate the replacement of either light source.

3.3 Overscan

The [redacted] engineers feel that is is desirable to have a clear distance between the edge of the format and the edge of the film support of a least 0.100 inch each side of the film. This is desirable to provide optimum blanking of the flying spot so that the halo effect provided by the phospher persistence and the light scattering within the glass faceplate of the tube will not provide incorrect signals to the phototube. From preliminary layouts, it appears that it would be unwise to increase the platen opening to allow 0.100 inch spacing between the format edge and the support. Therefore, it is difficult to predict the boundary effect that this will have on the output print. Tests will be conducted at final assembly to determine what effect the reduction of film support area will have on the flatness of the film plane. The results of these tests must then be evaluated and compared against the photographic results desired.

3.4 Output Quality

The quality of the output film with respect to image and resolution will be held to the highest standards. Because the output resolution is dependent upon the slit width, and because the CRT trace width has not been determined, it is presently unknown if a slight resolution degradation will occur. Preliminary indications are that if the CRT trace does not exceed 1 1/2 mm, then the present resolution values will remain.

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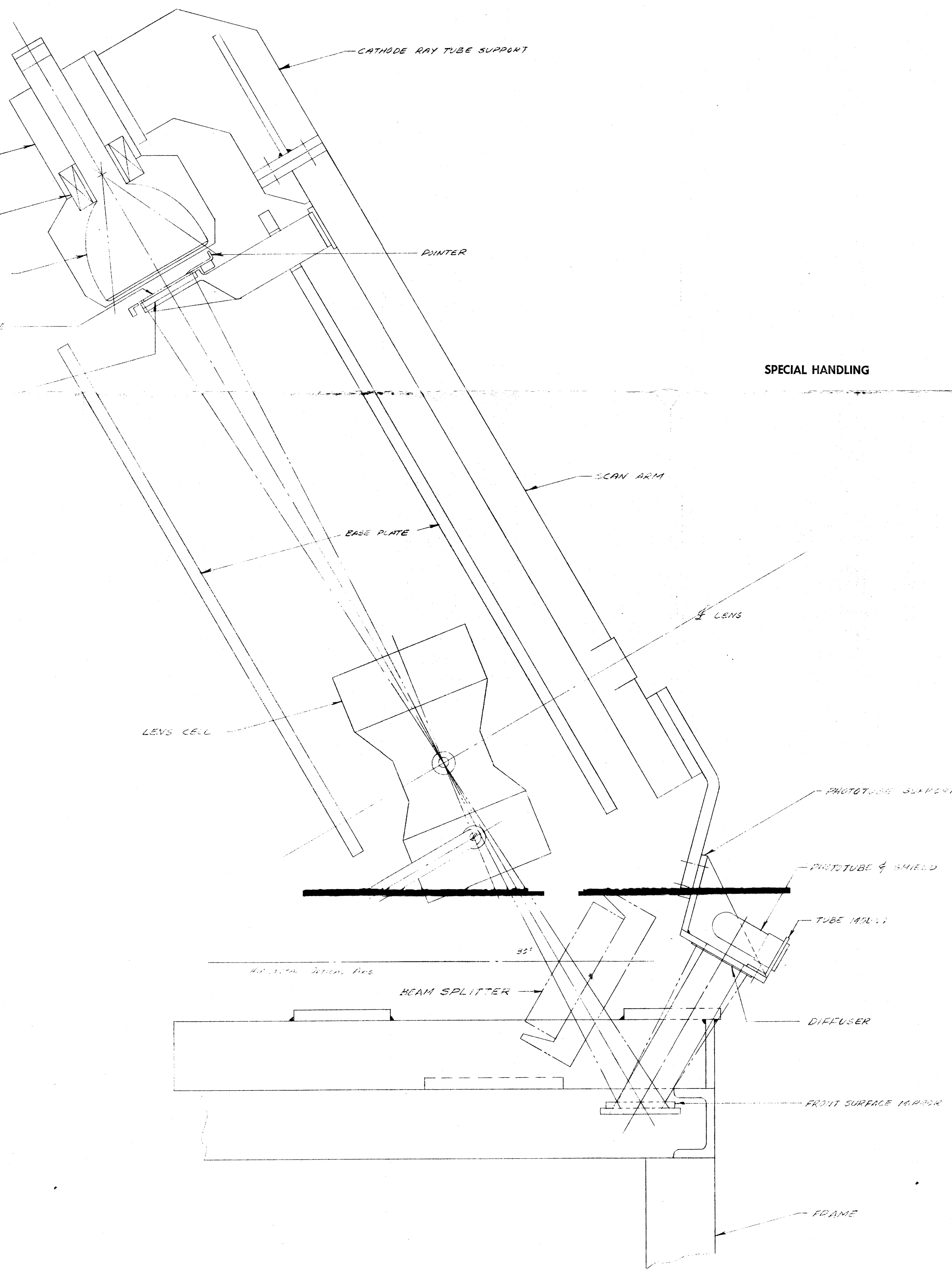

