Item-12

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

TECHNICAL DEVELOPMENT PROGRAM

JUNE 1963

THE NPIC'S TECHNICAL DEVELOPMENT PROGRAM
(June 1963)

The Plans and Development Staff is responsible for the technical development of procedures and equipment to ensure timely, efficient, and accurate photographic intelligence production. This responsibility, reflected in its planning and developmental activities, mirrors the growth of the Exploitation effort alongside that of Collection. The importance of this partnership is accented in the latest COMOR Requirements Paper, dated 18 April 1963, which covers the periods up to 1968. At the present time, the NPIC is involved with about 35 commercial companies in the development and procurement of specialized photographic exploitation equipment.

THE PURPOSE OF THIS REPORT

This report presents a narrative summary of the research and development efforts of the Plans and Development Staff in the technical development field. In discussing equipment development, an attempt has been made to present some of the background and planning that precedes such development. Together with the Contract Status Report, it will provide a more complete picture of the Center's development efforts. It should also provide a means of communicating with those whose backgrounds are non-technical, but whose duties require a fairly detailed knowledge of a complex field. Although technical terminology has been avoided to a great extent, some recourse to technical terms is unavoidable. Periodically as additional information becomes significant, this report will be up-dated. Further contributions or comments will be welcome.

For purposes of convenience equipment under development is grouped into four sections as follows:

I. Photo Interpretation, Photogrammetry, Mensuration Devices
II. Photo Reproduction and Processing
III. Data Management and Indexing
IV. Lenses, Studies, and Special Techniques

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Assistant for Plans and Development

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(A) VIEWERS AND READERS

(1) Photo Interpretation Tools

The increasing image quality and film sizes of the typical photographic source materials being analyzed at the Center indicate approaching obsolescence of the basic tools presently being used by the photo interpreter; namely the 7X tube magnifier particularly as a measuring device and the Zoom 70 microstereoscope. In addition, the continued use of the Zoom 70 has resulted in the recognition of the need for viewing techniques which are not possible with the present equipment. So in the same fashion that the interchangeable, clip-on, stereoscopic and monoscopic heads were conceived, new modifications and auxiliary devices are being developed which are intended to extend and useful life and area of application of these basic instruments.

It now appears that it will be practical to retrofit the Zoom 70 with 360° image rotation. It is also probable that another clip-on, rhomboid system can be produced which will increase the available image separation accommodation to 10 inches.

Another study is being conducted to determine the feasibility of developing an optical relay system mounted in a tube, two of which could be fastened to corresponding rhomboids of two Zoom 70's, thus permitting simultaneous dual viewing of a single stereo pair.

In order to be prepared for viewing photographic records that definitely exceed the resolution capability of the Zoom 70 an immediate adaptation of two Bausch and Lomb high performance laboratory microscopes is being developed (maximum resolution is in excess of 1000 lines per millimeter) which will allow stereoscopic viewing of a wide variety of film sizes. It is anticipated that this device will furnish the photo interpreter with adequate information extraction capability for several years. In turn it should also furnish a performance standard from which the design objectives for future viewing equipment may be derived.

Relative dimensions have continued to be a primary clue to specific identification. The tube magnifier has generally been the means of extracting the basic data. This relativity often can be utilized without rectification, but the resolution and precision of the tube magnifier is no longer up to the task. Consequently, there are several developments in progress that will soon be available for evaluation by the photo interpreters. The first is a fixed power 40X microscope fitted with

a micrometer eyepiece graduated to one hundred-thousandth of a foot. This device is interchangeable with the Zoom 70 in its mounting ring. The second is a group of finely divided stage reticles graduated to two ten-thousandths of a foot. These are recorded on glass discs about .25"thick and 1.5" in diameter. The reticles will be available in various colors and densities. These devices may be placed under any direct viewing system, such as the Zoom 70. The last approach being studied is comparable in size and application to the second system described above. In this case the glass disc will be fitted with a screw type micrometer instead of the fixed reticle. Such a system will obscure less imagery than a fixed reticle and may provide greater precision.

(2) Richardson Film Reader

This equipment, under development, is basically a photo interpretation instrument with a built-in measurement capability. In appearance it will be similar to the Richardson Film Viewer Model 705M now operating in the NPIC. However, it will have a completely redesigned film transport, a more elaborate control panel and indexing crosswires mounted to the rear of the screen. The film transport will be capable of sensing film movement through the film gate to an accuracy of approximately $\pm$ 25 microns for measurement along the length of the film. This will be accomplished by a metering capstan drive. Measurement across the width of the film will be accomplished by a band drive which moves the entire film transport back and forth over the optical axis of the lens perpendicular to the edge of the film. The crosswires mounted to the rear of the screen will serve as a fixed reference point relative to the film movement measurement. Readout will be accomplished by a Digital Accumulator and Transmission Unit, as described later in this paper.

