Proposal for:

Modulated-Light Film Viewing System Study

[redacted]

STATINTL

Declass Review by NIMA/DOD

STATINTL

[redacted]

April 20, 1964

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7

TABLE OF CONTENTS

I. INTRODUCTION AND SUMMARY

This proposal is submitted [redacted] for a study of the requirements for a "Modulated Light Viewing System", as set forth in the Request for Proposal [redacted] believes that the selection of a particular system to satisfy the expressed requirements can best be made after the completion of a study of the essential technical considerations. The proposal submitted at this time comprises a six-month study of possible systems, including experimental work to show the comparative performance and feasibility of certain critical components. When the proposed study has been completed, and the various trade-offs discussed with the contracting agency, a definite system selection will be made and used as the basis for firm recommendations and cost estimates for equipment development.

It is apparent that any system which will embody the performance capabilities which are outlined in the RFP will require incorporation of television-type techniques. Reasons for this conclusion are partly detailed later in this document [redacted]

Section II outlines some of the main technical considerations which [redacted] presently believes of importance. It is followed in Sections III and IV by a more detailed discussion of two definite possible approaches, to illustrate in more detail some of the foreseen problem areas. Several of the particularly interesting technical problems arising from the requirements for enhancement of picture areas of high information density are outlined in Section V. The organization of the program is given in Section VI.

II. TECHNICAL APPROACH

Stated briefly, the requirements for a modulated-light film viewing system are:

a. Illumination of up to 1000 foot-lamberts with 2000 foot-lamberts desirable.

b. The illumination to be modulated inversely proportional to the transmittance of the film.

c. The illumination to be modulated directly proportional to the spatial frequency or in other words, density of information content.

d. The size and position of the area illuminated by the modulated light shall be independently controllable.

e. Visually perceptible flicker or smear (upon moving the film) are not permitted.

f. Spurious effects resulting from unidirectional scan are not permitted.

It is the inclusion of requirement (c) above which rather severely constrains the system, and yet also gives rise to some interesting possibilities discussed in Section V., Enhancement. Without resort to conceptually involved and probably technically unfeasible schemes such as multiple parallel sensors with automatic comparison of adjacent members, a sequential sampling process is required to detect the presence of detail in a photograph. This leads to the requirement for a scanning process, and rules out exclusive use of a semi-passive process, such as a photo-chromic layer over the photograph. (In the present state of the art, photochromic materials are too slow-acting to meet the requirements of no smear when moving the film). Furthermore it is difficult to conceive how one might increase the light behind an area of high information density without some scanning process which would selectively illuminate the particular area with either sufficient light to overcome the damping effect of the photochromism, or perhaps light of some wavelength which will quench the photochromic effect. In addition a finely resolved scanning probe would be required to detect the presence of high information density. Hence two scanning beams are required even with a semi-passive system. One advantage such a system would have over others (particularly if an efficiently and rapidly quenchable photochromic material were available) is that the illumination could be provided by an unmodulated and relatively inexpensive source.

A cathode ray tube constitutes an easily modulated light source, and were it not for requirement (c) again, a flat-face CRT in conjunction with a photomultiplier, feedback amplifiers, and scanning circuitry, could be made to fulfill all the system requirements (except perhaps that of a 10 x 40 inch size). Because the spot size need not be small, (1/2 inch has been found to be satisfactory in the Log Etronic printer) the rather thick glass faceplate required would present no real problem.

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7

However when requirement (c) is introduced, a second finely focused scanning beam must be introduced. Furthermore, the fine beam must be separated spectrally from the illuminating beam so that it may be detected separately. This last requirement might be avoided if the fine beam were "tagged" with a pulse modulation and detected synchronously; however, in the presence of large illumination, the signal-to-noise ratio would probably be too small to be useful.

Another system using a directly viewed flat CRT to provide illumination is possible if the fine probe is relegated to a vidicon camera imaged onto the modulated light area. Here the presence or absence of high information density would be detected by the vidicon which is scanned synchronously with the illuminating beam. The automatic dodging would be provided by a photomultiplier pickup. The principal defect with this system is that the highest spatial frequency which could be detected would be about 1.5 cycles/mm referred to the photograph.

