U. S. NAVAL AIR DEVELOPMENT CENTER

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REPORT NO. NADC-ML-6803 27 FEBRUARY 1968

OPERATIONAL STUDY OF PILOTS' VISUAL REQUIREMENTS

FINAL REPORT
AIRTASK NO. A3153302/2C01/F012-07-01

PREPARED BY

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Aerospace Crew Equipment Department

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This report is a preliminary study in which visual tasks, lighting utility, and ambient external light levels were examined on a time-task basis in an instrumented F4B aircraft. Methods included photometric and electrical recordings of the internal and external lighting environment of the aircraft. Also pilot interviews, questionnaires, and direct observations of pilots in the F4B and other aircraft were employed. The results indicate that the methods employed are practical and that the visual tasks performed and ambient external lighting conditions are important determinants of lighting utility inside the cockpit.

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PREFACE

Perhaps more than any other type of mission, night flight operations place an extremely heavy burden upon the visual and perceptual capacities of aviators. Not only are visual references more difficult to acquire under night flight conditions, but once acquired, they are frequently critical for the successful completion of a mission At night, when the pilot's visual capabilities are usually limited, extraneous light, reflections, glare, unevenly illuminated instruments, and other lighting problems come to further plague the pilot, compromising both his safety and the performance of his mission.

The development of modern aircraft weapons systems has relied upon design criteria based upon limitations and capabilities of the pilot. Design criteria on seat arrangement, instrument panel configuration, control location and actuation, crew station geometry, and a host of other variables have been with us for some time, and have proved their value in providing better aircrew safety and better mission performance

Aircraft cockpit lighting systems, on the other hand, have not been so amenable to quantification or to the establishment of adequate design criteria. The problem has largely been due to a relative uncertainty as to the actual visual tasks to be performed and to the actual visual requirements of night flight operations. Before meaningful design criteria can be established, it must first be determined what is desired or required for the conditions under which the criteria are to be applied.

Because of concern for the safety and efficiency of naval aviators during night flight operations, as well as concern for the costs and compromises inherent in any cockpit lighting system, the Aerospace Crew Equipment Laboratory, Naval Air Engineering Center, sponsored a three-day conference on cockpit lighting problems in November of 1965. As a result of this conference, the attending representatives from the Bureau of Medicine and Surgery, the National Bureau of Standards, the Naval Aviation Safety Center, the Naval Air Systems Command, and the Office of Naval Research recommended that a series of investigations, developing into a long-term study, be conducted to determine the visual tasks and the visual requirements of pilots during night flight operations. This study was to obtain information under actual operating conditions as well as under controlled laboratory conditions. It was anticipated that, in this manner, meaningful recommendations as to cockpit lighting could be made. The long-term program was to be formulated under AIRTASK No. A34533503/2001/F012-07-01.

This report represents a preliminary study, investigating only one group of factors in aircrew lighting problems. The study is concerned with the interrelationships among visual tasks, mission profile, lighting utility, and external light level on a time-task basis. The methods employed show themselves to be not only feasible, but practical as well. It is expected that further research along lines such as those initiated in this study will aid in the clarification of lighting problems and in the establishment of meaningful design criteria.

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I. BACKGROUND

A. Discussion of Problem

For many years the Naval Air Systems Command and the Aerospace Crew Equipment Laboratory have exerted considerable leadership in fostering Navy pilot safety improvements. This has been done, at least in part, because these agencies were not content to just approve equipment as it came to them but, on the contrary, actively generated the necessary research to develop innovations. This farsighted research was not confined to the machine and associated equipment only, but also was applied to understanding the man and his capacities. It was within this context that the Aerospace Crew Equipment Laboratory fostered research to investigate the relationship between the cockpit environment and visual performance during operational flights.

This particular study dealt with the identification and description of visual tasks required of pilots during typical night flight missions and actual operating conditions. A task, which under carefully controlled laboratory conditions would be of rather elementary concern, becomes infinitely more complex when actual flight conditions are encountered. All conditions of flight cannot be accurately reproduced in simulators. However, certain simulator studies and training courses would aid in quantifying many parameters not measurable in flying aircraft.

There are a number of alternatives when it comes to investigating the visual task. Nearly all of these alternatives focus around eye movement evaluation. This ocular movement can be determined with varying degrees of precision using cameras, eye movement devices, direct observation, and/or by head movement recorders. All of these techniques can be used in simulation but few under actual flight conditions. More difficulty is encountered when the pilot must be evaluated in a tandem or single place aircraft. The method of obtaining the information, i.e. the pilots visual tasks, his choice of lighting, the exterior lighting conditions, must then be considered. A possible solution would be to choose an aircraft with space available for equipment and an observer.

The manner in which the pilot uses his interior lighting system depends primarily on the mission requirement. In addition, the pilot will adjust his interior lighting levels as the outside lighting conditions vary. This variation and usage of the lighting and lighting system must be established before it can be related to the visual task. Once the visual task is established, and the environment and the manner in which the pilot makes use of the interior lighting system is known, then an evaluation as to the compromises of pilot safety and mission performance can be made. This study will establish some background for determining the value and feasibility of this type program in the operational squadrons, using the actual aircraft in real missions.

B. Review of Literature

One of the initial steps in this study was to review studies which seemed appropriate to this particular investigation. Reports were collected, which in general, dealt with the pilots' visual task and visual environment during non-daylight flight intervals.

Reports dealing with the visual task and methods of observation serve to point up the fact that the visual difficulties are not isolated to the interior or the exterior of the cockpit. These two areas are interrelated in that the outside ambient lighting and the resultant setting of the interior lighting level is a prime factor in the limitation of the pilot's visual task ability. This limitation may take the form of compromises in efficiency, safety or accuracy.

The studies of visual recovery and observations of the numerous common occurrences of exposure to low light levels indicated that the extremes of visual requirements, such as flash blindness, must be relegated to a separate study. The night vision trainer provided an important guide in the establishing of the problem situations with which the pilots are faced in actual service.

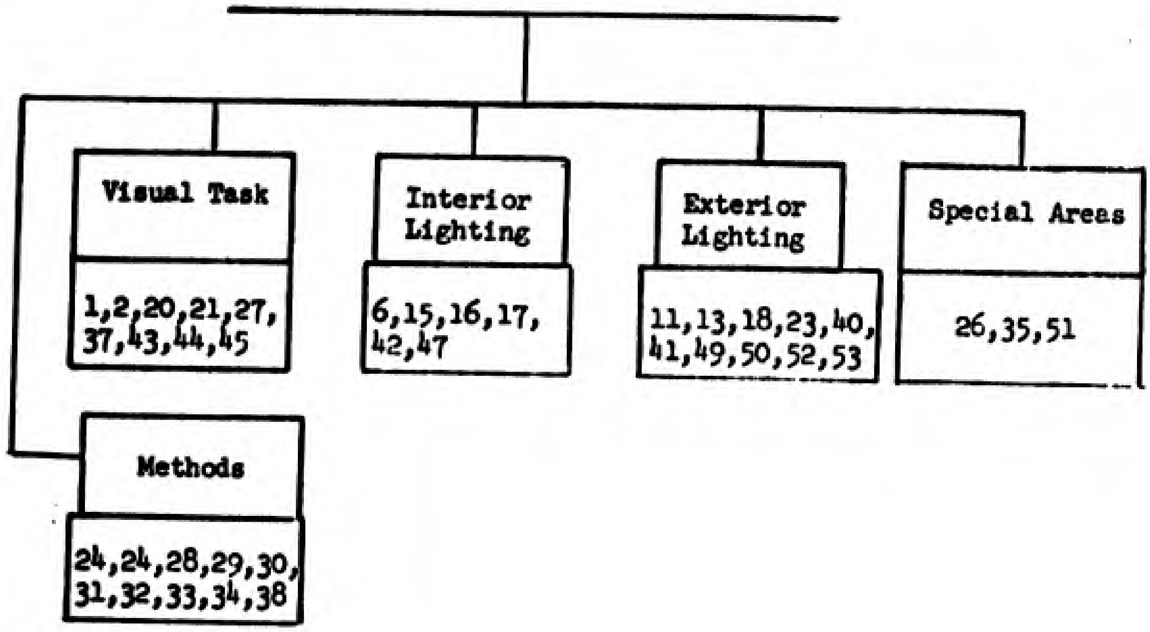
Reports dealing with specific problem areas of interior lighting and exterior aircraft lighting were reviewed. Reports describing the general night sky conditions were also studied.

In reviewing previous studies concerned with eye fixation and scan patterns, it could be seen that great difficulty would be encountered when the methods of these studies were applied to actual night flights. Many types of eye movement detection devices were evaluated. Polymetrics V-D165, a commercially available, head-worn camera system, and Sperry's helmet sight were considered, along with other filming techniques. Head and helmet movement sensing devices, infrared eye movement and camera devices were reviewed.

Many studies have related the visual task to the lighting environment. Since it is the operational situation which determines the requirements for "the need to see," then the interior lighting must be subordinate to this need. Any lighting system would, therefore, be a compromise between the light required for the necessary task to see an instrument and that low level of light required for visibility outside the cockpit. It would then appear that much could be done to enhance pilot safety and improve his performance if his visual task were lessened. Since the load placed on the pilot is becoming more stringent, every possible step must be taken to improve existing and new equipment so as to eliminate ambiguous, fatiguing and inappropriate visual stimulation.

A pilot study was needed to determine these actual operating conditions of both interior and exterior lighting in relation to a required visual task.

REPORT REFERENCES - BIBLIOGRAPHY NUMBERS



C. Consultation with Experts

The preliminary design specifications for this study were made after consultation with various North American Aviation, Inc. personnel. It was decided to investigate the feasible alternatives with local plant personnel who have had similar design and management experiences. Test pilots, simulation group personnel, photography experts, and electro-optical personnel were consulted. As a result, a test plan was designed and presented to the program collaborators at the Aerospace Crew Equipment Laboratory at the Naval Air Engineering Center, Philadelphia, Pennsylvania. After this meeting with ACEL personnel, it was decided to further evaluate and refine the techniques which seemed appropriate for this study. A series of interviews was arranged at the Patuxent River Naval Air Test Center (NATC) to gather further opinions from pilots and research personnel. These meetings included Dr. Kelley, three Navy test pilots, a Marine test pilot, and a test pilot assigned to NATC from the Royal Navy. At this meeting various techniques were discussed which could be utilized in gathering data appropriate to this investigation. Another meeting was held with Tommy Momiyama, Carrier Suitability Branch, and his staff to discuss lighting problems encountered in their research. Also contacted was Harry Mann who supervised a major portion of the exterior lighting hardware studies for NATC.

After these meetings and consultation with ACEL, the techniques for evaluation were determined.

II. DISCUSSION OF THE STUDY

An early look at some of the variables upon which this study was based revealed that the pilot's personal experience and consequently his preference for a particular cockpit presentation had much to do with his criticism or lack of criticism for his aircraft environment. The fact that the pilots are proud of their aircraft and their ability to adapt to a situation which may be less than desirable must be recognized in the analysis of their answers.

A. The Human

The pilot's visual tasks are quantifiable only to a limited degree, based on the supposition that vision is ninety percent mental. The analysis of the visual task must be based on: (1) observations of the pilot, (2) conclusions that the tasks were performed, and (3) pilots' statements of the tasks performed. The approach was to prepare a visual task sheet and, from the information obtained, list the task breakdown of each phase of the flight.

Determination of the visual task on a time basis is complicated by the ability of the experienced pilot to monitor a complex display in a brief scan. This was supported in preliminary interviews with pilots. The two distinct modes for visual sightings are the fast scan and the concentrated visual check wherein the pilot is looking for a particular bit of information. It was reported that many pilots scan the instrument panel, engine instruments for example, move on to an outside visual check, and then glance back at one particular instrument. The reason given was that a thought process had begun that intruded on their attention and called for a recheck--either a positive or negative signal was present.

The visual tasks are so varied and of such magnitude that it is almost impossible for a study to be completed in all areas before the state of the art of aircraft design renders them obsolete. Consequently, this study will endeavor to touch on those fundamentals involving the pilot and the aircraft in a particular mission environment.

The attention given to any particular group of instruments is likely to be related to the immediate task. The study will rate these tasks as to levels of importance in three different categories. These are:

1. Take-off and landing phase
2. General phase of flying and navigating an aircraft
3. Specific phase of mission accomplishment

B. The Aircraft

Aircraft may be separated into types by the missions for which they are designed. In identifying the visual tasks of pilots during night flights, it was realized that the visual tasks are related to the extent that the human eye has to see to allow comprehension of a situation. The pilots themselves rendered evident this cogency that the visual tasks must be separated by aircraft types.

A possible grouping of aircraft types is suggested and will be re-evaluated in the recommendations portion of this study.

Group I	All Single Place Attack and Fighter Aircraft
Group II	(a) All 2 place (Tandem) Attack and Fighter Aircraft (b) All 2 place (Side by Side) Attack and Fighter Aircraft
Group III	(a) All Patrol Aircraft (Carrier Operable) (b) All Patrol Aircraft (Not Carrier Operable) (c) All Transport
Group IV	(a) Helicopter (b) VSTOL Type
Group V	Special grouping of (a) Observation (b) Reconnaissance (c) Trainers

The rationale for this suggested grouping is based on the visual work load of the pilot or team. Group I represents those aircraft where the pilot has the entire load. The pilot would have no assistance in the monitoring of the instruments, in the selection of radio channels, or in scanning for a target or traffic. His selection of the interior lighting must, therefore, be attuned to his external visual task. Group II represents that grouping of aircraft where the visual work load in the aircraft is shared by the two operators. Group III represents aircraft where the work load is shared by the team. This group normally performs extended duration type missions. Group IV is a special group where the visual task is of a specific nature, i.e. the pilot has to contend with external visual tasks that are most demanding for extended periods. Normally this grouping is a two man team. Group V is a special group of aircraft where the visual task is a special consideration.

C. The Technique

The long range objectives of the overall program, of which this is a pilot study, are: (1) to provide background information to the personnel establishing the requirements for the visual task from personnel using the aircraft in fleet operations, and (2) to realistically associate the visual task with the operational environment.

The overall program will be based on the operational aircraft of the fleet in conjunction with the necessary simulator programs. This pilot study, in addition to the basic task, will serve as a platform for the recommendations of the overall program. For this purpose, the techniques and procedures of this pilot study are included in this final report.

Basically the task may be broken down into its essentials as follows:

1. Identify and describe visual tasks.
2. Internal and external variables affecting those visual tasks.
3. Physiological and psychological variables affecting those visual tasks.
4. Requirements to perform those visual tasks.
5. Variables affecting performance of those visual tasks, and variables compromising requirements of those visual tasks.

A graphic picture of the pilot's visual tasks will be presented. This will be accomplished by observing the man, observing his actions and the result of his actions, acquiring his opinions and listing his tasks. In addition, the lighting environment will be monitored and measured, both inside and outside the cockpit.

The summarization will tie these two areas together and provide a basis for the conclusions and recommendations which follow. This methodology is represented in the flow chart (Figure 1) and presented for those concerned with operational studies. The results may be found in Section III, page 27. The Conclusions are found in Section IV, page 70, and the Recommendations in Section V, page 72.

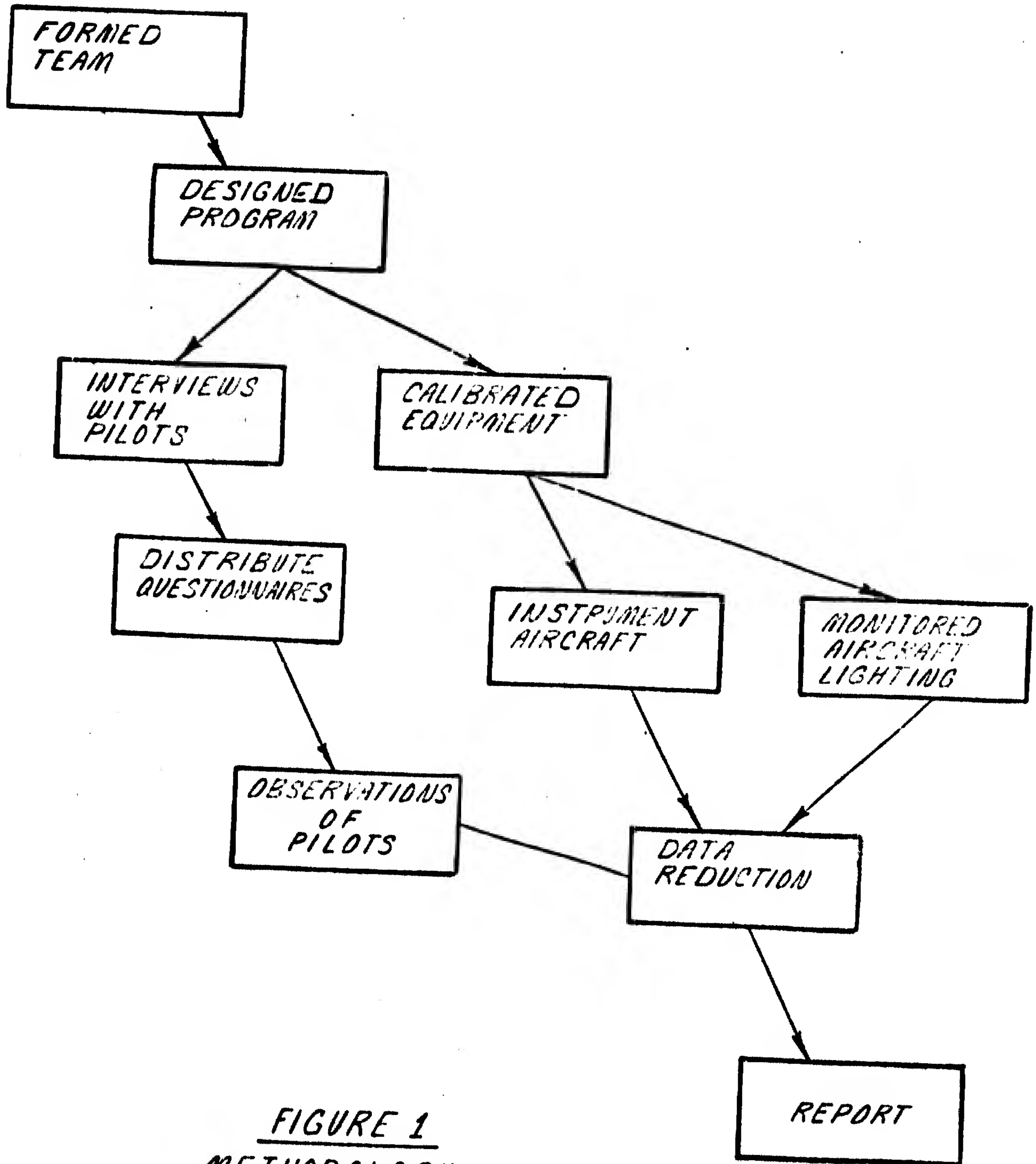


FIGURE 1
METHODOLOGY

Briefly the program involved:

1. A review of existing research.

2. Study of U.S. Navy handbooks for all aircraft types involved.

3. Interviews with pilots concerning the problem areas in which visual tasks and interior lighting are primary. It should be noted that visual task will, in this study, be concerned with the human factor aspect of cockpit lighting and quantitative data on operational interior lighting.

4. Formulated preliminary questionnaires and interviewed operational squadrons.

5. Formulated test plan and interviewed operational squadrons and Naval test pilots.

6. Finalized program, constructed and calibrated test equipment.

7. Interviewed pilots.

8. Distributed questionnaires.

9. Observed pilots.

10. Measured interior lighting

11. Made inflight recording of interior lighting and external ambient lighting conditions.

The instrumentation package was designed to allow monitoring of the external sky conditions while recording the interior light selections made by the pilot in flight.

The method of monitoring interior and exterior lighting levels was established as providing the best indication of the lighting levels as associated with the visual tasks.

The interior lighting of the subject aircraft cockpit was monitored utilizing a Pritchard photometer, Spretra brightness meters Model UB and SB with power packs. In addition, an ACEL lighting engineer participated using a Pritchard photometer with integrating cosine lens and a G.E. brightness meter. A black cover was necessary to avoid stray light and afford complete darkness in the cockpit measurements. A tripod was required in making the readings and since the front seat was not removed in the aircraft under observation, some instruments and consoles were impractical to measure. However, to supplement the readings, the total light flux was taken for each step of interior lighting control system.

The light levels obtained were correlated with the actual settings recorded in observations of an operational training mission.

The arrangement for the aircraft inflight monitoring is represented in Figure 3 block diagram, Figure 4 wiring diagram, Fig.5& 6 schematic, photographs Figures 7, 8, 9 and 10, and resultant sample tape as depicted in Figure 11.

The sensors selected, to monitor the outside ambient lighting condition, were Clairex 505L photoconductive cells, designated as CL1 for forward sensor, CL2 for left sensor, and CL3 for right sensor. These cells were selected for their sensitivity (see Figure 2); cadmium sulfide peaks at 5500° Angstroms and closely matches the response of the human eye. They act as light sensitive resistors with the resistance decreasing with increasing light. The cells were calibrated as indicated in Figure 2aand automatically compensate for the reduction in light caused by the canopy and windscreen.

Since the majority of the illuminance of the night sky is reflected light, it was decided to calibrate the sensors in foot lamberts.

CELL SENSITIVITY CURVE OVERLAID ON ROD-CONE CURVES

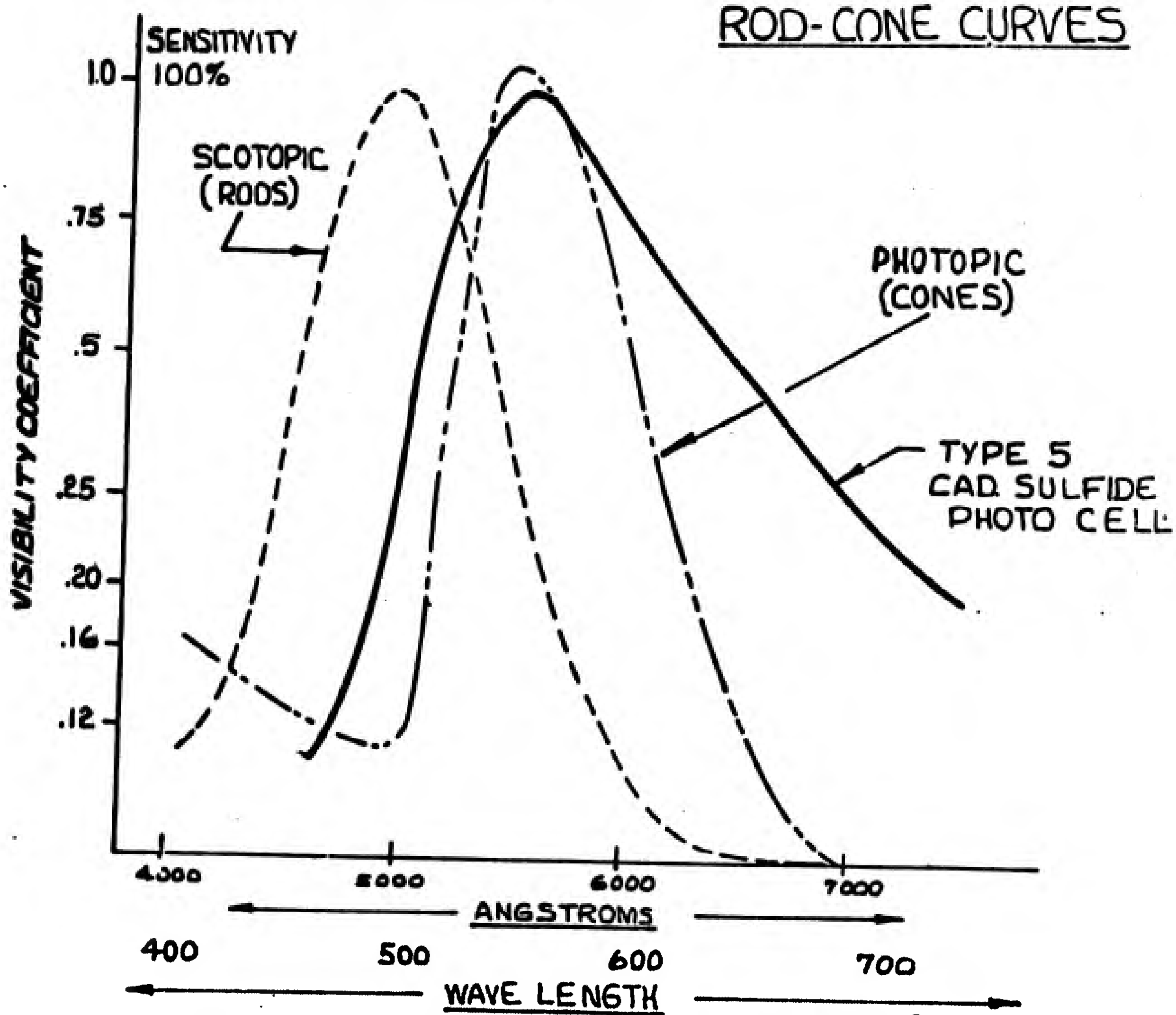


FIGURE 2

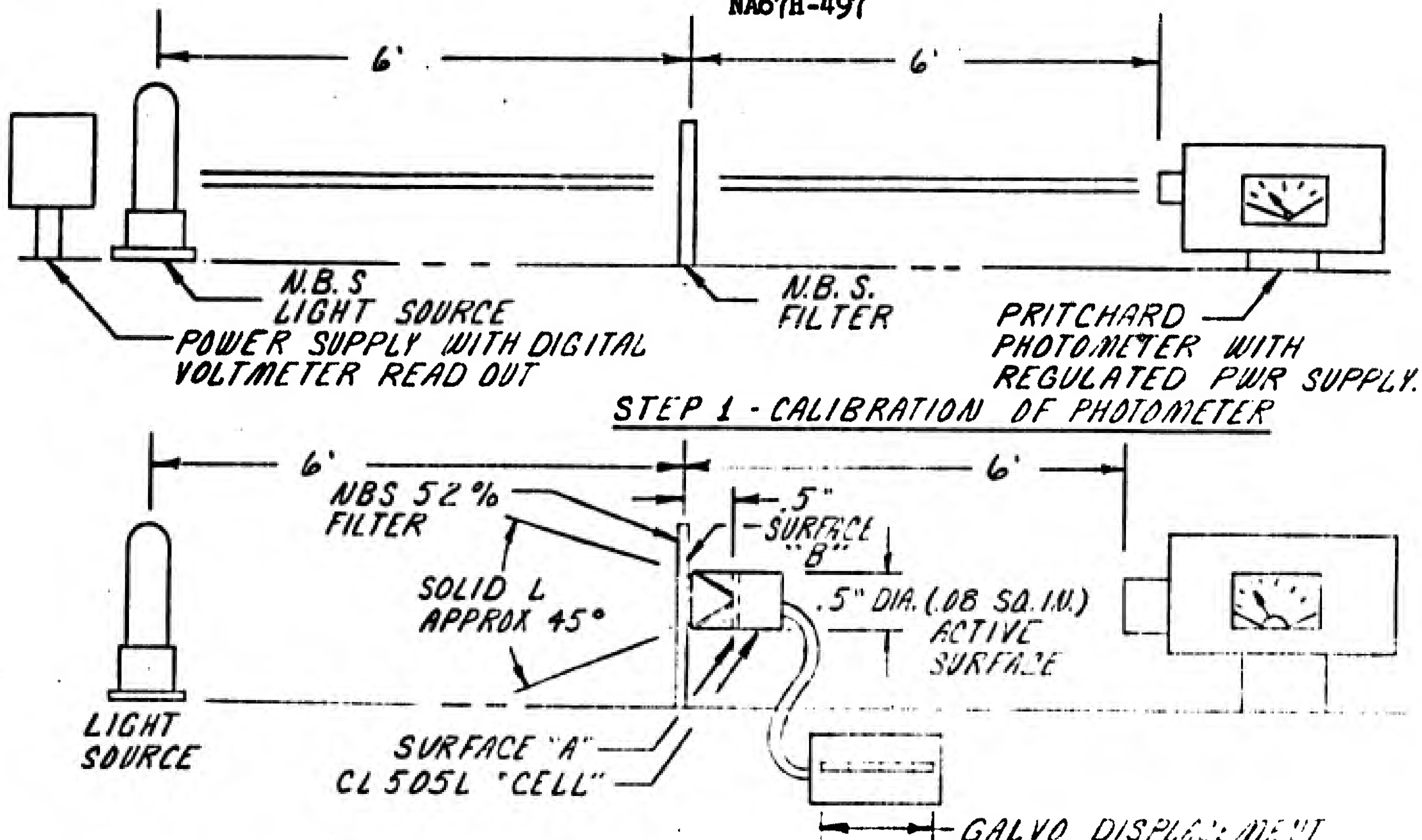


Figure 2a

Light flux falling on a unit area of a surface can properly be measured in lumens per square foot. The lumen is defined in terms of the light flux per unit solid angle in a particular direction. An isotropic point source being impossible to obtain, 6 ft. was used as a distance suitable for the general measurements to be made in this study.

The average brightness expressed in this report as foot-lamberts may be said to be the brightness at the surface B, integrated through the area subtended by the solid area and calibrated as shown.

The shield serves the dual purpose of prohibiting the interior lighting from affecting the light flux on the sensor and allows for that light which would strike the sensor surface at an angle greater than 45° to be ignored.

The incident light, considered a point source in the calibration run for practical purposes, provided a reading on the sensor of approximately 10 times the value of the secondary source (the NBS filter). All three sensors were within 10% which was considered satisfactory for this program.

The expression "average or general light level" will be used in this report to represent the brightness in foot lamberts of the sky condition, ground lighting, reflection from cloud and haze, and other aircraft in the area.