(3) New Rear Projection Reader

Since contracting for the Richardson Reader research and development activities have been undertaken for upgrading the various items of viewing and measuring equipment already in-house. Because of the delays in the development of the Richardson Reader because of technical problems encountered, and development activities for upgrading rear projection equipment, it was decided to develop in parallel another film reader. For this instrument, development effort is being devoted to four significant problem areas, all of which contribute to the final image quality. It is this image quality that determines the degree of information extraction. The four areas are:

1. The light source and condensing lenses.
2. The film transport and cooling system.

3. The projection lens system.
4. The viewing screen.

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25X1A5a1 A contract titled High Illumination Projection Study, with [redacted] covers the light source, condensing lenses and film cooling. In this contract the light source itself is being given intensive study and research; the condenser system is to be examined and optimum designs presented. [redacted] has been given authority to 25X1A5a1 have a special light source designed and built, if necessary. The contract requires that the light source area be optimized to afford the proper amount of light so that it exceeds the nominal requirement for visual viewing purposes; that the heat at the film plane be reduced so that it does not affect the mensuration requirements of the instrument; and that a set of criteria be devised and tested to determine if the rear projection viewer/reader meets a set of predetermined specifications.

The film transport will be one of the major design phases of the new reader, since it is an important factor in measurement accuracy as well as viewing comfort. In addition the film cooling problem will be closely worked out with the [redacted] as one of the major factors in designing the transport.

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25X1A5a1 A contract has been drawn up with [redacted] to advance the state of the art in lens designs for the community by studying the use of nonspherical (aspheric) surfaces on all of the surfaces of a lens. This lens design applied to projection lenses will allow a maximum of light transmission, a minimum of aberrations and distortions and improve the resolution over the entire format of the area being viewed. In other words, the lens function will be maximized.

25X1A5a1 The screen involves no NPIC-sponsored development activity at present. A study by [redacted] covering 114 sample materials having a potential as screening material or being specifically designed as a screen material was recently completed. Close surveillance is being exercised over developments in this area. As progress is made in the various areas, in-house readers will be upgraded by integrating new criteria into specifications for new models.

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Proposals have been solicited and evaluated for the production of the new reader. [redacted] has been selected and a contract is presently being prepared.

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(4) Data Block Reader

In order that the NPIC have a capability for rapid readout of binary information recorded on film by dot images, the design and fabrication of a "Data Block Reader" has been conceived to fulfill this requirement. In addition, if the "Data Block Reader" were installed at the film processing site, there would be a significant savings in time from the method of producing data information now contemplated. Although the NPIC has a readout capability, the present method is slow, whereas the proposed instrumentation will be capable of producing a readout from either negative or positive film at the rate of 200 feet per minute with the inherent versatility of recording from film widths of 70 mm to 10 inches. Data received from the reader can be fed directly into a computer or can be recorded on media such as typed hard copy, a card deck, punched tape or magnetic tape.

(5) Electronic Image Manipulation Viewer

The device under consideration is essentially an electro/optical device with CRT presentation which will perform all of the operations on a photographic image that are normally performed in a photographic laboratory by darkroom or specialized instrumentation procedures i.e., image reversal, gamma change, density contraction or expansion, edge enhancement, contouring, differential stretching (rectification), etc. Design objectives are general allowing the contractor flexibility to exercise his imagination and capability in the design and construction of the multiple capability instrument.

This device is envisioned as an aid to the interpreter in allowing him to perform maximum photographic image manipulation for immediate identifications and decisions.

(6) Stereoscope Large Light Tables

This instrument, originally conceived in 1958 and finally delivered as a successful prototype in March 1963, is basically a versatile tripower stereoscope (3X, 6X and 12X) mounted over a light table with a motorized film transport system. It is designed for scanning either two rolls of $9\frac{1}{2}$" wide material from conventional cameras or four rolls from split format 18" x 18" cameras. Actually almost any format can be scanned on this instrument since provision has been made for operator control of all variables in film handling, such as independent direction of film travel, variable tension, (including reversal), adjustment for tracking, image rotation, fast of slow movement mirror

image viewing. Any width film can be accommodated through the use of spool adapters from 35 mm wide to 18 inches wide.

(B) COMPARATORS

(1) Versatile Stereoscopic Point Transfer Device

The greatly increased computer capacity of the Center provides a capability for processing a much greater quantity of precise photographic data. It follows that means must be provided to assist the analyst in extracting such data. One of the most significant systems of data available to the analytical photogrammetrist is the correlation of photographic images of the same object point on different photographs. This includes the data available on sequential stereoscopic exposures in a single flight line, convergent stereoscopic coverage, adjacent overlap areas between flight lines, coincidental overlap from different missions, and overlap of exposures taken with different camera systems. The data required for this type of analytical computation are precision rectangular coordinates of the corresponding photo image points. Extraction of this data necessitates precise cross-identification of these points and measurement on a precision comparator. The Nistri Stereo comparators TA-3 and RIC-1 were designed to accomplish both these tasks simultaneously, but this equipment does not accommodate the wide range of situations characteristic of reconnaissance photography. Stereoscopic point marking devices have been built by Wild, called the PUG-1 and PUG-2 but these are also limited to very special applications.

