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DESIGN PROPOSAL FOR ONE BINOCULAR AND
ONE MONOCULAR PERISCOPE FOR HANFORD WORKS

February 10, 1949

GENERAL ENGINEERING AND CONSULTING LABORATORY

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

*asked for thru Lil Staller
3/9/49 -
missing sergs Report herein*

~~D-O-A-~~

~~C-O-103~~

~~C-O-106~~

~~T-62694-928-C-103~~

By

G. R. Rede

CLASSIFICATION CANCELLED

DATE 11-28-55

For The Atomic Energy Commission

H. P. Canale

Chief, Declassification Branch *mcl*

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Larry E. Williams
Authorizing Official

08/02/2007

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SUBJECT: DESIGN PROPOSAL FOR ONE BINOCULAR AND ONE MONOCULAR PERISCOPE FOR HANFORD WORKS

February 9, 1949

INTRODUCTION

This proposal covers design and manufacture of a periscope system for use with remote maintenance crane for building 201-R, Hanford Works. The system will consist of a binocular periscope and a monocular periscope designed according to the intent of General Electric Specification HW-4014 (Kellex Specification H-30-11) which covers the monocular system, and the draft of Kellex specifications for the binocular system. (Final copy of the latter specifications has not yet been received.)

The design shall be coordinated with the builders of the crane and control console to insure an overall integrated design. Changes in detail required to better meet the basic intent of the system will be made as required. Such changes shall be subject to approval by Kellex.

GENERAL LAYOUT

The general layout will consist of a telescoping binocular periscope mounted on a truss below the main idler girder of the crane, a telescoping monocular periscope mounted on a truss on the drive girder side of the crane, a binocular eyepiece for the operator and means for shifting the view observed through this eyepiece from the binocular periscope to the monocular periscope, and an identical eyepiece for use by an observer who will use the monocular periscope when the operator is not using it. In addition, necessary motors and controls will be furnished for: extending and retracting,

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scanning, changing magnification and focusing adjustments. Means will also be furnished for locking in the extend and retract motion with the travel of the single I-beam hoist or of the main trolley. A spare eyepiece will be supplied.

The two trusses mentioned above and other supporting structure for the periscope will be furnished by the crane manufacturer and they and the periscopes shall be arranged so as not to touch other parts of the crane except at the ends of the trusses. This feature is required to minimize transmitting vibrations and deflections of the crane into the optical system.

The principle of the binocular periscope design and a discussion of its features is covered in the attached report "Binocular Periscope Development Report, Project C-187, C and D" by Norman F. Barnes. It should be noted that the system proposed has advantages optically over other systems in letting through a large light flux, employing relatively simple optics, having minimum distortions due to mechanical vibration, and a minimum of moving parts. In order to change power the system shown on Kollmorgen drawings D-0-4 and D-0-5 has been developed.

Its moving parts are two mirrors for changing magnification (mirror #1 on the $1\frac{1}{4}$ and $2\frac{1}{2}$ power) and two moving mirrors for each power for affecting scanning. The latter mirrors and the objective lenses are all that need be moved to change depth of focus. The mechanical system for accomplishing movement of the mirrors and

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lenses has been made a combination linkage and cam system (shown in part on Drawing A-62694-933) which system has advantages of a minimum of moving parts and inherently minimizes any backlash error in the system, such as would result if gears or other means were used.

The system as described above, differs from the Kellex specifications noted in the first paragraph and from the detailed description which follows, in that certain changes have been made to increase the value of the system to the operator. In particular, the Kellex specifications and the detailed description indicate the position of the binocular periscope along side of the main idler girder and above the single I-beam hoist, rather than below the main idler girder. Placing the binocular periscope below the main idler girder is necessary in order to provide an unobstructed view. Also the system proposed above indicates one eyepiece for the operator instead of two. This change is recommended for more comfortable and efficient use of the control and viewing systems in that the operator need not shift his head with the possible loss of his orientation with the controls. This system has an advantage in substituting a transfer system for the operator's monocular system resulting in a decrease in overall optics. The optics will be inside the cab and readily accessible and the observer's and operator's eyepieces will be identical and easily interchanged.