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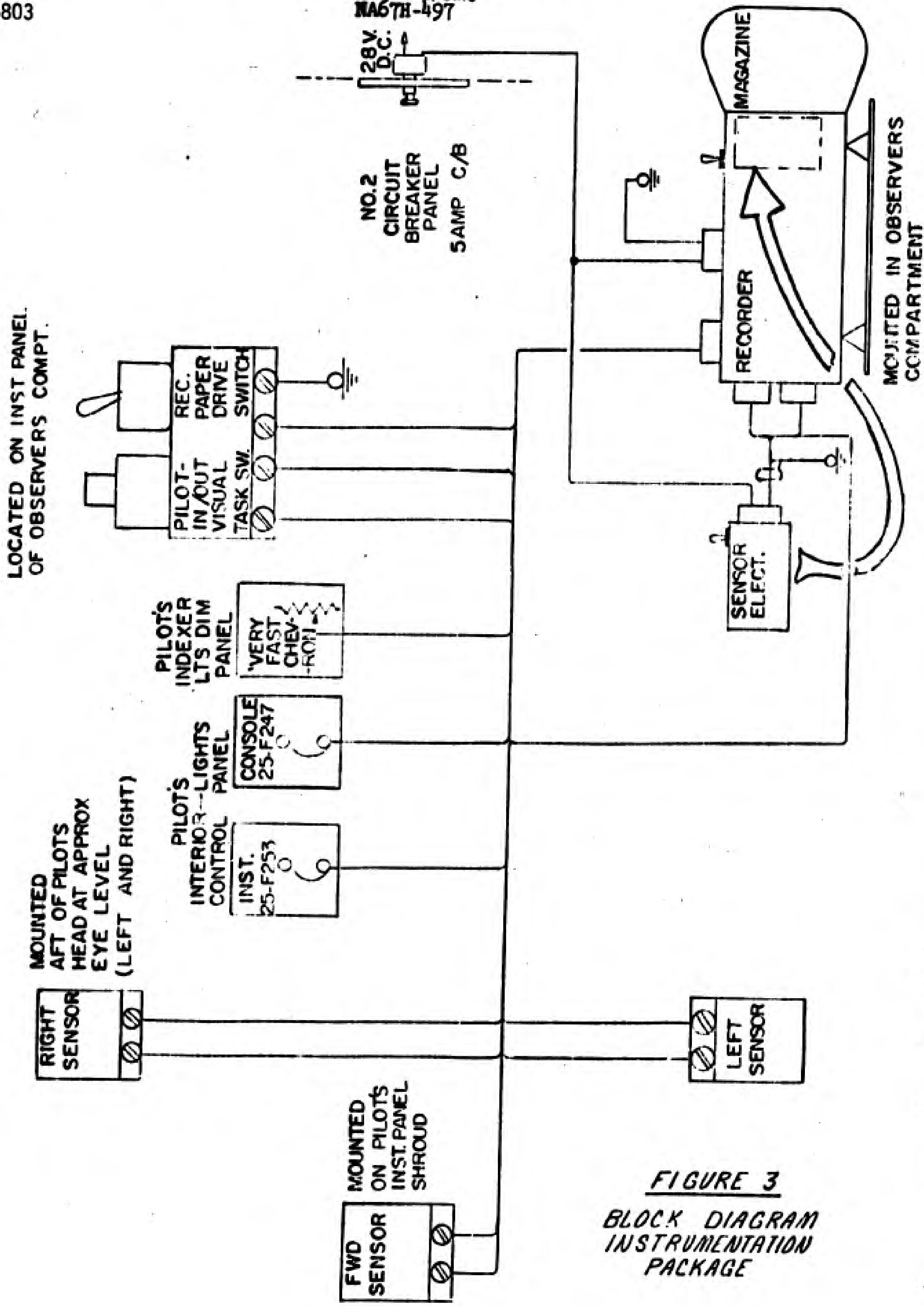

FIGURE 3

BLOCK DIAGRAM INSTRUMENTATION PACKAGE

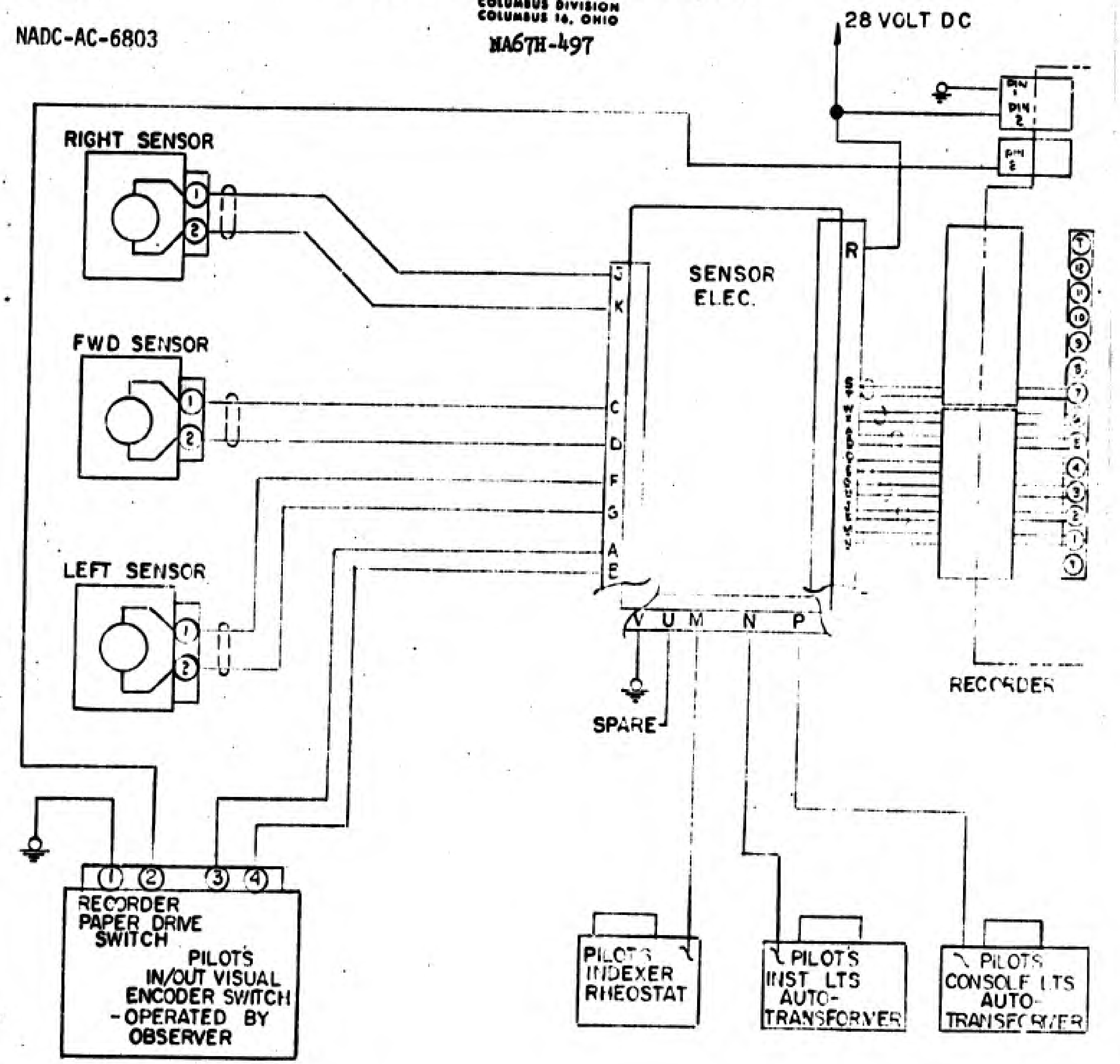

FIGURE 4

WIRING DIAGRAM
INSTRUMENTATION PACKAGE

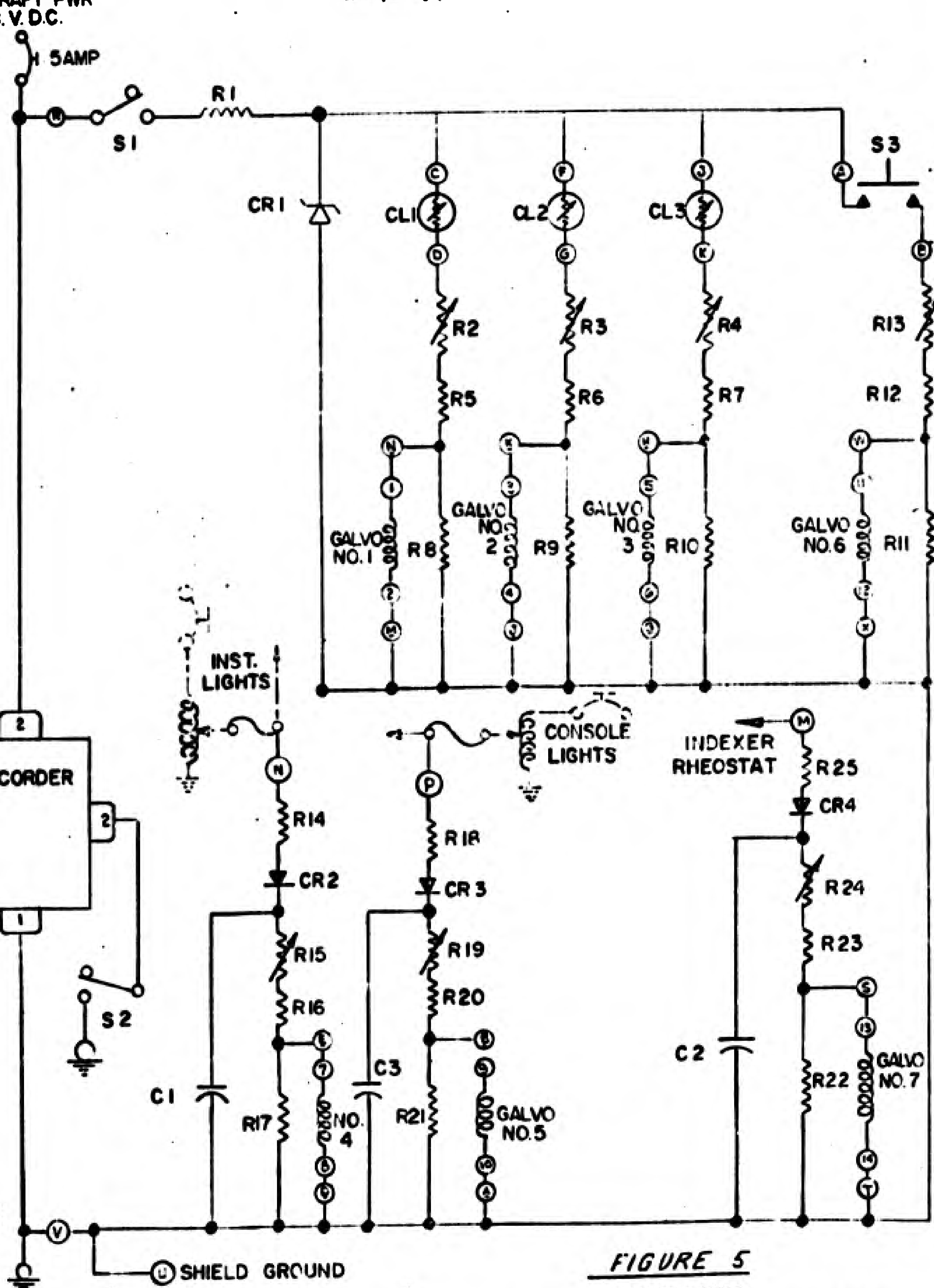

FIGURE 5

SCHEMATIC-
INSTRUMENTATION PACKAGE

SENSOR ELECTRONICS PARTS LIST

R1	2000 ohms 1/2 watt 10%
R2	200K ohms TRIMPOT
R3	50K ohms TRIMPOT
R4	50K ohms TRIMPOT
R5	75K ohms 1/2 watt
R6	220K ohms 1/2 watt
R7	220K ohms 1/2 watt
R8	350 ohms 1/2 watt
R9	350 ohms 1/2 watt
R10	350 ohms 1/2 watt
R11	350 ohms 1/2 watt
R12	75K ohms 1/2 watt
R13	50K ohms TRIMPOT
R14	330 ohms 1/2 watt
R15	100K ohms 1/2 watt TRIMPOT
R16	390K ohms 1/2 watt
R17	350 ohms 1/2 watt
R18	330 ohms 1/2 watt
R19	100K ohms 1/2 watt TRIMPOT
R20	390K ohms 1/2 watt
R21	350 ohms 1/2 watt
R22	350 ohms 1/2 watt
R23	390K ohms 1/2 watt
R24	100K ohms 1/2 watt TRIMPOT
R25	330 ohms 1/2 watt
CR1	IN3019 9.1V 20 mill.
CR2	IN91
CR3	IN91
CR4	IN91
C1	TVA 1300 Sprague 50V
C2	TVA 1300
C3	TE 1300
S1	Sensor Power Sw.
S2	Paper Drive Switch
S3	Pilots Visual Task Encoder Sw.
CB	5 Amp Standard MS Circuit Breaker
CL1	CL505CL Sensor Forward
CL2	CL505CL Sensor Left
CL3	CL505CL Sensor Right

FIGURE 6

SENSOR ELECTRONICS PARTS LIST

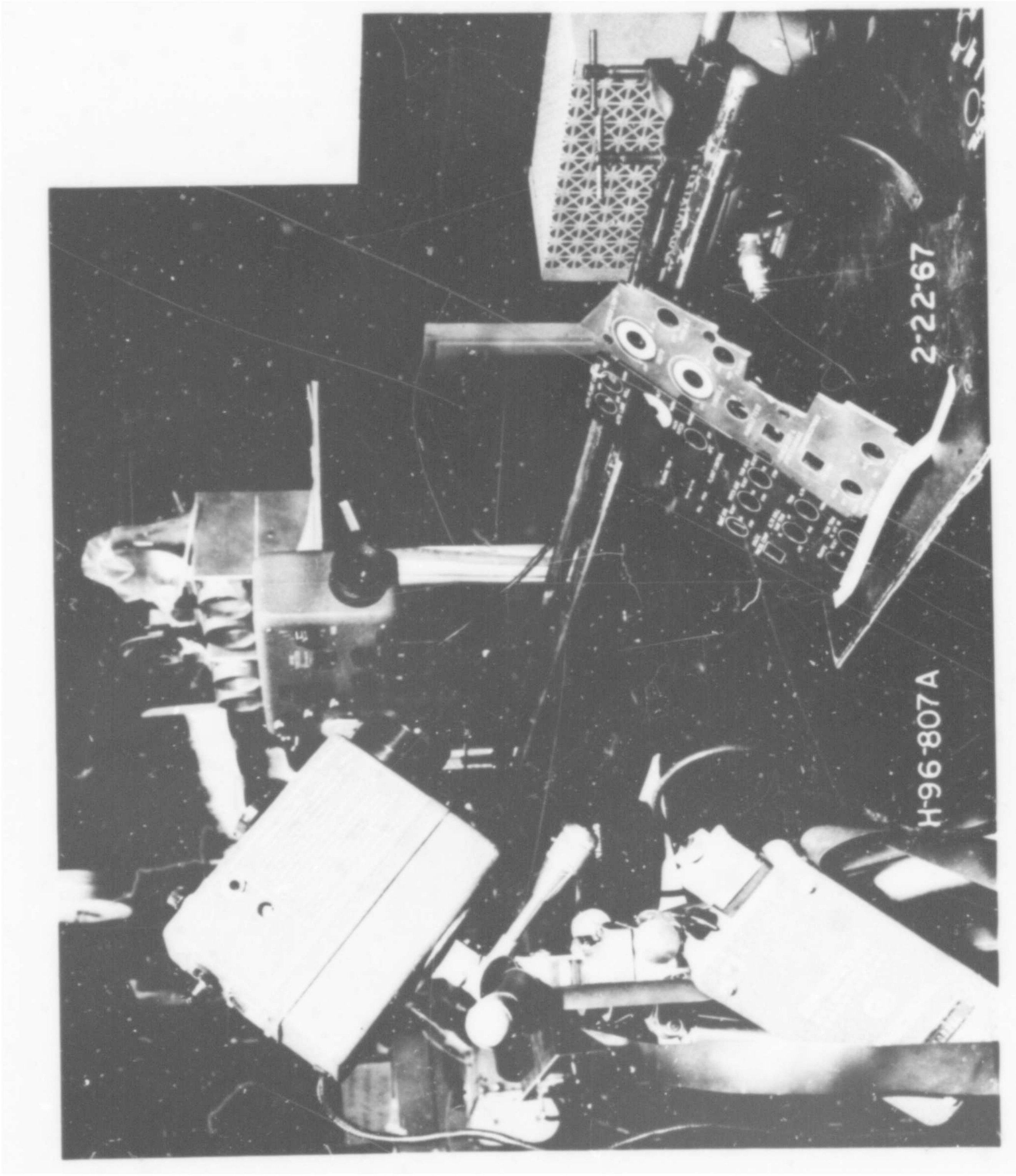

FIG. 7 - CONSOLE PANEL COMPARISONS

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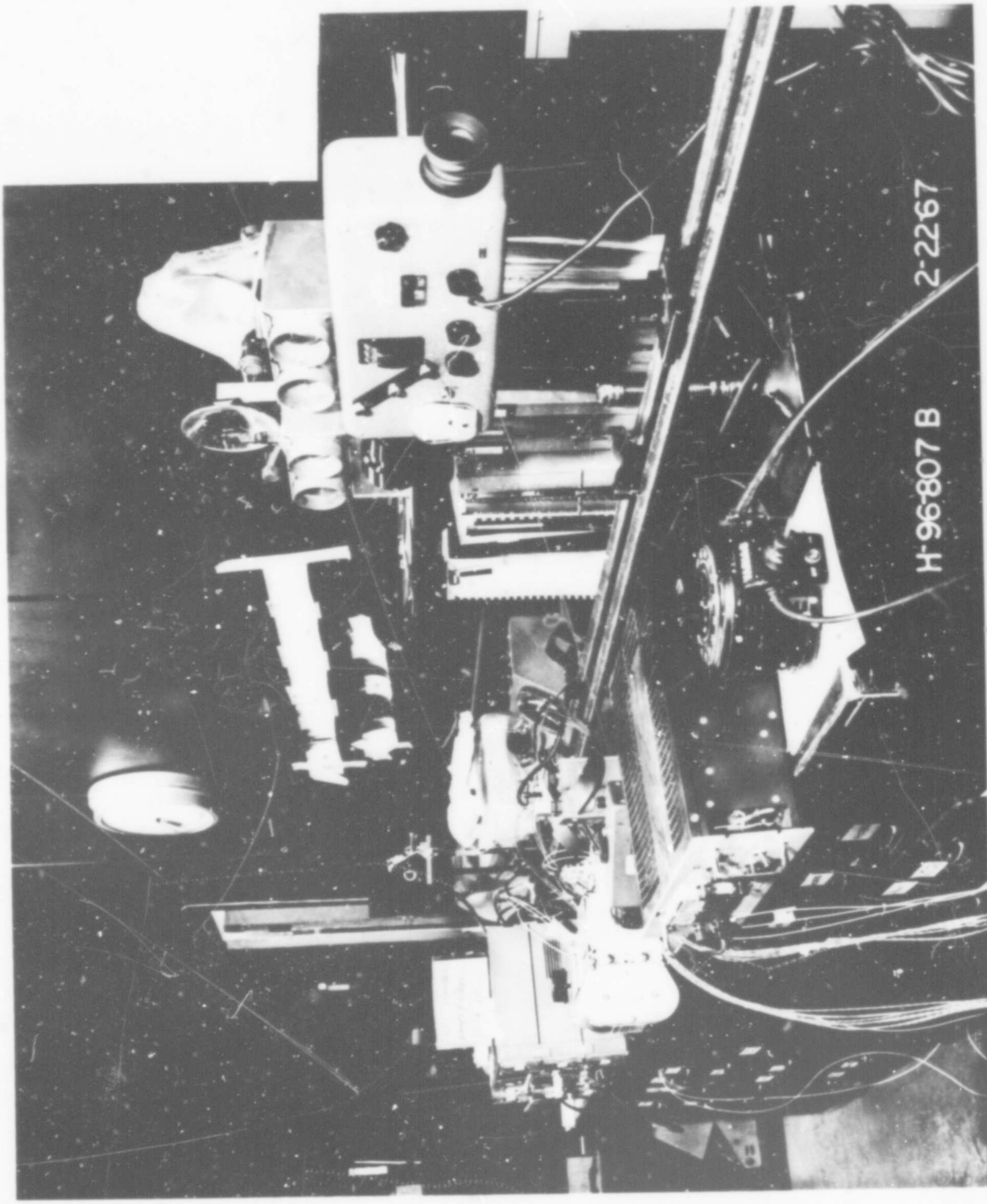

FIG. 8 - SENSOR CALIBRATION

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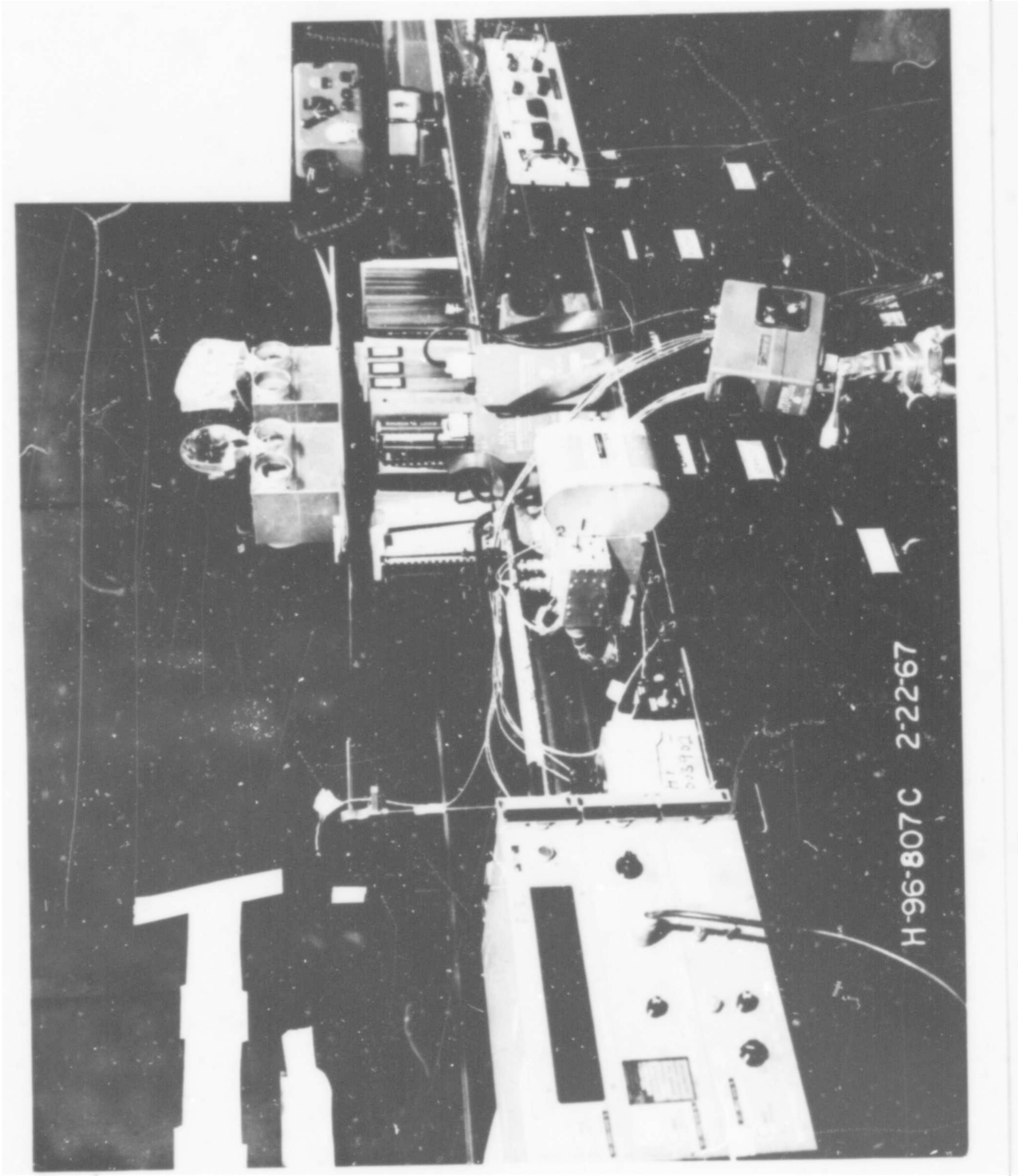

FIG. 9 - RECORDER AND SENSOR ELECTRONICS

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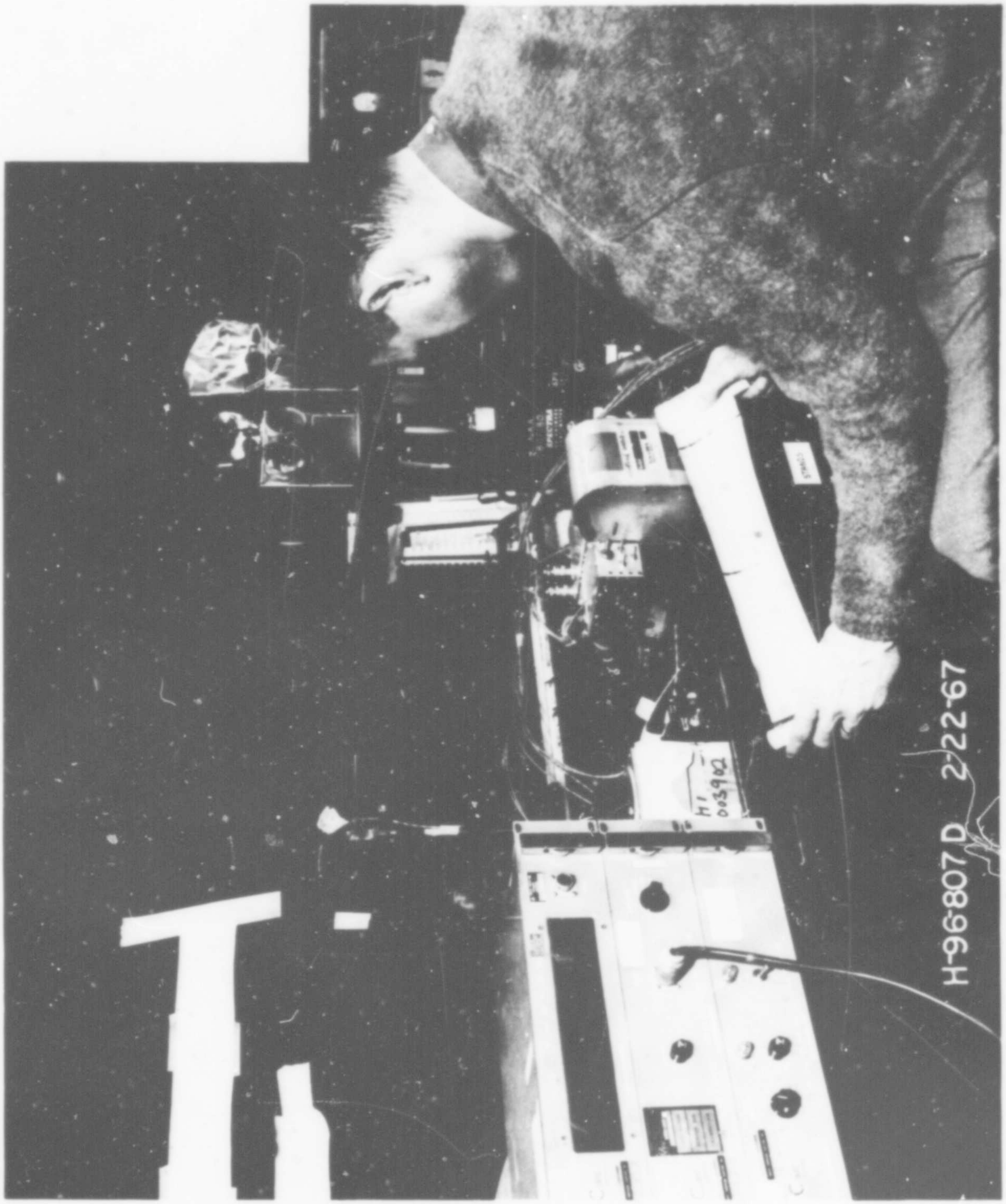


FIG. 10 - INSTRUMENTATION PACKAGE CALIBRATION

PHOTO NO: CAN-385843(L)-1-68

A model 409 sensor oscillograph recorder was obtained for use on this program from the Naval Air Engineering Center, along with a spare magazine and enough linograph recording paper for 24 flights. The recorder has the capability of operating up to 10 hours, however, it was decided to make one flight per tape (3 hours) to allow analysis of the tape to be expedited. The sensor electronics box was designed and fabricated to mount to the side of the recorder. The location, mounting and hookup were simplified by the assistance of Aero-Structure Lab of Naval Air Engineering Cent .

The monitoring of the console and instrument lighting was accomplished simply by setting the galvonometer trace to a voltage level and recording this voltage. The brightness and light flux were then measured and correlated with the position of the auto transformer which determined this voltage. The F-4 has a 28 volt auto-transformer (6437 OECO) which controls the console lights and a similar transformer feeding a 5V step-down transformer controlling the instrument lighting.

The resultant trace deflection is then read as auto transformer setting and all readings may be thus converted to brightness (foot lamberts) and light flux.

The encoder switch is designed to allow the observer to monitor the pilots primary visual task and record when it is either inside or outside the cockpit. This basic task definition is far from the desired goal but will give an indication of the inside (assumed on instruments) or outside (either has a visual target or is seeking to ascertain if there is one). It will also pinpoint the times so that the analysis of the visual work load may be correlated to what the pilot reported he was doing. The switch was mounted in the Radar Intercept Officer's compartment so that the observer, who in this case was the RIO, could monitor the pilot's visual tasks utilizing one of the pilot's three mirrors.

Included in the RIO compartment was a switch for turning the recorder drive motor on and off. A circuit breaker and a system switch were placed in the compartment in the event a malfunction occurred. The magazine was easily changed without removing any other equipment. The location of the equipment in this model aircraft (F-4B) occupied the space in which the APC is normally installed. The visual load, i.e. the scan pattern, apparently is reduced when this system is utilized. However, the normal visual tasks (other than landing) remain generally the same.

A sample tape from the recorder is shown in Figure 11. An explanation is in order here to provide meaning to the data which follow. The sample tape was taken from Flight No. 3, the first "touch and go" on the simulated carrier field. This field is laid out and lighted, with the exception of the drop lights, in the same manner as a CVA60 vessel. Trace identification number:

1. Shows the trace of the forward sensor which is monitoring the light which penetrates the forward wind screen at approximately the pilots angle of vision with the meatball during the final leg of the approach to the simulated carrier practise landing field. Trace reading shows steady at 0 light and a peak at approximately .001 ft. lamberts brightness.

2. Shows trace of the left sensor which has been placed at approximately the eye level of the pilot. The look angle is directly outboard. Trace shows ambient light on the left is almost steady zero with peak of approximately .001.

3. Shows the trace of the right sensor. The right sensor is showing practically no change as the aircraft touched down and pulled up for the go-around. There were no lights to the right at this field.

4. Shows the trace of the instruments auto-transformer setting. This pilot had placed his instrument lights at No. 7 position (approximately 3.5 volts on the 5 volt lighting system).

5. Shows the trace of the consoles auto-transformer setting that the pilot had chosen on this particular night. He had selected the maximum position No. 10 (approximately 27.8 volts).

6. Shows the time that pilot was observed to be looking outside. Presumably he is on the "ball" and subsequent interviews established this fact. This particular run shows 40 seconds on the ball with two quick scans outside immediately after touchdown and then back on instruments for the pullup.