It thus became apparent that full utilization of the precision, rear projection, roll-film comparators presently being developed for the Center, required associate development of a versatile stereoscopic point transfer device.

Invitations have been extended for proposals for the development of such a device. It will consist of a versatile, roll-film, scanning stereoviewer fitted with a precision point-marking system. The viewing system will be capable of handling one or two rolls of film from 35 mm to $9\frac{1}{2}$ inches in width. Independent zoom magnification of each eye-train from 5X to 125X is required. Maximum resolution is to be 625 lines per millimeter. Highly versatile optical and mechanical scanning motions will be incorporated. The point marking system will provide minute round marks about 20 microns in diameter at the selected image points. These marks will be accompanied by a more prominent "flagging" mark and

an identification number. They will be readily visible in the comparator and will be the basis of reference for the position measurement, which may be accomplished manually by the operator or automatically by a system within the comparator. By these means it is intended that the Center will be equipped to extract greater quantities of meaningful data from a wide variety of photographic sources.

(2) GIANT Comparator

GIANT is the name given to a complex, automated rear projection comparator developed for the Center in April 1960. The GIANT was intended to be a Nadir Determination Device which would automatically track the boundary between the atmosphere and the earth in photographs of the apparent horizon. In addition it was to be used as a rear projection comparator with automated read-out including a visual digital display and a paper tape punch. Image positioning was accomplished through joy stick control.

In actual operation deficiencies in the operation became apparent. It was learned that the resolution of the tracking system exceeded the resolution of the horizon image so that this aspect of the system never functioned properly. In addition, the enlargement, resolution and brightness of the projected image were inadequate; the positioning system was not properly coordinated to the precision of the measuring engine; and the film transport system was designed for only 70 mm film size accommodation.

Since the GIANT did possess some good basic elements - namely, the 9" x 9" Mann Comparator, an excellent cabinet and a good electronic counter for the automated digitizing system - and since there is continuing need for good precision comparators, it was decided that an investigation into the feasibility of modifying the GIANT to correct these deficiencies should be undertaken. A contract for accomplishing this investigation was let in June 1962. It was felt from the outset that a good general purpose rear projection comparator could be salvaged from the GIANT. It now appears that it will, indeed, be feasible to modify the GIANT into a good rear projection comparator. Furthermore, incorporating an automatic star image centering system into the comparator is proposed. Thus it appears that the GIANT may yet become a useful instrument for the Center.

(3) Nuclear Research Instruments Dual-Screen Comparator

This machine is a high precision film comparator with a capacity to measure format areas up to $9\frac{1}{2}$" by 30". The measuring sensors are a modification of the Ferranti Moire Fringe system with a least-count of

two-microns. Film transport is accomplished by air bearings instead of the conventional lapped method.

Operator viewing is accomplished by a simultaneous two-screen presentation. The larger screen, 40" x 40", is used for scanning purposes, with a fixed magnification of 8x. The smaller screen, approximately 12" x 17", is used for measuring purposes and presents 8x, 16x, or 30x magnification. The area of high magnification is indicated on the low magnification image. In addition, a crosshair is also projected on the small screen as a fixed reference point.

Illumination is provided by a 2500 watt water-cooled, mercury vapor arc lamp which provides illumination for the crosshair projection as well as the image projected on both screens. A unique vacuum film clamping and transport device will accommodate film widths from 70 mm to $9\frac{1}{2}$" in roll form. Data reduction is accomplished by connection of the comparator directly on line with the 490 UNIVAC computer. A description of a similar data reduction system follows later in this paper under a Digital Accumulator and Transmission Unit.

(4) Mann Comparator

This machine, under development, is a modified Mann Model 880 two-coordinate comparator capable of accepting film formats up to 18" x 18". Measurement is accomplished on both axes by precision ground and lapped lead screws. Readout is available either on a coded disc which is directly readable by the operator, or from a position resolver which, when connected to an electronic digital accumulator, will provide paper tape and typewriter print out. Viewing is accomplished by a microscope assembly which gives a continuously variable magnification of 12X to 40X. A crosshair is constantly visible in the optical path. The modifications consist of a selsyn-drive system for the secondary axis, a selsyn-driven high-intensity light source, and provisions for accepting a projection viewing screen.

(5) Chip Comparator

This item is under contract negotiation. Basically it will be designed to accept a stereo pair of 70 mm by 100 mm chips with a usable image area of 70 mm square. The remaining 70 mm x 30 mm area will contain information in binary form to relate the chip to the frame from which it was produced and contain the coordinate relationship of the chip to the principal point of the full format.

Precision measurement will be provided by an interferometer capable of providing a two-micron least-count over the entire format area. Data reduction will be provided by the Digital Accumulator and Transmission Unit described elsewhere in this paper. This data transmission unit will have the capability of extracting automatically the binary encoded information on the chip. Viewing will be provided by a modified Bausch and Lomb Dynazoom optical microscope system with fixed crosshair in the optical path.