The details given in the description to follow and the drawings noted will be changed where necessary to conform with the changes in position of the binocular periscope mentioned above.

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DETAILED DESCRIPTION, OPTICAL

In view of the fact that the Kollmorgen Optical Corporation has already performed a large amount of the optical design necessary for these periscopes, in the design of the twin tube binocular periscope which they previously recommended, and at the suggestion of the Kellex Corporation, we have contracted with the Kollmorgen Corporation for the preliminary optical design of these two periscopes. They have now completed their preliminary engineering and have made a quotation to us for all the final optical engineering work to complete the periscopes and/or the manufacture of the optical parts according to their drawings:

D-O-4
D-O-5

C-O-103
C-O-106

The Kollmorgen Optical Corporation has stated that their minimum delivery is eight months after the receipt of the order from us. This period is particularly necessary for the supply of the large high-quality optical parts and the glass for them.

The layout of the system may best be understood by referring to drawing C-O-106. Starting at the head end (object end) of each periscope is a unit which travels cross-canyon on rails mounted to the trusses provided by the crane manufacturers. The optics for the head of the binocular are shown on drawings D-O-4 and D-O-5. It consists of three systems, for $1\frac{1}{4}$, $2\frac{1}{2}$, and 5 power magnification, and the means for changing magnification. The system uses the polarizing prism method described in N. F. Barnes' report. The head also carries the

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outer erector lens whose position relative to the head optics must be maintained.

The optics of the monocular head are shown on C-0-106. Scanning is achieved by rotating prisms 11 and 12 and lenses 9 and 10 as a unit about the periscope axis. Dove prism 14 is rotated through half the angle in an opposite direction to prevent rotation of the image in the eyepiece.

The body of each periscope consists of a telescoping portion suspended below the trusses, and stationary sections which will be located near or in the cab. Within the body of the periscope are two high-power telescopes arranged to permit extension and retraction without changing magnification.

The stationary portion of the body will enter the cab through the ends, rather than through the wall next to the barrier wall. The diagonal system contemplated in the Kellex specifications is not feasible with optics available. The system proposed has optical advantages in utilizing only bends which are parallel to or at right angles to the planes of polarization resulting in simpler optics. It has, in addition, an advantage in that the cab may be made wider. Also, the parts of the periscope which would otherwise be between the wall and cab are mechanically protected and are more accessible. The mechanical design is simplified.

The eyepieces are shown on Drawing C-0-103. Three identical units will be furnished, one for the operator, one for the observer,

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and a spare to be used in either place. The units will be designed to be readily interchanged.

For use with the monocular periscope, the eyepiece merely acts as a light splitter; no light is lost.

DESIGN DETAILS, MECHANICAL

The proposed design for the binocular periscope is shown on Sketch T-62694-925. The performance of the periscope will be in accordance with Kellex specifications. In order to obtain proper depth perception it is necessary to use different base lengths at the head for the various magnifications. The following values will be used:

<u>Power</u>	<u>Base Lengths</u>
1 $\frac{1}{4}$	3 1/8"
2 $\frac{1}{2}$	12 $\frac{1}{2}$ "
5	25"

Proper convergence and focussing is obtained by simultaneously rotating the head mirrors in opposite directions and moving the objective lenses along the optic axis. Scanning is accomplished by rotating the head mirrors in the same direction. Changing powers is accomplished by turning the selection mirrors in or out of the system.

The mechanism for converging and scanning is shown in schematic drawing A-62694-933. It consists of:

1. A plate, which is free to move up or down along vertical tracks.
2. A gear, free to turn about a shaft mounted in the plate.
3. A set of six levers, (one for each head mirror), which are free to pivot about shafts mounted in the plate.

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4. A tie rod, to which are connected the lower ends of the levers by means of bearing joints.
5. A gear arm, fixed to the gear, and also joined with a bearing joint to the tie rod.
6. A set of six links, connected by means of bearing joints to the upper ends of the levers, and extending vertically downward.
7. Six mirror arms, one affixed to each mirror, which are free to pivot about shafts fastened to the frame of the optical system.

For converging, the plate is moved up or down. Since the gear and the levers are pivoted about shafts in the plate, and the tie rod ties the lower ends of the levers together, the plate, gear, gear arm, levers, and tie rod all move as a unit. The vertical links transmit this motion to the mirror arms, which turn the mirrors on opposite sides of the head in opposite directions to change the angle of convergence of the lines of sight.