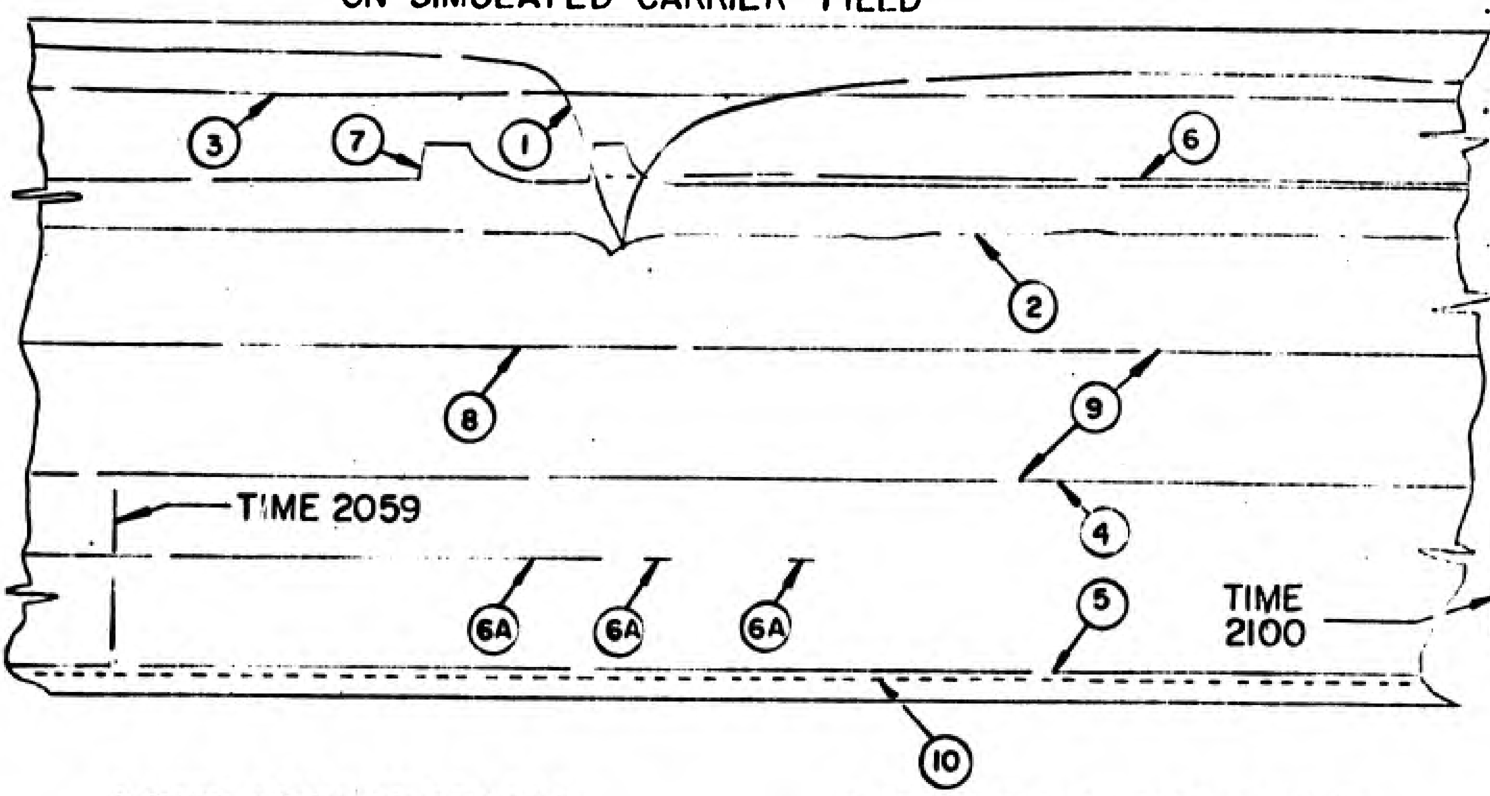
7. Shows trace of the indexer (angle of attack indexer) rheostat setting which in this run indicates that the pilot elected to set the indexer brightness at approximately 4 volts. No measurements could be obtained at this low setting and no explanation could be given as to the reason it was set so low although it could still be detected with the eye. The interruption in the trace is caused by the fact that this signal is taken from the lower chevron output which indicates a "slightly fast or very fast" situation. When the gear is pulled up this signal disappears and shows on the trace as 0.

8. Shows the reference trace which allows convenient trace identification and orientation of trace position.

9. Represents a typical trace interruption which allows each trace to be identified.

10. Represents 1 second intervals which are sufficient for this study. However, this particular recorder shows about 6% error. An oscilloscope was used to establish accurate distance interval time marker and calibration tape marked accordingly. The human element in making observations is no doubt inaccurate; consequently, all times noted should be considered approximate.

SAMPLE RECORDER TAPE
FLIGHT NO. 3, FIRST "TOUCH & GO"
ON SIMULATED CARRIER FIELD



1. FWD LOOKING SENSOR
2. LEFT SENSOR
3. RIGHT SENSOR
4. INSTRUMENT LIGHTING
5. CONSOLE LIGHTING
6. ENCODER SWITCH-PILOT'S VISUAL TASK-INSIDE

6A. PILOT'S VISUAL TASK-OUTSIDE

7. INDEXER RHEOSTAT SETTING-SIGNAL FROM LOWER CHEVRON
8. REFERENCE TRACE
9. TRACE IDENTIFICATION MARK
10. TIMING MARK

FIGURE 11

SAMPLE RECORDER TAPE SEGMENT

The observation methods that were to be used during the actual flights by the team ACEL Naval Officer utilizing a check sheet were changed after the program was started. In practically all Naval aircraft where two or more men constitute the flight crew, the operational procedures are carried out by the crew functioning as a team. To place an observer in the second seat would prohibit operation of the aircraft in the normal manner. The flight, if made carrying an observer, would be strictly a round robin flight. The second man, in all cases, has specific duties and in some cases is actually participating in the landing procedure. For these reasons, the second crew man was asked, where possible, to serve as our observer. He was briefed on the program, given an abbreviated check card as shown in Figure 12, and debriefed along with the pilot at the completion of the flight. The interview outline is included in Appendix B.

The feasibility of this study method was discussed with Naval personnel prior to implementation. Visits were made to Patuxent River, NAS Norfolk and Oceana where preliminary questionnaires were distributed. During these visits, it was emphasized to the team that pilots could not participate in the in-flight observations and maintain the normalcy of a night operational flight. This led to the proviso that the observer or flight crewman make the observations of the pilot's basic visual task.

An instrumentation package was placed in an F-4B aircraft (Serial No. 151503) of Fighter Squadron VF-103. This squadron was located at Oceana NAS. The package was installed on 24 February 1967. The team members interviewed pilots, observed all forms of pilot activity, and made ground observations of take-offs and landings, including simulated carrier night landings. Team personnel were available and the instrumentation package was in a "go" status for 16 possible flights at this station. Only four flights were made as a result of the aircraft being placed in a "down" status or being weathered in. The program called for carrier flights to be made, however, due to circumstances beyond the control of the Navy and the Contractor, the aircraft could not be scheduled and the instrumentation package was removed on 24 March 1967.

During the period ending 24 March 1967, the team personnel interviewed pilots, observed ready room activities, visited the Safety Center and obtained questionnaires previously distributed. In addition, the program provided for visits to Quonset Point, Glenview NAS, the carrier Saratoga (dockside at Mayport), Cecil Field, NAS Jacksonville, Pensacola and Sanford Naval Air Stations. Pilots of various aircraft types were interviewed with observations made of many types of aircraft and over 300 questionnaires distributed.

Questionnaires were distributed to pilots of the following types of aircraft: Fighter, Attack, Transport, Patrol, Helicopter, Reconnaissance and Trainer. Interviews were conducted with pilots of fighter and attack aircraft, including F-4, A-4, A-6 and F-8. Interviews were conducted in the aircraft with pilots of Fighter, Attack, Patrol and Helicopters. Measurements were made of Fighter aircraft cockpits (F-4B), with observations being made of Fighter, Attack and Patrol aircraft cockpits.

FLIGHT NO #3 DATE 3/1/67

TYPE OF NIGHT FLIGHT	AIR INTERCEPTS & NIGHT BOUNCES
TIME-THAT THE RECORDER TAPE TURNED ON	on at 19:40 off at 2120 'Hot Fuel' on at 2148
TIME-THAT A/C PASSED L.S.O. ON FIRST "T.&G."	1st "C" 2048.5 2nd "C" 2156
TIME-TAPE TURNED OFF	off at 2218
NOTES	

PILOT Loy Oaker LT.
R.I.O. Bill Clayton Ens

FLIGHT #3 R.I.O. INSTRUCTIONS A/C 204

1. ENGAGE C/B ON #2 CIRCUIT BREAKER PANEL.
2. TURN ON RECORDER DURING ENGINE RUN UP PERIOD. NOTE TIME RECORDER TURNED ON.
3. NOTE TIME OF FIRST 'BOUNCE' AS YOU PASS L.S.O. ON THE FIRST SERIES OF 'TOUCH AND GO' LANDINGS.
4. OBSERVING THE PILOTS EYES - THE MIRROR, PUSH THE ENCODER SWITCH WHENEVER THE PILOT LOOKS OUT OF THE COCKPIT — LANDING PATTERN IS THE PRIMARY AREA OF INTEREST.
5. TURN OFF TAPE AT END OF FLIGHT. NOTE TIME.

IF OBSERVING PILOTS EYE MOVEMENT AND OPERATING PUSH BUTTON IN ANY WAY INTERFERES WITH NORMAL FLIGHT DUTIES — ABORT THE OBSERVATIONS AND NOTE TIMES ONLY.

FIGURE 12

INSTRUCTION CARD FOR OBSERVER

The following table represents the general procedure established as a guide in performing the aircraft interior checks of the lighting equipment.

PROCEDURE FOR PILOT'S COMPARTMENT VISUAL STUDY CHECKOUT USED BY TEAM

1. Stray Light: Visual check - use scale 18" 12" 36", according to MIL Specifications

2. Functional check of all lighting: Operate through all phases.

3. Reflectance: Note if present - Do the instruments have anti-diffusing coating?

4. Glare and Reflected Light: Windshield and canopy - Note.

5. Uniformity: Ratio of Individual instruments and console panels. Note: To be more precisely checked after brightness readings are taken.

6. Dial Face Obstructions: Note by visual check.

7. Tracking of Instruments and Consoles: Do they appear to decrease uniformly as controls are lowered? Note any disparagement.

8. Notes to be taken as to features this aircraft under observation may have or lack: Using questionnaires as guide.

   Example: Kneeboard lights - indented controls; lighting controls with reference numbers on dial, etc.

9. Warning and Caution Lights: Dimming feature - Yes, No.

   Example: Fire Warning Lights, Few Caution Lights, Not Dimmed.

10. Check Video Displays for compliance with paragraphs 3.5 and 3.6.2 of MIL-L-18276C (if possible).

11. Cleanliness of Windshield and Canopy.

12. Make Photometric Readings: Record.

The "outline" shows the general presentation made to those responsible people making possible the visits to the individual squadrons and to the pilots themselves. The simple outline was a necessity and is considered to be a requirement for visits to Naval personnel by civilian employees. The most efficient method is one that allows the people with whom contact must be made to grasp the entire program of "what-why and who" in one brief reading as the press of operational duties and training does not permit lengthy, time consuming interview periods. See Appendices B and C.

The preliminary questionnaires and the final questionnaires, the interview form, are included in the Appendix as tools used in this program.

PLAN FOR OPERATIONAL STUDY OF
PILOTS' NIGHT VISUAL REQUIREMENTS

N00156-67-C-1100
For Naval Air
Engineering Center

OUTLINE

I. Purpose:

A. To study visual tasks required of pilots during night flight operations.

B. To study those environmental variables (both internal and external) which may affect the performance of the visual task.

C. To identify those parameters of pilots' night visual tasks which need further definition and study.

II. Personnel involved in the study:

A. Aerospace crew equipment laboratory, Naval Air Engineering Center assigned Naval Officer and North American Aviation Engineer and Psychologist will perform the study and evaluations.

B. Navy pilots will be the source of information for this study.

III. Methods of study:

A. Questionnaires

B. Inflight observations

C. Pilot interviews

D. Informal conversations with pilots

E. Photometric measurements (with limited inflight recording)

III. RESULTS

The results of this study are compiled in the following order:

A. Observation and Interview - The task breakdown, identification and description.

B. Questionnaire - The form, typical answers, summarization and tabulation.

C. Recorded Information - The results of instrumentation and photometric measurement.

A. Observations and Interviews

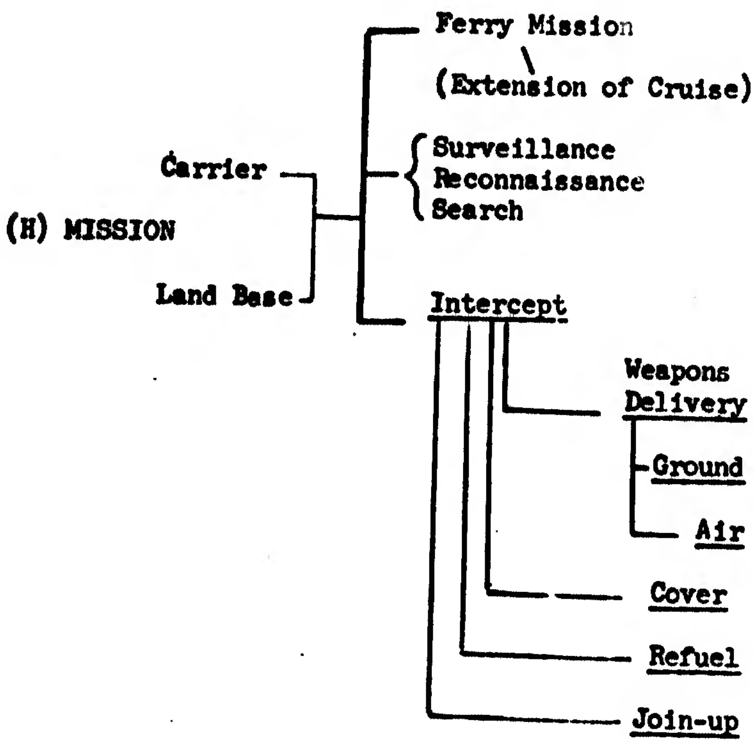
1. Task Breakdown

The visual tasks are grouped in the following table by their basic classification. The table presents, in simple terms, just what the tasks are. It shows the generalization of these tasks. This table will represent the basic tasks of a fighter pilot and show the proper perspective for the visual task separation by the aircraft groups. It will also point out the similarities in all phases of the pilot's visual task.

PILOT SITUATION		VISUAL TASK	LIGHTING CONDITION
(A) BRIEFING	Carrier	Read Notices-Blackboard TV-Weather, Notes on Mission-Select Maps, Radio Info. Notation. Eat-Relax-Equip.Check	- Dark Adaptation
	Land Base	SAME	- Normal Room Lighting
(B) PREFLIGHT	Carrier	Inspect aircraft-Sign-off Sheet-Stores Check-Equip. Check	- Reduced lighting Must make personal effort to avoid destroying dark adaptation or wear (not normally) red goggles.
	Land Base	SAME	- No dark adaptation. Technique other than red lens flash.

PILOT SITUATION		VISUAL TASK	LIGHTING CONDITION
(C) COCKPIT CHECKOUT	Carrier	Seat Check & Strap-in Console Check-Plane Captain-Instruments, Ext. & Int. Lts. Set-Start A/C.	- Must use care to avoid outside lights of other A/C. Int. lts. set as desired. Red lens flash-personal gear.
	Land Base	SAME	- Same, except for lights-very bright on hangers, tow carts & taxi lts. of other A/C moving in area.
(D) TAXI	Carrier	Watch plane directors, other A/C deck lights-guide lights, personnel on deck-equip. on deck. Some signals require radio transmission.	- Deck lighting Lo-level red. Plane director's lighted wands.
	Land Base	Ramp area traffic-Taxiway Plane Director-Plane Captain Other A/C & vehicles in area.	- No lighting precautions. Blue light-Taxiway No apparent standardization of runways - Intersection & turnoffs poor.
(E) TAKE-OFF	Carrier	Plane Capt. Launch Officer Flight Inst., Eng. Inst., Gyro.	- Normal sky cond. Not applicable as pilot looks at gyro-I.F.R. immediately after launch.
	Land Base	Radio check-Other A/C taxiing area-Eng. & flight inst. Runway-other A/C in area airborne.	- Runway lights. Horiz. sky contrast conditions-Inst. flight not always required at night.

PILOT SITUATION	VISUAL TASK	LIGHTING CONDITION
(F) CLIMB OUT (To heading & alt. assigned or local pattern) — Carrier	Flight Inst.-Utility Sys. Eng. Inst. - Other A/C radio freq. shift.	- Sky conditions. Ext. lights preset - period where adj. to int.lts.may be made.
Land Base	Flight Inst.-Nav. Inst.-Utility-Other A/C in area-Radio freq.	- More concerned with A/C in area. Scan will be more frequent. To make visual check here.
(G) CRUISE — Carrier	Flight Inst.-Nav. Inst.-Eng. Inst.-Radio-Scan outside other A/C traffic. Radar is energized. Normal scan Out-In-Alert.	- Anti-collision off. Ext. lts. as sky cond. dictates. Int. lts. as desired.
Land Base	Flight Inst.-Nav. Inst.-Eng. Inst.-Radio scan of in & out more frequent other A/C traffic-If no radar, will fly segment flight.	Anti-Collision on, except sect. flight. Sky condition dictates Ext. lts. setup & usually Int.lts. reqmt.



PILOT SITUATION		VISUAL TASK	LIGHTING CONDITION
(I) LAND	Carrier	CCA Control-Nav.-Flight Inst.-Radio-Other A/C-Detect. of carrier hdg. Glidescope-Meatball-Drop lights Indexer-Gyro-Meatball.	- Drop lights & general carrier lt. vary - Mirror or Fresnal lens.
	Land Base	Same, except no drop lights & unless on FMLP, no mirror or Fresnal lens.	- Other A/C in area more concern.
(J) TAXI	Carrier	Plane Director - Signalman. Same as Taxi for Take-off.	- Lo level red floods, lighted wands.
	Land Base	Same as taxi for Take-off.	- Blue taxi lts., white runways, flood & spot lts.

2. Ready Room Activities

Identification and description of the visual tasks in the ready room are essential in understanding the duties of the pilot. The briefing session is a prime factor in establishing the highest possible confidence level in the pilot. In the briefing the majority of the planning and operational procedures are reviewed, questioned and resolved. Lectures on safety, training and flight syllabi are presented. Pilots here formulate any tactics which are to be executed in the projected mission.

Carrier Ready Room activities are essentially the same, except for the dark adaptation requirements, which are not required on land bases. Night training flights which originate during the twilight hours generally permit the preflight inspection to be held in daylight so that any pre-conditioning would be a wasted effort. The transition to complete darkness usually takes place so slowly as to allow a natural state of dark adaptation to be acquired during the flight.

Most of the pilot stimulation in the ready room is auditory. Vision plays a secondary role, with the exception of reading charts and transcribing the data necessary for the upcoming mission. The atmosphere might best be described as an easy, relaxed, informal gathering of professionals with a common purpose. This has the effect of stimulating the confidence of the crews. Pilot and crew members continually check one another informally during this briefing so there is little chance that an important time, frequency, or position coordinate could be missed. This atmosphere was apparent during all briefings attended by the team, regardless of the mission or time.

3. Preflight

Preflight consists of a basic inspection of the exterior of the aircraft and, to the extent required, a checkout of the control surfaces, landing gear, tanks and stores. Carrier and land based preflight tasks are similar.

Approximately half of the pilots interviewed and observed in the preflight task use clear lens flashlights; the others use a standard red lens flashlight. Occasionally a screwdriver is obtained from a plane captain to verify a panel fastener secured or door properly closed.

The average time involved, from all observations, is 12 minutes, and the procedure in NATOPS manual is generally followed for all aircraft types. The time and manner in which the checkout is made varies from pilot to pilot and from aircraft to aircraft. This variation indicates the pilot's confidence level in his aircraft and crew.

The pilot is aware of the extremely bright floodlights mounted on the hanger. The comments concerning these lights were: "You just have to get used to them--just don't look directly at them." The floodlights are distracting when bringing aircraft in to park; however, they are necessary, not only to park the aircraft, but for service and maintenance personnel and to allow traffic to move about safely.

An example of a walk-around diagram for a preflight of an F-4B is given in Figure 13. The pilots are generally accompanied by the R.I.O. They start in a position by the ladder and move to area as designated below:

(a) ① The inspection of this area involves a good visual check of the nose gear and wheel well and takes approximately 1/2 to 1 minute; another 1/2 minute is given to a check of the radome area, probe vents and condition of the radome itself.

(b) ② Ducts and doors are inspected, including a good look down the intake area with the flashlight; the average time is 1/2 minute.

(c) ③ The wing condition is observed by both sight and feel, the fold area and all control surfaces occupying another 1/2 minute.

(d) ④ A pause at the wing tip where lights are checked and condition of the wing is given a good visual check. Both upper and lower surfaces are viewed with the aid of a flashlight. Wing condition check involves a visual as well as what some pilots refer to as a shake test. Time is about 1/2 minute.

(e) ⑤ The particular route followed by the pilots varies and the sequence differs, but in general all pilots check the main gear and wells when looking over the external stores. The check at this point involves about 1-1/2 minutes, and much more extensive use of the flashlight in close quarters. The answer given by pilots to the question, "Why clear flashlight rather than red?", was in most cases: "Hydraulic fluid not immediately evident under red lens flashlight, especially on a clear surface".

(f) ⑥ The centerline tank and lower section of the aircraft follows. This involves another 1/2 minute, with the pilot looking for doors secured, the drains dry and all reservoirs full.

(g) ⑦ Another 1/2 minute is involved in the engine exhaust visual check. It is apparent that in this area the red light is inadequate for a thorough visual inspection.

(h) ⑧ The stabilizer and rudder inspection requires another 1/2 minute. Particular attention is paid to freedom of movement of the horizontal stabilizer. The exterior lights are not operationally checked at this point.

(i) ⑨ The drag chute area and rudder is given a visual inspection, with some attention being paid to tail hook area. Approximate time involved is 1/2 minute.

(j) ⑩ The stabilizer on the left side is checked in the same manner, with the time being approximately 1/2 minute. If some flaw is noted, then the crew is called, and as much time as necessary is taken to correct the difficulty. This may be the reason that the pilots head out to the aircraft 30 to 40 minutes before flight time.

(k) ⑪ The left engine exhaust area requires another 1/2 minute to check auxiliary doors and access doors. Note: Most preflight items are visible, requiring no doors to be opened. The more rigorous inspection and checks are usually held prior to an aircraft's being placed in an "up status". Note here that the Ready Room, as well as the Maintenance Shop, posts the reason for aircraft being down so that pilots and operations know the status. This serves to expedite scheduling, as well as to instill confidence in pilots, for they may then satisfy themselves concerning any discrepancy and remove that sense of, "Were the repairs made correctly?"

(l) ⑫ The left main gear and underside of the aircraft are checked in the same manner as the right side, and this check consumes approximately 1-1/2 minutes.

(m) (13) The control surfaces are visually and physically inspected as the pilot walks around the wing. Time consumed is approximately 1/2 minute.

(n) (14) The left wing is inspected in the same manner as the right wing and requires another 1/2 minute.

(o) (15) Leading edge of the left wing requires the same amount of time as the right wing--another 1/2 minute.

(p) (16) The last preflight check takes place at the left engine inlet ramp area and involves approximately 1/2 minute.

The summary of these tasks shows approximately 12 minutes average time, with exposure to 12-14 ft. lamberts brightness in the pilot's average visual task. Most of the land based preflights of this squadron at Oceana, take place in semi-dusk condition, with flashlight being required on the underside of the aircraft. The pilots of land based aircraft do not attempt to dark adapt, but at the same time avoid looking directly at high intensity lighting of other aircraft, carts and the hangar area. Some squadrons, such as ASW and Air/Sea rescue teams did utilize dark adaptation techniques.

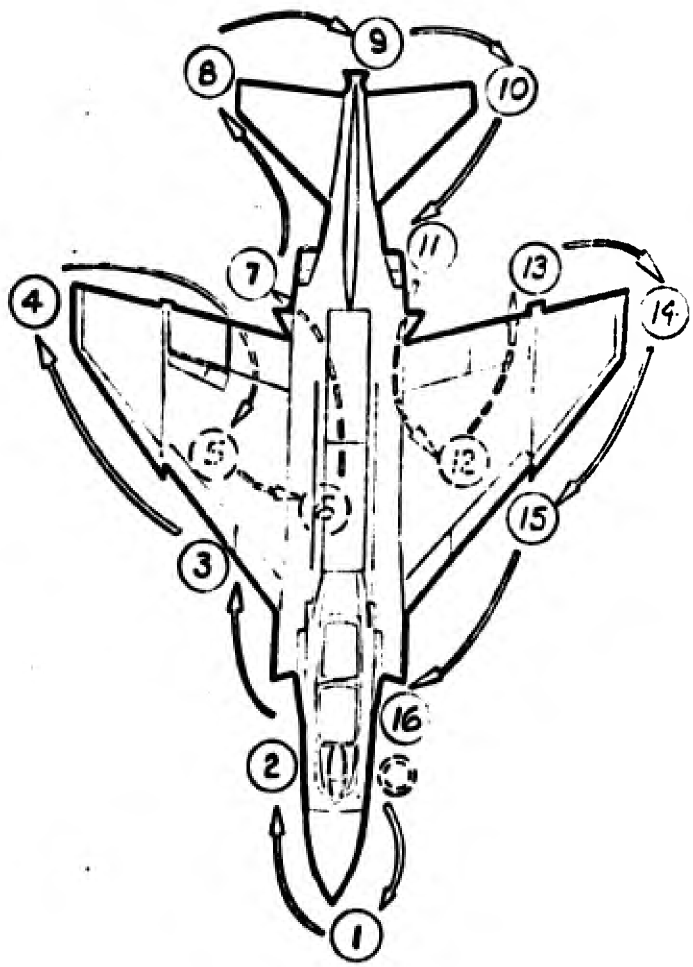


FIGURE 13

TYPICAL PROCEDURE FOR PREFLIGHT

4. **Interior Checks**

There are no noted deviations from NAVAIR procedures, although the sequence was rapid and encompassed many tasks at one time. The interior checks are listed in the handbook for each aircraft and are quite extensive. For example, the F-4 lists 135 items for pilot alone. These items, according to the experienced pilots, are all quite similar for jet aircraft.

During the entry into the cockpit, the pilot is normally accompanied by the plane captain. While the "strap-in" is in process, the pilot is checking the console control panels for handle and switch positions. The handbook procedures do not indicate what lighting system is to be used during these checks. At this point, external power is available on the aircraft, but there are approximately 65 items to be checked before external power is selected. In normal night flight preparation the plane captain holds a red flashlight to assist the pilot in finding the necessary equipment within the cockpit. Note: No pilots interviewed indicated that they carried more than one flashlight. The majority of these carried standard Boy Scout type, right angle head with clip.

The strap-in procedure is usually a simple one, with the plane captain assisting the pilot. The inspection of the seat seemed to occupy more of the pilot's attention than any other preflight check.

During this procedure the pilots use a scan pattern, starting at the aft left console and continuing slowly around the cockpit to the aft right console. Here they preset their interior and exterior lights to their personal preference and then switch on external power.

The interior light level setting is, in almost every case, what the pilot personally desires, based on his experience, familiarity with the aircraft field lighting and the flight plan. Very few pilots indicated, nor did the tape show; that a setting was made for preflight and then changed for the take-off. I.F.R. flights were no different than V.F.R. flights in this regard. Pilots indicated that the carrier settings for interior lights are usually higher than land based flights. This is understandable in that the first 30 seconds of carrier launch flights are "full on" gyro, airspeed and altimeter, even on a clear night. The primary job on carrier launch is "get in the air, climb and acquire heading, then worry about other aircraft in the area and seeing outside the cockpit."

B. Questionnaire Results

A summary of the questionnaires is presented in this section. A more detailed summary may be found in Appendix C.

The majority of the questionnaires were completed by experienced pilots operating current types of Navy aircraft.

The questionnaires were separated by aircraft types and the answers reviewed by subjects of interest predominating, as follows: Taxiway lighting, carrier lighting, inflight refueling, most severe visual task, lighting problems in the cockpit, insufficiently lighted instruments, aircraft exterior lighting, caution-warning lights, reflection, kneeboard lights, gunsights, and carrier landings.

Land Based Taxiway Lighting. Fourteen out of twenty-eight pilots of the A-4 responded with inputs such as: Five felt blue taxi lights inadequate; 3 found the curved and angled taxiways confusing due to spacing, 2 mentioned the unsatisfactory intersections, 2 mentioned the large gaps in taxiway lights, and 2 felt very strongly about the excess of white lights around the hangar areas. This approximate proportion was spread throughout all types of aircraft. Helicopter, patrol and reconnaissance pilots felt more strongly about excess of white lights. Twelve of 44 helicopter pilots stated excess white lights were dangerous and distracting.

Carrier Deck Lighting. Answers indicate that pilots desire white or red flood on deck. Also on forward and cat areas. Of the 28 A-4 pilots, 7 - white flood the deck; 5 - red flood the deck; and 8 - light the forward area. On drop lights for line up, standard comment was, "It has solved my line up problem." It was noted that of 28 RA-5C pilots, 9 expressed a preference for white floods and 4 for red floods. Of 44 helicopter pilots, 4 preferred white floods and 9 red floods. The helicopter pilot has the problem of picking up the LSE in the landing pad area, rather than the LSO. The "update and standardize" comment occurred only 3 times out of 226, while 23 of 226 noted "light the forward area."

Inflight Refueling. Many inputs centered around the basket and probe with 18 of 226 suggesting "outline the tanker aircraft," 48 comments on lighting basket and probe from receiver aircraft, and 13 (10 of which were A-4 pilots) wanted the hose lighted also. This indicates a need for determining the relative motion and closure rate in the last few feet of join-up during inflight refueling.

Most Severe Visual Task During Night Carrier Landing. A majority of the pilots answered that "line up" was the most severe visual task performed during night carrier landing; however, many commented that "centerline drop lights have solved the problem of line up." Pilots answering "line up" are as follows: On the A-4, 11 of 28; EA-1F, 7 of 16; F-8, 3 of 8, RA-5C, 16 of 28; and S-2, 7 of 21. Surprisingly, 12 of 44 helicopter pilots indicated "line up." Flying the ball and the shift from a static cockpit environment to a dynamic environment (IFR to VFR) were listed by other pilots.

Lighting Problems in the Cockpit. Reflections on windshield and canopies was the most severe problem listed by pilots as follows: A-4, 10 of 28; A-6, 6 of 12; RA-5C, 12 of 28; and helicopter, 21 of 44. If the pilot sets the instrument lighting at a comfortable level (to see the instruments), this light is reflected on the windshield and canopy. Therefore, he must compromise because he must be able to see outside as well as inside the aircraft. RA-5C, P-3, P-2 and helicopter pilots also listed non-uniformity and unequal intensity of instrument lighting.

Instruments Insufficiently Lighted. Numerous instruments were mentioned. The outstanding ones are listed here by aircraft types. DME (TACAN): 6 A-4 pilots, 6 EA-1F pilots, 10 P-3 and P-2 pilots, and 5 (for location, not light) RA-5C pilots. The other most frequent instrument noted was radio channel readouts, where a remote indicator was not used. Thirteen RA-5C pilots mentioned fuel totalizer counters.

Aircraft Exterior Lighting. This produced many similar comments expressing the desire for recognition at a greater distance. Strobe lights, as on commercial jets, were frequently noted; also the need for more than one light so the pilot can tell "aircraft attitude and direction." Many suggestions on this subject centered around the need to see. "Need relative motion cue" was common from helicopter pilots.

Console Lighting. Most felt that console lighting produced reflections. F-8, P-3, P-2, S-2 and helicopters have inadequate lighting or counters are not lighted sufficiently.