FIG. 1

SECTION II

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ADAPTATION OF AUTOMATIC DODGING
AND EXPOSURE CONTROL
TO THE RECTIFIER

- A Technical Proposal -

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SPECIAL HANDLING

ADAPTATION OF AUTOMATIC DODGING AND EXPOSURE CONTROL TO THE [redacted] RECTIFIER

-A Technical Proposal-

SUMMARY

By modulating the velocity of the spot on a cathode-ray tube, a dodging light source may be substituted in the [redacted] rectifier without modification of the present means of controling the light source motion. Using [redacted]edalist F-4 paper (five meter-candle-seconds), the exposure time is estimated at 50 seconds; exposures on type 5427 would be shorter, depending primarily on processing. Exposure time with this basic system would be the same for any negative.

A brief discussion shows that in an "advanced" system, derived from this basic one, exposure time could be shortened to an estimated 14 seconds on Medalist F-4 when using an average negative. The advanced system would require complete integration of the dodging control and the light source traverse control.

APPLICATION

General

The description of the [redacted] rectifier may be over-simplified by saying that it divides the negative into a large number of narrow strips and exposes the strips sequentially while adjusting the projection system to conform to the Scheimpflug condition, thus restoring vertical panoramic photography to Cartesian co-ordinates.

In the practical instrument, the negative is curved cylindrically with the lens between the concave side of the film and the flat paper.[1] The region of negative exposed at one time is limited by a slit at the negative, parallel to the axis of the cylinder. As the slit is moved around the circumference of the negative cylinder, the lens is tilted so that a plane, tangent to the cylinder at the slit, intersects the lens plane and the paper plane along a single line, preserving sharp imagery.

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1. For clarity and simplicity the term "negative" is used for the transparency (object), regardless of whether it is photographically a positive or negative. Similarly, "paper" will be used to refer to the photosensitive emulsion in the image plane, regardless of whether the final support is paper or film.

Rectifier Parameters

In subsequent discussions of exposure times, line (slit) widths, etc., the following rectifier parameters are assumed:

Lens		
Focal length	F	11.65 inches
Relative aperture	N	f/4.0
Magnification, lens plane parallel to paper		
	M_o	1.875
Angular motion of slit	θ	
Maximum	$\pm\theta_{max}$	±40 degrees
Negative		
Nominal size		70 mm.
Image width		2.25 inches
Image length		25 inches
Exposing slit		1 by 57 mm.

It is further assumed that the only motion of the lens is angular and that the axis of the negative cylinder is at the lens.

Exposure Uniformity

As the exposing slit moves around the negative cylinder, the illuminance at the paper varies as a function of the lens-paper distance, the angle of incidence on the paper and the projected area of the exit pupil of the lens. To maintain constant exposure with a conventional, constant brightness, light source, the rate at which the slit travels is varied as a function of the slit position.

BASIC APPROACH

Optical Arrangement (Figure 1)

Light Source. Use of a cathode-ray tube as a dodging light source requires a line scan, which may itself replace the exposing slit. The second direction of scan is formed by moving the tube in the same manner as a conventional light source is moved. The cathode-ray tube is normally defocused in dodging printers to permit higher brightness; high definition is unimportant since detail is transmitted optically.

Use of a type 5WP11 or similar flat faced tube, normally defocused for dodging, will produce a line width which will concentrate most of the luminous energy in a 1 mm strip of negative, if the outer surface of the faceplate almost touches the negative.

Use of a physical slit would probably entail adjustment difficulties: If the trace were not aligned with the slit it would be difficult to see what corrective measures to take. Once adjusted, stability of trace position would probably be primarily limited by mechanical stability of the yoke mount.