(6) Stellar Comparator

The Stellar comparator will be a high precision rear projection comparator with a $9\frac{1}{2}$" x $9\frac{1}{2}$" usable measuring area. Positioning will be semiautomatic with the operator manually (by joystick) placing the stellar image within the field of the autometric capability and the automatic lock-on servo-system then taking over and determining the center of the stellar mass. The requirements for this instrument are still under consideration and firm design specifications have not been drawn up yet for soliciting proposals.

(C) MISCELLANEOUS

(1) Change Detector

The Change Detector is a device that will automatically register, compare, and display photographic data from two views of a common area taken at different times, presenting visually the changes that have taken place between the times the two photographs were taken. Studies have been made of the optical and electrical requirements of the various components and a breadboard model has been designed and fabricated, successfully demonstrating the feasibility of the principle.

The current design of the Change Detector has a resolution limitation of 20 line pairs per millimeter. Recent studies have shown that the resolution capability can be increased to at least 50 line pairs per millimeter. Further increase in resolution would require an advance in the state-of-the-art.

(2) Microdensitometer for Film Evaluation and Mensuration

The NPIC needs a capability in the field of microdensitometry to adequately fulfill requirements levied by other facilities in evaluation of original negative, duplicate negative and duplicate positive

film materials. To date only a class II instrument is available. For film evaluation another microdensitometer is on order which will allow use of full frame 70 mm film without the necessity for production of film chips. In the near future there will be available a class I instrument that will incorporate the necessary accuracies in direct density determination, synchronized chart and image scan travel and variable scan spot sizes to allow mensuration procedures to be interpreted after its scan over a film transparency. It is the function of this instrument to be as versatile as possible by incorporating such features as a fine screen viewing during scanning of the film image, a capability for recording a photomicrograph at any point along the scan or obtaining a visual readout of density in addition to having a capability for coupling the output through a computer.

SECTION II

PHOTO REPRODUCTION AND PROCESSING

(A) DRYERS AND PROCESSORS

(B) RECTIFIERS, PRINTERS, AND ENLARGERS

(C) MISCELLANEOUS

(A) DRYERS AND PROCESSORS

(1) Roll Film Dryer

From 1957 to January 1963, the roll film dryer, manufactured by Heico, was used continuously by NPIC, and was the only film dryer in use during this period of time. This dryer accepted all widths of aerial roll film from 70 mm to 9½" and could be operated continuously at speeds up to 30 feet per minute. It used the principle of dehydrated air rather than heat to remove the moisture from the processed film. The dehydration equipment necessary to operate this dryer was a sizeable package of considerable weight utilizing 45 KVA of electrical energy to regenerate the desicant.

We are purchasing a new roll film dryer which can be attached to the HTA/1 Film processor or can be used separately with other equipment. This new dryer employs the air bearing principle in which the film is transported through the drying cabinet on a cushion of air which is warmed slightly above ambient temperatures. This dryer will consume approximately 25 amperes of electrical energy at 230 volts and will achieve proper drying and conditioning of the roll film to ambient RH measurements at approximately 30 feet per minute. The dryer occupies only 1/5 the space of the former equipment.

(2) HTA/5 Film Processor

The HTA/5 roll film processor (under development) is designed to accommodate all widths of roll film from 70 mm to 9½ inches, and will employ a new principle of film transport in which the exposed film will pass through the various chemical solutions and through the dryer by the principle of liquid and air bearings. This will permit the film to be transported from dry to dry untouched on either emulsion or base side.

Since the liquid bearings form a cushion for transporting the film they will also provide excellent agitation and turbulence of the chemicals in close proximity to the film emulsions. This type of turbulence will allow for the shortest processing cycle and uniform processing across the width of the film. By employing the liquid and air bearing principles virtually no tension or friction is induced and in the absence of tension there will be no tracking problems throughout the processor and dryer.

A console for the unexposed film is designed to accommodate an entire mission of film so that it may be processed uncut. Following the

drying cycle the film will be rewound in a similar console or in one or two smaller take up reels. This processor when installed at the NPIC will provide the capability of high quality processing of original materials when required.

(3) Cut Sheet Processor

A cut sheet film processor (under development) will be designed to accommodate all film sizes from 8 x 10 inches to 30 x 40 inches. This processor will have three separate developer compartments: one for half tone chemistry, one for line, and the third for continuous tone. The operator can select the compartment to be used and the film will be properly routed to that developer compartment for processing; or, the films can be notched or coded and be transported automatically through the short-stop fixing, washing and drying compartments and emerge ready for use. It is envisioned that the three copy cameras and the several vacuum printing frames currently in use at the NPIC will generate sufficient quantities of cut sheet film materials to make the operation of this type processor both economical and efficient.