The spectral separation of illuminating beam and fine beam is useful also so that the fine beam could be made invisible to the observer, and not distract him. Thus these constraints lead to two separate cathode ray tubes imaged onto the photograph and scanned synchronously. This system is described more fully in Section III below. Its principal failing is that it is incapable of providing sufficient illumination with presently available components, but the more detailed explanation given in Section III is presented to show the main characteristics to be considered in the proposed work for a purely electronic system.

A mechanically scanned light beam system is also conceivable and perhaps feasible and should also be considered in the general studies. Here an intense light source would be modulated by an optical modulator, and then made to scan the photograph by mechanical means. This system is more fully described in Section IV. The principal defects of this system are that the modulator is difficult and expensive to drive, no entirely suitable modulator is available, changing size and position of the modulated area is unwieldy, and without extreme mechanical complexity, only a unidrectional scan is possible.

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7

III. CRT Scanning System

Main Light Source

To achieve a brightness of 1000 foot-lamberts on a 9" x 9" area from a CRT face not in contact with the transparency requires a high efficiency optical system. Reflection optics [redacted] provide this because the effective aperture can be made to approach the theoretical limit of f/.5. Based on 26" diameter the speed is about f/.8. The light transmission efficiency, however, is not 100 percent but something less depending on the reflectance of the mirror and the type of lead glass (for x-ray attenuation) used in the correcting plate. The overall light transmission of the system described herein is 20 percent. This efficiency together with a magnification of the CRT raster (4" x 4") of 2.25 to 1 gives a 25 to 1 reduction in the light. The [redacted] kinescope is rated for 25000 foot-lamberts <u>high light</u> brightness, which would provide 1000 foot lamberts on the 9" x 9" area. Maximum average brightness however is only 13,000 foot-lamberts which would provide maximum average illumination of the transparency of only 500 foot-lamberts. Use of a diffuser under the film would reduce this figure further. The CRT would be overloaded, if a transparency were viewed which was very dense all over. To prevent this the tube would have to run at reduced current, also reducing the light. Possibly a regulator could be developed to prevent the average ultor current from exceeding a prescribed value.

The above discussion is based on the feasibility of the design and construction of a correcting plate for a 4' throw instead of the usual 60' to 80' throw. The reflective optics designed for theatre TV projection when used at 4' produce excessive vignetting of the light pattern. A properly corrected plate for the 4' throw would have to be calculated and designed.

Light from the [redacted] optical system is reflected by means of a 45° mirror to the transparency being viewed. This is done for two reasons. First, it is desirable to adequately shield the operator from the 75 KV X-rays; second, the mirror provides a means of superposing the light from the Detail Sensor Light source. The effect of the hole in the center of the 45° mirror is to increase the vignetting of the main light source. The correcting plate would be designed with this in mind.

Detail Sensor Light Source

To provide a brightness modulation as a function of spatial frequency, a detail sensor is required. A kinescope with a P15 phosphor is very well suited for this application since the spectral characteristic of this phosphor has an intense peak at 3900 Å, and a broader peak at 5000 Å. The longer wavelengths could be readily filtered out to make the light invisible to the operator, and yet