Phototube. The entrance pupil of the phototube must correspond to the entrance pupil of the lens, otherwise the unsharp mask on the cathode-ray tube will not be in register with the image on the negative. Normally the pickup to the phototube is made between the negative and lens using a pellicle and a suitably positioned phototube aperture. The luminous flux density through such an aperture is greater than at any point below the lens.

STAT The optical path in the [redacted] rectifier is already folded between lens and paper; since introduction of additional optical elements is undesirable, this mirror may be selected to transmit, say, 10 percent of the incident light to the phototube. If the phototube is coupled to the exposing slit so that it is in line with the slit and the lens, a simple opal glass diffuser between the mirror and the phototube should allow satisfactory sampling.

Basic Dodging and Exposure Control System.

Either of two types of dodging can be used in this application: d-c intensity modulation or velocity modulation. With the former, the spot brightness at the cathode-ray tube is adjusted as a function of the negative transmission so that the illumination on the phototube is maintained at a constant predetermined value. The densest dodging element which can be properly printed corresponds to the brightest value which the spot can assume; if dodging is required in denser regions, the tube must be made still dimmer in the thin regions.

Velocity Modulation. (Figure 2) With velocity modulation dodging, the spot is moved at a speed instantaneously proportional to the transmission of the portion of the negative illuminated by the spot; the time to scan a line is proportional to the average opacity of the line. Since the cathode-ray tube is always at its brightest, it is apparent that the exposure time of a line can never be greater than with intensity modulation; usually it will be substantially less. Velocity modulation offers the greatest potential in ultimate performance and is simpler in terms of equipment.

Second Axis Control. The second scanning axis is normally analogous to a mechanical ratchet and pawl; after each velocity modulated scanning line is completed, the spot is moved down to the next line. Line spacing is independent of scanning time required by the dodging axis.

Since the mechanical second-axis-scan of the [redacted] rectifier STAT cannot respond in the required staircase (step) function, some other technique must be adopted to make line spacing independent of scan period. One such means is to assign a suitable maximum scan period and start a new line after each such period has elapsed. The spot would be blanked after the completion of each line and unblanked at the start of the next period starting the next line.

The maximum scan period must correspond to the greatest anticipated average opacity expected in a single line, resulting in rather inefficient use of the cathode-ray tube for thin negatives. Techniques to use the light source more effectively will be discussed at a later point. Such techniques, however, involve close inter-relationship between the mechanics of the rectifier and the dodging control, whereas the maximum-scan-period technique minimizes these inter-relationships and makes use of the existing method of compensating exposure by variation of light source speed.

Run-stop and Auxiliaries Functions. A pair of limit switches at the ends of rectifier motion would blank the cathode-ray tube before the start and at the end of the exposure; during recycle of the mechanism, the tube would be held off by a run-stop flip-flop or holding relay.

A control to stop the rectifier travel in mid-position (exposure axis perpendicular to paper) must be provided to permit checking scan length. If this position can be established precisely enough, the trace position and angle can also be checked and adjusted, using a reference line on the easel.

Anticipated Characteristics and Performance.

It is difficult to estimate performance in terms of [redacted] type 5427 film, STAT unless precise data are available on processing, sensitometry to a P11 phosphor, and equivalent printing density. (The equivalent printing density (epd) is the print density which is obtained when a printer with automatic exposure control is first calibrated subjectively using a negative and is then used to make a test print with no negative. For paper prints the epd is about 0.6.)

The following estimated data, based on [redacted] Medalist F-4 paper may be STAT used as a basis for finding performance on other materials.

Spacing, crt faceplate to negative	0.031 inch
Effective phosphor to negative distance	0.178 inch

Spot size at phosphor	d_s	.011 inch
Effective spot size at negative	D_s	.040 inch
Scanning density at negative, minimum		4.6 lines/mm 117.2 lines/in
Scan overlap, minimum		78.4 percent
Minimum scan period	t_o	0.5 milliseconds
*Maximum scan period, Average line opacity = 25	t_{25}	12.5 milliseconds
Exposure	E	5 meter-candle-seconds
*Exposure time, Average line opacity = 25	T_{25}	50 seconds

The exposure time with this basic system will be the same for all negatives. It is assumed that the scan line replaces the slit; incorporation of a physical slit will probably increase exposure time.