(B) RECTIFIERS, PRINTERS, AND ENLARGERS

(1) Electronic Photographic Rectifier

The Hycon H-229 Electronic Photographic Rectifier is designed to rectify photography from a wide range of panoramic or framing cameras. The Hycon equipment does not require focusing control changes during operation or between successive rectifications. This feature enables the H-229 Photographic Rectifier to obtain better photographic resolution and accuracy with more versatile performance than other rectifiers. Additional enlargement is not required to establish a common scale between rectified photographs originally taken at different altitudes.

An H-229 rectifier consists of three units: reader, printer, and control console. Photographic transparencies are located on the reader platen. A precision flying spot scanner (television scanner) is used to convert the image to electrical signals by light spot scans. Scans are computer controlled to pick up a succession of line images parallel in the object plane.

Modification of the H-229 is contracted. As proposed the rectifier will be able to rectify all imagery, including that of the moon and other planets, as well as that from convergent panoramic cameras.

(2) B & L Rectifier with Super Reprogon Lens

The existing Reprogon lenses manufactured by Wild Heerbrugg for the VG-1 enlarger has been expanded in focal length for use with the B & L Two Stage Rectifier which is presently equipped with Metrogon lenses. The Metrogon lenses have a resolution of approximately 40 lines per millimeter on axis. The Super Reprogon lens will resolve approximately 100 lines per millimeter with virtually no distortion. In the single stage rectification mode up to and including 45 degrees the Super Reprogon lens will improve the photographic quality of the resultant image by a factor of approximately 2. While in the 2-stage mode with extremely high tilts the image improvement over the Metrogon lens system will not be significant.

(3) High Resolution Printer

Several of the current programs at the NPIC require the generation of additional copies of film in the form of duplicate positives and negatives. One piece of equipment essential to the duplication process is the photographic printer. In the past, equipment has been developed employing roll film continuous printing techniques in which the original negative and the reproduction material are brought together and passed around a drum through which light is passed by means of a slit aperture. However, the amount of resolution that can be transferred by this continuous flow printing techniques is affected by the shape of the drum and the principal radius. Since the material on the outerside must necessarily travel at a faster rate than the material in direct contact with the drum, regardless of the size of diameter of the drum, an equal resolution transfer cannot be accomplished.

A characteristic of developed silver images is that the emulsion has a surface topography. This fact precludes total contact between the negative and printing materials. One obvious means of reducing these voids of intimate contact is by means of a vacuum system. Roll film printers cannot use vacuum contact. However, a vacuum printer (the step-and-repeat type) is being designed to cope with resolution exceeding 300 lines per millimeter. With proper light source design, such a printer can be made to operate at speeds equivalent to 25 feet per minute when compared to continuous printing. The printer will be designed to accommodate all film widths from 70 mm to 9½ inches and up to 50 inches in format length. It will have the added advantage of printing several copies from each negative frame as programmed, thus substantially reducing the wear and tear on the original negative.

Interchangeable light sources will permit the use of non-silver and color materials.

(4) Chip Printer

Preliminary investigation is under way to produce a photographic chip printer with the capability of putting the necessary information in binary form on a chip designed for use in the stereo chip comparator. This chip will be 70 mm x 100 mm with a 30 mm x 70 mm data block area and 70 mm square image area. Until this item is developed only partial utilization of the Univac 490 can be realized.

(5) Precision Enlarger /3x-12x/

In addition to those already in-house, an enlarger soon to be delivered is the Precision Enlarger /3x-12x/. This precision enlarger is designed to cover a 70 mm square negative format with a magnification range of from 3 to 12 diameters enlargement with a fluid plastic film gate to accept all widths of negatives from 70 mm through 9½ inches. The enlarger will be of autofocus design with a vacuum type easel to accommodate both film and paper reproductions. The negative, lens and easel planes will be plane parallel to within one minute of arc throughout the entire magnification range. It will be equipped with two light sources: a tungsten source for use with color materials, and a high-intensity mercury source for black and white material. This enlarger will fill the gap between the Wild VG-1 and the Kodak 10-20-40. The present optical system will have a resolution of approximately 150 lines per millimeter and provision has been made in the design to accommodate a lens of higher resolving power when such a lens becomes available.

(C) MISCELLANEOUS

(1) Non-Silver Reproduction Materials

As the state-of-the-art advances in the field of optics and in the field of conventional silver emulsions to the point where 200 to 300 lines per millimeter is being recorded and delivered from operational systems, the need arises for a reproduction material which approaches 1000 lines per millimeter so that no appreciable loss in resolution is incurred from the original negative. Unfortunately, to gain higher resolution in conventional silver halide materials, the silver particles must be made microscopically small with a resultant loss of speed and sensitivity. Conventional silver halide emulsions have been manufactured which can accept 1000 lines per millimeter, however, the extremely longer exposure times necessary to record this information make it infeasible for use as a

reproduction material. In addition, there is very often an attendant loss in tonal or density scale in these high resolution materials.