Caution and Warning Lights. This category received the most singular response of any one subject. Pilots of aircraft with Master Caution systems felt that warning lights also needed dimming; and some aircraft types require more dimming capability for all warning and caution lights. Others felt the warning and caution lights should be grouped. Many pilots carry tape whenever scheduled for night operations.

Kneeboard Lights. The most frequent comment was "No good." The pilots want a good light in the cockpit.

Numerous categorizations and many methods of analysis could be performed on the questionnaires in hand and enroute. These will be kept available as a base for any future programs.

It would appear that pilots are highly adaptable professionals who can get used to almost anything. Many times the reply, "It's not right but you learn to live with it," comes up, both on the questionnaire and in personal interview.

If the pilot's visual task is going to be alleviated, and the writers feel it should be, bothersome, distracting, and unnecessary visual stimuli should be eliminated. There is no visual task in total darkness. Illumination is the key to efficient visual interpretation at night. Deceiving, bothersome, and ambiguous illumination must be eliminated as much as possible from the pilot's environment.

The summary of the questionnaires and the insight gained from a thorough review indicates that the severity of the visual task is directly related to the proximity of the aircraft to the ground or adjacent aircraft. This was verified by the repeated and consistent inputs during the interviews where the pilots emphasized the "need" to see an external point or object. The inflight monitoring confirmed this observation. The majority of the inflight changes occurred in those periods where the external targets were to become more and more important. The lowering of the inside light setting as the external light level dropped is very simply a result of the pilot becoming dark adapted. He is attempting to maintain his maximum visual acuity.

C. Recorded Information

The instrumentation, the de-briefings and the photometric measurements allowed the compilation of information to be made in the following order:

1. Flight No. 1
2. Flight No. 2
3. Flight No. 3
4. Flight No. 4
5. Photometric Measurements and observations.

1. Flight No. 1 - Date: Monday, 27 February 1967
Aircraft: F-4B (151503)
Questionnaire: Previously completed
Pilot: Lt(JG) Skinner, Hours - Day 360, Night 60
RIO: Lt(JG) Marshik, Hours - Day 290, Night 90

In discussing the aircraft lighting and the visual tasks with the pilot, the following notes were made:

The Indexer - The pilot indicated that since he kept the light level fairly high, it is easily picked up in his peripheral vision. (The tape shows that he did leave the indexer high, -16 to 18 volts.)

Airspeed Indicator - The pilot mentioned that this instrument is "poorly lighted." The measurements show the comparatively low brightness levels.

Rate of Climb Indicator - This pilot found this instrument difficult to read; observation showed it to be less brightly lighted.

Pneumatic Pressure Indicator - The pilot indicated that it is difficult to read. This particular arrangement has panel lighted instruments. The indicator is a 2 inch standard round instrument set into a panel which is lighted by five or six MS25010 type lamp assemblies. The reflections and glare of this instrument, partly due to the viewing angle, affords little contrast and as a result is difficult to read.

Right Engine Tachometer - The pilot indicated that the instrument was more difficult to read than the left tachometer, possibly due to the viewing angle as the lighting was identical.

Gyro - The pilot reported that this instrument was too bright. This was somewhat inconsistent as a majority of the pilots felt that the gyro was not bright enough. New pilots, those with relatively few hours, tend to carry the interior lights at a higher level than the experienced pilots. The explanation is that with the instruments lighting at a high level, the large area of the gyro produces considerably more light flux than the adjacent instruments. If the instruments are lighted at a lower setting of the instrument panel, then the gyro is, according to the pilots, beautifully lighted. As may be seen from the charts, this caused problems with a few of the other instruments. This lack of uniformity, as represented in Figure 24, is of no great concern to the pilot, but studies have shown that this is one of the major factors in eye fatigue. The recorder tape taken from this flight showed that

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Pneumatic Pressure Indicator - The pilot indicated that it is difficult to read. This particular arrangement has panel lighted instruments. The indicator is a 2 inch standard round instrument set into a panel which is lighted by five or six MS25010 type lamp assemblies. The reflections and glare of this instrument, partly due to the viewing angle, affords little contrast and as a result is difficult to read.

Right Engine Tachometer - The pilot indicated that the instrument was more difficult to read than the left tachometer, possibly due to the viewing angle as the lighting was identical.

Gyro - The pilot reported that this instrument was too bright. This was somewhat inconsistent as a majority of the pilots felt that the gyro was not bright enough. New pilots, those with relatively few hours, tend to carry the interior lights at a higher level than the experienced pilots. The explanation is that with the instruments lighting at a high level, the large area of the gyro produces considerably more light flux than the adjacent instruments. If the instruments are lighted at a lower setting of the instrument panel, then the gyro is, according to the pilots, beautifully lighted. As may be seen from the charts, this caused problems with a few of the other instruments. This lack of uniformity, as represented in Figure 24, is of no great concern to the pilot, but studies have shown that this is one of the major factors in eye fatigue. The recorder tape taken from this flight showed that the pilot changed his instruments lighting control from the No. 9 position to the No. 8 position. This change lowered the light flux from 3.2×10^{-3} FC to 1.6×10^{-3} FC.

Weather - There was considerable turbulence with winds up to 20 knots, scattered clouds and some haze.

Briefing - The briefing took place at 1700. The pilot had flown Monday afternoon with a night flight the preceding Thursday. The briefing required approximately 30 minutes. This particular training mission was briefed for Night Intercepts and Touch and Go landings at a simulated carrier landing field.

Preflight - The preflight checkout procedure averaged 12 minutes with the cockpit check consuming another 6 minutes. This pilot set his instrument and console lights at the No. 9 position for his cockpit check, taxi and take-off. The indexer rheostat was left at 16-17 volts (approximately .0002 FC).

The Flight -

1912 - The recorder is turned on. Approximately 2 minutes after leaving the run-up area, the aircraft is airborne. Five seconds after lift-off the pilot has brought the gear up. As he started the take-off run, the forward sensor registered .01 ft. lamberts, the left sensor .01 ft. lamberts, and the right sensor, very low, .005. The hangars are located to the left in this take-off.

1915 - During the lift-off the pilot's attention is primarily on the instruments with quick scans out to the left, forward and right. The interviews later established the concern of the pilots for traffic at this field (Oceana). Immediately after lift off with nose high attitude, the pilot's attention is "on the gages" with the outside light level dropping to very low level (approximately .005 ft.lamberts).

1916 - During the climb the scan pattern is being maintained. The pilot is under Air Control during this phase and must fly the prescribed course. The pattern of teamwork is evident here as the RIO is functioning as the eyes of the pilot in that he too makes frequent scans outside the aircraft.

1918 - Reduced the setting of the instrument lighting to Position No. 7. The pilot reached his cruise altitude and proceeded with the pre-planned heading.

1920 - The left sensor is showing approximately .007 ft.lamberts with the right sensor at .001 ft. lamberts and the left sensor almost 0 ft.lamberts.

1930 - The orbiting period was completed and the pilot headed for the FMLP area. The scan pattern is frequent and is reported as being rapid during turns and whenever traffic is suspected in the area.

1934 - A series of "Touch and Go" landings was made. The pilot reported that due to the wind conditions, he was holding "Fast to slightly Fast" on the approach. The first landing was a wave-off with long outside scan in the forward direction. The RIO is calling airspeed and altitude on this particular flight. The average time for the go-around was 3-1/2 minutes. The pilot was "on the ball" for 48 seconds. The average time "on the ball" is 30 seconds.

1953 - A "hot fuel turn around" was made and the second section of this flight was aborted shortly after take-off due to the wind conditions.

Note that night recoveries will normally be affected in the same manner as an instrument flight. All night landings on an actual carrier will be Carrier Controlled Approaches (CCA). This "round the race track" pattern is established due to the field location and traffic. The last 2 to 3 miles are the critical periods of the landing and, as a result, this pattern is satisfactory for carrier simulation.

2. Flight No. 2 - Date: Tuesday, 28 February 1967
Aircraft: F-4B (151503) (No APC System)
Questionnaires: Pilot indicated completed.
Pilot: Lt. Cdr. Colgan, Ops Officer, Hours 3500 Day, 600 Night.
RIO: Lt. Lance De St. Croix, Hours - 600 Day, 150 Night

This flight was briefed at 1700 for 1815 takeoff. The scheduled flight involved serving as the target for intercept aircraft, six touch and go night landings, a hot fuel turnaround and six more touch and go landings. Tape was not obtained on this flight. The report of this flight is based entirely on a briefing and debriefing by the pilot and RIO.

This pilot utilized a red flashlight and approximately 10 minutes for preflighting the aircraft. The RIO assisting in this responsibility no doubt increased the speed with which checks were made.

The flight started at 1840, with night touch and go's commencing at 1931. The flight ended at 20:55. Weather: Clear, 10 knot wind, scattered clouds, moon low in sky, some haze. Sunset at 18:57. Temperature 47° with 15-30 knot gusts.

The "FENTRAS" carrier simulated landing field is shown in Figure 14. This simulated field represents the actual approach as shown in Figure 15. The shaded area shows the pilot external scan pattern as taken from notes of debriefing immediately after landing. Figure 16 represents the card containing visual signals required on this CVA type carrier.

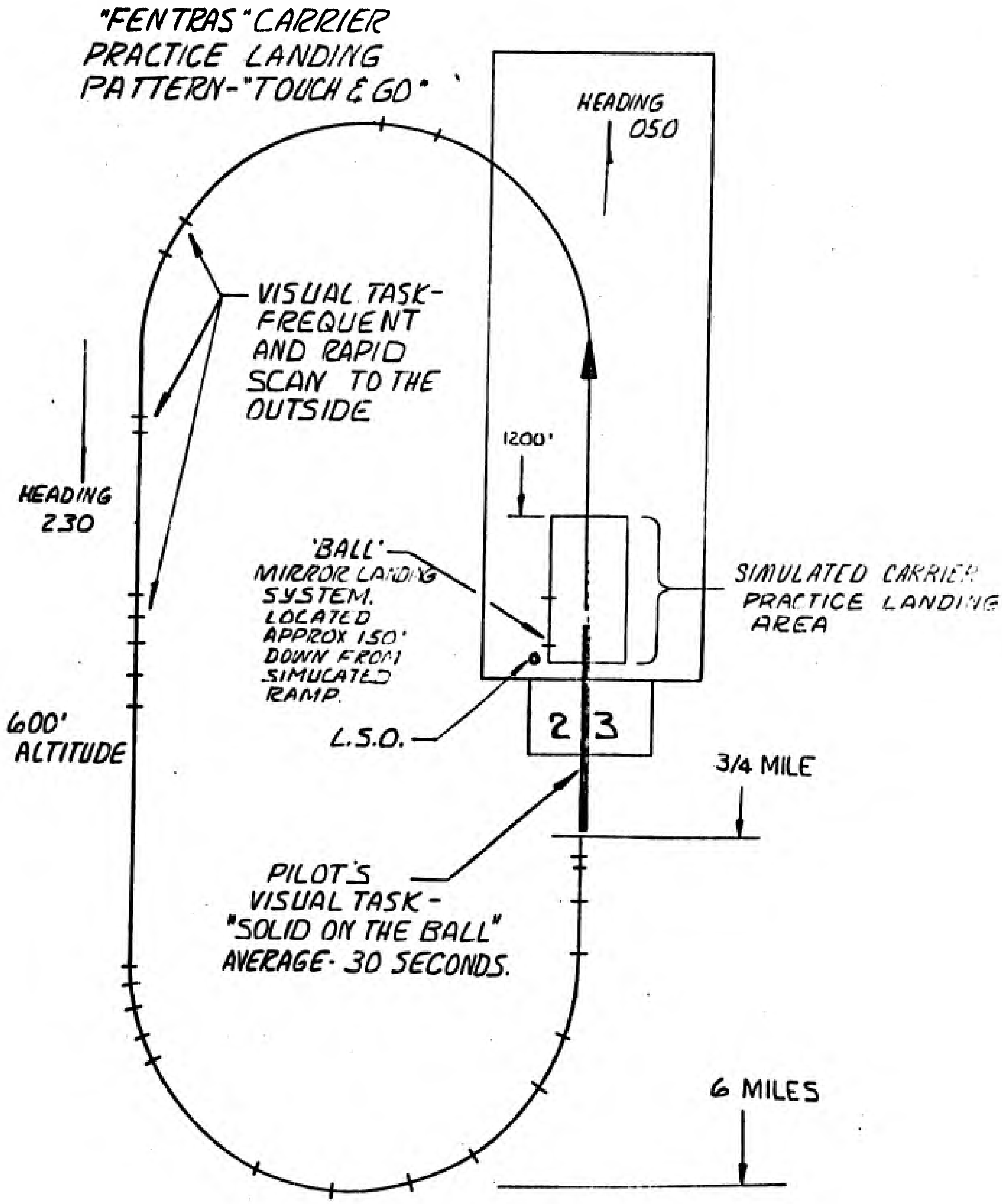

FIGURE NO. 14

SIMULATED CARRIER LANDING PATTERN

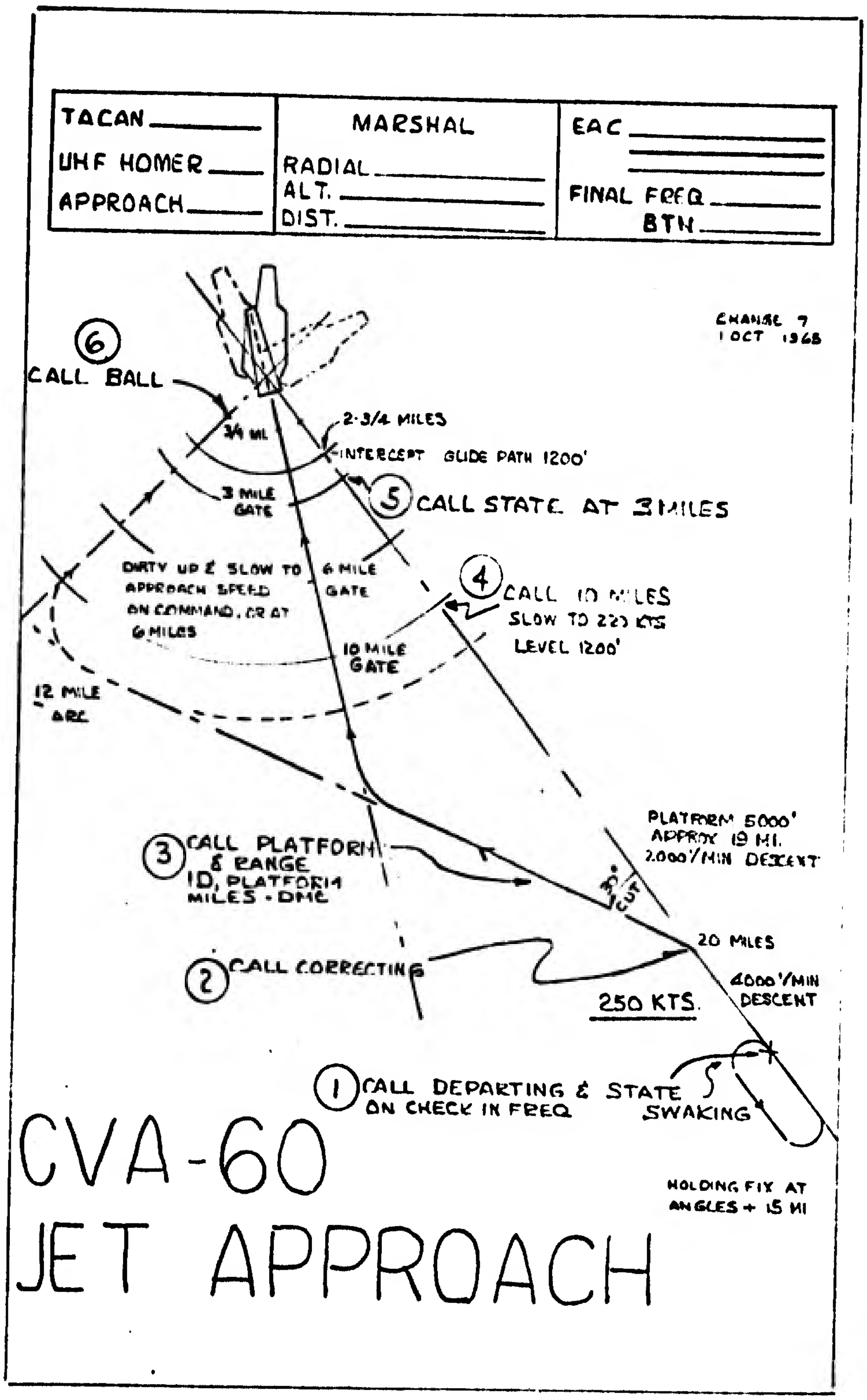

FIGURE NO. 15

TYPICAL 'APPROACH PLATE' CARD FOR JET NIGHT CARRIER LANDING

LOST COMMUNICATIONS VISUAL SIGNALS
(Reverse Side of Approach Plate)

AIRCRAFT TO SHIP SIGNALS

IMMEDIATE LANDING REQUIRED

DAY: Fly close aboard the PORT side of the ship landing configuration, hook DOWN, rocking wings and/or rock wings from 45° position until groove.

NIGHT: Same, with A/C lights BRT/STDY and short flashes on the taxi light (anti-collision light OUT). If on an approach, flash taxi light between 3 and 1-1/2 miles astern. Flash nav. lights if taxi light is out.

DELAYED LANDING: (Cannot complete mission, will land at scheduled recovery time.)

DAY: Fly close aboard PORT side of ship, clean config., hook DOWN, rocking wings.

NIGHT: Same, with lights BRT/FLASH. Anti-collision light on. Orbit overhead at 2000'.

BINGOING TO BEACH:

DAY: Fly close aboard PORT side, clean config., hook UP, rocking wings. If a launch is not in progress, make a starboard 90° turn across the bow ahead of the ship, then turn to the proper Bingo heading.

NIGHT: Same, with lights BRT/STDY, anti-collision light OUT.

SHIP TO AIRCRAFT SIGNALS.

1. Blinking green light from tower or flashing cut lights from LSO. Runway lights on.	Burn down to land.
2. Blinking red waveoff lights or red flares from LSO.	Maximum conserve, stay within vis. dist. of ship.
3. Runway lights out with center line lights on or off.	Closed deck.
4. Flashing green cut and red wave off lights on mirror.	Aircraft in groove proceed to divert field.
5. Steady 3 second cut lights or ALDIS lamp.	LSO has acknowledged positive control of A/C.

FIGURE 16.
LOST COMMUNICATIONS VISUAL SIGNALS

The scan pattern of this more experienced pilot was as reported at the last leg of the landing pattern to be primarily on the ball, at 600 ft. altitude with his scan pattern inside the aircraft covering airspeed, altitude, approach indexer and angle of attack indicated.

During the debriefing, this pilot commented on the susceptibility of pilots to vertigo induced by anticollision light, especially in the "clag." (Sky condition affecting visibility from aircraft lights, i.e. haze, fog, etc.) Notation from this interview: During the final phase of landing, "Watch the ball all the way in" seems to be a rule inviolate. One experienced pilot indicated that, "every landing should come as a surprise," meaning the pilot should have no clue as to the moment the hook engages since he has not been watching the deck, but has had his eyes on meatball and lineup. With the APC system there is no reason to watch the airspeed. If proper glide slope is acquired and aircraft attitude is correct, the aircraft will pick up the wire every time. During the debriefing, the following comments were made by the pilot, "Reflections are just something you have to get used to and are not distracting except on the blackest of nights, at which time you should have interior lights down, thereby reducing the reflections.

"On the occasions when I needed the instrument floods, they were inadequate for lighting the most needed instrument, the gyro.

"One thing that does bother me is the leakage around the gunsight, coming from the radar projection . . . . I blank it out with a piece of tape, or whatever is handy.

"Cat shot is one place where you must protect your eyes, especially from the plane in front. An A/B takeoff from the plane in front is a pretty high intensity light until he is away. I'm on gyro airspeed and altitude indicator anyway so I don't look."

3. <u>Flight No. 3</u> - Date: Wednesday, 1 March 1967
Aircraft: F-4B (151503)
Questionnaires: Previously completed
Pilot: Lt. Oakes, Hours - Day 1500, Night 200
RIO: Ens. Clayton, Hours - Day 200, Night 40

The interview revealed 48 hours since this pilot's last night flight. This flight was scheduled for VFR night intercepts with touch and go night bounces to follow.

The standard pre-flight strap-in and cockpit check was made. This pilot utilized a standard Navy flashlight (clear lens). The interior lights were set to his preference. Tape showed instruments set at Position No. 6 and console at No. 10.

NOTE: Position settings of autotransformer indicate relative settings: 0 - Off; 1, 2, 3, ... 10 (maximum).

The taxi lights were utilized even though the time was 1845 and still light. It was indicated that the lights were used "more to fill dark voids on the taxi strip" as the result of twilight conditions.

Weather: exceptionally clear, 20 mile visibility, winds 10 to 15 knots.

1940 - The recorder was turned on approximately 1 minute before takeoff. Primary attention was outside on the takeoff run except for scanning airspeed and engine instruments.

1943 - Takeoff was accomplished.

1950 - During climb-out the pilot almost constantly looked outside the aircraft except for checks on airspeed, engine instruments and wheels and flaps. (Two aircraft were on this mission with anti-collision lights turned on.)

1955 - The cruise was accomplished with the pilot's attention outside the aircraft most of the time. Instrument lights were set to Position 7 (reported) and the console to Position 4 or 5. The floods were on dim with the radar scope turned all the way down.

2011 - The tactical training mission, intercepts, was carried out with the pilot reportedly looking outside most of the time. The tape shows infrequent scans outside.

2019 - Intercept was made with the second aircraft flying closely alongside for about 1 minute. The anticollision light was operating. The pilot was scanning outside.

2033 - The final intercept was completed. The RIO reported that if the switch were under the left foot, he would have been able to maintain a better record. In reality, the switch could only be engaged when the RIO was free of his normal duties.

2050 - The pilot was vectored to the marshalling point and made 7 touch and go landings. He returned to the field for a hot fuel turn-around and made 7 more touch and go landings.

2057 - The pilot adjusted indexer rheostat to the desired level. The pilot averages 30 seconds on the ball on almost every touch and go landing.

2102 - The pilot adjusted the indexer rheostat to approximately the No. 6 position after the touch and go's.

2112 - The time on the ball has steadily risen to 50 seconds. This is in part due to the clarity of the night and earlier acquisition of the ball.

2148 - The second series of touch and go landings was started.

2155 - The instruments are positioned in the No. 7 position with the consoles full bright. The indexer position is unchanged.

2217 - This flight was secured.

4. Flight No. 4 - Date: Thursday, 2 March 1967
Aircraft: F-4B (151503
Questionnaires: Previously completed.
Pilot: Lt. Skinner, Hours - Day 360, Night 60
RIO: Ens. Tillman, Hours - Day 200, Night 50

The flight was scheduled for Night Intercept and night bounces (touch and go landings at carrier-simulated practice field). The preflight took 20 minutes and cockpit checkout 6 minutes. The recorder was turned on at 1830 after engine start.

The night intercept mission was scheduled for approximately one hour with carrier landing practice at 1930. The night takeoff was made under VFR conditions (twilight).

1830 - The recorder was turned on.

1833 - During the taxi to the runup area the recorder shows the pilot "outside" continuously, with the takeoff taking place at 1834. During the first few minutes in the cockpit this pilot changed the interior lights to his desired setting. Instruments were at Position 7, and the consoles at Position 7. This change occurred during the taxi period.

1839 - VFR conditions were in effect, with the pilot running the consoles up to 10 and then back to 8.

1845 - The tape shows the pilot again dropping instruments to 6 as outside light level fluctuated.

1850 - The pilot reduced the instrument and console lighting to Position 6 as light level outside slowly dropped.

1942 - During the first touch and go landing, the tape showed approximately 30 seconds on the ball.

1950 - The pilot again adjusted the instrument lighting level to Position No. 7. At the same time he increased the brightness level of the indexer to Position 5.

The second stage of the flight occurred with the consoles at 7 and instruments at 7. This was an abbreviated flight due to the failure of the auxiliary doors (14 minute flight).

2050 - The pilot secured the aircraft.

Summary of Aircraft F-4B (151503) at LSO position:

1st Wave Off 1942	Time	Elapsed Time
1st Touch & Go	19:45:26	2 min. 34 sec.
2nd Touch & Go	19:49:24	3 min. 58 sec.
3rd Touch & Go	19:53:15	3 min. 51 sec.
4th Touch & Go	19:56:44	3 min. 29 sec.
5th Touch & Go	20:00:27	3 min. 43 sec.
6th Touch & Go	20:04:16	3 min. 39 sec.

5. Photometric Measurements and Observations

In an attempt to present the data in a more readily comprehensible fashion, the following graphs were prepared. Reference to Figures 17, 18 and 19, which present the data taken from an operational F-4B (151503), must not be construed as being representative of all Fighter aircraft in the Naval service. This particular aircraft was one of twelve of this type observed and is typical of its type. For the pilot's compartment the aircraft has a lighting system for the instruments, which is 5 volt integral lighting.

Figures 20 through 25 show the general relationship of the total light flux variation as a result of the measurements taken. The instruments as a group are shown plotted against the instrument autotransformer positions, 0-10. The consoles, both left and right, are plotted along with the indexer. These plots represent the instruments when read with no other lighting present. No attempt was made to show the interrelationship of the infinite combinations. Justification may be made by the input from the pilots that "the instrument lighting is the primary concern - consoles are secondary" and the pilot is little concerned with being able to read a particular switch. He will be able to reach and know where to place the switch by feel. This is typical of fighter pilots and less so with other types. The opinions of the pilots showed their disregard for the console lighting other than it supplied the background for orientation and did not distract from primary visual tasks of "flying the bird." Observation of many flaws in operational aircraft supported this supposition. For example, bright spots were evident on console panels where the paint had been scratched and no effort made to correct; nomenclature is almost illegible in strong light; and other evidence of hard usage which would not be tolerated on the primary flight instruments.

NORTH AMERICAN AVIATION, INC.
COLUMBUS DIVISION
COLUMBUS 16, OHIO
NA67H-497

FIELD MEASUREMENTS (FT. LAMBERTS) A/C— F4B

INSTRUMENTS	AUTO-TRANSFORMER SETTINGS (POSITION)									
POSITION NO. →	10	9	8	7	6	5	4	3	2	1
1. ATTITUDE DIRECTOR IND. BANK POINTER	42	.31	.16	.076	.048	.024	.010	0065	—	—
2. ATTITUDE DIRECTOR IND. UPPER SPHERE	.62	45	.175	.105	.050	.022	0135	0055	—	—
3. ATTITUDE DIRECTOR IND. STEERING NEEDLE	1.15	.32	.165	.080	.040	.031	.010	0075	—	—
4. AIRSPEED INDICATOR AVERAGE TYPIFIED BY POINTER	.39	.25	.10	.065	.039	0165	0055	0022	—	—
5. BAROMETRIC ALTIMETER AVERAGE TYPIFIED BY POINTER	.71	43	.25	.125	.072	.045	.032	.015	—	—
6. HORIZONTAL SITUATION INDICATOR STEERING NEEDLE	46	.30	.13	.081	.053	.020	.010	005	—	—
7. HORIZONTAL SITUATION INDICATOR TYPICAL NUMERAL	.63	.40	.31	.114	.060	.017	005	—	—	—
8 HORIZONTAL SITUATION INDICATOR COUNTER	1.30	.76	.37	.125	.067	.025	.010	.004	—	—

FIGURE 17
INSTRUMENTS - BRIGHTNESS MEASUREMENTS

Form 351-F

NORTH AMERICAN AVIATION, INC.