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7

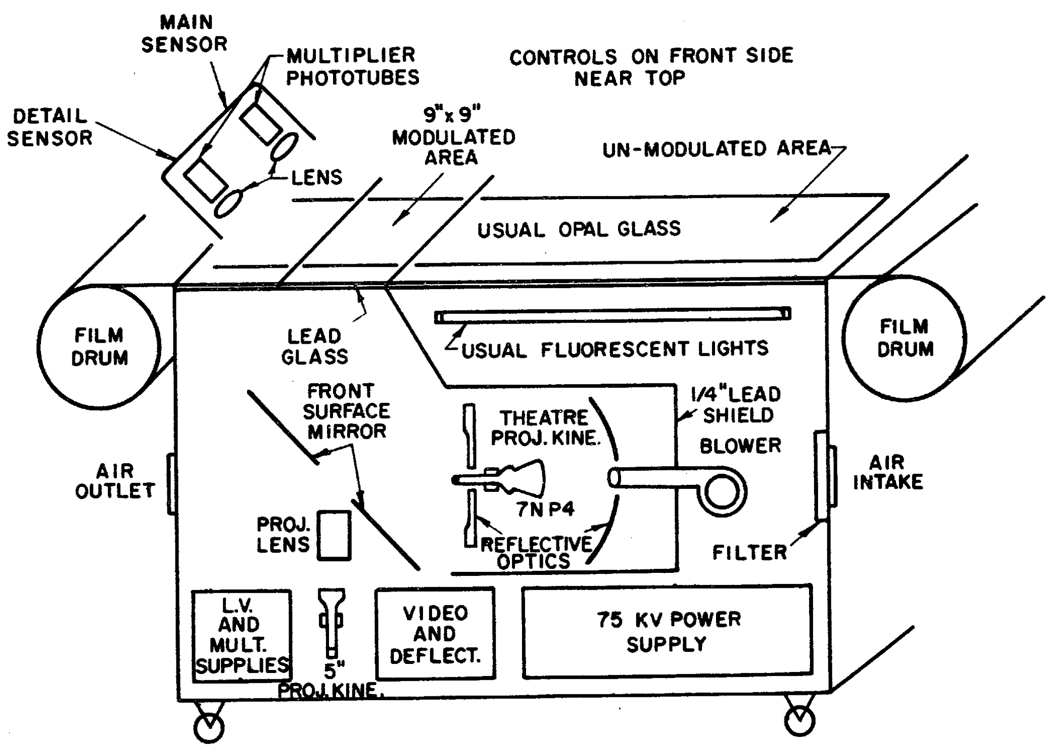


Figure 1. Modulated-Light Film Viewing System
(Using CRT Light Sources)

would be available for other uses as discussed in Section V. The persistence of the phosphor is short, so that the relatively high frequency detection channel is possible. (Of course the main light source would require filtering so that it generated no light at the detail sensor wavelengths. Room lights should also be attenuated at these wavelengths -3700 to 4100 Å, to provide maximum signal-to-noise ratio in the detail sensor channel).

75 KV Power Supply

STAT

This supply occupies about the same volume of space as the [redacted] optical system. It is shown as part of the light box in Figure 1. To reduce the size of the light box package it may well have to be externally situated. This would require a 75 KV connector, which is expensive.

The supply should be reliable, well protected against overload and breakdown, should be regulated for changes of line voltage or load current, and should have a minimum of ripple.

Deflecting Generator

The same generator would be used to deflect the beams of both CRT' s. "Box" scanning is contemplated rather than uni-directional scanning because it lends itself better to enhancement effects if desired later. For example, simple differentiation of the video signal produces a white or black edge all around an object with "box" scanning. With uni-directional scanning the effect is lost when the edge of the object is parallel to a scanning line. "Box" scanning is generally used in low frame rate systems for printing pictures. For direct viewing with no flicker deflecting circuitry would have to be developed. This is not considered difficult.

Main and Detail Sensors

The problem here is to place the sensors in such a position that they will sense the area of the transparency under the viewing microscope, yet not obstruct the view. To mount the sensor directly on the microscope would simplify the problem but complicate the microscope. To take care of both direct and microscope viewing the best compromise seems to be to mount them on the side of the 9" x 9" area at a low viewing angle (see Figure 1). This means that corrections such as graded density filters will have to be made to minimize shading.

Multiplier and Low Voltage Power Supplier

These suppliers are conventional and may be purchased from any suitable vendor. They could be mounted on the sides or ends of the viewer or in a remote package along with the 75 KV supply if desired.

Video and Processing Amplifiers

The video amplifier for the Detail Sensor would be wide band but no difficulty is anticipated. The corresponding amplifier for the main sensor would be narrow band and would be conventional. Video processing may not be required with "box" scanning. If it is, circuitry would have to be developed for this type scanning.

IV. Mechanically Scanned Light Beam System

The use of a modulated light beam with mechanical scanning represents a possibility, and is described below.

Such a method of scanning with a modulated light beam is shown in Figure 2. This technique, as shown, scans the 9" × 9" area unidirectionally. Being unidirectional, the position of the probing light can be adjusted with respect to the position of the illuminating light. Thus, if the modulation response delay is prohibitively large, the probing light can be advanced to compensate for this delay.