Exposure time and maximum scan period (*) are based on an assumed value of 25 for the average opacity of the negative across any scanning line; exposure time is proportional to the largest average opacity of any line on any negative. Measurement of the average opacity of 148 vertical aerial negatives (entire negative) yielded a maximum opacity of 18 for the worst negative; only 5 percent exceeded an opacity of 16. No corresponding data for single lines are available.

Thus, while aerial film may have opacities of 200 or greater (density 2.3), in practice the extreme values seldom occur over an area the size of the scanning spot and a substantially lower value of opacity may be assumed.

The above exposure time estimate does not allow for variation in the projected area of the lens exit pupil with cathode-ray tube position. This factor should have little effect in view of the low precision of the average opacity estimate.

Operation.

The operator will not use the controls on the dodging control unit in routine printing. The exposure cycle will be started and the rectifier recycled by operation of the presently used rectifier controls. Controls and indicators on the dodging control unit will be used only for adjustment and for indication of operation.

Electronic raster adjustment controls will provide for (1) independent adjustment of each end of the scan length, (2) rotation of the scan to make it parallel to the axis of the negative cylinder and (3) positioning the scan in a direction perpendicular to spot motion. Exposure will be independent of scan length.

An exposure mode switch will permit turning the cathode-ray tube on for such adjustments. It also will select either automatic dodging with exposure control or no dodging with manual exposure control.

An exposure end-point control will select the maximum scan period (scan repetition rate) in terms of the maximum dodging opacity for the worst line. This control, in conjunction with the present control for the average speed of the light source, will determine the actual exposure level.

The percentage of time the cathode-ray tube is turned-on will be indicated by an exposure efficiency meter, calibrated in percent. This meter will be particularly important in establishing the setting of the exposure end-point control during initial calibration. In addition, a fault indicator will light if the end-point control is adjusted for too low a value of opacity.

Other Data.

Construction. The control unit will be housed in a 18-1/2 by 26-1/2 by 14-1/2 inch cabinet (height, width, depth). Estimated weight is 75 pounds.

Where practical, electronic sub-assemblies will be constructed on plug-in modules such as that shown in Fig. 3. General construction shall be to best commercial practice.

Power Requirement. Power consumption at 117 volts (60 cycles) will be 200 watts or less. Performance shall be unaffected by variations in input voltage from 105 to 130 volts.

Manual. Instructions to commercial standards will be provided for adjustment of the installed control; maintenance instructions shall include block diagram theory, detailed explaination of unusual circuits, schematic diagrams, and component location diagrams.

No operating instruction manual will be provided, since this must be incorporated into the operating manual for the entire instrument.

ADVANCED APPROACHES

The basic system outlined above has two distinct disadvantages: (1) it does not permit shorter exposure times for thin negatives and (2) the actual exposure is a function of the setting of two controls: the existing traverse speed (motor) control and the exposure end-point control.

Variable Exposure Time.

Both these disadvantages may be overcome by using the dodging control to establish the instantaneous traverse speed of the light source, while also maintaining the desired line spacing. In essence, successive sweeps would be triggered as a function of traverse motion, rather than at a constant rate. Either the sweep frequency or the blanking duty cycle would then be used to control the traverse motor speed, causing it to run faster for thin negatives.

Traverse motion could be measured by any of several techniques, such as a moire pattern detector or other photoelectric incremental quantizer. Compensation of exposure for variation of the lower conjugate and angle of incidence on the paper could be performed either by using varying line spacing, based on the properties on the motion detector, or by introducing the correction factor into the spot velocity control. The latter technique STAT has been used successfully in the [redacted] E-16 control (for the [redacted] STAT
STAT [redacted] autofocus rectifier) to correct principle axis exposure over a 5.8 to 1 magnification range.

Estimated Performance.

The exposure time for such a control system would be very nearly proportional to the average negative opacity for the entire negative. In the sample of 148 vertical aerial negatives referred to earlier, the average negative corresponded to a printing opacity of 6.9. This would give, for an average negative, an exposure time of approximately 14 seconds on Medalist F-4, shorter on type 5427.

Further, the liklihood of bars on the print caused by irregular motion of the light source would be minimized, as exposure uniformity would be independent of time. While a new instrument may work very smoothly and show no tendency to produce bars, poor maintenance and accumulated dirt will eventually cause irregular movement and banding.