COLUMBUS DIVISION
COLUMBUS 16, OHIO

NADC-AC-6803

NA67H-497

FIELD MEASUREMENTS (FT. LAMBERTS) A/C — F4B

INSTRUMENTS	AUTO-TRANSFORMER SETTINGS (POSITION)									
POSITION NO. →	10	9	8	7	6	5	4	3	2	1
9. ANGLE OF ATTACK IND. AVERAGE TYPIFIED BY POINTER	1.0	.60	.31	.17	.100	.045	.025	.014	—	—
10. FUEL FLOW INDICATOR MAJOR SCALE INDICIA BY *2	.50	.29	.19	.12	.06	.037	.025	.015	—	—
11. LEFT CONSOLE INBOARD ROW-AVERAGE READING	1.30	.81	.22	.10	.06	.03	.013	—	—	—
12. LEFT CONSOLE OUTBOARD ROW-AVERAGE READING	1.2	.62	.20	.09	.045	.027	.010	—	—	—
13. RIGHT CONSOLE INBOARD ROW-AVERAGE READING	3.0	1.1	.62	.25	.12	.05	.01	—	—	—
14. RIGHT CONSOLE OUTBOARD ROW-AVERAGE READING	2.0	1.0	.51	.22	.09	.05	.02	—	—	—
15. AVERAGE BRIGHTNESS RATIO OF THE CONSOLE 3.6 AT 28 V.	—	—	—	—	—	—	—	—	—	—
16. AVERAGE BRIGHTNESS RATIO OF THE INSTRUMENTS 24 AT 5V.	—	—	—	—	—	—	—	—	—	—

FIGURE 18

INSTRUMENTS & CONSOLES-BRIGHTNESS MEASUREMENTS

FIELD MEASUREMENTS (FT. CANDLES) A/C— F4B

ITEM	AUTO-TRANSFORMER SETTINGS (POSITION)									
POSITION NO. →	10	9	8	7	6	5	4	3	2	1
17. TOTAL INSTRUMENT PANEL	5.3×10^{-3}	3.2×10^{-3}	1.65×10^{-3}	9.6×10^{-4}	5.2×10^{-4}	3.0×10^{-4}	1.5×10^{-4}	1.0×10^{-4}	5.0×10^{-5}	3.0×10^{-5}
18. TOTAL CONSOLES LEFT AND RIGHT SIDE	$7. \times 10^{-4}$	4.5×10^{-4}	$3. \times 10^{-4}$	$2. \times 10^{-4}$	1.5×10^{-4}	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}	1.0×10^{-4}
19. ANGLE OF ATTACK INDEXER (BOTH CHEVRONS & DONUT INDICATING)	1.8×10^{-3}	$7. \times 10^{-4}$	3.2×10^{-4}	$2. \times 10^{-4}$	1.5×10^{-4}	1.2×10^{-4}	$5. \times 10^{-5}$	$4. \times 10^{-5}$	$4. \times 10^{-5}$	$3. \times 10^{-5}$
20. CONSOLE FLOODS BRIGHT—.76 F.C. MEDIUM—.087 F.C. DIM — .003 F.C.	—	—	—	—	—	—	—	—	—	—
21. (2) FIRE WARN LTS WITH INST. PANEL LIGHTS POSITIONED AS INDICATED ——	4.1×10^{-2}	3.9×10^{-2}	3.8×10^{-2}	3.7×10^{-2}	3.7×10^{-2}	3.6×10^{-2}	3.6×10^{-2}	3.6×10^{-2}	3.6×10^{-2}	3.6×10^{-2}
22. (1) MASTER CAUTION LT WITH INST PANEL LTS POSITIONED AS INDICATED ——	6.8×10^{-3}	4.7×10^{-3}	3.1×10^{-3}	2.4×10^{-3}	2.0×10^{-3}	1.8×10^{-3}	1.6×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
23. (1) WARN LT & (1) CAUTION LT WITH INST LTS POSITIONED AS INDICATED.	5.0×10^{-2}	4.8×10^{-2}	4.7×10^{-2}	4.6×10^{-2}	4.6×10^{-2}	4.5×10^{-2}	4.5×10^{-2}	4.5×10^{-2}	4.5×10^{-2}	4.5×10^{-2}
24. INDEXER ALONE — INST OFF 8×10^{-3} F.C.	—	—	—	—	—	—	—	—	—	—

FIGURE 19

LIGHT FLUX MEASUREMENTS

NADC-AC-6003

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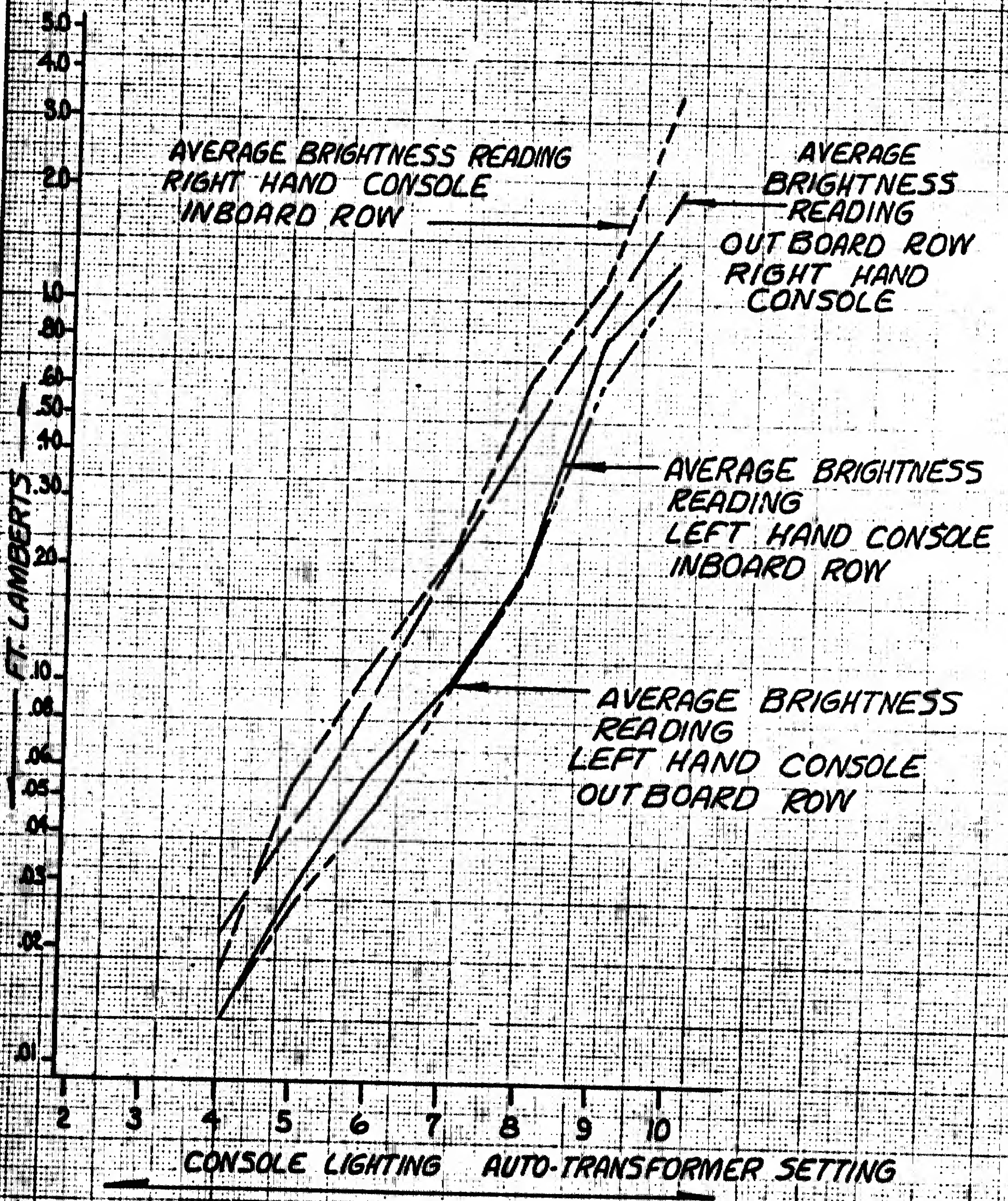

CONSOLE BRIGHTNESS CURVE

FIGURE NO. 20

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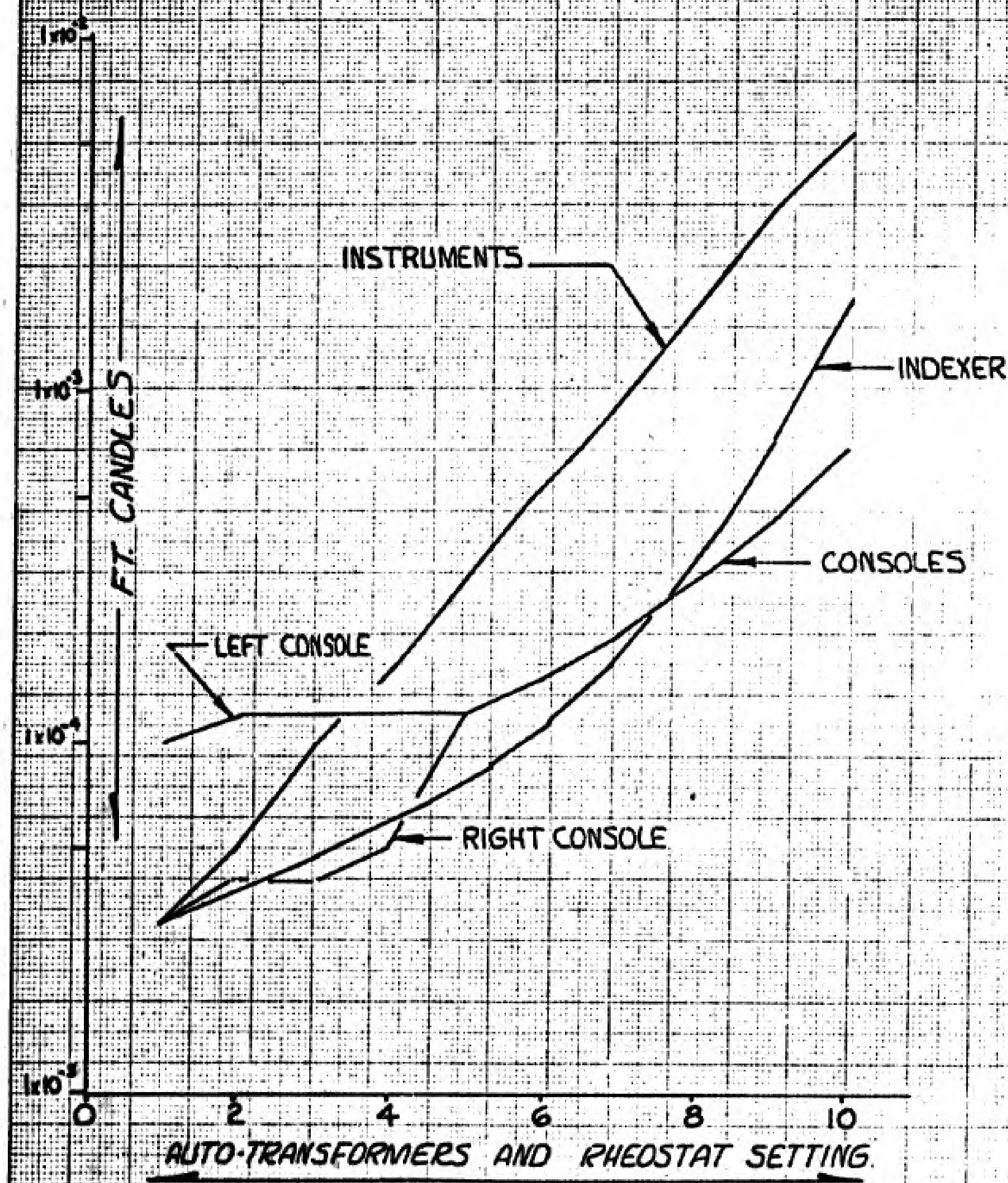

CONSOLE-INSTRUMENTS AND INDEXER LIGHT FLUX CURVE

FIGURE NO. 21

FORM 113-N-2 NADC-AL-6803

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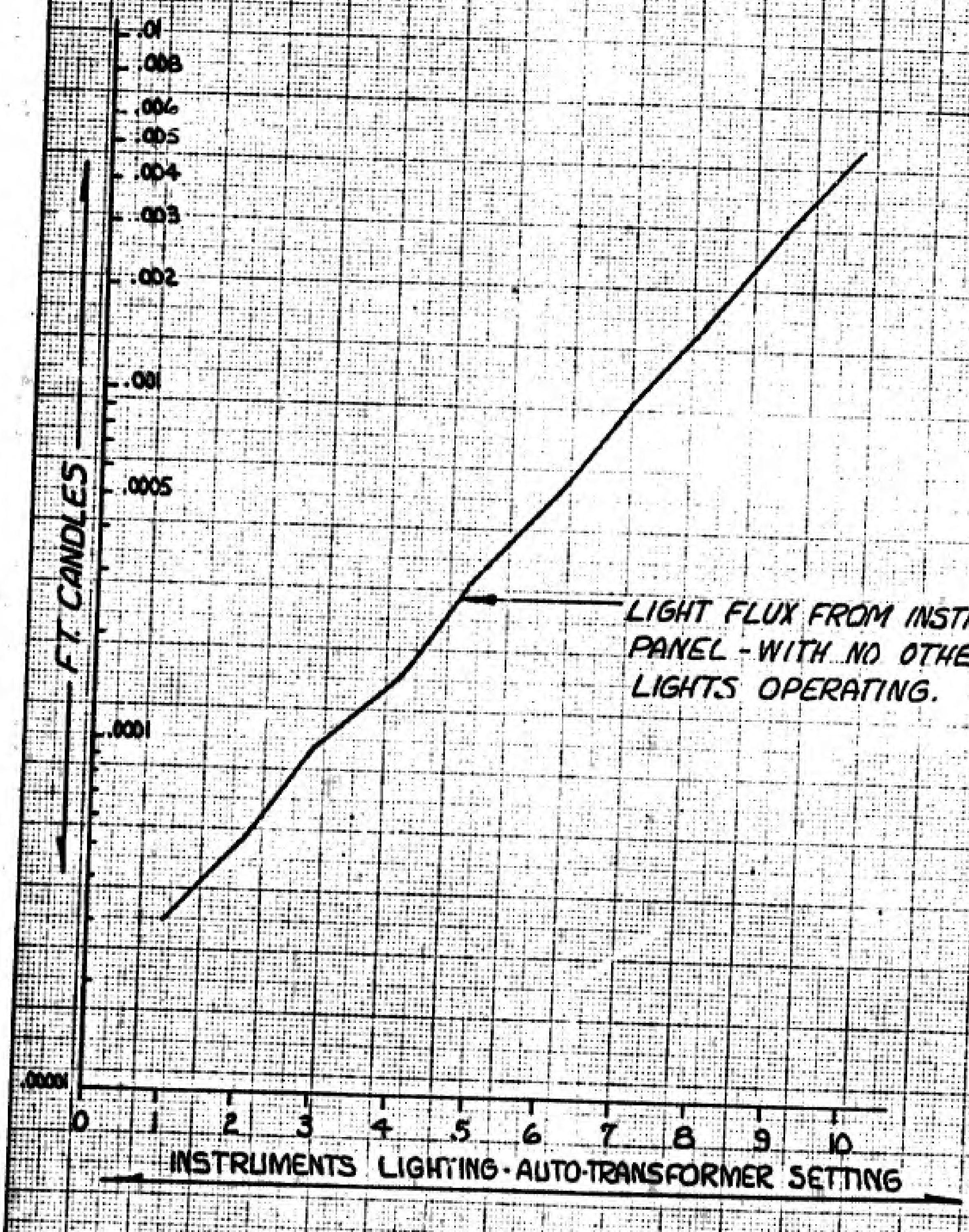

INSTRUMENTS LIGHT FLUX CURVE

FIGURE NO. 22

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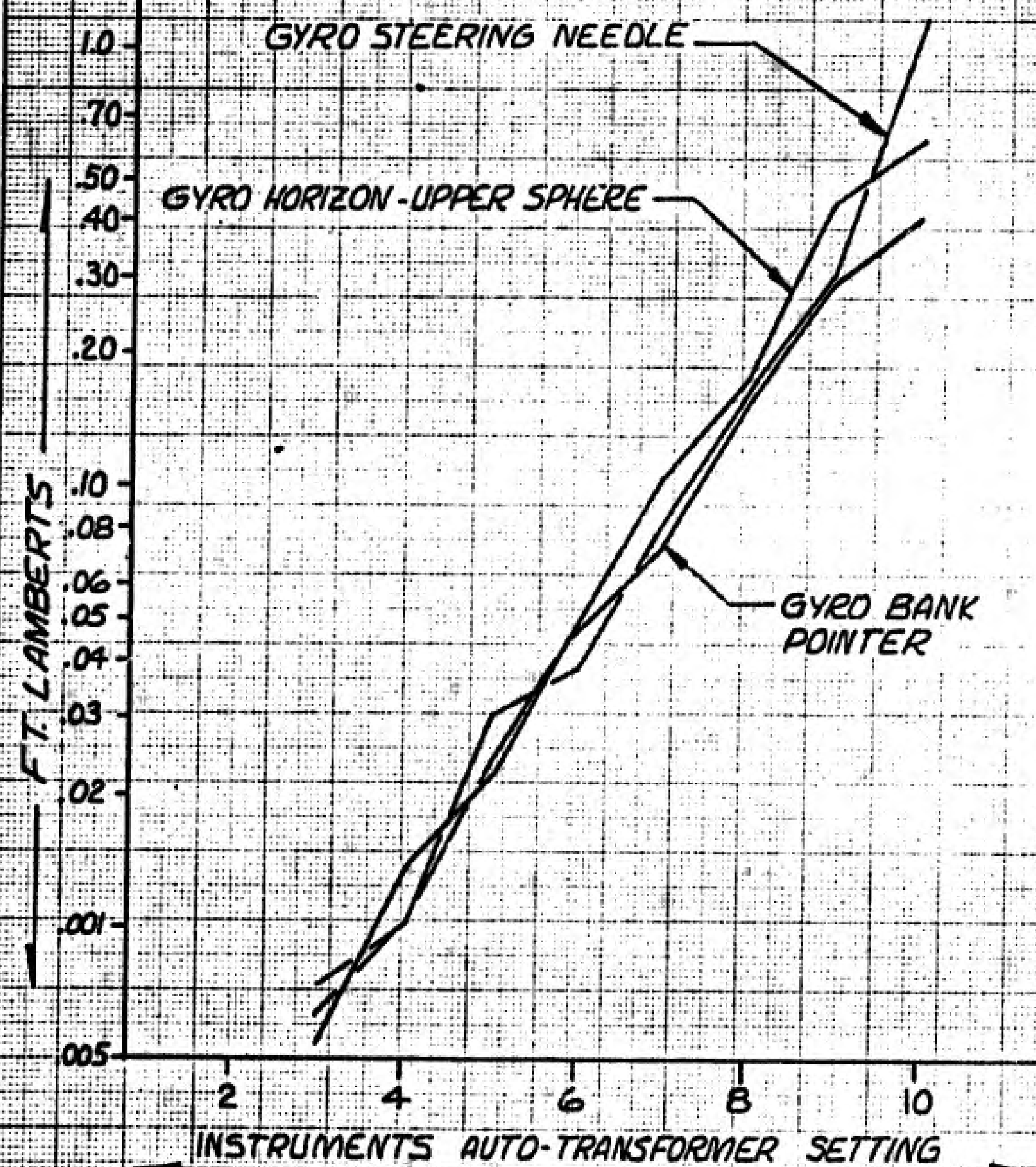

GYRO BRIGHTNESS CURVE

FIGURE NO. 23.

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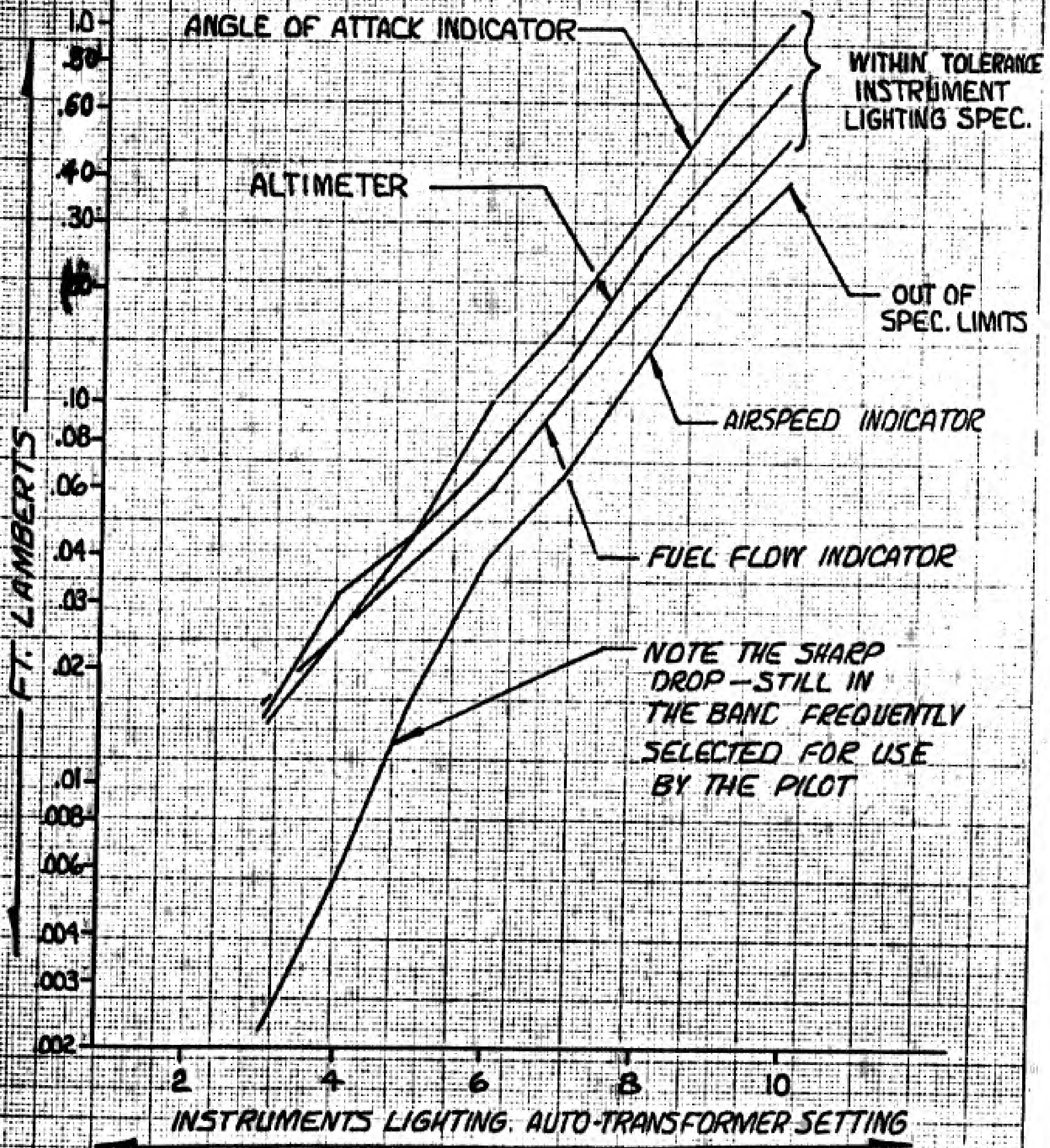
DATE:		MODEL NO.



PRIMARY FLIGHT INSTRUMENTS
BRIGHTNESS CURVE
FIGURE NO. 24

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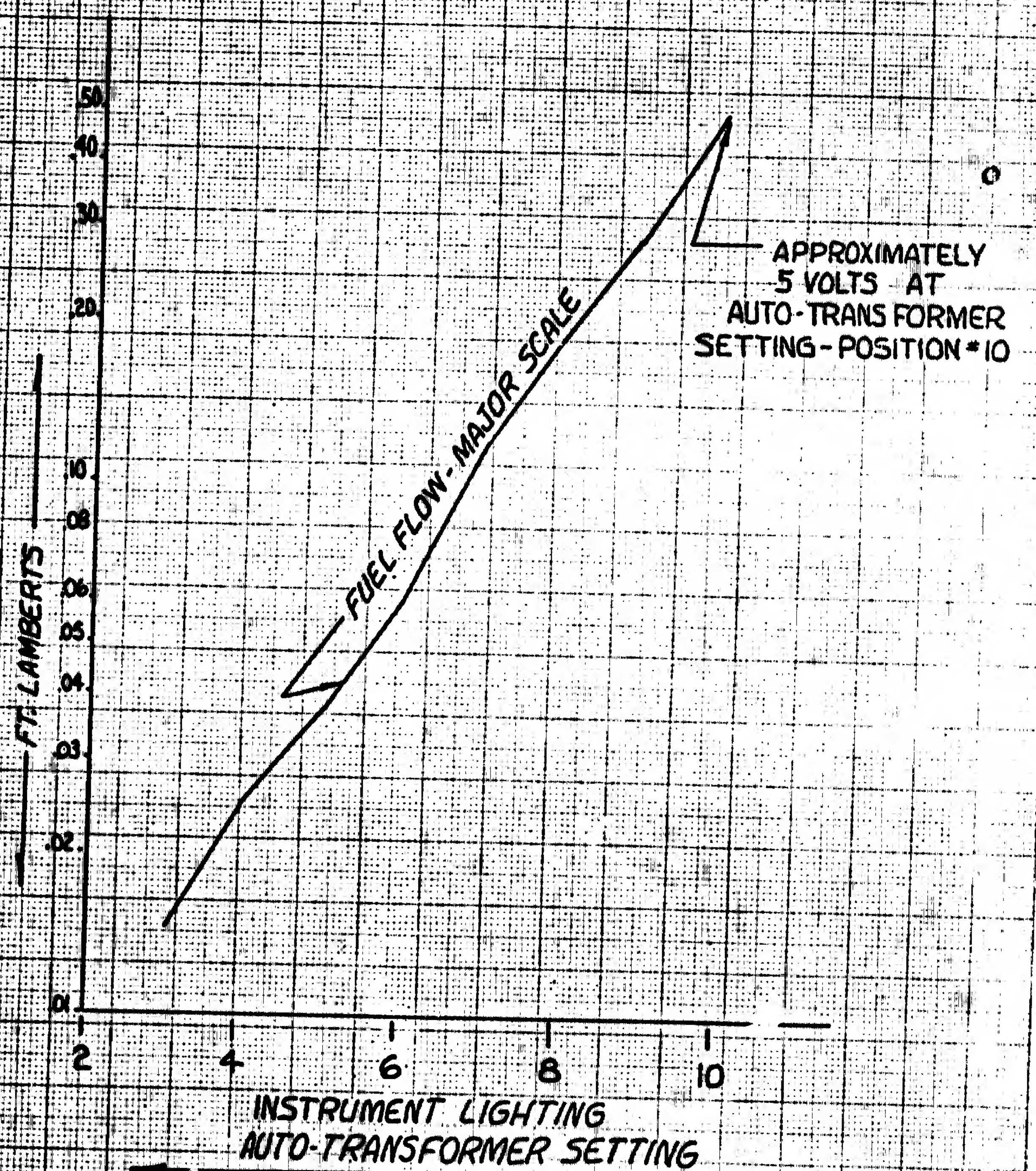


FUEL FLOW INDICATOR
BRIGHTNESS CURVE

FIGURE NO. 25

The Figure 26 table was prepared from observations and questioning of the many pilots concerned with the group of fighter and attack aircraft. The pilots of the A-6 paid little attention to the control settings. The control is a thumbwheel type unit with a range of positions from 1 to 13. Some fighter pilots indicated that a little more selectivity of the instrument lighting would be a decided advantage. This is no doubt due to the conventional instruments, such as airspeed and rate of climb indicators, not being as well presented for quick scan as the primary flight instruments. The data shows no trend as to age or experience except that the younger pilot seems to carry interior lighting at a higher level.

General Summary of Landing-Takeoff, Night Flight:

The pilot after a preflight and aircraft check makes a normal VFR takeoff. The visual tasks are basically orientation of the aircraft. This requires checking the area to assure clearance, whether it is moving out to the runway area or pulling in to the fuel pit. This procedure is standardized on all bases and carriers to some extent. It is the responsibility of every pilot to be familiar with this routine. The aircraft is directed to a clear area and the pilot is then on his own. The taxiway layout is usually away from the ramp area so that as soon as the aircraft is headed away from the hangar area, the taxiway lighting becomes his outside world. If it is to be a group take-off, the aircraft follow one another to the run-up area. According to the interviews, the pilots do not use their taxi lights during group takeoff, the leader being the exception with the last man maintaining his exterior lighting and anti-collision as required. Pilots make a conscious effort not to look directly at the exhaust of the plane directly ahead. Normally, separation is maintained by the pilot's peripheral vision.

Lighting at Navy bases is more than adequate for normal night takeoff and taxi. The pilots indicated that on extremely dark nights, the base lighting is actually too bright.

The takeoff is made with the pilot having an established scan pattern, utilizing the side lights and centerline lights for lineup. Training and familiarity with the aircraft determine his frequency of outside to inside viewing. The normal pattern, if one were to average the pinputs, would find the pilot looking out at lineup, in at enginc instruments, etc., keeping the lineup, airspeed, buildup and engine instruments in mind to determine the aircraft status by the go/no-go point for takeoff decision. Immediately after rotation, noting the units on the angle of attack indicator, a quick scan of the gyro, heading, airspeed and altimeter, is made.

The scan pattern then is primarily runway for lineup, airspeed for takeoff, runway threshold lights and an area forward of the field, to the left and right of the runway, for clearance of the field. Heading is acquired from GCI/CIC and then radar vectored to the intercept area. The pilot during this period is primarily watching: aircraft heading, the altimeter, the airspeed, while frequently checking left, forward and right of the aircraft. Even though he can visually acquire few targets in the night sky, it is necessary to scan the area.

The RIO will direct aircraft maneuvers until the pilot has acquired the target visually. Enroute procedures are a team function with the intercept proper being a coordinated team effort by RIO and pilot.

Formation flights at night are not a normal activity unless visibility is excellent. Radar trail is more common for formation flights on a dark night, if such flights are necessary.

Except for carrier qualifications, all night recoveries are made utilizing TACAN/CCA. This recovery procedure, which is the most taxing phase of a night flight, may be broken down into basics of:

(a) Radar Vector to Marshall Point
(b) Base Descent
(c) Carrier Heading
(d) Glide Slope Acquisition
(e) Lineup
(f) Meat Ball
(g) Taxi-clear

a. Radar Vector to Marshall Point

The pilot upon entering this holding pattern has the primary task of watching for other aircraft, maintaining his altitude and pattern. This visual task is one in which he is assisted by the RIO. A racetrack pattern is flown at a prescribed airspeed and altitude.

b. Base Descent

During this phase the pilot's primary visual task is the acquisition of heading from monitoring his AAI-Gyro. At the same time he monitors his airspeed, altimeter and rate of descent. Primary heading is given by CCA.

c. Carrier Heading

On arriving at the 20 mile gate, a new rate of descent is established. Generally the pilot acquires a new heading. This new heading is for identification purposes as well as vectory to the carrier for final line up.

d. Glide Slope Acquisition

The pilot is still scanning his flight instruments as he penetrates to the point where visual sighting of the carrier may be made. Small corrections are made for line up as far out as possible.

e. Lineup

As he picks up heading of the carrier visually, reference is made to drop lights which allow him to quickly determine direction of lineup and exactly when lined up. His scan pattern is now entirely carrier-instruments (gyro A/S, altimeter, angle of attack). At this point the pilot is aware of no other visual areas with the RIO assuming the responsibility of monitoring the area for traffic. The pilot's scope will usually be off, with the aircraft in the landing configuration.

f. Meat Ball

After the 6 miles gate, the pilot will be in the approach configuration with the scan of landing gear, flaps and utility systems already completed. His angle of attack will be established in the next few seconds and he will be preparing to start his final descent. The primary task now is to acquire the ball. He will have no further contact once he calls "Roger Ball."

The scan pattern is, in some cases, shared by the RIO. Some pilots request the RIO to call A/S, altitude or power-no power by "accel-decel." When the pilot calls the ball, he has indicated that he has the ball in sight, solid contact with mirror or Fresnal system. He will now be alternating his visual task between the "meat ball," lineup, airspeed, altitude, angle of attack, as a check against the indexer. A few seconds later he is almost entirely on the indexer, meat ball and lineup. The last 30 seconds of landing are entirely on "meat ball - lineup."

g. Taxi

The deck spotter gives direction to taxi the aircraft to parking area and maintains control until shutdown.

6. Summary of Observations and Recorded Data

A graphic presentation of the in-flight recordings showing pilot selected positions of the autotransformers and the external light levels is presented in Figure 27. Figures 28 through 32 are compiled in five tables describing the visual task on a time basis for the basic tasks of Take-Off, Climbout, Join Up, Mission-Cruise and Landing.

Table I expands the final 30 seconds of the landing task, ref. Figure 32. The final 30 seconds is typical and Table I represents the summary of all flights observed. The "30 second" period of the landing pattern is the most critical phase of the night flight.

Additional sample segments are included in Appendix A (Figures 35 through 41).