Due to the required tolerances this would require extremely fine adjustments. The synchronization of the multifaced reflectors would also require extremely fine adjustments. The rotational speed of the high speed mirror drum is inversely proportional to the size of the illuminating spot size and the number of faces on the mirror drum, but in the range of spot size considered, the speed of the high speed mirror drum will not be prohibitively large.

The optical system, as shown, is compact and should readily fit inside the standard size viewers with little problem.

Unmodulated areas on both sides of the modulated area could have separate controls. It may be desirable to have clear glass instead of opal glass for the modulated area depending upon the beam requirements.

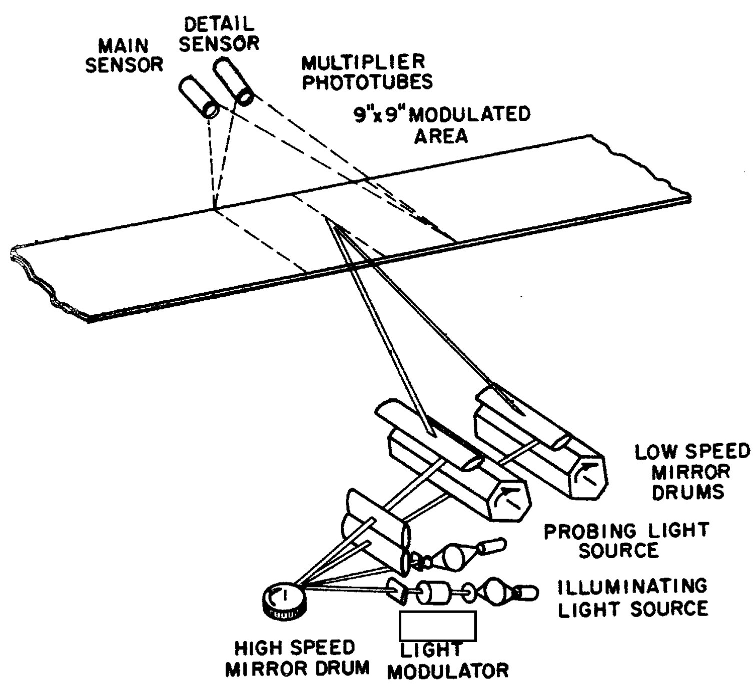
Though it is not shown in the figure, various methods for reducing the size of the modulated area have been investigated. One of the methods would be to have several multi-faced reflectors on each shaft. On any one shaft, each reflector would have a different number of faces. Rotating at the same speed, the total amount of illumination would be scanned over a smaller area. This shifting of reflectors could by accomplished readily without varying the speed of rotation.

Another method would involve the insertion of different condensing lens systems.

It is conceivable that the entire optical system could be balanced in such a manner that would allow translation of this smaller modulated light area to any position in the original larger modulated area.

The scanning frequencies in the system as shown can be adjusted for interlacing and overlap if required.

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7



STAT

Figure 2. Mechanical Scanning Technique Using Light Modulator

STAT

Methods for bidirectional scanning has been investigated in order to overcome the problems of uni-directional scanning. One possible method of obtaining bi-directional scanning is with the use of counter-rotating multi-faced reflectors. There would be problems with synchronization inherent with such a system.

The problem of modulation of the light beam is a difficult one. When a scanning speed is used which is fast enough so that there is no flicker, the modulation bandwidth capability should be approximately 360,000 c.p.s. This high modulation rate rules out mechanical modulation methods. An electro optical light modulator of [redacted] crystal [redacted] can be made to function effectively at these frequencies, but is not entirely suitable for several reasons.

The modulation is accomplished by varying the retardation of a polarized light beam, and thus requires two polarizers which are only about 35% transparent at best. The cell itself is about 80% transparent, and hence for the large light flux required absorbs sufficient heat that special cooling would be required (max operating temperature is 90^{o}F).

The modulation is accomplished by varying the voltage applied across the cell. For 5:1 modulation about 3500V peak-to-peak swing is required. Certainly this is not easily or cheaply accomplished.