For scanning, the gear is turned. The gear arm transmits this motion to the tie rod which moves horizontally from side to side. The levers, pivoting about their shafts mounted in the plate, transmit the motion to the links, which cause the mirror arms to rotate all the mirrors in the same direction.

It is planned to connect the motion of the objective lenses to the converging motion of the mirrors by means of cams placed on the plate. These cams will be so shaped as to cause the lens motion to follow the curve described by the mirror motion.

All parts of the periscope will be made either dust tight or

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pressurized with filtered air to keep the optical parts clean.

The head car body houses the head optical systems and the drive mechanism for extension and retraction of the periscope. Drawing T-62694-923 shows the car body. It is suspended directly below two parallel channels, placed as shown in the drawing. Rails, mounted on the bottom flanges of the channels, permit the car to travel across the working space on four flanged wheels.

The rails mounted on the bottom flanges of the channels are adjustable in height above the flanges in order to compensate for sag in the girder. Adjustment is obtained by supporting the rails on small screw jacks clamped to the flanges at regular intervals. The rack is mounted with teeth vertical, and the pinion is made wider than the rack to allow vertical motion relative to the rack.

A reversible motor will drive the car. This motor drives, through a speed reducing gear train, a pinion meshing with a rack fixed to the channels. It is proposed to fabricate the car body of aluminum sheet stock.

The first inverter lens is carried in a lens support tube fastened to the car. This tube maintains the correct optical distance between the objectives and the first inverter lens. Baffles are distributed along its length to prevent scattering of light.

The proposed telescoping section consists of aluminum tubes having internal diameters approximately $\frac{1}{2}$ inch apart, from $13\frac{1}{2}$ inches for the largest to $3\frac{1}{2}$ inches for the smallest. The wall thickness of the proposed tubes is $\frac{3}{32}$ inch.

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At the cab-end of the telescoping section, each tube is fastened to an aluminum support plate, each of which is suspended from the rails by two rollers. As the periscope extends, the tube supports maintain optical alignment and eliminate sag in the tube. When extension is complete the supports are evenly spaced along the telescoping section.

Each of the telescoping tubes contains a baffle at the head end. Each tube except the largest has an outside flange at the head-end and an inside flange at the cab end to act as stops. During extension, each tube pulls out the next smaller tube by having its inside flange catch on the outside flange of the smaller tube.

The tube supports also support the power cable running to the head. The cable passes through rollers in each support just above the tube. (7)

The largest telescoping tube is fastened to the head car body. The smallest tube is bolted to a junction box containing a mirror placed as shown in drawing C-0-106, which serves to turn the light beam 90°. The mirror is so mounted as to be adjustable about two perpendicular axes after installation.

Switching between the monocular and binocular systems will be arranged so it can be accomplished in one second, or less. The system shall also be arranged so during the changeover the operator is not left "blind", but has a transition view consisting of part binocular and part monocular vision. One such system is shown on sketch K-62694-934, wherein two 45° mirrors are used.

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MONOCULAR PERISCOPE

The mechanical design of the body of the monocular periscope is very similar to that of the binocular periscope. The supporting structure, telescoping section, upper rear junction box, and lower rear junction box are the same. The monocular periscope, however, has a separate eyepiece.

The greatest difference between the two periscopes lies in the optical design of the head. Since only monocular vision is required, the optical design is much simpler for this periscope than for the binocular periscope.

The distances from the second inverter lens to the two eyepieces which serve the monocular periscope must always be the same. The tube length from the second inverter lens to the separate eyepiece is less than that to the combination eyepiece. This difference must be compensated for by placing additional length in the tube leading from the horizontal cab-entrance to the separate eyepiece.

The 45° mirror at the junction of the cab-entrance tube and the separate eyepiece must be out of the system when the mirror for the combination eyepiece is in the "monocular" position. Otherwise it will interfere with vision through the combination eyepiece to the monocular periscope. It is proposed to provide a mechanical linkage between the two mirrors which will eliminate any interference between them.