FIGURE 26

DESIRED SETTING FOR INTERIOR LIGHTING, PILOT REPORTED

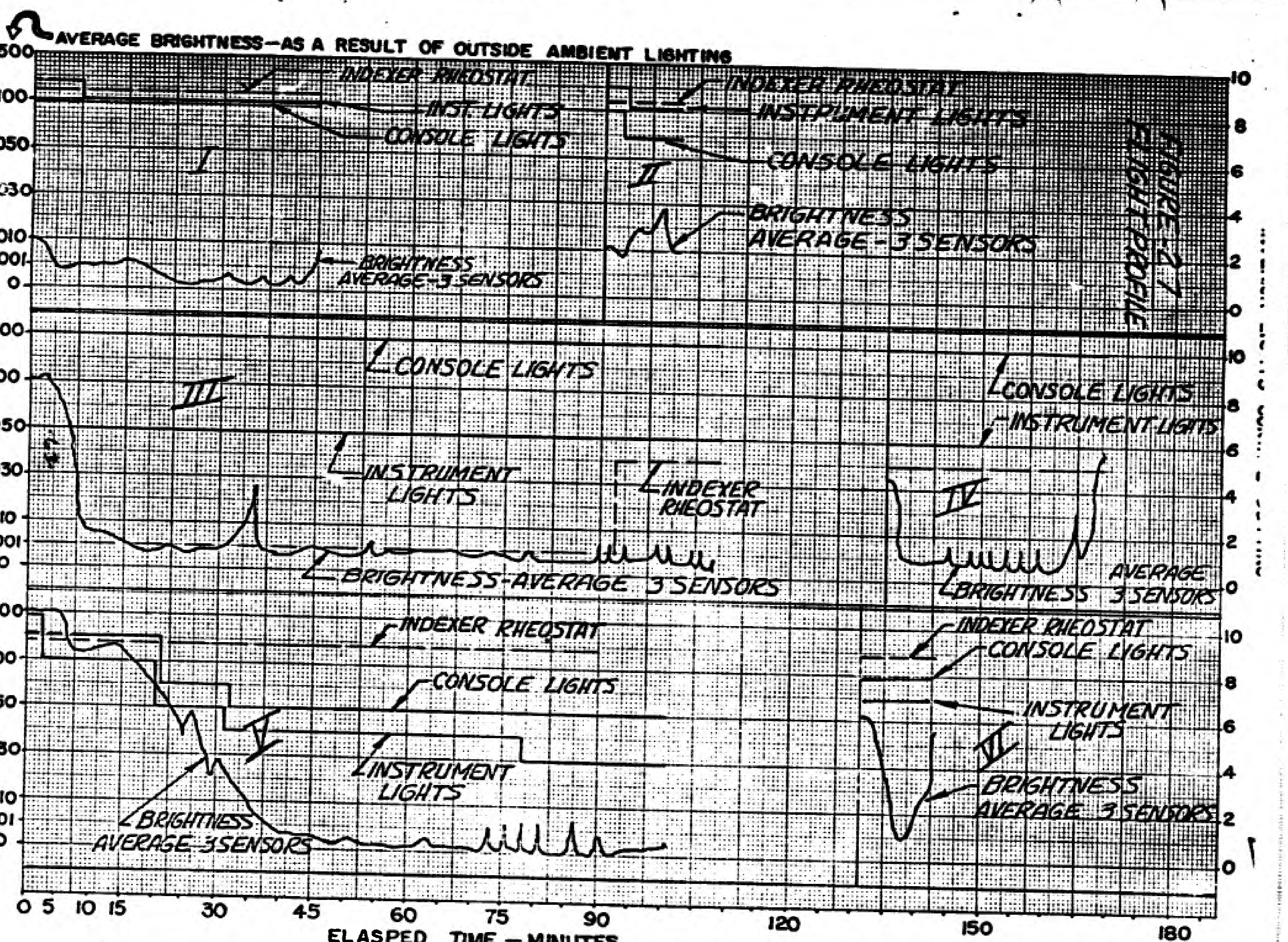
MANEUVER	CONSOLE SETTING * Carrier	CONSOLE SETTING * Land	INSTRUMENT SETTING * Carrier	INSTRUMENT SETTING * Land	SKY CONDITION (Average Sky Brightness)
Takeoff					
1. Pilot A	Pos. 5	Pos. 7	Pos. 8	Pos. 6	.01 Clear
2. " B	" 5	" 5	" 8	" 7	"
3. " C	" 6	" 7	" 7	" 8	"
4. " D	" 4	" 4	" 9	" 5	"
5. " E	" 5	" 6	" 7	" 9	"
6. " F	" 5	" 10	" 10	" 8	"
Climb					
1. Pilot A	Pos. 5	Pos. 7	Pos. 8	Pos. 6	.01 Clear
2. " B	" 5	" 5	" 8	" 7	"
3. " C	" 6	" 7	" 7	" 8	"
4. " D	" 4	" 4	" 8	" 5	"
5. " E	" 5	" 6	" 7	" 9	"
6. " F	" 5	" 10	" 9	" 8	"
Altitude					
1. Pilot A	Pos. 5	Pos. 6	Pos. 7	Pos. 6	.01 Clear
2. " B	" 4	" 5	" 6	" 7	"
3. " C	" 3	" 7	" 5	" 6	"
4. " D	" 5	" 4	" 4	" 5	"
5. " E	" 4	" 5	" 6	" 8	"
6. " F	" 4	" 6	" 7	" 7	"
Low Level Flight					
1. Pilot A	Pos. 3	Pos. 5	Pos. 6	Pos. 6	.01 Clear
2. " B	" 3	" 5	" 6	" 5	"
3. " C	" 3	" 4	" 5	" 3	"
4. " D	" 5	" 4	" 5	" 4	"
5. " E	" 4	" 5	" 6	" 5	"
6. " F	" 4	" 6	" 5	" 8	"
VFR					
1. Pilot A	Pos. 4-3	Pos. 4	Pos. 6	Pos. 6	.01 Clear
2. " B	" 6-3	" 5	" 6	" 5	"
3. " C	" 4-3	" 4	" 8	" 6	"
4. " D	" 3-5	" 4	" 5	" 7	"
5. " E	" 4	" 5	" 8	" 8	"
6. " F	" 7-5	" 6	" 8	" 9	"

* For brightness values of auto transformer settings, see field measurements, Figure 17. Position of console setting indicates relative setting: 0 - Off, 1, 2, 3 . . . . 10 (maximum). NOTE: A 6-3 setting means a variation in settings from 6 to 3.

FIGURE 26 (cont'd)

MANEUVER	CONSOLE SETTING Carrier	CONSOLE SETTING Land	INSTRUMENT SETTING Carrier	INSTRUMENT SETTING Land	SKY CONDITION (Average Sky Brightness)
Instrument Flight					
1. Pilot A	Pos. 4-3	Pos. 4	Pos. 7	Pos. 6	.001 Murky
2. " B	" 6-3	" 5	" 7	" 5	"
3. " C	" 4	" 4	" 5	" 7	"
4. " D	" 3-5	" 4	" 6	" 6	"
5. " E	" 4	" 5	" 5	" 5	"
6. " F	" 7-5	" 5	" 3	" 6	"
Landing					
1. Pilot A	Pos. 4	Pos. 4	Pos. 5	Pos. 7	.01 Clear
2. " B	" 6	" 5	" 6	" 6	"
3. " C	" 4	" 6	" 4	" 5	"
4. " D	" 3	" 5	" 5	" 6	"
5. " E	" 7	" 4	" 4	" 5	"
6. " F	" 5	" 7	" 6	" 8	"

Pilot A - Commander	- 5000 hours	-	experienced in all aircraft
Pilot B - Lt. Commander	- 3200 hours	-	experienced in all aircraft
Pilot C - Lt. Commander	- 2800 hours	-	experienced in fighters and jets
Pilot D - Lieutenant	- 1600 hours	-	experienced in fighters and jets
Pilot E - Lieutenant	- 1200 hours	-	moderate experience in jets
Pilot F - Lieutenant JG	- 400 hours	-	little experience in jets



AVERAGE BRIGHTNESS—AS A RESULT OF OUTSIDE AMBIENT LIGHTING
FIGURE-27
FLIGHT PROFILE
INDEXER RHEOSTAT
INST LIGHTS
CONSOLE LIGHTS
I
BRIGHTNESS
AVERAGE-3 SENSORS
II
INSTRUMENT LIGHTS
III
IV
V
VI
.500
.100
.050
.030
.010
.001
0
10
8
6
4
2
0 5 10 15 30 45 60 75 90 120 150 180
ELASPED TIME — MINUTES

VISUAL TASK TABLE

A/C F-4B — CARRIER / LAND ✓ SINGLE ELEMENT — BASIC TASK V.F.R. TAKE OFF

TIME	IDENTIFICATION	DESCRIPTION	INTERIOR LIGHT	EXTERNAL ENVIRONMENT/ VARIABLE
19:50	RUNWAY CHECK	CHECKS LINE UP CONDITION OF RUN-WAY & CLEARANCE	CONSOLE FLOODS	EXT. LTS SET AS REQ'D FOR SINGLE PLANE TAKE OFF
TIME AT	E.G.T. INDICATOR R.P.M. INDICATOR	MONITORING ENGINE PERFORMANCE	PRESET: MED. TO DIM.	ANTI-COLLISION: ON ALL OTHERS: BRT-STEADY
BRAKE RELEASE +5 SEC	& FUEL FLOW SCAN RUNWAY	PREPARATION FOR TAKE-OFF	INST. LTS PRESET	SOME LOCATIONS-A/C WERE OBSERVED USING BRT-FLASHING.
	AND THE RUNWAY AREA	MOVING LINE UP	POSITION NO. 8	FWD SENSOR - .003 LEFT SENSOR - .03
	AIRSPEED INDICATOR	DETERMINE IF SPEED BUILD-UP RATE IS SUFFICIENT	CONSOLE PANEL LTS	RIGHT SENSOR - .001 OUTSIDE VISUAL TASK
+10SEC	"GO- NO GO" POINT ON RUNWAY	DECIDES IF A/C WILL FLY	PRESET POSITION NO. 10	15 SEC. INTERMITTENTLY
	RUNWAY AIRSPEED IND.	LINE UP	INDEXER RHEOSTAT SETTING	PILOTS USUALLY GO 'ON INSTRUMENTS'
	ENGINE INST., FUEL FLOW IND.	ENG. CHECK PRIOR TO T/O DECISION	LEFT AS IS OR	AFTER TAKE-OFF, MOST PILOTS WILL
+15 SEC.	RUNWAY	LINE UP AND TRAFFIC CHECK	SET OFF OR LOW-POS. 2	STAY V.F.R. IF HORIZ. REF. IS
	HORIZON SCAN	DECIDES IF WILL HAVE VISUAL ATTITUDE REF	INST. FLOOD USUALLY	AVAILABLE. VISUAL TASK - 15 SEC.
	AIRSPEED IND. ANGLE OF ATTACK	CHECKS THAT A/C FLY & ANGLE	BRT OR DIM.	OUTSIDE.
+20SEC	LIFT OFF & HORIZON SCAN	WHERE TOOK PLACE AND ATTITUDE REF.	RECOMMEND BRT. PER HANDBOOK	FWD SENSOR - .001 LEFT SENSOR .02-.01
	SCAN CAUTION LTS. & ENG. INSTRUMENTS	VERIFY SYS O.K. DURING CLEAN UP	UTILITY "OFF"	RIGHT SENSOR - .001
	SCANS LEFT, FWD & RIGHT	VERIFY TRAFFIC CLEAR FOR CLIMB	FLASHLIGHT IS HOOKED	VISUAL TASK 15 SECONDS
+25SEC	GEAR INDICATION & UTILITY IND.	QUICK SCAN TO CONFIRM SYS.	IN HARNESS LEG STRAP OR	OUTSIDE SCAN PATTERN
	GYRO IND., ALT. & ANGLE OF ATTACK	ESTABLISH THE PROPER ATTITUDE & CLIMB ANGLE.	ON LANYARD AROUND NECK	WIDELY VARIABLE PILOT TO PILOT
	R/C, AIRSPEED, GYRO & HEADING.	ESTABLISH THE CLIMB RATE & DIRECTION	HI ALT LT 'OFF'	FWD SENSOR - <.001 LEFT SENSOR - .005
+30SEC.	SCANS OUTSIDE, A/S ANGLE OF ATTACK & GYRO IND.	ACQUISITION OF REQUIRED CLIMB PATTERN	ADV. LTS MECH. DIM.	RIGHT SENSOR - .005

FIGURE 28
VISUAL TASK TABLE - TAKEOFF

VISUAL TASK TABLE

A/C F-4B CARRIER ________ LAND ✓ SINGLE ELEMENT BASIC TASK V.F.R. CLIMBOUT

TIME	IDENTIFICATION	DESCRIPTION	INTERIOR LIGHT	EXTERNAL ENVIRONMENT/VARIABLE
1951	FLAP & GEAR CHECK ANGLE OF ATTACK IND.	A/C CLEAN FOR CLIMB & CLIMB ANGLE SELECTED	GENERALLY NO CHANGE	EXT LTS - PRE SELECTED TO BRT - STEADY
	AIRSPEED INDICATOR SCANS OUTSIDE	SET UP FOR CLIMB SCHEDULE	IS MADE TO	ANTI-COLLISION LT.-ON SCANS OUTSIDE FOR
	CLOCK, RATE OF CLIMB & GYRO	MAINTAIN THE A/C ATTITUDE	INT. OR EXT. LTS.	PERIOD OF 30 SEC. FWD SENSOR - .001
	ENG. INST. SCAN: TACH., E.G.T., OIL & NOZ.	DETERMINE ENG. PERFORMING SAT.		LEFT SENSOR - .005 RIGHT SENSOR - .005
1952	SCAN OUTSIDE, GYRO A/S & ALT.	TRAFFIC, ATTITUDE & ALTITUDE OF A/C		HORIZON STILL IN TWILIGHT CONDITION.
	OXYGEN & VENT. SYS. RADIO FREQ. SELECT.	SYS OPERATIVE & COMM. SHIFT		AREA AROUND FIELD DARK.
	TURN & SLIP INDICATOR GYRO & HEADING IND.	A/C ATTITUDE & HEADING		SCANS OUTSIDE 15 SEC. 'SHORTER INTERVALS.
1953	SCAN OUTSIDE LEFT, FWD & RIGHT	TRAFFIC & OUTSIDE ATTITUDE REF.		FWD SENSOR - .001-0 LEFT SENSOR - .005
	FUEL FLOW & EXH. NOZZLE POS. IND.	ENGINE & FUEL A/C PERFORMANCE		RIGHT SENSOR - .005 'SOME PILOTS STAYED
	ENG. TEMP & OIL PRESSURE.	MAINTAIN HIS "CONFIDENCE LEVEL"		ON GAGES - WITH RAPID SCANS OUTSIDE - OTHER
	SCAN OUTSIDE, TRAFFIC & WEATHER	ASCERTAINS THAT CLIMB ATTITUDE IS SATISFACTORY		PILOTS STAY V.F.R. IF FEASIBLE.
	INTERIOR & EXT SELECT IF REQ'D.	SET UP LIGHTS AS REQ'D OR DESIRED	INST LTS LOWERED	FWD SENSOR - .001 LEFT SENSOR - .005
1954	A/S, GYRO, HDG ALT., R/C, & CLOCK	MAINTAIN AIRCRAFT ATTITUDE & R/C.	TO POS. 6 OR 7	RIGHT SENSOR - .001 'USE HORIZ & GROUND
	SCAN OUTSIDE SCAN ENG. INST.	CHECKING TRAFFIC AND ENG. AS A/C TOPS OFF CLIMB	CONSOLE LIGHTS	LIGHTS FOR ATTITUDE REF. FREQUENTLY.
	SCAN ADVISORY LTS & HEADING IND.	SCAN OF PANEL AS PICKS UP HDG.	LOWERED TO POS. 8	SCAN OUTSIDE IN 10 SEC. INTERVALS
	SCAN OUTSIDE, GYRO, T/S & HDG.	QUICK CHECK OUT BEFORE TURNING		FWD SENSOR - .001-0 LEFT SENSOR - .005
1955	ALT., A/S, GYRO & HEADING SCAN	SCANS RAPIDLY A/C ATTITUDE		RIGHT SENSOR - .001
	RADIO CHAN SELECTION HEADING & ALT.	CLEARING PATTERN VERIFY COURSE AND ALTITUDE.		

FIGURE 29

VISUAL TASK TABLE - CLIMBOUT

VISUAL TASK TABLE

A/C F-4B   CARRIER LAND ______   BASIC TASK JOIN UP

TIME	IDENTIFICATION	DESCRIPTION	INTERIOR LIGHT	EXTERNAL ENVIRONMENT/VARIABLE
2015	SCANS OUTSIDE 15-20 SECONDS	ACQUIRE VISUAL CONTACT OF	INST. LTS REMAIN	FWD SENSOR <.001 RIGHT SENSOR <.001
	COMM SELECT IND-CHANNEL	ANOTHER A/C COMM FREQ SHIFT	AT POS. NO. 6.	LEFT SENSOR SHOWS .005 AND A/C CLOSING
	GYRO, A/S. ALT HEADING IND.	MAINTAIN A/C ATTITUDE	CONSOLE LIGHTS	ALONGSIDE FOR ONE MINUTE INTERVAL
2018	ENG. INSTRUMENT SCAN.	SPEED & DIRECTION FOR CLOSURE	REMAIN AT POS. 8	A/C OFF - EXT LIGHT SELECTED
	FLIGHT INST. SCAN..	BY A/C.	SCOPE INTENSITY PRESET	DIM & STEADY
2019	SCANS OUTSIDE 15-20 SECONDS	SCAN IS RAPIDLY IN-OUT- HOLDING		EXTERNAL LTS & LIGHT LEVELS
	HEADING. GYRO, A/S & ALT. IND SCAN	A/C COURSE STEADY.		REMAIN CONSTANT
2020	SCANS OUTSIDE BACK TO GYRO	IN TURN; CHECK CLEAR		THE CONTRAST IN HIGHER LIGHT
	HEADING IND A/S. ALT.	OF TRAFFIC & A/C HOLDING.		LEVELS IN EAST TEND TO INDUCE
2021	SCANS OUTSIDE 5 SECONDS	BREAKING FORMATION		SOME VERTIGO WHILE ORBITING
	COMM SHIFT IND-CHANNEL	COMM FREQ SHIFT-CONSOLE & IND		"NO WAY TO KEEP THIS DISTRACTION
	ENG INST. & ALT CHECK	POWER AND SPEED CHANGE		OUT OF VISION; REMAIN ON
2022	RADAR SCOPE	DESCENT PATTERN		GAGES-STRONG TO OFFSET VERTIGO.
	A/S. ALT. GYRO & HEADING.	SET UP- CHECKING		RADAR SCOPE "LEAKS" LIGHT ONTO SIGHT
	SCANS OUTSIDE FREQUENTLY	TRAFFIC LEFT & RIGHT		AND FWD. WINDSCREEN
2023	ALTITUDE IND. HEADING & GYRO	DURING DESCENT - RADAR - NOT		
	R/C & CLOCK, ENG INSTRUMENTS	CAPABLE OF PICKING UP A/C		
2025	RADAR. SCOPE SCANS OUTSIDE	IN SECTORS AT 3 & 9 O'CLOCK	NO CHANGE	EXT. LIGHTING CONSTANT - A/C BACK ON.

FIGURE 30
VISUAL TASK TABLE - JOIN UP

VISUAL TASK TABLE

A/C F-4B CARRIER LAND ________ BASIC TASK MISSION & CRUISE

TIME	IDENTIFICATION	DESCRIPTION	INTERIOR LIGHT	EXTERNAL ENVIRONMENT/ VARIABLE
2030	ALT, GYRO, A/S, OUTSIDE 15 SEC.	ACQUISITION OF PRE-PLANNED	CONSOLE LIGHTS	FWD SENSOR-.002-0 LEFT SENSOR-.04-.005
	HEADING IND. LEFT CONSOLE	COURSE. PWR & FUEL STATE	POSITION #10	RIGHT SENSOR-.04-.005
	ENG. INST. OUTSIDE 5 SEC.	PERFORMANCE & TRAFFIC		AIRCRAFT APPROACHED LEFT SIDE
2035	FUEL QUANTITY & TANK CHECK	DETERMINE FUEL BURN RATE	INST. LTS POSITION	
	CLOCK & AAI KNEE BOARD	CHECKS ETA & A/C LOCATION	#6	FWD SENSOR-<.001 LEFT SENSOR-.008
	GYO. A/S & ALT OUTSIDE 10 SEC	VERIFY A/C ATTITUDE		RIGHT SENSOR-<.001
2040	COURSE & DIST CHECK RADAR REPEATER	HEADING CHECK TURN DOWN		
	GYRO & A.A.I.	TO ASSIST IN EXT. VISION.		LIGHT LEVEL DROPPING AS
	CHECK VISUAL-OUTSIDE 15 SEC	A/C PICK UP		AIRCRAFT HEADS IN.
	GYRO, A/S RIGHT CONSOLE	A/C ATTITUDE SCAN CAUTION LTS		
2043	OUTSIDE 10SEC ACQUIRE HDG.	TRAFFIC CHECK & COURSE CORRECT.		A/C CLOSES ON LEFT SIDE
	GYRO. A/S. ALT OUTSIDE 10SEC	A/C ATTITUDE TRAFFIC		
	FUEL QTY KNEEBOARD	MENTAL CALC. ON		
	GYRO A/S & ALT OUTSIDE 20SEC	TOUCH & GO. TRAFFIC		
2044	ENG INST. SCAN R/C — ALT.	ENG. PERFORM. & ALTITUDE		
	HEADING & A/S CLOCK			
	COMM FREQ IND RIGHT CONSOLE	RADIO FREQ SHIFT & ICOM		AIRCRAFT PASSING LEFT SIDE.
2045	A/S. ALT & GYRO OUT SIDE 10 SEC.	ARRIVE MARSHALL CHECK TRAFFIC & VISUAL CK OILCC.	NO CHANGE	GROUND LIGHTS ALLOW LOCATION FIX.

FIGURE 31

VISUAL TASK TABLE - CRUISE & MISSION

VISUAL TASK TABLE

A/C F-4B — CARRIER SIMULATED / LAND CARRIER FIELD — BASIC TASK LANDING

TIME	IDENTIFICATION	DESCRIPTION	INTERIOR LIGHT	EXTERNAL ENVIRONMENT/ VARIABLE
2046	GYRO A/S & ALT IND. SCANS OUT-	MAINTAIN A/C ALTITUDE	INST. LTS UNCHG'D	APPROACHING MARSHALL POINT
	SIDE. CHECKS ENG INSTS.	QUICK SCAN OF ENG PRIOR	AT POS. NO 7	OTHER TRAFFIC IN AREA - MUST
2054	SCANS OUTSIDE & RUNWAY FOR	TO LANDING CONFIGURATION	CONSOLES UNCHG'D	WATCH TRAFFIC, AIRCRAFT ATTITUDE,
	LINEUP A/S & ALT SCANS L.S.O.	RUNWAY ℄ FOR A/C POSITION	AT POS. NO. 10	AND HOLD IN THE PATTERN
2058	ON "THE BALL" 30 SECONDS	1ST TOUCH & GO EYES STEADY	CHG'D INDEXER	FWD SENSOR SHOWING 'O' TO
	GYRO - AIRSPEED THEN SCANS OUT	WATCHING THE BALL GYRO ON PULLUP	LIGHT LEVEL	.005 AS AIRCRAFT PASSING L.S.O.
2105	AROUND PATTERN SCANNING INSTS	2ND TOUCH & GO		
	AND OUTSIDE			
2109		3RD TOUCH & GO		
2112		4th TOUCH & GO		
2115		5th TOUCH & GO		
2118		6th TOUCH & GO		

FIGURE 32

VISUAL TASK TABLE - LANDING

TABLE I - TYPICAL VISUAL TASK
SCAN PATTERN - JET LANDING
AT NIGHT ON A CARRIER CONTROLLED APPROACH

Time	Visual Task
0000	On leaving the marshall point, the primary scan is of the heading, gyro and altimeter. (Barometric altimeter is normally used with radar altimeter for verification.) The scan of the exterior lights setting is made and selection made. Harness locks are checked (not necessarily a visual check). A visual check is made of the hook position indication, anti-ice and pitot heat, etc., depending on the temperature, rain, fog, dew point, etc. Radio check-in frequency is set or verified. (Some RIO's assume this task - pilot will verify, depending on the team training level.) The pilot will now make an engine instrument and fuel state scan (RIO may assume fuel and radio check-in responsibility). Then scan airspeed and heading (TACAN-DME) and set up rate of descent (4000 ft/min) and verify position of other aircraft in pattern.
0001	Makes an identifying turn - checking heading, airspeed, altimeter and gyro.
00015	Checking heading (DME) - radio frequency check for final control, scanning altimeter, airspeed and gyro. Scanning forward for visual pickup on carrier, scans left and right for traffic.
0002	Scans airspeed, altimeter and heading, visual check on landing gear and check list. Quick check on fuel, radio and gyro. Scans forward to acquire carrier visually.
00025	Visual sighting of carrier. Scanning rate of climb (R/C), airspeed (A/S), altimeter, gyro - heading - may be scanning rapidly out to carrier to attempt to acquire line-up and average the ball. May call "Roger Ball".
0003	Initially scans R/C, airspeed, gyro; ball and drop lights on carrier then back to indexer, with gyro if no horizon ref visible. Scanning, ball, airspeed, indexer, (angle of attack units set check), gyro, line-up, ball line-up and indexer.
00035	Call "Roger Ball" by this time or will voluntarily wave off.
	The next 30 seconds are almost always "solid on the ball line-up" with quick scans to indexer and, in extreme cases, airspeed, gyro.
00037	Now holding "solid visual" on "Ball - line-up". As ball passes on the left he will not look at deck - swings his scan in to gyro as if he is going to bolter, scan is forward/gyro - throttle fwd, and stick back - if hook misses, he is ready to fly off.

IV. CONCLUSIONS

The overall program consists of a systematic investigation of all the various lighting characteristics which will allow establishment of a valid lighting design criteria compatible with the pilot's needs on a mission requirement basis. The overall program provides for complete operational analysis of the visual task requirements.

This pilot study is the initial phase of this overall program. In the studied evaluation of the techniques used, the goals desired and the description and identification of the visual tasks under various mission profiles, this study has, by trying these techniques in operational squadrons, evaluating to a limited degree the actual aircraft, and interviewing hundreds of pilots, gained the required knowledge to make the conclusions and recommendations which follow.

The conclusions, based on the methods used in this pilot study, are that the overall program must be conducted on an instrumented aircraft operating from an operational squadron in conjunction with a laboratory study where measurements of aircraft may be made. It is the conclusion of the writers that the recording of the selected values of the interior lighting, along with the recorded visual tasks and external environment, are the proper techniques for the overall program.

In addition, the knowledge acquired through the analysis of the interviews, questionnaires, measurements and recordings are listed in more specific areas. The validity is discussed along with the relationships found between the lighting environment and the pilot's visual tasks.

Summarization of the pilots visual tasks, based on the questionnaires and interviews, was essentially verified by the measured and recorded data. Observations of the pilots in their aircraft environment provided the proper background for the interpretation of the opinions and the data gathered. The key visual tasks, as related to safety, efficiency and performance, were substantiated by discussions and explanations of the visual tasks by the pilots.

The performance of the visual tasks is determined by two major factors: (1) What does the pilot need to see?, and (2) How well is it lighted? The first is a function of his immediate task and the mission. The second is a function of the lighting environment. In one case, inside the aircraft, this lighting environment is controlled and in the second case, outside the aircraft, the lighting condition is a combination of night sky conditions and what lighting there may be on the target. If in the immediate task the pilot needs to see a target outside the aircraft, then all the interior lighting becomes a compromise. Thus the relationship of the inside lighting and the outside lighting is a continual compromise to the pilots visual acuity. The complexity of the visual task inside the cockpit serves to widen the compromise to which pilots are subjected at night.

The equipment providing visual cues should be designed to convey to the pilot the message or signal without causing any more mental calculation than is necessary. The absence of clutter in the cockpit is tremendously important. The visual task of the pilot must be one in which the pilot may comprehend a situation which is existing or imminent without undue interference or distraction. A prime example is the datum board in an S2 aircraft. The side-by-side arrangement is ideal for a team effort, but the comparatively brightly lighted datum board is very distracting to the pilot. The A-6 aircraft, which has a similar seating arrangement, allows for this condition by shielding the electronic displays.

The aircraft has suffered from the standardization of lighting techniques over the past few years. Usually the aircraft is designed for a specific series of missions. An example is the helicopter or any vehicle where visual tasks are primarily based on external cues, even at night. This aircraft is found to have a lighting system which results in stray light and reflections. The helicopter, in air-sea rescue work or in ASW work, must operate in close proximity to other aircraft and the water, and yet has an interior lighting system similar to a transport or attack aircraft. The helicopter pilot's visual tasks are very demanding and require specific lighting techniques. The lighting on a patrol aircraft, for example, was found to be the most standardized. Yet this lighting, as a result of the duration of the mission, is responsible for excessive eye strain. The patrol aircraft should have the most flexible lighting control to allow the pilot the wide range of selection which this type mission requires. Large transport aircraft are usually well equipped with electronic visual aids, since space and power are available. Fighter and attack aircraft were found to be lighted and designed more carefully than almost any other aircraft observed. In these fighter and attack aircraft there are many areas where consideration for the visual task is relegated to a secondary position. For example, it is frustrating to the pilot to attempt to read a utility instrument and be forced to turn the lighting control up from a previously selected level. What actually takes place is that the pilot will read the information under the inadequate light and proceed with his normal task. This has the effect of (1) lowering his feeling of confidence, and (2) adding that small amount of eyestrain which is immeasurable but does contribute to the total eyestrain buildup throughout the flight, thereby reducing his abilities at the end of the flight. The night carrier landing requires the highest rate of proficiency and visual-mental alertness. In this time period the effects of eyestrain, fatigue and frustration experienced in the flight may compromise the pilot's ability to make a correct decision.

The primary interest of the pilot is in his instrument displays which are so interlocked in the scan pattern as to be viewed as one large display. For example, the gyro and airspeed altimeter are viewed in a rapid sweep from one to the other and these instruments, even though properly lighted, present a poor picture to the pilot because of the differing indicia size and spacing, the letter and numeral size and spacing, and the light flux from total instrument. The design of the instruments must be as strongly considered as the method used to light these instruments. The consoles play a secondary role. The majority of pilots know where each control and switch is located and are generally not too concerned with the uniformity and legibility necessary on the instrument panel.

Each aircraft type is designed for a primary mission. A lighting system must be conceived and tailored to each aircraft type.

V. RECOMMENDATIONS

The following recommendations are presented as a result of the analysis performed on the data gathered throughout this program.

A. Aircraft Interior Lighting

The importance of proper lighting and its effect on the performance of visual tasks is readily apparent when it is realised that the visual task and lighting environment are directly related. The following recommendations for further research and/or evaluation, with reference to the airciaft lighting, are presented.

1. The primary mission and the pilot's visual tasks involved in its performance must establish the requirements for the lighting design. Proper consideration should be given lighting during the early stages of design. The functional mockup, which helps to establish the configuration of the crew stations, should include lighting along with the design of the displays and controls.

2. The instrument panel, being of primary interest to the pilot, requires that the instruments be designed to present a total picture rather than be individually lighted to meet a standard instrument specification. Fine or small markings, many letters on one instrument next to large markings, and few letters do not present a uniform display and may be distracting to the pilots visual tasks.

3. There should be an industry standardization of the size, shape and location of interior lighting controls for the types of aircraft, i.e. attack, transport, etc. Extended cruise may well require the light level of the primary flight instruments to be carried at a higher level than other instruments. Separate controls should be provided to give this flexibility when needed.

4. A few of the specific items found during the study to be worthy of further investigation are:

   a. Provide a master warning system for caution and warning lights with a dimming capability for all lights and automatic dimming for those primary warning lights which at present are not dimmable.

   b. Provide kneeboard light capability on certain aircraft. This light should be mounted and oriented to illuminate either left or right knee. The light on the knee should be controlled as to intensity, illuminate an adequate area at the knee and be selective of color and operation.

c. Consider modifying current instruments to incorporate non-reflective coatings.

d. Incorporate into all integral and wedge lighted instruments the feature of lamp replacement without disassembly.

B. Pilot/Flight Crew

1. The visual task of the pilot is determined by the mission and environment. The efficiency, safety and proficiency of the pilot could be increased if a simulator containing a realistic lighting facsimile of the outside world were included in the night vision training requirements for the Navy. This training device would not replace the existing weapons system trainer, but would supplement the operational training so that the capability of the pilot and system might best be utilized in the field.

