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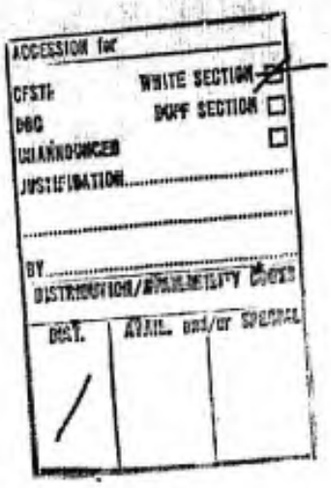

A TECHNIC FOR PHOTOGRAPHING HUMAN RETINAL CIRCULATION DURING BLACKOUT ON THE USAFSAM HUMAN CENTRIFUGE

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FOREWORD

This report was prepared in the Biodynamics Branch under task No. 793003. The work was accomplished between November 1964 and July 1967, and the paper was received for publication on 22 December 1967.

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This report has been reviewed and is approved.

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ABSTRACT

To study the human retina on a moment-to-moment basis during the rapid sequence of events occurring before, during, and after a blackout episode on the human centrifuge requires a technic which will not harm the subject, yet will allow constant viewing. In a previous study an ophthalmoscope was used to study the retinal changes and then the subjective impressions of the investigator were recounted to a medical illustrator.

A method has now been developed using a modified Zeiss fundus camera which allows photographs to be taken of the retinal circulation every 0.6 second during the entire $+G_z$ maneuver at the subject's blackout level.

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I. INTRODUCTION

In the past years, the experimental observation of blackout both during centrifuge studies and in aircraft maneuvers has been primarily subjective with the exception of one study on the human centrifuge using direct ophthalmoscopy. In this instance, the experiment required proper positioning of the subject and the observer during a positive G ($+G_z$) maneuver sufficient to impair cerebral blood flow and retinal circulation. The rapid retinal circulatory changes remained the subjective impression of the observer and were either described in a narrative manner or, in the one study cited above, interpreted by a medical illustrator. Duane[1] used the latter method in his study using the U.S. Navy human centrifuge located in Johnsville, Pa. Photography of the human retina on a moment-to-moment basis during the rapid sequence of events occurring before, during, and after a blackout episode on the centrifuge remained to be accomplished. The most important factors enabling one to take in-focus pictures on a moment-to-moment basis during loss of vision as a result of centrifugal force are: (a) proper restraint of the subject's head in the fundus camera frame; (b) the ability of the subject to fixate on an object and maintain focus on this object with his dilated pupil at all times during the centrifuge run; and (c) an experienced subject who has a rather low blackout tolerance and is not subject to episodes of nystagmus as a result of the angular acceleration during the onset and offset periods of the centrifuge profile.

[1]Duane, T. D. Observations on the fundus oculi during black-out. Arch. Ophthal. 51:342-355 (1954).

II. METHODS

A Zeiss fundus camera was modified in the USAFSAM Instrument Shop so as to restrain the subject's head in the camera mount and to withstand gravitational stress up to about 6 G. In the first series of pictures, normal color photographs were taken up to and including blackout on the human subject. In a second series, a Robot automatic advance attachment was obtained that allowed the taking of photographs every 0.6 second and this, in turn, enabled investigators to perform fluorescence angiography during gravitational stress. Modifications to the Zeiss fundus camera to achieve these results are described below.

Fundus camera proper

Three units were designed for the purpose of immobilizing the camera head to the subject and to the camera table top and yet allow for adjustment of focus on the retina. The first unit, the horizontal stabilizer unit, was installed to support the camera during $+G_z$ acceleration. Physically, its dimensions are 6 by 17 in. The base of the horizontal stabilizing unit was raised 6 in. by using four cast aluminum bars (1 by 1 by 6 in.) placed on each side of the horizontal adjustment arms. A half circle of 5-in. radius was removed from the posterior portion of the base plate in order to allow for operation of the horizontal lamp adjusting lever. A cast aluminum bar (1¼ by ¾ by 4¾ in.) was attached below the Zeiss