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The extension and retraction and focusing controls are to be the same as for the binocular periscope. Since there are only two powers, $3/4$ and $2\frac{1}{2}$, the system requires only a two position switch to change powers.

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Enclosed with this proposal are the following:

- 1 EAH-69 Binocular Periscope Development Report, by
N. F. Barnes, (with sketch of periscope attached)
- 1 T-62694-925 Sketch of Binocular Periscope
- 1 M-62694-931 Sketch of Relative Positions in Canyon
- 1 P-62694-926 Sketch of Eyepieces and Controls of
Periscopes
- 1 A-62694-933 Schematic Diagram of Mechanism for
Converging and Scanning
- 1 K-62694-934 Sketch of System for Selecting Periscope
Served by Operator's Eyepiece
- 1 C-O-103 Eyepiece
- 1 C-O-106 General Electric Binocular and Monocular
Periscope
- 1 D-O-4 Proposed Head for Binocular Periscope
- 1 D-O-5 Detailed Drawing of Proposed Head for Binocular
Periscope

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BINOCULAR PERISCOPE DEVELOPMENT REPORT
PROJECT C-187 C and D

October 29, 1948

GENERAL ENGINEERING AND CONSULTING LABORATORY
GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

By
Norman F. Barnes

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The work covered by this contract can be divided into two parts:

1. The development and design of an optical system through the use of which two optical beams may be combined into one and later separated; in other words, a system for making a monocular periscope binocular.
2. The design of the remainder of the periscope system to conform with the required physical and optical specifications.

In the investigation of various methods by which the binocular system could be achieved seven methods were studied. These are as follows:

1. Flicker System

In this arrangement the left and right beams would be alternately admitted to the optical system. A synchronized flicker unit at the ocular end of the periscope would subsequently separate the two beams. In this system it would be desirable to use a beam splitter so that light would be available for both the right and left hand beams at all times, rather than using a rotating mirror or similar device for alternately swinging the optical system first through the left path, then through the right path, and back again. The difficulty with this latter method would arise from mechanical vibra-

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tions in the optical system introducing serious vibration errors. By means of chopping rather than switching them back and forth, one is able to eliminate the rotation or other movement of optical components, since the beam is merely interrupted at the proper time.

2. Crossed Field System

In this case identity of the two beams is maintained by using separate parts of the lens fields.

3. Polaroid Method

This scheme uses polaroides and 50% mirrors for the separation and combination of the two beams. The method is very inefficient from the standpoint of flux transmission of the system.

4. Channel or Fluted Spectrum Method

In this case special interference filters would be used to alternately transmit and reflect adjacent spectral regions of the light coming from the two beams. Thus, wavelengths 1, 3, 5, 7, etc. would be reflected by the filter; while wavelengths 2, 4, 6, 8, etc. would be transmitted. Procurement of the required interference filters is a major problem at the present time in the consideration of this method.

5. Twin Tubes System

Here two identical optical systems are used side by side. They may be both housed in a single tube.

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6. Bichromatic System

This is really a modification of the Channel Method in which only two colors are used, one being for the left beam and the other for the right beam. The psychological effect of two fields of different color is the objectionable feature of this method.

7. Polarizing Prism Method

In this case the right and left beams are combined into a single beam by means of a specially designed prism which not only combines the two beams but also polarizes each beam at right angles to the other. Thus two beams of polarized light are incident upon the double prism or cube. Emerging from this prism are two beams polarized at right angles and superimposed. A similar system in the ocular end of the periscope separates the two polarizing beams so that each may be viewed by the observer.

From the standpoint of minimum complexity of optical design, total flux transmission of the system, minimum complexity of the mechanical design, system aberrations, vibration, and system size, it was concluded that the potentialities of the last or polarized prism method definitely outweighed those of the other systems. As a result of these conclusions development work was started to demonstrate and prove the principles involved in this method. A U. S. Navy Bureau of Ships submarine periscope,

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Design No. 92KA40T/1.9, Registry No. 1236, was disassembled and modified for use in the development of the binocular aspects of the desired system.