2. Equip the pilots with dual color capability flashlights as indicated in Figure 33. This would provide the pilot with the means to determine conditions where a red flashlight is inadequate. This red/white capability would allow the pilot to maintain his confidence level while retaining the maximum dark adaptation.

C. Carriers, Runways & Facilities

1. The carrier deck lighting procedure should be standardized. It is the pilot's recommendation that the CVA-60 or CVA-66 type of lighting be adopted. "Drop lights" are the most valuable in assisting the pilot in his visual task of "line up." Red or white low-level floods were suggested throughout the program. Spotting lights and additional taxi guidance lighting on the carrier deck were frequently mentioned as being worthy of investigation.

2. Turn off areas on land based runways are adequately lighted with two blue lights, however, these are reportedly inadequate in conditions where visibility is restricted, i.e. haze, fog, rain, and where runway angles or curvature prevent visual acquisition of the two blue lights.

3. Runways are inadequately lighted (dark void) at intersections. This is undesirable because the weight and turning radius of today's aircraft limit braking ability, and a pilot may well be at an intersection before realizing it, thus causing needless wear on brakes, tires and nerves.

D. Future Studies of Lighting and Visual Tasks

It is recommended that a continuing program of the study of the visual task of the pilot be established. The program must be so designed as to allow the long range planning to be established and continuity of purpose and method be unbroken. The phasing of the overall program would be important in that sequential studies could be conducted on the appropriate weapon systems trainer of the type aircraft currently being studied in preparation for operational analysis.

The basic outline of a feasible plan would be:

1. Instrument an aircraft.

   a. Automatic recording of ambient lighting external environment.

   b. Automatic recording of interior lighting environment.

   c. Automatic recording of pilot's eye movement.

   d. Automatic recording of pilot's non-physical stress. (Automated Block Diagram shown in Figure 34.)

2. Place the aircraft in an operational squadron.

   a. Utilize the entire squadron, each pilot to operate the subject aircraft on approximately six flights which would be spread over the time period that the aircraft is assigned to the squadron.

   b. The subject aircraft to remain in the squadron for a period of six to eight months.

   c. Indoctrinate squadron personnel in instrumentation requirements.

   d. Provide for data transmission to research facility via common carrier.

3. Provide continuous aircraft availability.

   a. Sequential studies--as one type of aircraft is in operational status, a separate type would be in the process of being instrumented.

   b. Instrumentation packages built up, checked out for forthcoming aircraft.

4. Conduct a study in conjunction with each instrumented aircraft type.

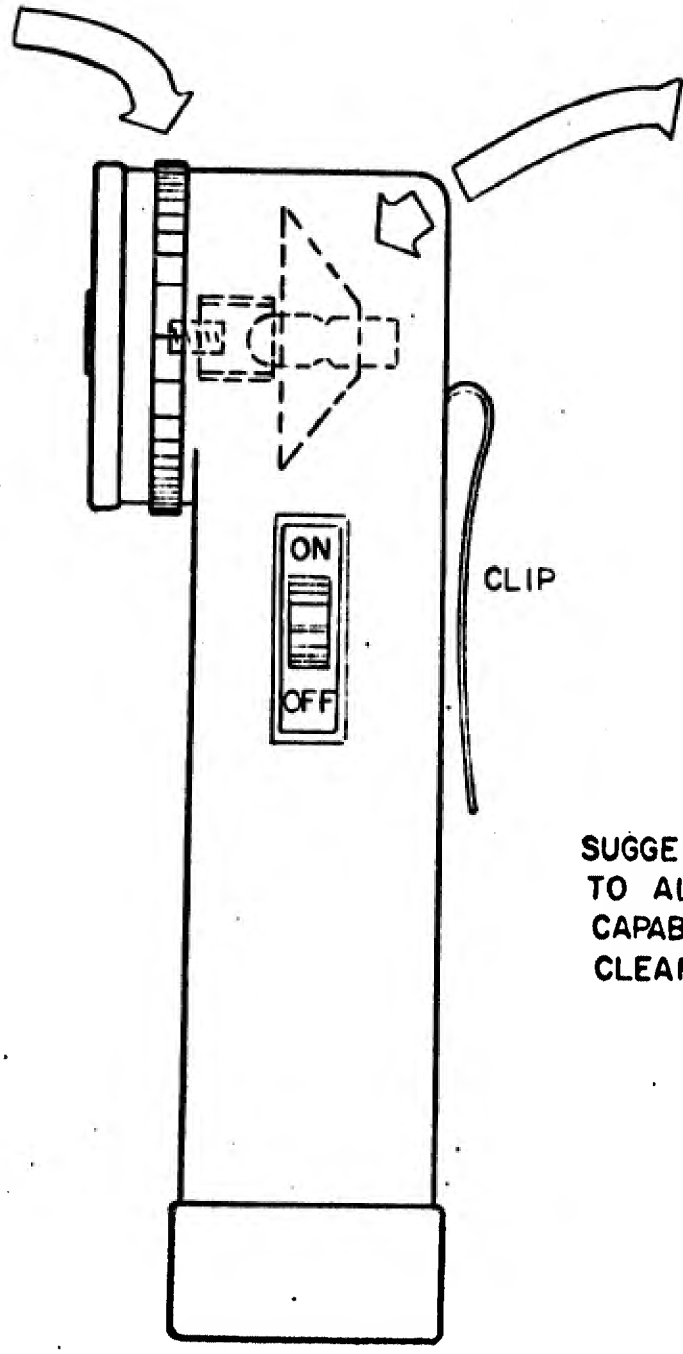
   a. Use the cockpit or weapon systems trainer and the pilots of the squadron to establish the theoretical task and interior environment prior to receiving operational data on the aircraft type.

   b. Adapt an existing simulator facility which has a three axis cockpit simulator, moving target presentation and dark room capability to the actual environment found in operational studies.

   c. Establish the flight envelopes found to be the most severe and determine those factors which are contributing to the system causing these areas of the flight to rate three or four times the difficulty of the normal flight-experiments to be conducted based on training--changing the interior lighting, equipment location, lighting and color.

5. Provide the test aircraft with the improvements and the techniques resolved to the original squadron for actual flights to receive comparisons and operational verification for time period sufficient to allow all pilots to test the aircraft. Direct interviews should be sufficient to establish value.

6. Recommend changes to new aircraft design. Should take place at conclusion of overall program.



SUGGESTED FLASHLIGHT TO ALLOW DUAL CAPABILITY OF RED AND CLEAR LIGHTING.

FIGURE 33

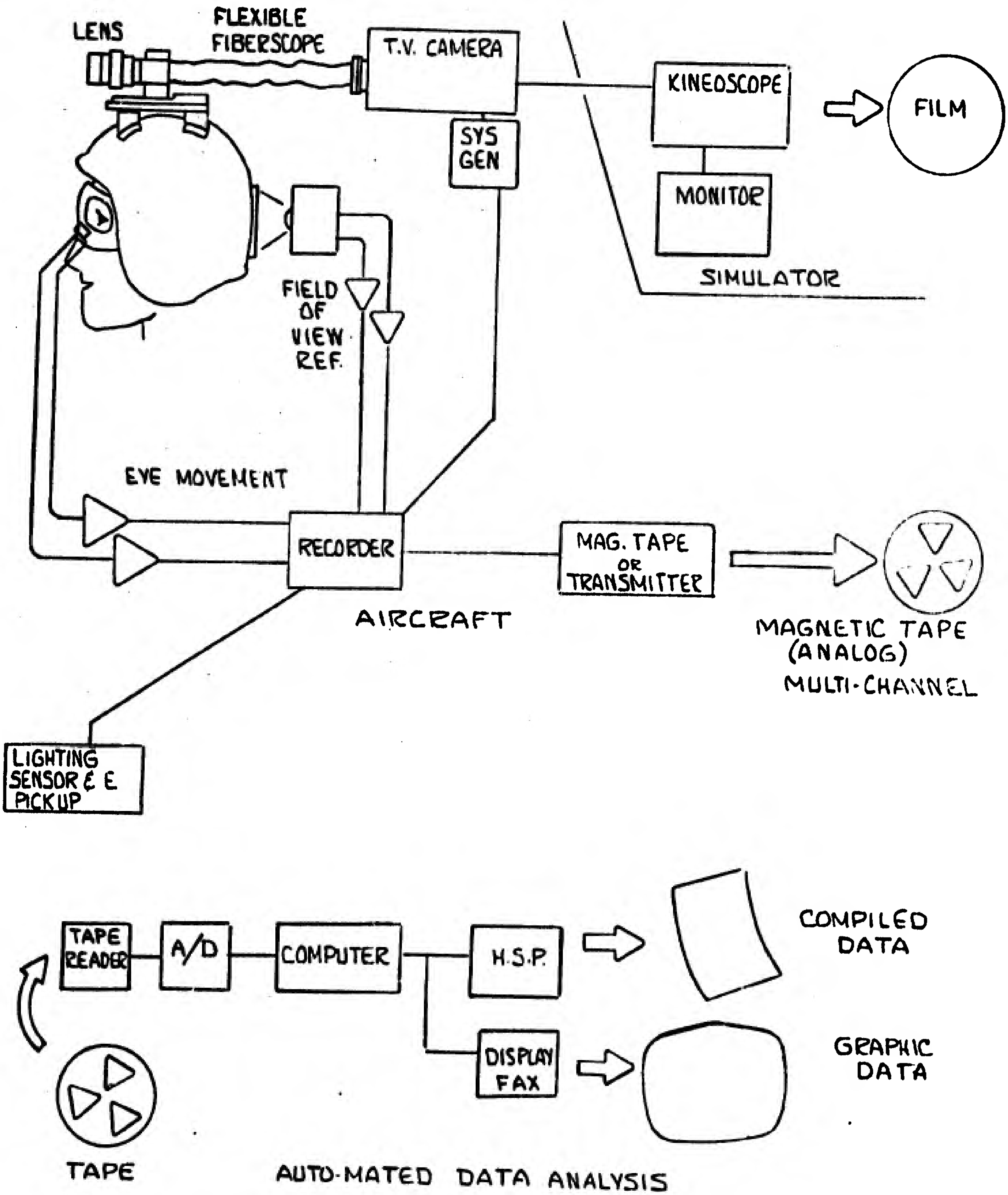


FIGURE 34
BLOCK DIAGRAM-VISUAL TASK SIMULATION STUDY

ACKNOWLEDGMENT

Appreciation is extended to LCDR R. Kelly, Mr. T. S. Momiyama, Naval Air Test Center, Patuxent River, Maryland; LCDR A. M. Lindsey, COMFAIR Norfolk, Virginia; and the officers and men of VF-103, whose support made this program possible.

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APPENDIX A

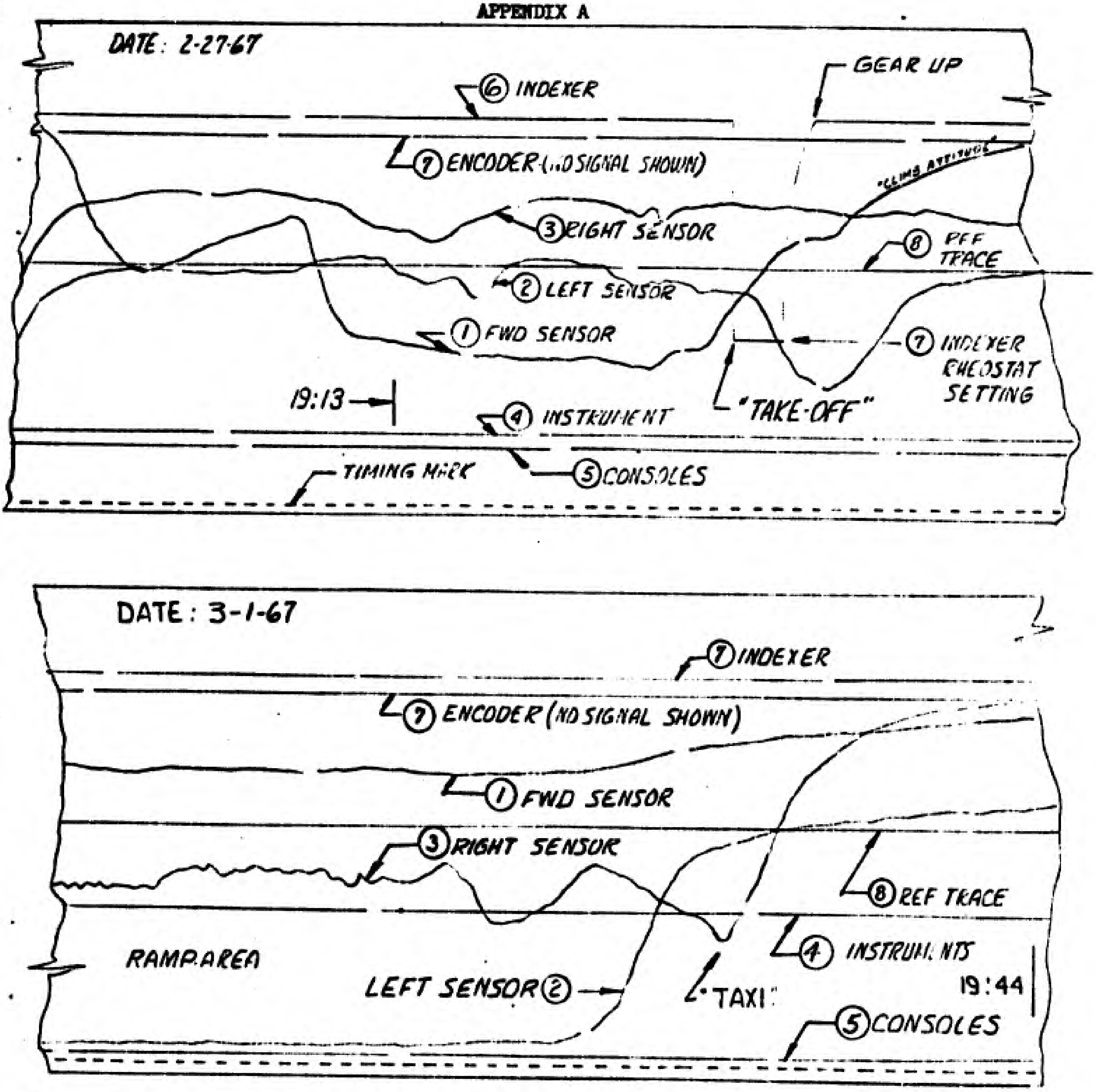

FIGURE 35
SAMPLE RECORDER TAPES
FROM ACTUAL FLIGHTS

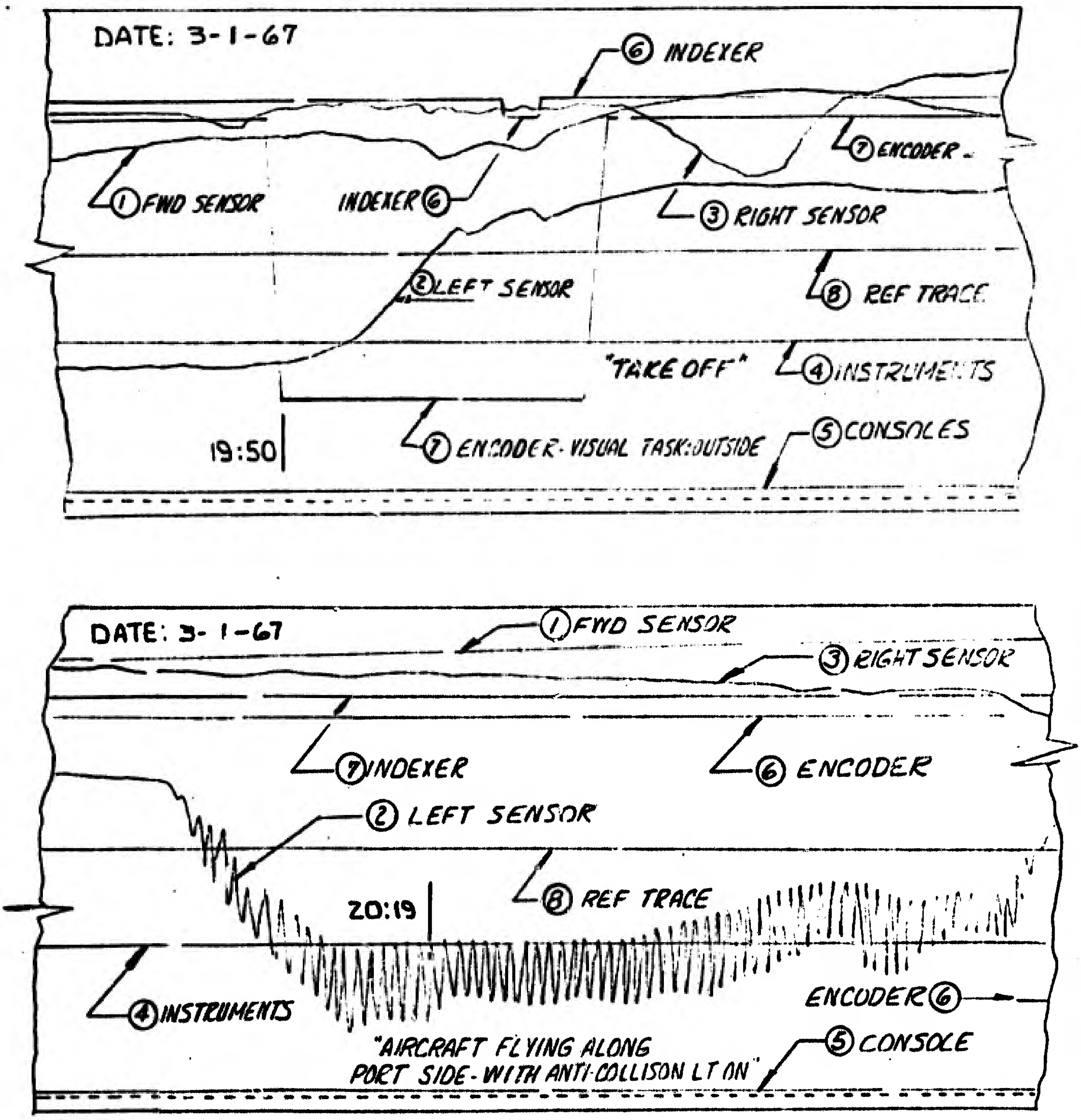

FIGURE 36
SAMPLE RECORDER TAPES
FROM ACTUAL FLIGHTS

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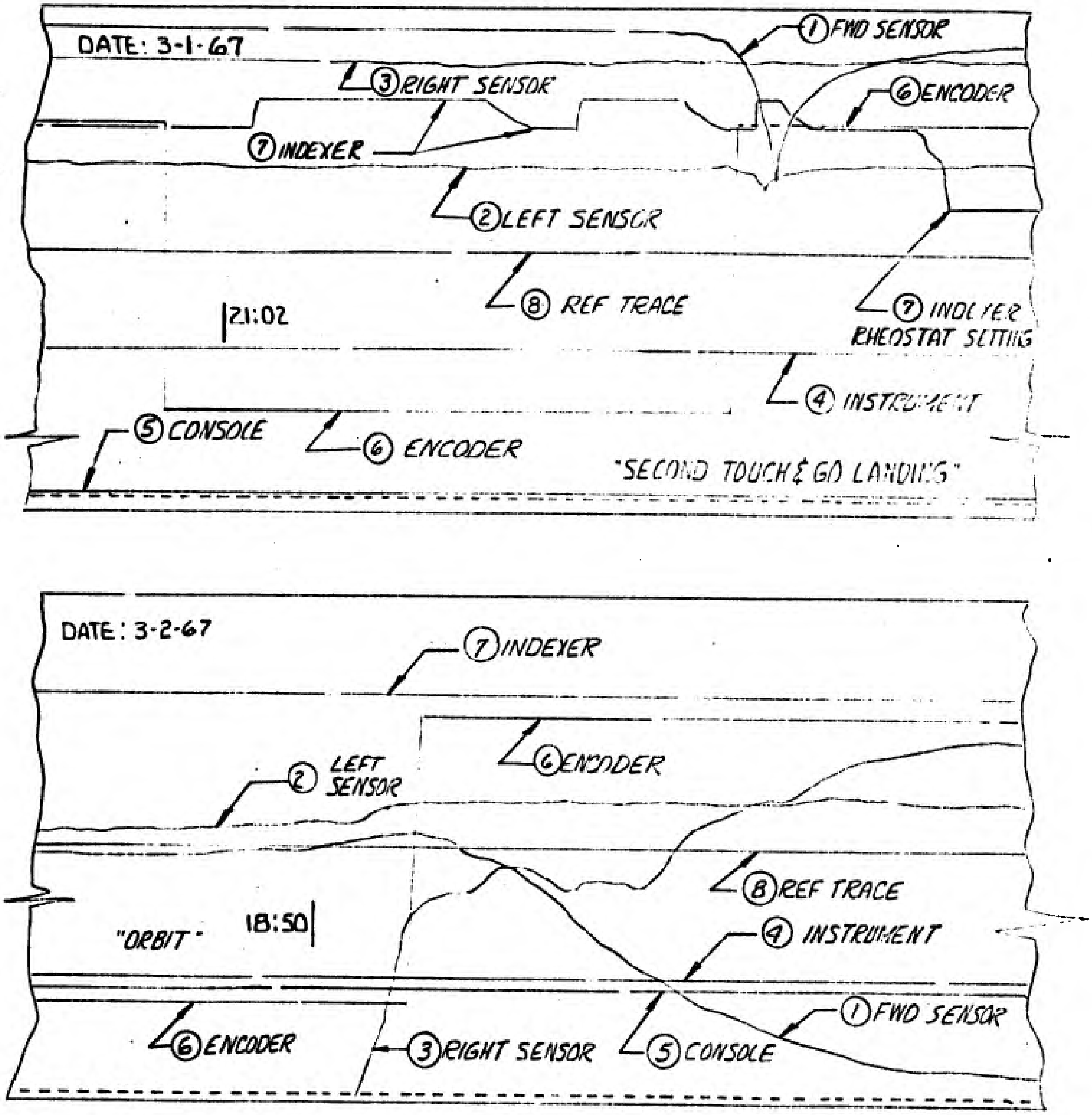


FIGURE 37
SAMPLE RECORDER TAPES
FROM ACTUAL FLIGHTS

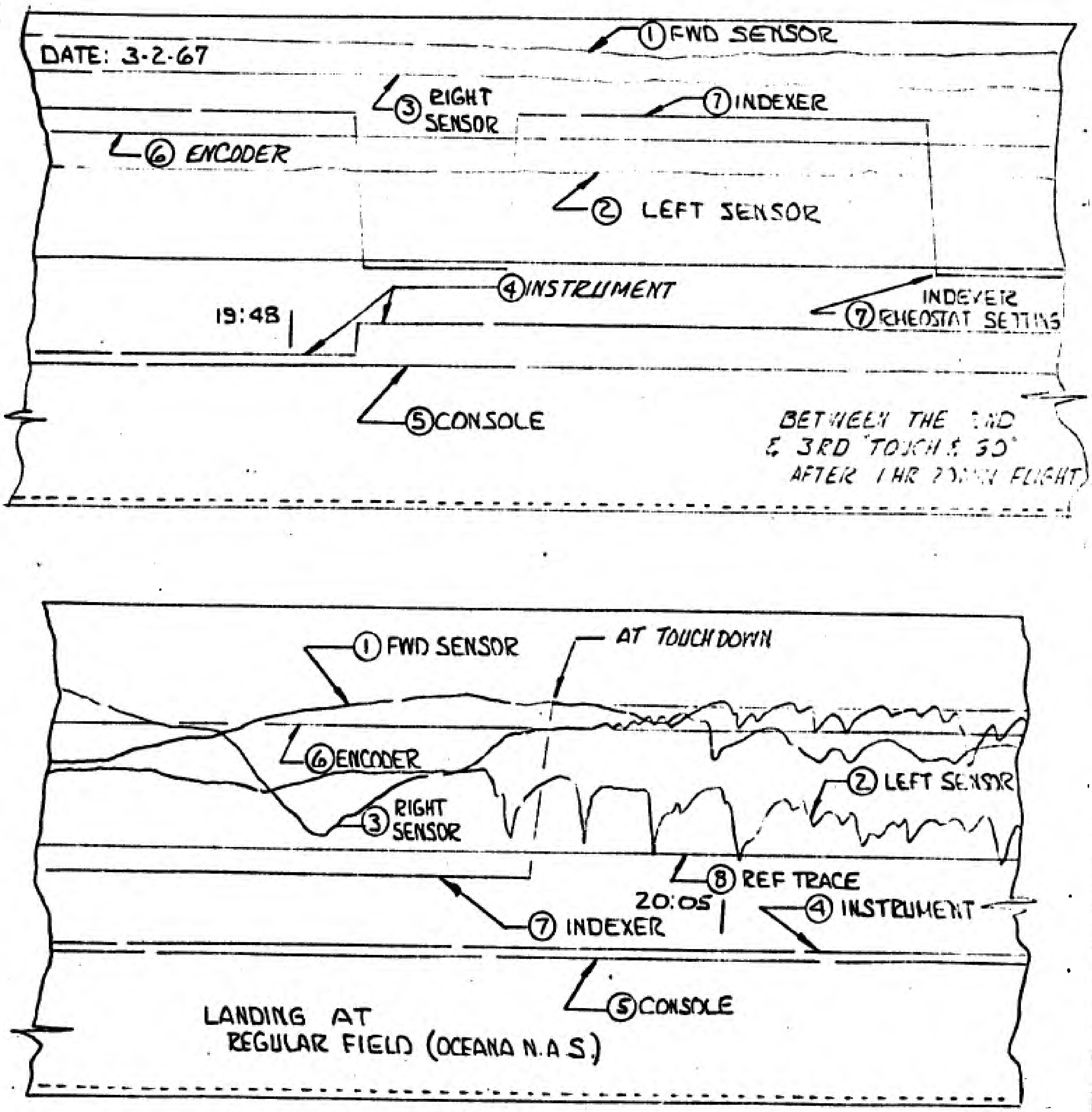
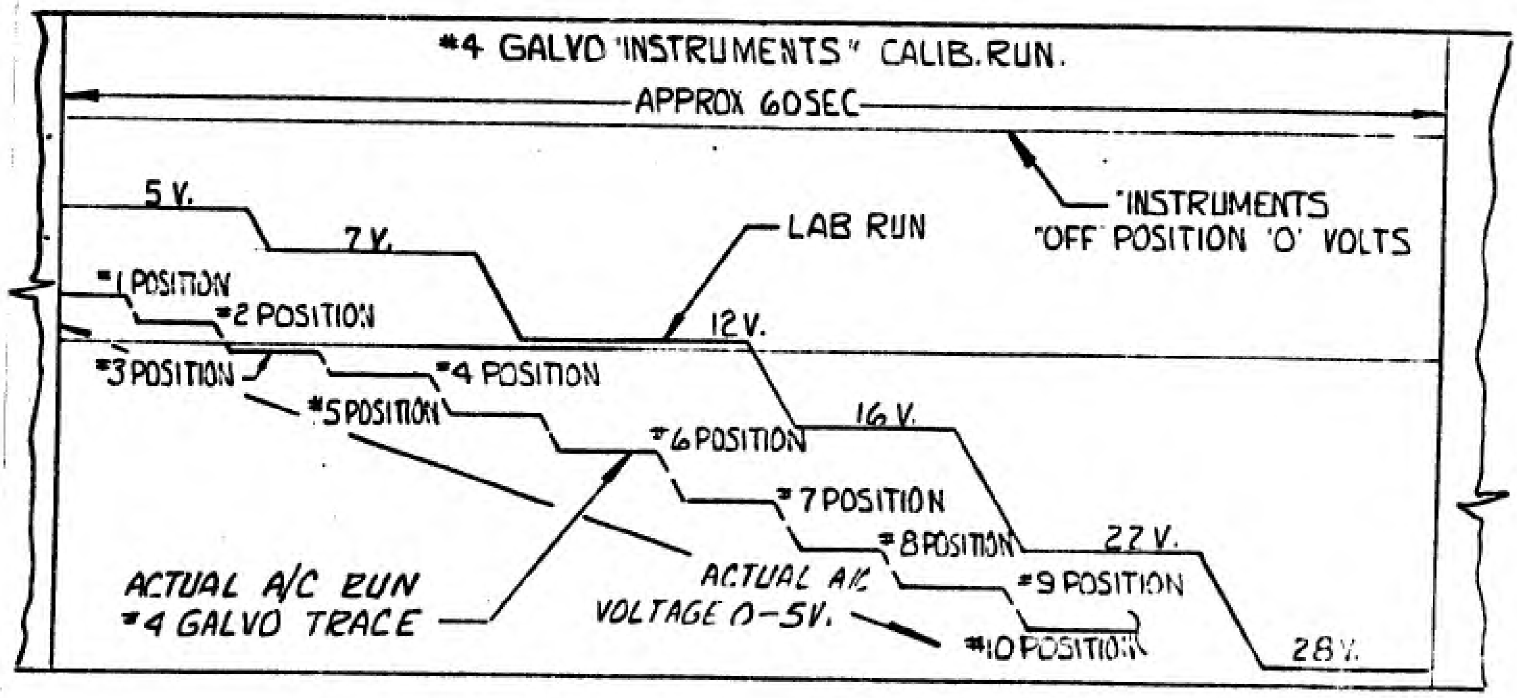