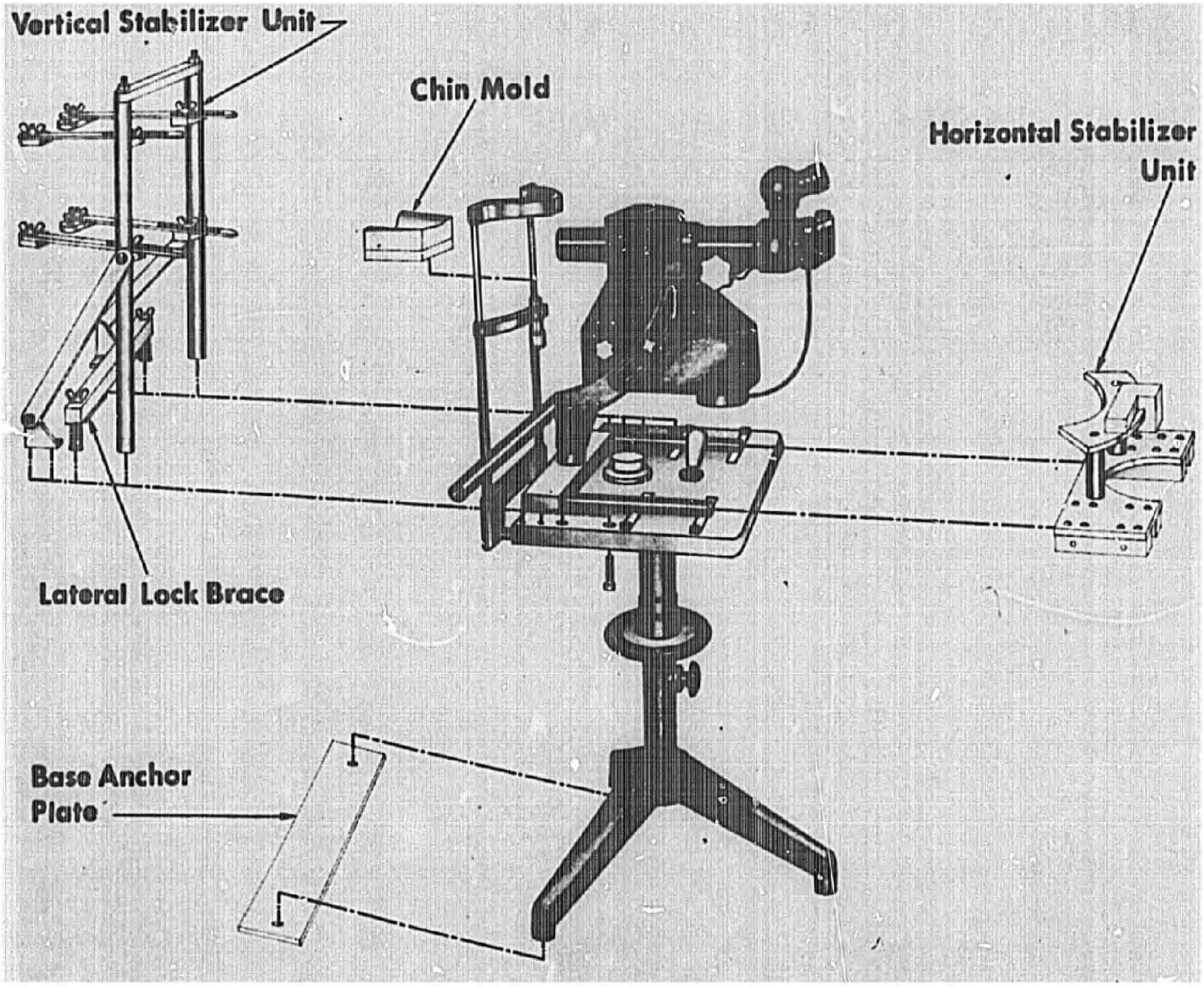

FIGURE 1

Modification of retinal camera for $+G_z$ centrifuge studies. Five units added to the Zeiss fundus camera re-enforce it to withstand gravitational stresses up to 6 G.

camera's main housing, anterior to the flash unit. An additional bar (1¾ in. by ½ in., with a ½ in. lip) was attached to the rear left of the first bar and provides the lock screw which prevents horizontal movement of the fundus camera.