The initial experimental setup used a polarizing prism directly in front of the periscope objective lens, that is, between the objective lens and the object being viewed. Since only one such prism was available for use at that time, the separation of the two beams at the ocular and was accomplished by means of a 50% mirror and two polaroid discs. As the result of the successful result obtained by this method two additional polarizing prisms of larger diameter were ordered from the Eastman Kodak Company, who made the original prism. These prisms are expected to arrive during the first week of November.

The specifications around which the proposed periscope has been designed are as follows:

1. Overall system magnification $1\frac{1}{4}X$, $2\frac{1}{2}X$, and $5X$.
2. Stereo base length less than 3 feet.
3. Exit pupil - 4 mm.
4. Apparent field in the ocular - not less than 45 degrees.
5. Eye relief - 1 inch minimum
6. Far point to be viewed (vertically downward) - 50 feet.

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7. Near point to be viewed (vertically downward) - 10 feet.
8. Top horizontal projection - 6 feet minimum, 39 feet maximum.
9. Eye pieces - adjustable interpupillary distance and focus.
10. Viewing position of eye pieces - 30 degrees from the vertical.
11. Scanning about the telescope axis - $\pm$ 15 degrees from the vertical.
12. Other working dimensions as given by the Kellex Corporation and shown in attached print.

The attached isometric drawing shows a schematic view of the proposed periscope. Lens and mirrors are numbered from left to right, starting at the objective end.

OPTICAL SYSTEM DESIGN SUMMARY

1. In order to keep the field angle within the extendable relay or inverter system as small as possible (1° or less), the ratio of the focal length of the first relay lens L5 to that of the objective lens L3 should be large (10 or greater).

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2. The region in which extension occurs must be collimated otherwise the magnification will vary with extension.
3. The first relay lens must, therefore, be in the horizontal, extendable section between the extension point and the objective lens. In other words, the extension must occur to the right of L5.
4. Since the retracted length of the top, horizontal section is 6 feet, the focal length of the first relay lens is limited to about the value of six feet. The first focal point of this lens L5 can be located on the object side of the bend at M3. Any increase in the focal length of L5 will extend the objective end of the periscope into the pit and thereby reduce mechanical clearance.
5. From the standpoint of the ocular design, considering the size of the image to be viewed and reasonable f/numbers of such an ocular, it is necessary to keep the focal length of the ocular 4 cm. (about $1\frac{1}{2}$ inches) or greater. Since the maximum magnification of the system is 5X, this means that the focal length of the objective is 20 cm. (7.9 inches) or greater depending upon the ocular focal length. If the relay system itself has unit magnification, i.e. both relay lenses have the same focal length, the magnification of the periscope can be approximated by $M = \text{focal}$

708-20

length of objective/focal length of ocular. Though this equation holds for objects at infinity, it can be used for approximation purposes here. Hence if the ocular focal length is 4 cm., the objective focal length must be 20 cm. (7.9 inches) for an overall 5X magnification as noted above.

6. According to step (1) and using an objective focal length of 20 cm. the focal length of the first relay lens L5 should be at least $20 \times 10 = 200$ cm. or about 79 inches. For a focal length of 200 cm. the angular field within the relay lenses will be 1° if the apparent field at the ocular is 50° so that the actual field in object space is 10° for the 5X total power.
7. To increase the apparent field to a value greater than 50° means that the second relay lens L6 will become excessively large in diameter. This follows from the fact that (a) the focal length of the first relay lens L5 cannot be increased (Step 4) and (b) the focal length of the objective lens L3 cannot be decreased (Step 5). Now the ratio of the focal lengths of lenses L3 and L5 determine the reduction of the actual field in object space to the value it has in the relay system. Thus

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$$\frac{F3}{F5} = \frac{20 \text{ cm.}}{200 \text{ cm.}} = \frac{1}{10}$$

where F3 is the focal length of lens L3

and F5 is the focal length of lens L5

Therefore, since the actual angle is 10° for a 5X periscope having an apparent field of 50° at the ocular, the angular field within the relay system will be $10^\circ \times \frac{1}{10} = 1^\circ$. For maximum extension of the periscope the two relay lenses will be about 38.7 feet apart. The divergence of a one degree beam is 8.1 inches in 38.7 feet. Hence lens L6 must have a diameter of 8.1 inches plus the diameter of L5 in order to collect all the flux from L5 when the periscope is fully extended. If the angular field within the relay system is increased to 2° , lens L6 will have to have a diameter equal to that of L5 plus 16.2 inches, all of which will make L6 too large. Hence an apparent field of 50° at the ocular is suggested.