FIGURE 38
SAMPLE RECORDER TAPES
FROM ACTUAL FLIGHTS



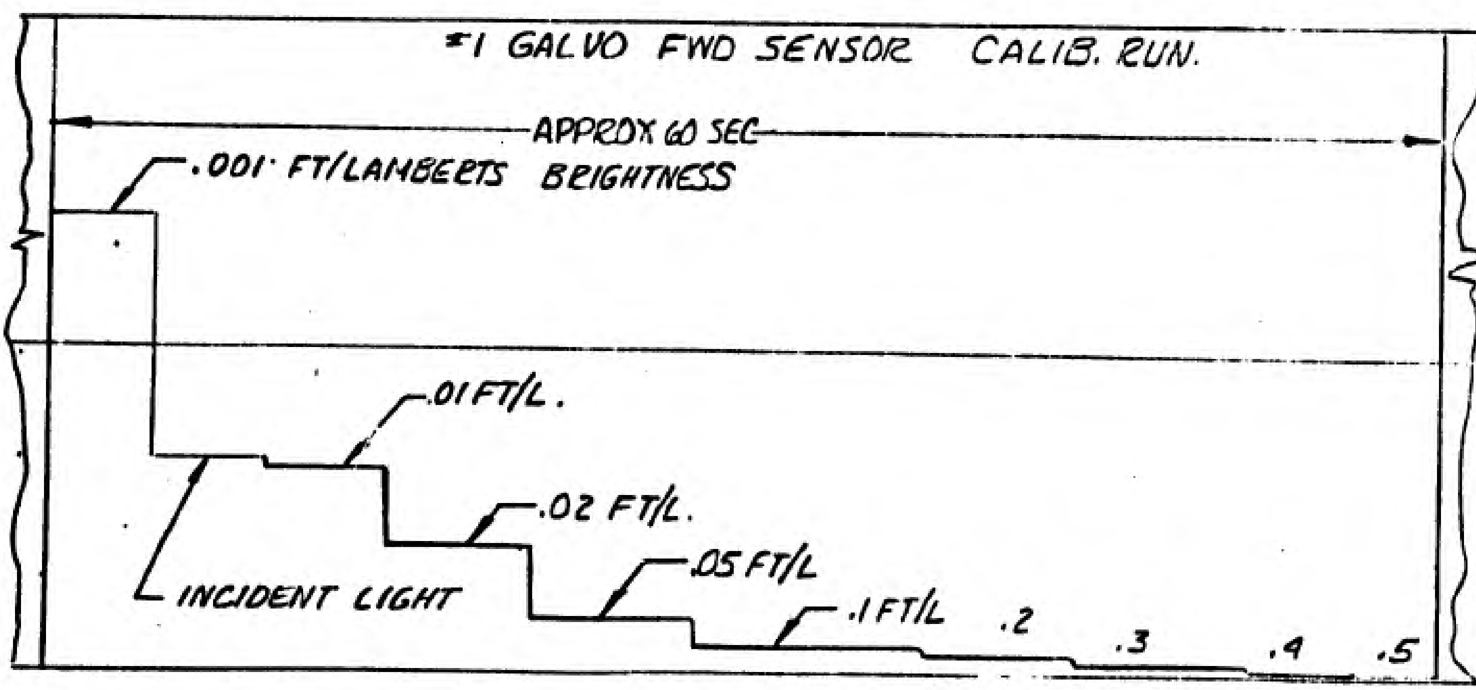
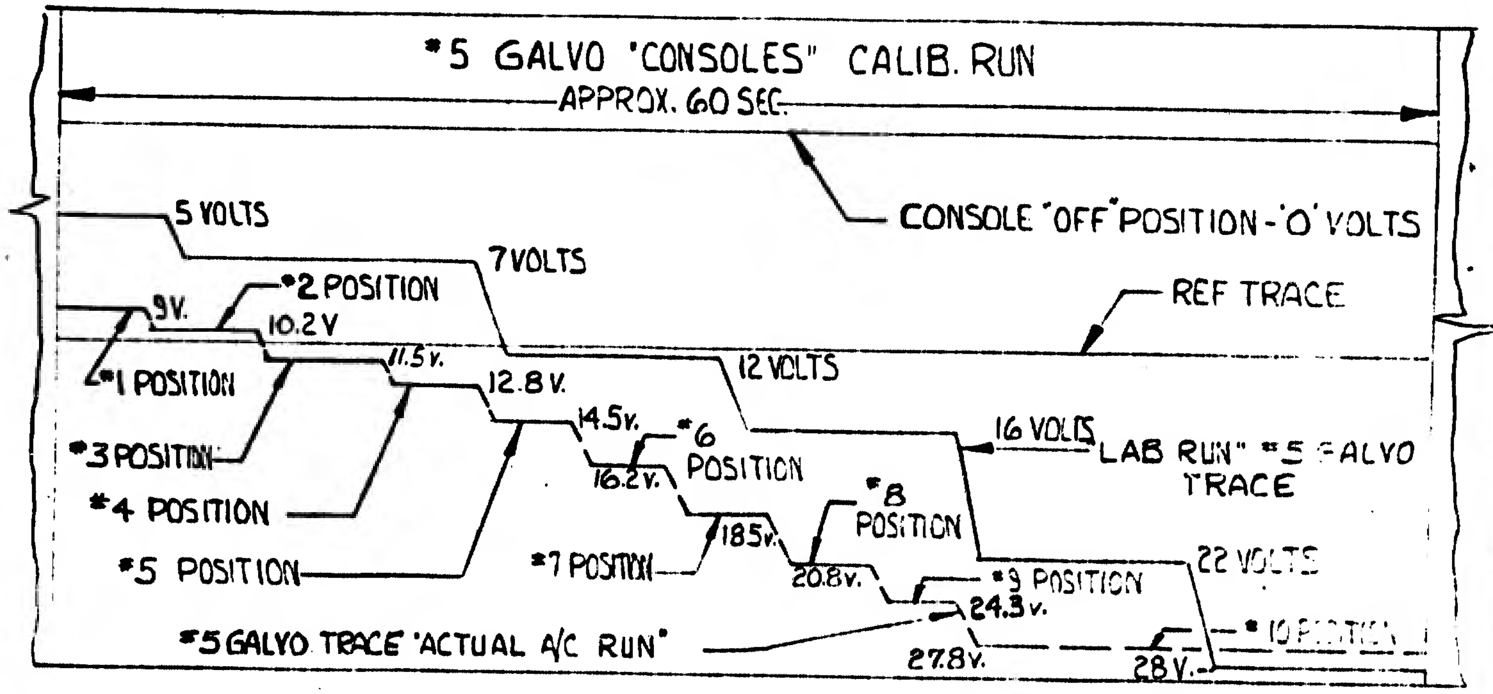


FIGURE 39
SAMPLE TAPES FROM LAB
CALIBRATION RUN.



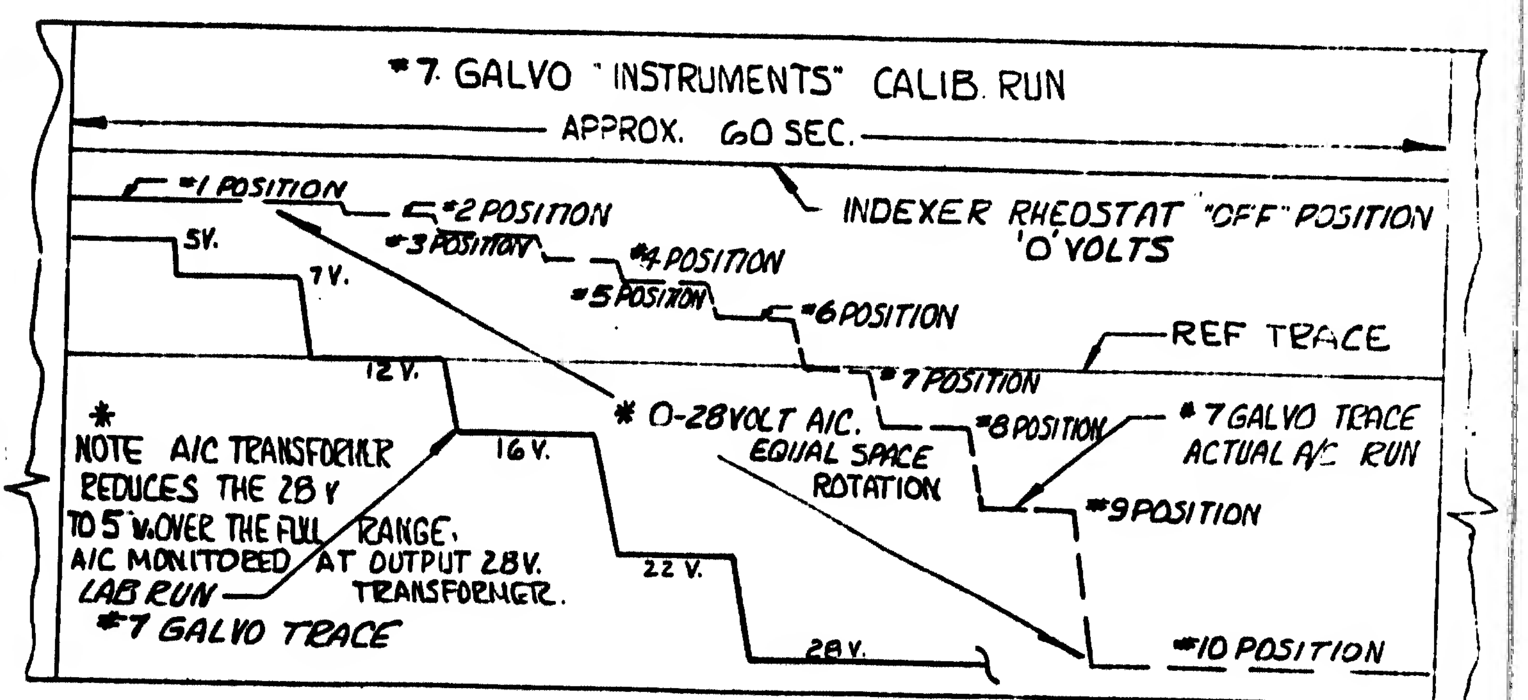


FIGURE 40
SAMPLE TAPES FROM LAB CALIBRATION RUN.

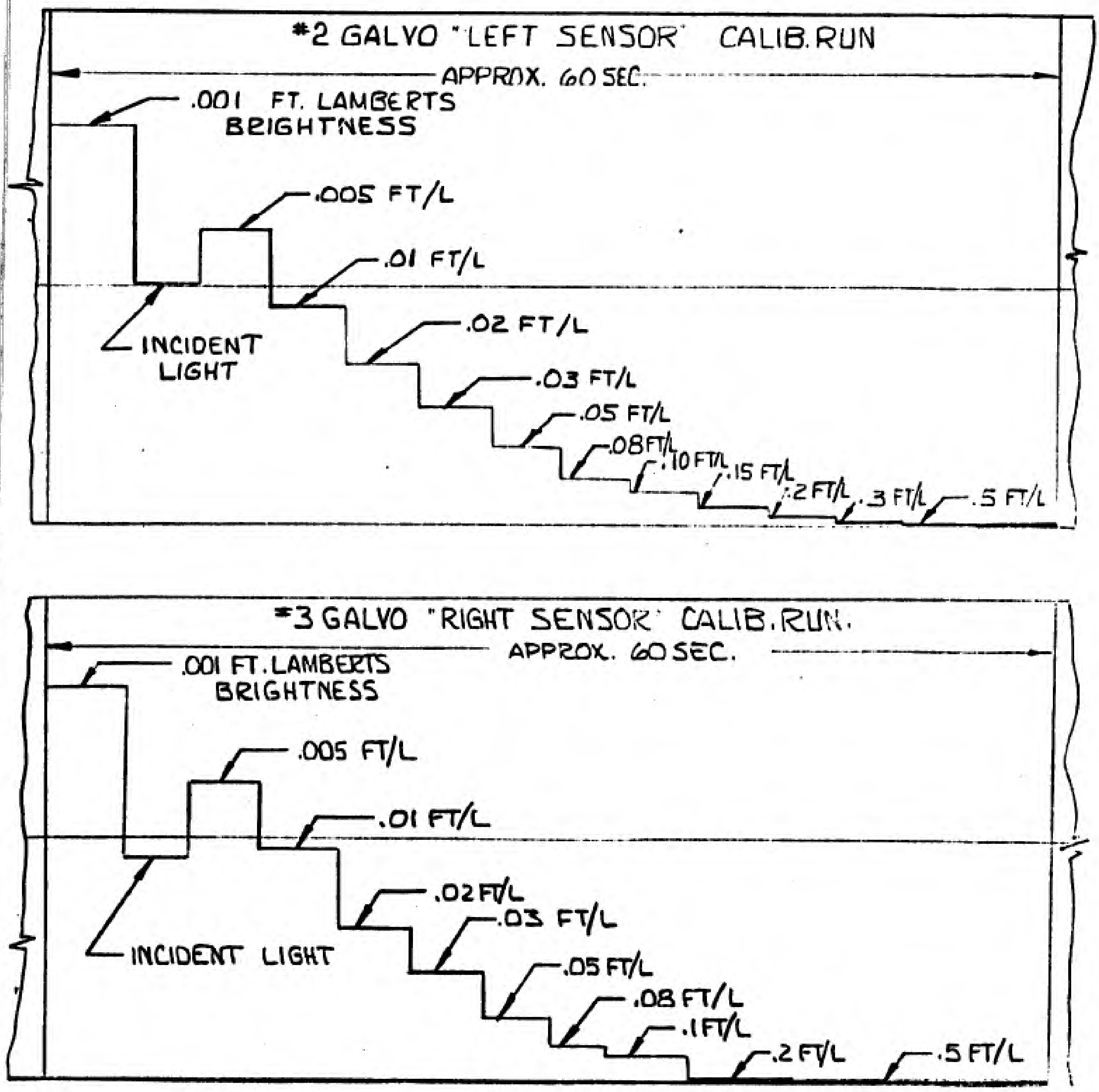


FIGURE 41
SAMPLE TAPES FROM LAB CALIBRATION RUN.

APPENDIX B

INTERVIEW OUTLINE

This outline is designed to provide a structured basis for the post flight interview. The interviewer will record only that information relevant to pilots' visual tasks.

Fill out identification data at the top of worksheet. On the remarks line record if the pilot has been under observation in flight and/or if he has filled out one of the general cockpit lighting questionnaires. If either of the conditions have been met by the interviewer, make sure enough information goes on the remarks line to identify pilot with flight on questionnaire.

Each interview will begin with an introduction and "I would like to talk with you briefly concerning a study that is being made by the Navy to determine the visual tasks of pilots at night. Since it is difficult to measure directly visual task, one very important source of information will be gained from these structured interviews with experienced pilots.

"Now try to think back to your last flight and give me some idea of what you did visually during pre-flight" etc.

Keep the interviewee on the subject as much as possible. Get the pilot to elaborate in any area that seems to have presented a visual problem. Make special note of these problems.

Form 351-F

NADC-AC-6803

NORTH AMERICAN AVIATION, INC.
COLUMBUS DIVISION
COLUMBUS 16, OHIO

NA67H-497

WORKSHEET FOR VISUAL TASK INTERVIEW

Identification Number ____________________ Date ____________________

Interviewer ____

Hours since last night flight ____________ Type A/C ____________

Approx. night flight hrs. ____________ Type of mission ____________

Type of A/C flown on last night mission ____________________

Type of A/C usually flown ____________________

Land based flight (check) ____________ Carrier flight(check) ______

Remarks

PRE-FLIGHT

TAXI

TAKEOFF (or CAT SHOT)

CLIMBOUT

CRUISE

MISSION

PRELIMINARY APPROACH

FINAL & LANDING

TAXI

POST FLIGHT

APPENDIX C

QUESTIONNAIRE RESULTS

The results of the questionnaire are based on a detailed perusal of one hundred ninety-two surveys plus an additional thirty-four questionnaires which were received late in the study.

The results therefore represent an examination of two hundred and twenty-six questionnaires gathered from east coast Navy air facilities. Summaries under questions were made by combining responses into categories for easier understanding. The total on each item may not add to two hundred twenty -six because some pilots left some questions blank. Percentage items were based upon those answering the question. "No replies" was not treated as a separate category.

1. Rank:

Ensign	3
Lt. Jg.	43
Lt.	78
Lt. CDR.	77
CDR.	25

2. Designator:

All those who filled out the questionnaire were pilots.

3. Present Primary Job:

There were almost as many primary jobs listed as pilots who filled out the form. The primary categories were however: pilot, OPS officer, safety officer, squadron X.O. or C.O. and test pilot.

4. Months Experience at Present Job.

Mean = 11 months

5. Total Approximate Flying Time as a Pilot:

Mean = 2308 Hrs.

6. Approximate Night Flying Time as a Pilot:

Mean = 520 Hours.

7. Type of Aircraft Currently Operating:

Approximate Hours in This Type Aircraft:

TYPE	MEAN HOURS	NO. OF A/C IN SAMPLE
A-4	631	27
A-6	571	11
C-118	1280	5
E-2	357	3
EA-1	832	10
F-4	197	8
F-8	450	2
RA-5	352	28
RF-8	584	7
S-2	1500	20
SH-3	602	40
SP-2	1086	43
SP-3	753	10
T-2	950	8

8. Have you ever received night vision training?

Yes. 98%

No. 2%

9. Have you ever received any training in aircraft attitude recognition at night?

Yes. 81%

No. 19%

10. Do you feel this type of training helped (or could help) in the identification of aircraft at night?

Yes. 81%

No. 19%

11. What could be done to improve aircraft visibility at night?

(listed by categories of response from highest to lowest)

Miscellaneous replies

Use strob lights

Brighter position lights

Reduce canopy reflection

Brighter position lights

More effective anti-collision lights

Light trailing edge of wing

12. a. Are flashing lights bothersome to you when flying? ______ If so, when?

Yes. 72%

No. 28%

When? (Listed by categories of response from highest to lowest)

I.F.R.

Hovering

In formation

At night

b. Are flashing lights of other aircraft bothersome to you? -- When?

Yes. 46%

No. 54%

When? (Listed by categories of response from highest to lowest)

I.F.R.

At night

Refueling in flight

On ground

13. What are the most critical lighting problems in join-up and formation flying? (listed by categories of response from highest to lowest)

Determining closure rate

Need to determine A/C attitude

Miscellaneous replies

Anti-collision lights too bright

Too much glare from inside cockpit

Adjusting cockpit light switches

Winglights too small

No reference lights on tail

14. Are there any specific lighting problems you have encountered taxiing at shore-based installations? Explain:

Yes. 66%

No. 34%

Explain: (listed by categories of response from highest to lowest)

Miscellaneous replies

Difficult to determine taxi ways

Confusion at intersections

Lights too far apart

Too many bright lights around base

Mat areas unlighted

15. Do lights from any source, or lack of them, cause you any concern or difficulty during or immediately after take-off from a shore base installation? Explain:

Yes 33%

No 77%

Explain: (listed by categories of response from highest to lowest)

Miscellaneous replies

Lights from areas adjacent to field distracting

Runway lights too bright

16. Have you noticed or found distracting, canopy or windshield reflections on your aircraft during night flights? Yes _____ No _____ Comment.

Yes. 83%

No. 17%

Comment: (listed by categories of response from highest to lowest)

Reflections on canopy and windshield

Console lights reflect on canopy

Miscellaneous replies

Cockpit lights must be dimmed too much to avoid glare

17. Have you ever run your seat up or down in an attempt to rid yourself of an annoying reflection in canopy or windshield?
Yes ______ No ______

Yes. 63%

No. 37%

Comment. Does no good just puts reflection in a different place.

18. What lighting problems have you encountered in night refueling operation? (listed by categories of response from highest to lowest)

Miscellaneous replies

Difficulty in seeing basket

Difficulty in determining closure rate

Insufficient drogue lighting

Tanker grimes light distracting

19. What lighting improvements could you suggest that would make air refueling easier?
(listed by categories of response from highest to lowest)

Miscellaneous replies

Better illumination for drogue

Put more light on tanker to show outline

Use reflective tape on basket

20. Approximately how many night carrier landings have you made?

Mean = 68 landings

21. What is the biggest lighting problem in night carrier landings? (listed by categories of response from highest to lowest)

Miscellaneous replies

Carrier deck lighting hard to see

a. lack of light

b. spotting edge and centerline lights

Depth perception difficult

Transition I.F.R. to V.F.R. difficult

Windshield and canopy reflections

Determining carriers attitude

Flying the "BALL"

22. Can you suggest any solution to this problem?
(listed by categories of response from highest to lowest)

Miscellaneous responses

Use more "red carpet" lights

Use more white flood lighting

Use more center line strobes and droplights

Increase deck light intensity

23. When do you have difficulty seeing other A/C in the pattern during night carrier operations?
(listed by categories of response from highest to lowest)

Miscellaneous responses

Always fly I.F.R.

Turn on final

During poor visibility

When directly behind another A/C

When anti-collision light is out

Right after wave off or take off

Always have difficulty

24. Are there any problems, associated with lighting, in carrier night "take-offs" for you as a pilot? Explain.

Yes. 41%

No. 59%

(listed by categories of response from highest to lowest)

Miscellaneous replies

Loss of light during "cat shot"

Transition from V.F.R. to I.F.R.

Must use flashlight as backup light

25. What could be done to improve the lighting environment on carrier decks? (listed by categories of response from highest to lowest)

Miscellaneous replies

White floods big improvement

High intensity red floods

More deck edge illumination

More "red carpet" lighting

26. Approximately how many hours of night A.S.W. flight operations have you completed?

Mean = 220 hours

27. Do you have any trouble keeping track of other airplanes or helicopters in the search area at night? Explain.

Yes. 51%

No. 49%

Explain: (listed by categories of response from highest to lowest)

Miscellaneous replies

Only small percentage of time visual

Flares and surface craft distracting

Only during poor weather

Difficult to identify various types of A/C

28. Is there any feature of aircraft lighting that creates a problem for you in performing a night search operation? Explain.

Yes. 63%

No. 37%

Explain: (listed by categories of response from highest to lowest)

Windshield and canopy reflections

Miscellaneous replies

Insufficient light on plotter

Insufficient light in cockpit

Lighting uneven on instruments

29. How many flight hours in night helicopter operations do you have?

Mean = 352 hours

30. Does light or lack of light create any problem when landing a helicopter at night? Explain.

Yes. 62%

No. 38%

Explain: (listed by categoires of response from highest to lowest)

Miscellaneous replies

Can't judge depth or rate of closure without more light

Lack of light prevents detection of drift

Lack of light makes everything more difficult

Canopy reflections a problem

31. What problems have you experienced in night ASW operations in helicopters that might be alleviated by an improved lighting system? (listed by categories of response from highest to lowest)

Miscellaneous replies

Canopy and windshield reflections

Forward rotating beacon causes vertigo

Poor knee board light

Poor nav. instrument lighting

32. What are the cockpit lighting problems peculiar to helicopters? (listed by categories of response from highest to lowest)

Cockpit reflections on canopy

Miscellaneous replies

Center console canopy glare

Rotors reflect light into cockpit

33. Can you suggest anything that could be done to lessen canopy reflection?
(listed by categories of response from highest to lowest)

Miscellaneous replies

Change texture of canopy Plexiglass

Shield instruments more effectively

Polarize windshield and instruments

Keep all lights dim inside cockpit

34. Do the variety of colors in the cockpit seem to create any special problems at night? If so explain.

Yes. 18%

No. 82%

Explain:

Responses to this question follow no pattern. Each pilot seems to have a favorite color that bothers him.

35. Is map reading a problem at night in a helicopter cockpit? Explain.

Yes. 77%

No. 23%

Explain: (Listed by categories of response from highest to lowest)

Miscellaneous replies

When lights set for best operations can't see maps.

No more difficult than other A/C

36. Are there any instruments in your aircraft that are not sufficiently lighted? Explain.

Yes. 71%

No. 29%

Explain: (Responses which were most common are listed by A/C type)

D.M.E. SP-2, EA-1, A-Y, A-6, RA5

Console lights inadequate SP 2, A-4, F-8

I.F.F. E-1, SP-3, A-6

Tacan A-4, RA,5

Radio channel selector A-4, F8, C118, SP-3

Landing gear circuit breaker A-4, A-6

Fuel gauge RA-5

Clock A-4

37. Is the warning light system in your aircraft effective? If not what could be done to improve the system?

Yes. 79%

No. 21%

(Responses which were most common are listed by A/C type)

All warning lights should be grouped with a master caution light. SH-3 SP-2

Can not set intensity. all types

Too many advisory lights. A-6

Should be able to dim advisory lights. A-4

Relocate warning lights. F-8

Lights too bright. F-8, RA-5

38. Are the advisory lights in your aircraft properly located?

Yes. 86%

No. 14%

(Responses which were most common are listed by A/C type)

Too widely scattered S-2, SH-3, E-1

Radar altimeter warning light hard to see A-6

Hard to see ones under arm E-2

39. Are the thunderstorm or HI-intensity lights useful?

Yes. 85%

No. 15%

(listed by categories of response from highest to lowest)

Miscellaneous replies

Never use them

Very useful

40. In your opinion what could be done to improve instrument lighting? (listed by categories of response from highest to lowest)

Miscellaneous replies

Use more integral lighting

Reduce windshield and canopy reflections

Eliminate direct light on instrument to cover glass

Uniform intensity control

Use white light

41. What is the most critical problem with regard to lighting in your cockpit? (Responses which were most common are listed by A/C type)

Canopy or windshield glare SH-3, F-8, C-118, F4, SP-2, A-6, RA-5

Center Console SH-3 A4

Nav. equipment switches difficult to see SH-3

Reading maps SP-2, S-2

Unsatisfactory light adjustment S-2

Inadequate knee board light F-4, F-8, A-4

42. Are there any lights within the cockpit which cause your visual tasks to be more difficult?

Yes. 51%

No. 49%

Comment: (listed by categories of response from highest to lowest)

Miscellaneous replies

Radios poorly lighted

Canopy and windshield reflections

Some advisory lights distracting

Kneeboard difficult to see

Need to be able to vary intensities better

Some lights too bright others too dim

43. Does unbalanced panel lighting cause any problem? Explain.

Yes. 26%

No. 74%

Explain (listed by categories of responses from highest to lowest)

Miscellaneous replies

Different intensity settings are distracting

Intensity must be too high to light dim instruments

Too many after thoughts in design

When pilot and co-pilot disagree on intensity

44. Do canopy reflections create night flying difficulties?

Yes. 80%

No. 20%

45. In your normal flying, on what occasion do you require a rapid change in interior light level?

72% of those answering this question required no change.

Comment (Listed by categories of response from highest to lowest)

Miscellaneous replies

Map and chart reading

During thunderstorms

Reading radio frequencies

For landings

Right after take-off (ship and shore)

46. Do you have any suggestions which might cut down canopy glare? Explain.

Yes. 47%

No. 73%

Comment: (listed by categories of response from highest to lowest)

Miscellaneous replies

Use glare shields some way

Use non glare instrument faces

Angle instruments

Recess instruments

Use back-lighting

Use tinted glass

47. What are the lighting problems created by the presence of radar scopes, gun sights, etc. in your cockpit? Explain.

40% of those writing comments reported no problem

Explain: (listed by categories of response from highest to lowest)

Miscellaneous replies

Gunsights too bright

Gunsight control too sensitive

Radar causes glare on canopy

Radar too bright for approach on landing

48. Which, if any, controls in your cockpit are difficult to find?

(Response: which were most common are listed by A/C types)

Radios SH-3, A-4, A-6

Overhead switches SH-3

IFF A-6, C118, S-2, F8, SP-2

Interior light switches F-8, RA-5

Flaps F-4

49. Why do you find these controls difficult to locate? (listed by categories of response from highest to lowest)

Miscellaneous replies

Inadequate lighting

Too many knobs around radios

Too close to one another

All toggle switches feel the same

Must twist body to reach them

50. Do you have any trouble locating maps and other equipment while flying at night? Explain.

Yes. 39%

No. 61%

Comment: (listed by categories of response from highest to lowest)

Miscellaneous replies

No place to put maps

Must use flashlight

Map cases inaccessible

51. Is it distracting to you that different pieces of equipment have different color advisory lights?

Yes. 7%

No. 93%

No consistent pattern of replies

52. Would a map case light be useful in your A/C?

Yes. 18%

No. 82%

No consistent pattern of replies

53. Is your knee board sufficiently lighted? If not, what could be done?

Yes. 18%

No. 82%

Suggestions: (listed by categories of response from highest to lowest)

Miscellaneous replies

Make light weight board with sturdy light

Put light on canopy

Make a reliable light

Use A/C power to plug into knee board

Use goose neck light

54. Do you consider the range of control of console and instrument panel lighting to be sufficient? Yes _____ No _____ Comment.

Yes. 87%

No. 13%

Comments: (Responses which were most common are listed by A/C types)

More separation needed SH-3

Need more rheostats A-4, SP-2, RA-5

55. Do you utilize any light other than supplied with your A/C at night? Yes _____ No _____ Describe.

Yes. 95%

No. 5%

Almost all pilots use a flashlight, generally Boy Scout type with red lens. Some report using a cigarette lighter.

56. Do you feel that your park adaption has been degraded by the lighting during starting period? Yes _____ No _____

Yes. 22%

No. 78%

57. Where do you position your controls for interior lights prior to take-off at a shore base?

Low 8%

Med. 56%

High 36%

58. Where do you position your controls for interior lights prior to take-off on a carrier?

Low 15%

Med. 60%

High 25%

59. On a carrier, immediately after take-off, do you feel that the interior lights should be turned up, down, or not concerned until after climbout?

Up 2%

Down 16%

Not concerned 82%

Comment: no time to change setting

60. You are on a lone operational flight (ferry aircraft Pax to Sanford), take-off 2100 hours, VFR, clear starlit night, no moon, reach cruise altitude and picked up heading. Where do you position your interior lighting controls?

Low 33%

Med 55%

High 22%

After one hour

Same 43%

Up 1%

Down 56%

61. Do you mark over, mask or remove any distracting lights? If so, what?

Yes. 52%

No. 48%

Mark over 17%

Mask 67%

Remove 16%

Most responses were idiosyncratic. Only the following received more than one response.

A/Q-S Control box	(mark over)	A-4
Doppler light	(mask)	SH-3
Wheel warning light	(mask)	A-4
Radar altimeter light	(mask)	SH-3, A-4
Anti-ice light	(mask)	SH-3
Engine door light	(mask)	RA-5
G.T.P. 4.	(mask)	SP-2

62. If you fly into an overcast at night, do you turn interior lights up? _____ Down? _____ Leave alone? _____

Up 13%

Down 13%

Leave Alone 74%

63. With regard to cockpit lighting name one outstanding aircraft. Pilots tended to name the A/C currently operating. Only seven chose other A/C and these were trainers, presumably the one in which they took instruction.

64. With regard to vision, name one outstanding aircraft.
Every A/C in questionnaire was mentioned. Only a few types were listed outside current assignment. They were: T-28, T-2, SP-2, SH-3.

65. Are there any instruments on your aircraft that are difficult to read at night? Yes _____ No _____ Name:

Yes. 73%

No. 27%

Name: (Responses which were most common are listed by A/C type)

Radio frequencies SH-3, C-118

B.D.H.I. SH-3, A-4

DME A-4, SP-2, E-1, RA 5

Gear Indicator A-6, F-8

M.A.D. SP-2

Compass SP-2

Fuel Totalizer RA-5

66. Would you prefer post lighting or any other method over integral lighting (transilluminated)? Yes _____ No _____ Comment:

Yes. 26%

No. 74%

Comment: (listed by category of response from highest to lowest)

Miscellaneous replies

Less glare from integral

Integral more reliable

Integral hard to repair

Post lights easy to change

Post lighting uneven

67. Have you modified any lighting in your aircraft? Instrument lights, maplights, etc.

Yes. 3%

No. 97%

68. Does your map storage area need a light?

Yes. 29%

No. 71%

69. Is the kneenoard in your aircraft sufficiently lighted? Yes ____ No ____
If not, what do you feel could be done to improve it?

Yes. 18%

No. 82%

Comment: (listed by category of response from highest to lowest)

Miscellaneous replies

Light knee board

Put swivel light on canopy

Use gooseneck lamp on side console

70. Do you preset your interior lights before you come into the landing pattern for a carrier or base landing? Yes ____ No ____

Yes. 63%

No. 37%

71. During your firing runs at night using your gunsight, were the lighting adjustments satisfactory? Yes____ No ____ Comment:

Yes. 47%

No. 53%

Comment: (listed by category of response from highest to lowest)

Gunsight too bright

Miscellaneous replies

Hard to keep adjusted

Red gunsight would help

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13. ABSTRACT

A preliminary study in which visual tasks, lighting utility, and ambient external light levels were examined on a time-task basis in an instrumented F4B aircraft. Methods included photometric and electrical recordings of the internal and external lighting environment of the aircraft. Also, pilot interviews, questionnaires, and direct observations of pilots in the F4B and other aircraft were employed. The results indicate that the methods employed are practical and that the visual tasks performed and ambient external lighting conditions are important determinants of lighting utility inside the cockpit.

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