Finally, the operator would be relieved of using two factors in determining exposure level; a single exposure index control would set all parameters.

Application.

There are at least three methods of obtaining line start signals from the rectifier, two methods of exposure compensation and two traverse speed control techniques. Selection of the optimum system for this application requires, then, that one person or group become intimately familiar with both the rectifier and electronic dodging. Lacking this multiple discipline, it would be premature to give a detailed proposal for the advanced system at this time.

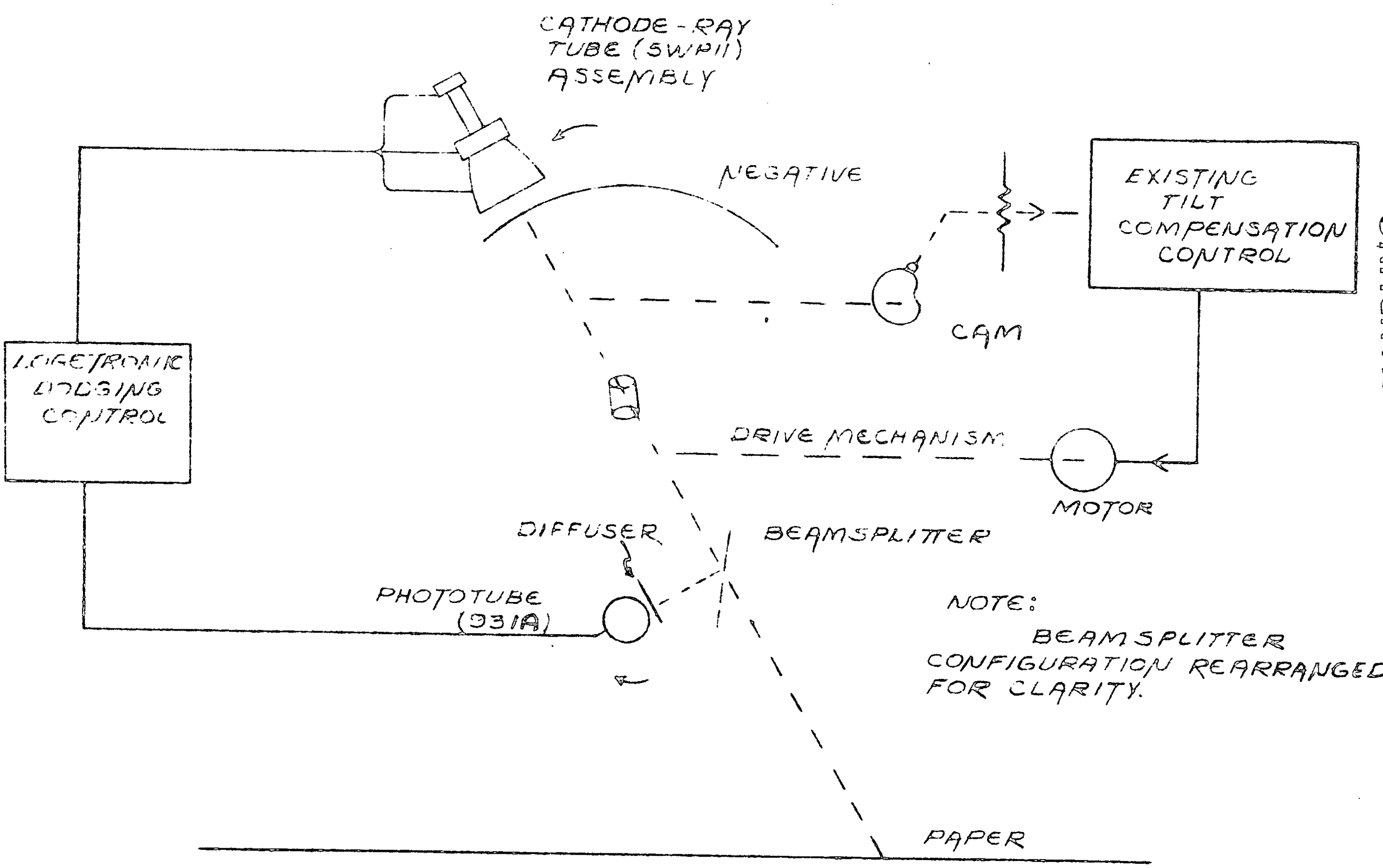

FIG 1. BASIC APPLICATION OF ELECTRONIC DODGING TO [redacted] RECTIFIER - SIMPLIFIED BLOCK DIA.