8. A field lens L4 is introduced at approximately the second focal point of the objective lens L3. It is the purpose of L4 to conserve flux by imaging L3 on L5. With $F3 = 20 \text{ cm.}$ and $F5 = 200 \text{ cm.}$, $F4 = 20 \text{ cm.}$ approximately. With a real field of 10° , L4 subtends an area having a diameter of 2.1 cm. at its location of 21 cm. from L3 for a near object distance of 10 feet. Thus the diameter of L4 is 2.1 cm. or approximately one inch.

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9. Lens L7 is separated from lens L6 by the sum of their focal lengths or by $200 \text{ cm.} + 4 \text{ cm.} = 204 \text{ cm.}$ Thus the image of L6 formed by L7 will be about 4 cm. from L7, so that even though the ocular is treated by a thin lens formula, the eye relief will be greater than 1 inch.
10. Lenses L6 and L7 form a 50 power telescope so that if a 4 mm. exit pupil is desired and if L6 is not to reduce this value, this lens must have a diameter of not less than $4 \text{ mm.} \times 50 = 20 \text{ cm. (7.9 inches).}$ However, with the persicope fully extended the spread of the beam within the relay system, as noted in Step 7, will be approximately 8 inches. Therefore, the total diameter of lens L6 should be approximately 16 inches in order to gather all the flux coming from lens L5. If this lens is less than 16 inches in diameter but not less than 8 inches the illumination at the edge of the field will decrease from a maximum for the 16 inch diameter to approximately zero for the 8 inch diameter lens. The illumination at the center of the field will remain approximately constant and the field angle itself will remain constant. From the standpoint of the availability of large diameter lenses it is recommended that a compromise be made between lens diameter and illumination at the edge of the field for the condition of maximum extension and that a value of approximately 12 inches be used for the

700-23

diameter of L6. Thus L6 will not be the aperture stop of the system when a 4 mm. exit pupil is used.

11. Consideration is next given to the diameter of the first relay lens L5. The image of L5 formed by L6 and L7 will be the exit pupil, whose value should not be less than 4 mm. In order that the diameter of lens L5 will fit this condition both when the periscope is closed and when it is extended, it is necessary that this diameter have a value of not less than 20 cm. (7.9 inches).
12. Since the objective lens L3 is made conjugate to lens L5 by means of field lens L4, the diameter of this objective lens should be not less than 2 cm. or approximately one inch.
13. There are three magnifications which the periscope will have: $1\frac{1}{4}X$, $2\frac{1}{2}X$, and $5X$. The overall system can either be designed for the $1\frac{1}{4}X$, with additional lenses being used to increase the power to higher values, or the system can be basically designed as a 5 power periscope, using supplementary lenses as required to reduce the power to the two lower values. From the standpoint of optical aberrations and diameter of the lens components it is far better to basically design the system for its maximum power and then reduce this power by means of supplementary lenses which can be added when necessary. Thus this proposed system has been designed as a 5 power periscope.

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In order to reduce this value to $2\frac{1}{2}$ or $1\frac{1}{4}$ power it will be necessary to introduce a Galilean telescope "working backwards". This telescope will be positioned between objective lens and the object. In order to obtain the $2\frac{1}{2}X$ overall magnification of the system it will be necessary for the Galilean telescope to be 2 power. For the overall magnification of $1\frac{1}{4}X$ the Galilean telescope will be 4 power. Since the image viewed by the eye in a Galilean telescope is usually placed at infinity, it will be necessary to make a slight adjustment in the optics of the Galilean system in order to position the image upon the object actually being viewed so that the periscope will not have to be refocused when a change of power is introduced. The reversed Galilean system will introduce a backward curving field which will help to compensate for the inward curving field introduced by the relay system. This will be of particular advantage for the $1\frac{1}{4}$ and $2\frac{1}{2}$ power systems where the actual fields in object space are 40 degrees and 20 degrees respectively.