In recent months several non-silver reproduction materials have been developed which are virtually grainless and are capable of resolving as much as 1000 lines per millimeter. These materials are usually dye sensitive and react to a very narrow spectral energy band. Some of these materials - such as Kalvar, Diazo and Horizons - appear to be promising as reproduction media. All of these materials require special printing techniques which will have to be developed as operational equipment if they are to be applicable. It is generally accepted that the reproduction material must have inherently three to five times the resolution capability of the original recorded data. These unconventional non-silver materials, as well as the printing equipment, are currently being investigated since we are now on the threshold of the 200-lines-per-millimeter input materials.

SECTION III

DATA MANAGEMENT AND INDEXING

(A) DATA PROCESSING DEVICES

(A) DATA PROCESSING DEVICES

(1) Digital Accumulator and Transmission Unit

This item is still in the proposal stage. It will be an universal readout device for the various mensuration devices which will transmit information to the computer on operator command via a Dataphone subset. In simplified description it will consist of:

a. A control panel sub-assembly made up of the necessary switches for the operator to generate the required indicative data, and numerical display unit.

b. An input circuit to take the pulse train or analog signal from the mensuration device and feed.

c. A digital accumulator to determine the numerical difference from reference.

d. A buffer storage unit to maintain the numerical value independent of the accumulator during readout.

e. A synchronized transmitter to transfer the data from the buffer storage unit and indicative data switches to the computer via the Dataphone on command of the operator.

Also associated with this unit but in no way connected with it is a Teletype Model 28 send-receive page printer to receive the computer-reduced reply from the data transmitted.

(2) Production X, Y Plotter

This instrument (under development) will be used on line with the Univac 490 to handle the general purpose plotting requirements, particularly coverage plots based on ephemeris information. It will consist of a 60 x 60 inch plotting surface, capable of producing overlays for the largest maps generally available. All functions, including vacuum hold-down and paper advance will be under computer control, requiring a minimum of operator attention. The logic of the system is digital and no analog techniques are used.

(3) Remote Station Plotter

This equipment (under development) will be a continuous drum-feed plotter capable of plotting data up to 29½ inches wide and 120 feet long under direct computer control. It is manufactured by California Computer Products and is designed to accept data from a Dataphone so it can be operated at any location in the building where there is a computer outlet. It will be used as a remote station plotter in conjunction with the film readers and chip comparators.

SECTION IV

LENSES, STUDIES, AND SPECIAL TECHNIQUES

(A) LENSES

(B) SPECIAL TECHNIQUES

(C) MISCELLANEOUS

(A) LENSES

(1) Aspheric Lens

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[redacted] will design a fully aspheric lens and will investigate methods of producing the aspheric surfaces of such a lens. As previously mentioned, this lens design will be applied to projection lenses for a Rear Projection Viewer Reader. This will allow a maximum of light transmission, minimize aberrations and distortions and improve the resolution over the entire format of the area of the material being viewed.

(B) SPECIAL TECHNIQUES

(1) Image Enhancement Device

Approximately two years ago a contract was let to construct a prototype image enhancement device incorporating the optical/electronic principles which appeared to be promising at that time in the general field of image enhancement. The instrument was designed for input materials consisting of photographic transparencies, positive or negative. This transparent image is scanned by a pencil of light from both a large and small spot, each of a different wave length. As the light passes through the image a beam splitter separates the two spots which are then converted to electronic signals which are manipulated by the electronic components to produce a modulated light source which is then used to create the enhanced photographic output. Many technical optical and electronic problems have been encountered in the building of this prototype instrument.

(2) Multiple Image Correlator (MIC) Mark I

The prototype image correlator, designated Mark I, is a device designed to register with precision as many as eight photographic images containing approximately the same geometry or imagery and to print these images simultaneously into a single photographic record enlarged approximately 25 diameters. The filling-in effect of the random grain patterns contained in the several negatives to be integrated results in a rather remarkable and spectacular improvement in the final record.

An evaluation program is currently being run on this prototype instrument which will result in establishing the parameters for the input

materials as well as operational techniques and procedures for optical utilization of the equipment. As an adjunct to this equipment a device is being fabricated to prepare the several negative formats into a circular chip form of approximately one inch in diameter. This device is called an image selector or "cookie cutter". The input materials for the MIC will come from several sources, including cinema photography, small format handheld cameras, and multiple lens systems. The simultaneous, rather than the divided exposure, method was chosen to overcome the reciprocity failure effect exhibtied when very short exposures are used.

The MIC MARK I has both manual and electronic registration. The electronic registration is necessary to achieve a degree of precision registration to within limits of the grain structure of the individual negatives. The MARK I MIC has been so singularly successful that a study contract has been let for a MARK II model which will have wider parameters of input materials, possibly including rectification.

(3) Automatad (Automatic Man-Made Target Detector)

AUTOMATAD (Automatic Man-Made Target Detector) is an optical-electronic device to extract straight line patterns from photographs.

When man constructs highways, airfields, buildings, etc., he tends to use straight lines instead of the irregularly curved lines of nature, such as the path of a river or the jagged lines of an outcropping of rock.