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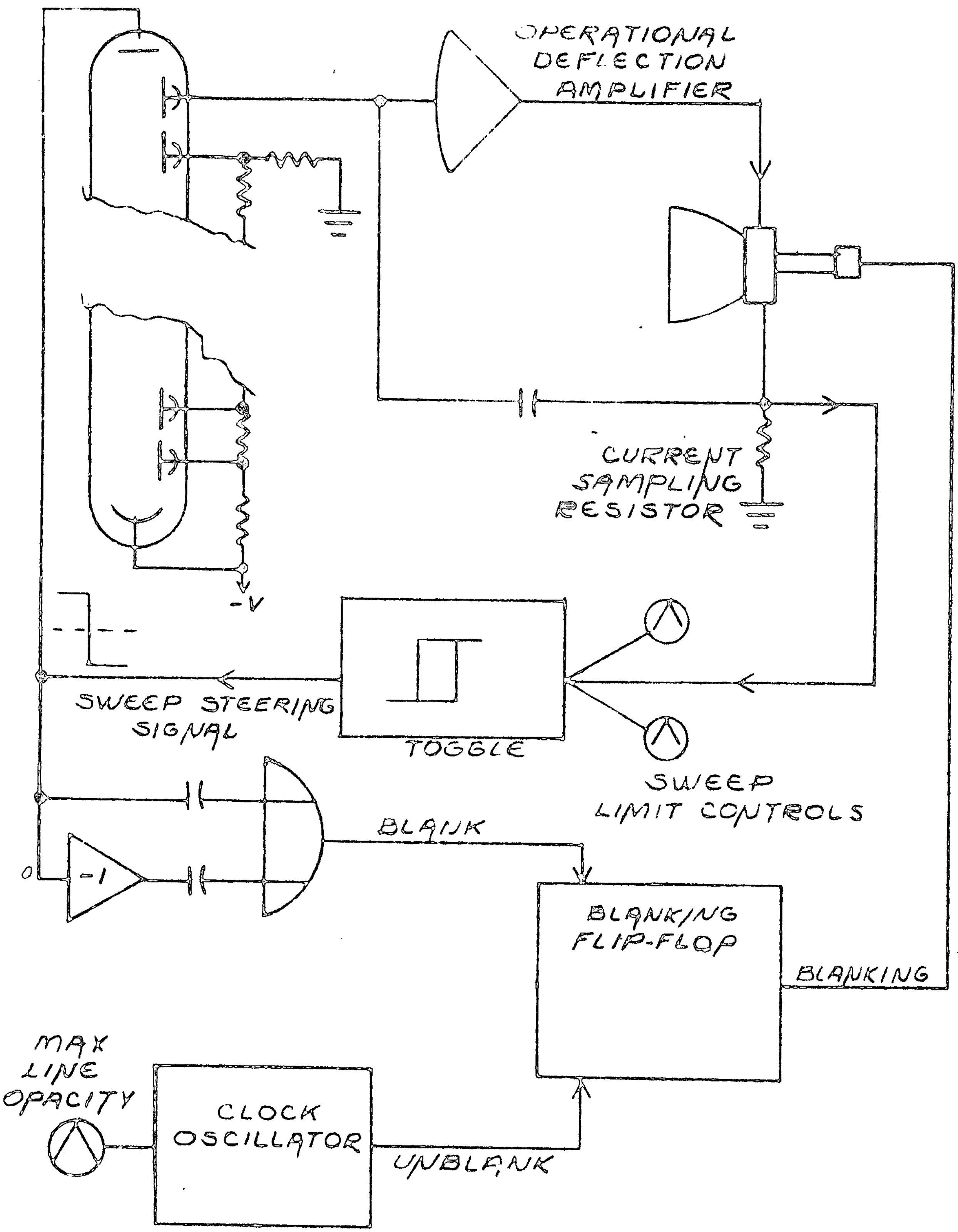

FIG 2. BLOCK DIAGRAM, BASIC DODGING CONTROL.

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