A further disadvantage of this type of modulator is that when white light is used, the spectral content will change as the potential across the cell is varied. This fact results from the characteristic that the retardation is greater for shorter wavelengths.

Other types of light valves are possible. Perhaps the most promising of these is the ultra-sonic light valve, but it too is not entirely suitable.

Much research is being conducted currently in this field, particularily in connection with the problem of modulating laser beams, and breakthroughs may be imminent.

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7

V. Enhancement Possibilities

There are several peripheral effects which are available as a consequence of the use of a five probe scanning beam for detection of high information density.

Because the diffuse illuminating beam and the fine probe beam are scanned synchronously, there will be considerable space between adjacent traces of the fine beam. If a small region of high information density were to fall between these tracks it would not have its illumination increased as desired. However it is possible that the fine beam track could be moved back and forth within the diffuse beam track at a cycling rate of a few cycles per second. The effect of this operation, which would be at the discretion of the operator, would be that such small regions would scintillate in brightness at the cycling rate, and the observer's attention would be drawn to them.

Another effect which might have value under certain circumstances is that the fine probe light could be made visible (by removal of filters), and not used for its normal purpose, but instead be made to superimpose on the main illumination a regular dot on line pattern which would beat with regularities in the photograph to form a moire pattern, and hence aid in detecting such regularities. The relative ease with which the spacing of the superimposed pattern might be changed would perhaps aid in finding a suitable one for the particular regularity to be detected.

It might also be possible that the fine beam could be used in limited areas to perform an effective contrast expansion of fine detail within its limits of resolution. It is envisioned that this effect would be used for close inspection, and could be implemented with modified use of the installed feedback amplifiers.

VI. ORGANIZATION OF THE PROGRAM

A six month study program involving the efforts of approximately two members of the technical staff, plus appropriate support, is proposed. The work will be the responsibility of the [redacted] members of the group have full use of both the specialized facilities [redacted]

General program management will be the responsibility of [redacted] Manager, Physical Research. The project engineer [redacted] Biographies of the above and others who are expected to be associated with the project are appended.

The work will consist of theoretical and limited experimental studies resulting in firm recommendations for prototype equipment development. By limited experimental studies is meant performance of such experiments as are deemed necessary to prove any calculated results where parameters are insufficiently well known to yield theoretical answers of high confidence, or where subjective evaluation is required in order to determine whether a particular technique is suitable.

It is felt that a completely operating breadboard may not be necessary for system design provided that all parts and functions of the system have been demonstrated and/or calculated with good confidence. The proposed program of work is as follows.

- A search and study will be made of all applicable phenomena, followed by more intensive study of the more promising techniques, some of which are expected to include those listed below.

- A study of the characteristics of photochronism and other semi-passive phenomena will be made to determine whether very recent improvements makes their use more attractive.

- Methods of improving the spatial frequency sensing resolution of a CRT-vidicon camera system will be investigated. If the resolution were improved, this system might be the most suitable.

STAT

- A study of the projection CRT system will be performed. Modified use of available [redacted] optics will be studied, taking into account the partial reduction of vignetting resulting from the use of negative feedback in the system.
- A study will be made of the subjective effect of the presence or absence of a diffusing layer directly under the film.
- A study will be made of the subjective effect of smear and flicker at various light levels, spot persistences and scanning patterns and rates.
- A study will be made of the mechanically scanned light beam system. In particular the optical system parameters will be investigated to determine closely source intensity and modulator flux requirements. Various modulator types will be re-examined to determine optimum type, and if necessary formulate specifications for a specific design.
- Studies of methods and cost of implementing the enhancement effects proposed will be performed if the customer deems that they are of sufficient value.
- A study of application to modulated-light rear-projection screen viewing will be made, and recommendations set forth. A proposal for development of this type of equipment will not necessarily be presented.
- Monthly letter reports describing progress will be submitted.
- A final report will be submitted including a firm recommendation for a specific system, including a budgetary estimate for building a working breadboard or prototype. If the customer should desire a firm estimate for this work [redacted] will be pleased to furnish same at no additional cost.

STATINTL

Next 2 Page(s) In Document Exempt

Approved For Release 2002/11/01 : CIA-RDP78B04747A001100050017-7