AUTOMATAD scans a 70 mm by 70 mm transparency in small (2 mm square), successive, overlapping, segments and produces a signal at each relatively rapid change of density crossed by a scan line. A signal on any one scan is compared to any signal on the next scan by electronically sliding the first scan along the second scan. If the two scans contain signals this is termed a "coincidence" and is assigned a value of 2 because there are signals on two successive scans. Since the significance of a "line" which is only two signals long is relatively meaningless, AUTOMATAD is designed to permit the operator to use a number of coincidences from 3 to 10. Use of the larger number of coincidences eliminates random signals caused by lines on the transparency which are too short to have any real meaning or are merely random spots. The electronic circuitry which compares the scans and finds and counts the coincidences is called the "logic".

The output of the logic circuitry is presented on the face of a second cathode ray tube. Since the equipment requires about 15 seconds to scan the entire 70 mm by 70 mm transparency and since the phosphor of the cathode ray tube glows for only a few thousandths of a second after the electron beam has moved on, the human eye cannot integrate the individual dots of light into a complete image. Therefore, a Polaroid camera is used to provide an image which shows all lines formed by the coincidence of three or more dots of light.

(4) Chip Cutter

A chip cutter consists of a pair of four-sided die cutters designed and configured to cut rectangular pieces from film frames in a single operation. These pieces are referred to as chips and are usually hand mounted on cards bearing data pertinent to the subject. These are studied for intelligence information as single frames (chips) or as stereo pairs.

At present no such device is available at the NPIC for cutting four sides of a chip in a single cutting operation. In lieu, therefore, chips are cut by hand with razor blades or knives. This method produces chips of varying sizes and shapes and does not lend itself to standardization of procedures, shapes or sizes. Furthermore, it is time consuming and many minor accidents have occurred as a result.

The objective is to develop a single mechanical device capable of producing standard sized chips, in a minimum time with the least effort and to eliminate the physical hazard.

The original concept was to incorporate the die cutting device into combination dual-viewing units with a built in stereoscope. However, results of a survey among management and operating personnel of the NPIC showed a unanimous preference for the simplest possible type of device that could be easily lifted and slipped under the film web for cutting single chips in lieu of the infinitely more complex equipment required for stereo viewing and simultaneous cutting of stereo pairs of chips.

A final survey is currently under way to determine the most desirable configuration and required size of such a device. Based on these findings, design parameters will be prepared for development.

(5) Spatial Filtering Image Viewer

Image edge enhancement always has been a problem in photo inter-

pretation. The instrument proposed will serve as a research tool to further the art of image reproduction through filtering techniques. The primary concept is to eliminate through spatial filters those images having frequencies above or below a preset level, thus retaining a restricted image frequency band and enhancing the retained image edges. For example, a building can be enhanced by eliminating low contrast images in its immediate vicinity. However, a great deal of additional work must be done in this field to obtain greater knowledge on practical photo interpretative applications to fully realize the capabilities of this type of instrumentation.

(6) Linear Phasolver

In an effort to develop a highly reliable measuring technique for large format film comparators, a linear phasolver system proposal is now under consideration for contracting.

The Phasolver is a precision device which accurately converts minute increments of mechanical motion to large electrical phase-shift information that can be easily processed and digitized by electronic equipment to provide a highly accurate readout.

At present almost all large format comparators rely on either a precision lead screw or the Ferranti Moire Fringe Techniques. Other measuring techniques have been tried from time to time but none has proven successful so far. Information available to date indicates that the Phasolver principle will produce a superior method of film measurement to any we have now.

While no direct usable equipment would result from the present proposal, a new measuring technique would be made available for incorporating into future comparator development.

(C) MISCELLANEOUS

(1) Test and Evaluation Program of the Image Quality Meter

The National Bureau of Standards (NBS) is conducting a test and evaluation program of the H-F Image Quality Meter, which is one of six production instruments placed strategically throughout the community. The Image Quality Meter is designed automatically to record resolution, acutance, and granularity and at the same time provide a microdensitometer trace as a cathode ray tube (CRT) display. The NBS program will

establish operational procedures necessary to obtain the above data. The quality meter is expected to replace vague and subjective evaluations of image quality in terms of resolution, acutance and granularity.

(2) Closed Circuit Television (CCTV)

P&DS is conducting a feasibility study of the application of CCTV to the operations of the NPIC. This study is considering CCTV in terms of security, image quality, alternate approaches and, probably the most important, the savings in time.

At present it appears that CCTV will provide a secure, flexible means of transmitting visual information within the Center. The next step will be to borrow or rent sufficient equipment to conduct tests to assure us that CCTV is both secure and useful before any action is taken to obtain a more complex CCTV system.