The second unit, the lateral lock brace, consists of two 3⅝ in. bolts inserted in the instrument table 3½ in. from the front, 1½ in. from the side. These bolts provide a quick-secure for a cast aluminum bar (21⅝ in. by ¾ in. sq.) which is placed over the horizontal adjustment legs to prevent lateral movement.

The third unit, the vertical stabilizer unit, consists of two rods, 24 in. long and ⅜ in. in diameter, firmly encased by cast aluminum tubes, 20¾ in. long, 1 in. O.D., placed 6 in. back from the front edge of the camera table top. The rods are further supported by a brace (13 by ¼ by 1 in.) extending from the tubing to the front of the table top. Two ½-in. sections are removed from the cast aluminum tubing at points 2¼ in. and 8½ in. from the top of the tubing. These sections are replaced with a horizontal bar 2½ in. long by ½ in. wide with a ⅜-in.-diameter hole in each end to fit in between the cast aluminum tubing and

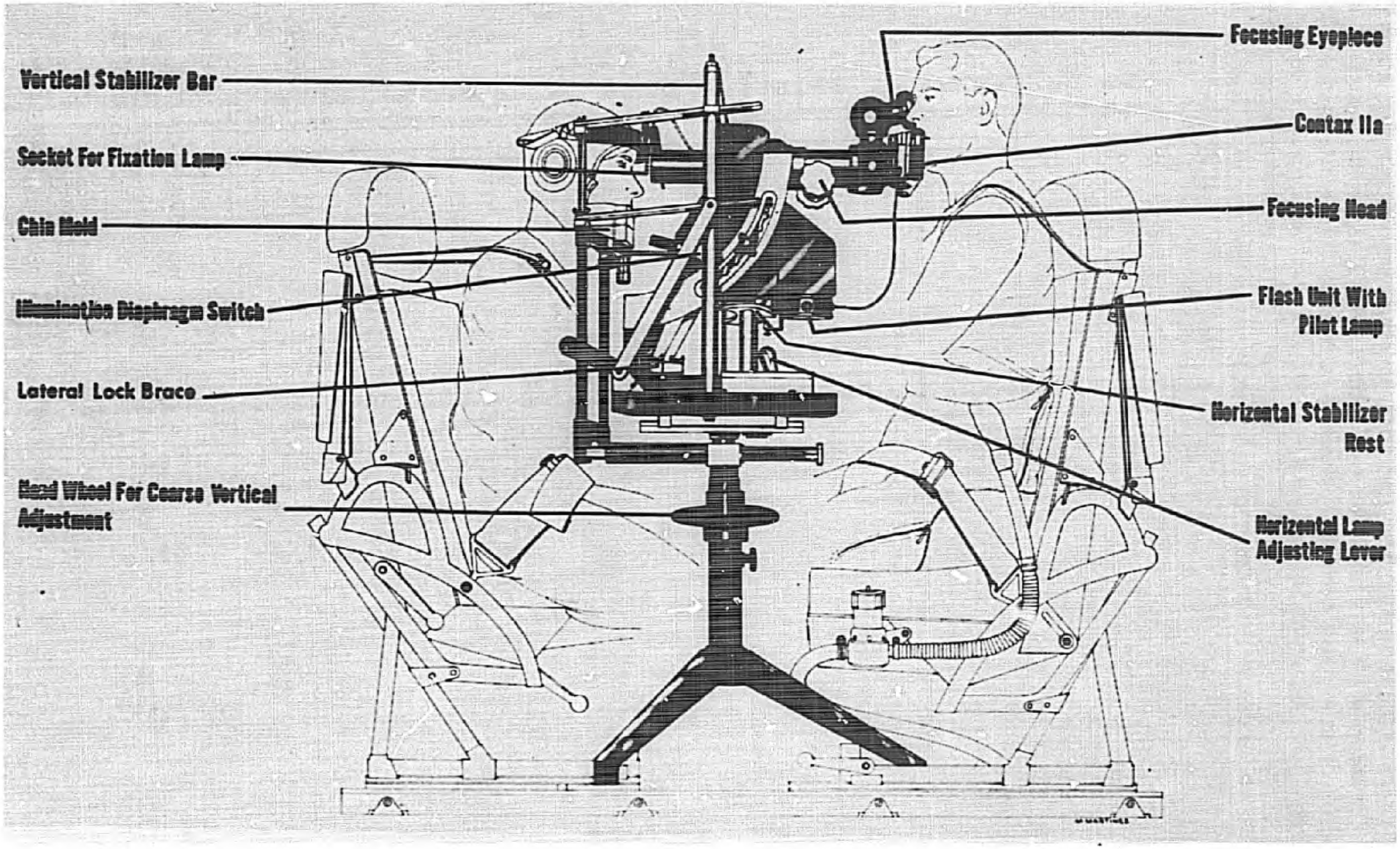

FIGURE 2

An operational view of the fundus camera system, illustrating the immobilization of the subject's head and the use of an antigravitational suit on the observer.

through which the 3/8-in. rod is inserted. This provides a lock screw to secure a brace between the subject's vertical headrest support bar and the vertical stabilizer unit. Horizontal support and lock screws are also placed on the subject's vertical support bars at the same level as on the vertical stabilizer bar.

The internal mechanism of the Zeiss fundus camera functions in a normal manner up to at least 6.0 G when the inertial vector is directed perpendicular to the long ocular tube. The regular spring used to lift the swingout mirror in the eyepiece was replaced by a stronger spring in order to withstand the G stress.

The Robot electronic flash generator and the transformer are placed outside of the human centrifuge. All power requirements for these items and for the camera proper are supplied through sixteen 10-ampere slip rings located at the center of the axis of rotation of the centrifuge.

Subject

The Zeiss chinrest was replaced with a hard rubber chin casting modeled from a subject and used for all experiments. A leather aviator's helmet is used to reduce pressure on the head caused by a restraining strap which holds the head firmly in the vertical headrest support. The headrest is also lined with foam rubber to reduce pressure points on the anterior surface of the head.