14. In order to obtain the ortho psychological viewing condition in which case the stereo base length increases directly as the power of the system, three base lengths are theoretically required: $3\frac{1}{2}$ inches for the $1\frac{1}{4}$ power, 7 inches for the $2\frac{1}{2}$ power, and 14 inches for the 5 power. However, in view of simplifying the mechanical design, it is suggested that only two base

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lengths be used: 14 and 7 inches, the former for the 5 power system and the latter for both the $1\frac{1}{4}$ and $2\frac{1}{2}$ power systems. The seven inch base length will provide a small amount stereo enhancement with the $1\frac{1}{4}$ power system but this effect will not be objectionable. The 14 inch base can be increased if desired to increase the stereo effect with the 5 power system.

15. As noted in Step 10 lenses L6 and L7 form a 50 power telescope. Therefore, this part of the system will have to be rigidly designed in order that vibration will not become a problem.
16. It will be necessary to provide for the angular adjustment of one of the mirrors M1 as well as the preceding Galilean system, in order to provide means of framing the two fields of view for various object distances. This adjustment can be made at the same time the focus adjustment is made, a separate focusing adjustment being provided to permit corrections for various observers.
17. The scanning motion of a total of 30 degrees will introduce rotation of the image of 15 degrees. It is suggested that such a rotation be considered satisfactory since the introduction of a Dove prism to compensate for such rotation will also either invert or revert the image. In order to obviate this last difficulty it would be

700-26

necessary to use two Dove prisms in series. The excessive size required of these prisms makes the incorporation of two such prisms in the design extremely difficult.

18. To change the power of the Galilean systems it is merely necessary to change the positive lens elements, placing the new ones at the proper distance from the negative elements.
19. While 10 to 15% polarization can be obtained by reflecting an unpolarized beam from a first surface aluminized mirror selection and orientation of such mirrors can be made to reduce this effect to a negligible one. Thus first surface mirrors will be satisfactory for use in this system. employing polarized light. In addition wave plates can be made to compensate for any residual ellipticity which may be present in the system.

SCHEMATIC BINOCULAR PERISCOPE DESIGN

GENERAL ENGINEERING & CONSULTING LABORATORY
GENERAL ELECTRIC COMPANY

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CPH 9632971

OCT 30 1948

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BINOCULAR
PERISCOPE

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GASKA
JAN. 21, 49

T-62694-925

700-3.9

BWMS
REN

PRINTED IN U.S.A.

FF-114 (1-47) rev.

700-30.

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BINOCULAR PERISCOPE
SKETCH

~~RESTRICTED~~BWM
REW

JANUARY 26, 1943

KOLINE HAGER

PC 45-1316

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SWITCH FOR SELECTING PERISCOPE SERVED BY
OPERATOR'S EYEPIECE

IN POSITION A, LIGHT IS DIRECTED FROM
BINOCCULAR PERISCOPE TO EYEPIECE.

IN POSITION B, LIGHT IS DIRECTED FROM
MONOCULAR PERISCOPE TO EYEPIECE.

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700-32 ←

MADE BY *H. J. Latham*
GENERAL ELECTRIC
WORKS

INSPECTED BY

1/2/44

K-62694-934

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REVISIONS

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○ LINK PIVOT
● ANCHORED PIVOT

SCHEMATIC DIAGRAM OF MECHANISM
FOR CONVERGING AND SCANNING

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POWER	BASE LENGTH	TRUE FIELD	OBJECTIVE FOCUSING RANGE	CONVERGENCE (EACH SIDE)	SCANNING ANGLE
1 1/4 X	3 1/8	37° 6' 51"	D: 4.272 R: 0.71	0.242 (1.4235 R) 1.076 (0.44 R)	± 30°
2 1/2 X	12 1/2	19° 3' 13"	D: 1.209 R: 0.285	0.242 (1.4235 R) 5.551 (2.38 R)	± 30°
5 X	25	9° 35' 35"	D: 0.604 R: 0.139	0.242 (1.4235 R) 11.46 (5.55 R)	± 30°

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PROPOSED HEAD FOR BINOCULAR PERISCOPE	BINOCULAR PERISCOPE
D-O-5	KOLLMORGEN OPTICAL CORP. BROOKLYN, N.Y.
	DRAWN BY 11-11-49
	CHECKED