(3) Color Film Studies

Interpreters of industrial areas have for many years felt that their interpretation effort would be enhanced by acquisition of color photography. However, acquisition vehicles in recent years have been programmed to such high altitudes that an excess of blue rays of the visible spectrum were registered on most color films. The blue portion of the spectrum is regarded as non-image-forming light which causes the over-all bluish cast and hence tends to obscure the image carried by other portions of the visible spectrum. The Plans and Development Staff in investigating the potential value of color film-camera combinations, has concluded that some merit may be attached to the use of color photography if acquired under controlled conditions. It is essential at this time that experiments be performed utilizing operational vehicles and a variety of film filter combinations to determine the real value of color photography for intelligence purposes. Steps are being taken to formulate a recommended testing procedure which will provide the empirical data necessary to select the proper vehicle-camera-film-filter combination required to acquire meaningful imagery for analysis of special installations. This testing procedure will then be submitted as advice to the acquisition components of the community for action.

A working party comprised of personnel from the Operational and Exploitation components of the NPIC has been invited by [redacted] to inspect 25X1A5a1
25X1A5a1 their new facilities at [redacted] and to discuss in depth particular requirements of Color Film Materials.

(4) Multi-Sensor Evaluation

The Plans and Development Staff, has endeavored to keep abreast of advancements in multi-band-sensing research. Recently a concerted effort has been made to evaluate the large number of sensors in relation to their value as intelligence acquisition instruments. Recent studies of the relative values of various sensors have shown that (1) the intelligence value of a combination of multi-sensors including panoramic photography is significantly greater than that of a combination not containing panoramic photography; (2) the additive use of radar, infrared and side looking radar was not found to enhance the intelligence values of the panoramic photography when used alone.

Sensors other than photography have very poor resolution and therefore should be synchronized with photography to acquire location and detail. The state-of-the-art today in multi-sensor systems is such that every sensor must be programmed or tuned to receive a specific frequency and band-width of radiation. In addition, some sensors can gather information in situations that would make others nearly blind. This means that each sensor must be sent to gather a specific bit of intelligence based on sensor characteristics, existing conditions, and knowledge of basic characteristics of the target. Based on knowledge now available it is anticipated that sensors other than photography would produce little, though spectacular, intelligence. Acquisitions from multi-sensor programs other than photography will probably be utilized very sparingly until such time as evaluation studies have shown that the value of multi-sensor acquisitions exceed the value found during current evaluation studies.

The Plans and Development Staff will continue to evaluate new and existing intelligence acquisition sensors which promise to provide information not now available from photography. It is anticipated that recommendations will be made to acquisition elements for experiments designed to allow the photo analyst to make a really meaningful comparison of new sensors and photography.

(5) Evaluation of Automatic Photographic Image Recognition Systems

The increasing development of both the quantitative and qualitative aspects of photographic intelligence requirements and acquisition capabilities indicates rapidly increasing demands for improvements in exploitation technology. A particularly significant factor is the disproportionately large manpower requirement characteristics of the exploitation phase. It has become obvious that a large-scale, high-

priority, development program for automation of the exploitation phase is required.

Developments in this realm may be divided into two basic categories:

(1) Automation which assists the analyst in film handling and viewing.

(2) Automation which assists the analyst in scanning and evaluating the photo image.

Although there are urgent requirements in both categories, it is apparent that a performance plateau has been reached. This plateau is basically defined by the available manpower and the limited efficiency of using highly-trained manpower for first-phase scanning of tremendous quantities of negatively significant or highly redundant photographic images. It is thus implied that a definite limit in the capacity for first-phase readout is being approached and that this limit will not be significantly changed by any developments in the first category.

For this reason members of the Plans and Development Staff have started a comprehensive, accelerated program for searching out and evaluating all the automatic image detection and recognition systems presently being proposed, developed or produced.

Initial results of this investigation indicate that important strides are being made in this field. One of the most promising areas of potential development for such automation is in the realm of "biological computers." This terminology is used to describe computer systems which generally consist of a sensory matrix, connected by a means of statistically significant coupling to the input of a digital computer, which is programmed in a fashion simulating brain mechanisms. Such systems are capable of being "taught" to recognize, with a high degree of reliability and discrimination a specific stimulus falling on the sensory matrix.

The PERCEPTRON which was developed by the Cornell Aeronautical Laboratory in 1958 is the generally accepted forerunner of these systems. Since that time many related systems have been developed by other organizations, and continued improvements have been made in the PERCEPTRON. The common denominator of limitation in all these systems appears to be the need for prenormalization, or standardization of scale and orientation of the image before it is presented to the sensory matrix. The complexity of the "biological computer" system precludes its utilization on

the mass of redundancy required to identify a single image in all its possible variations of scale and attitude. However, the potential capability of these systems for fine discrimination of photo images appears to be accepted. Therefore, most of the current development programs related to these systems are in the realm of prenormalization of the image.

Other means of image recognition such as correlation, shape analysis and unique power spectra generated by various scanning techniques must also be evaluated.

A tentative first phase goal of this program is the development of a system which will rapidly scan large quantities of film and accurately designate those photographs which contain images of probable intelligence value.

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