Observer

A sponge rubber padding fits over the focusing eyepiece to prevent injury to the observer during experiments. The observer is fitted with an anti-G garment to prevent blackout while the subject is at or near his own blackout threshold.

III. DISCUSSION

A large number of runs have been completed on the USAFSAM human centrifuge up to and including blackout levels on human subjects. Both color film (Kodachrome or Ektachrome) and black and white (Kodak Tri-X) were used. Subjects were preselected for their low blackout tolerance; thus, a larger number of runs could be conducted on the same subject during one period following pupillary dilatation. In one series of runs, called the gradual onset series, a subject was taken to a peak of 4 G but in a gradual manner (1 G every 15 seconds). In this sequence, pictures were taken at the rate of one every 0.5 G to a peak of 4 G, and then at the rate of about one per second during the offset or deceleration phase, in order to observe the reactive hyperemia occurring during the post-acceleration period. In all runs, the subject is pre-positioned with the chin and head angled slightly downward as a result of the inertial vector acting in a head-to-foot direction. The subject was usually depressed slightly in the seat and would come into focus when peak G was achieved. Normally, all adjustments to the camera and focus into the retina were achieved before starting the centrifuge and, with experienced subjects, no further or very moderate readjustment of the camera was required during the exposure to acceleration. Timing of the injection of fluorescein with the starting of the centrifuge is critical since the early arterial phase of the appearance of fluorescein must be achieved at the point of peak G for the centrifuge. In many instances, this did not occur; thus, repeat exposures were necessary.

IV. RESULTS

The modified Zeiss fundus camera has been exposed to a large number of centrifuge runs at the USAF School of Aerospace Medicine. Successful color and black and white pictures have been made on human subjects up to and including their individual blackout levels. Fluorescence angiography has also been achieved using the same modified camera with the addition of the Robot attachment that allows a faster picture-taking sequence.

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