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# U.S. ARMY HUMAN ENGINEERING LABORATORY HELICOPTER COCKPIT LIGHTING STUDY. PHASE I. AN EVALUATION OF CURRENT AND POTENTIAL INSTRUMENT PANEL LIGHTING TECHNIQUES FOR USE IN ARMY HELICOPTERS

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Human Engineering Laboratory
Aberdeen Proving Ground, Maryland

August 1974

Technical Note 7-74

# US ARMY HUMAN ENGINEERING LABORATORY HELICOPTER COCKPIT LIGHTING STUDY

## PHASE I – AN EVALUATION OF CURRENT AND POTENTIAL INSTRUMENT PANEL LIGHTING TECHNIQUES FOR USE IN ARMY HELICOPTERS

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This report contains the results of the first phase of a cockpit lighting study conducted by the U. S. Army Human Engineering Laboratory. The objective of the study is to evolve lighting specifications which will alleviate current cockpit lighting problems. The objective of this phase was to quantitatively identify the problems with current lighting systems in Army helicopters. It also investigated the potential improvements afforded by some of the state-of-the-art lighting techniques.

Luminance measurements were made at various points on instrument dial faces. Results are shown in tabular and pictorial forms. The results also showed that the current techniques of post and

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eyebrow lighting are unacceptable. From a comparison of all the techniques examined, the circular edge technique gave the best light distribution. Illuminance measurements were made at the pilots' eye positions for use in other phases of the lighting study.

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US ARMY HUMAN ENGINEERING LABORATORY
HELICOPTER COCKPIT LIGHTING STUDY

# PHASE I – AN EVALUATION OF CURRENT AND POTENTIAL INSTRUMENT PANEL LIGHTING TECHNIQUES FOR USE IN ARMY HELICOPTERS

## INTRODUCTION

Cockpit lighting systems have presented problems to pilots since their inception. These problems have been accented with the importance of low-level night flying using the unaided eye to accomplish the Army's mission and the need to maintain dark adaptation for best vision performance. One of the main problems is the uneven distribution of light, not only an uneven distribution between instruments, but even within instruments. This uneven distribution causes bright spots at higher levels of illumination and dark spots at the lower levels. Both of these conditions render that part of the instrument unreadable. The pilot is forced to make a choice. He may turn all his lights up to compensate for the dark spots and destroy his dark adaptation or leave the lights dim which causes loss of legibility and increases the time to cross-check his instruments and may be the cause for reading errors.

The U. S. Army Human Engineering Laboratory (HEL) has begun a project which will be aimed at correcting some of the current problems. The first step in any project, and the goal of this phase, is to properly identify the problem. To achieve this, measurements were taken of the luminance values of the markings at various positions. Measurements were made of the instrument panels of the UH-1H and OH-58A. With each type of aircraft, measurements were taken at high as well as low brightness settings. All measurements were made at night or in a covered cockpit to keep the influence of ambient light to a minimum. Photographs were also taken at each brightness setting to help point out the problems.

The data collected would then serve as a datum base against which future experimentation with various lighting techniques can be compared.

## APPARATUS

Gamma Scientific, Inc., Photometric System, consisting of the following:

- Luminance Standard Head, Model 220-1A
- Photometer, Model 2020
- Standard Lamp Source, Model 220
- Photomultiplier Detector Assembly, Model 2020-A
- Photometric Microscope, Model 700-10
- Fiber Optic Probe, Model 700-38
- Photopic Filter, 2020-1A S/N 7083
- Scotopic Filter, 2020-18 SN/ 7083
- Lamp Source Filter, 220-13

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## PROCEDURE

All of the measurements were made at night and the helicopters were positioned to eliminate the effects of the light coming from the aircraft hangar, surrounding buildings, etc. Meteorological conditions at the beginning of each test session were recorded.

After calibration, the photomultiplier detector assembly was used to measure the illuminance outside the aircraft as well as inside the aircraft at the pilot's design eye position. Both readings were made with all aircraft lights off. The purpose of these measurements was to determine how much of the ambient light reaches the pilot's eye.

The instrument and console lights were adjusted to the position where they were measured. At the "high" setting, the controls were turned to full brightness which corresponded to a voltage of 28 VDC. For the "low" setting, pilots who were currently flying night missions from Phillips Army Airfield were asked to mark control positions after they were adjusted to minimum brightness level for legibility of all instrument markings. The results are as follows:

| | |
|---|---|
| Pilot's flight instruments | 18 VDC |
| Copilot's flight instruments | 17.5 VDC |
| Engine instruments | 21 VDC |
| Center console | 22 VDC |
| Overhead console | 19 VDC |

Light levels in the test aircraft were then set to these levels. Photographs of the instrument panel were taken at this time.

Again, using the detector assembly, photometric measurements were made of the light density at the pilot's design eye position. The measurements consisted of a reading with instrument lights only, console lights only, and a third with both instrument and console lights. Each set of readings was taken once with a photopic filter and again with a scotopic filter. The equipment was recalibrated before each filter was used.

After recalibration, luminance measurements were made on the dial face of each instrument. Markings were measured at the 1, 4, 7 and 10 o'clock positions. Backgrounds were measured at the 12, 3, 6 and 9 o'clock positions. On those instruments whose scale is semi-circular, marking and background readings were taken at the same clock position. Pointers and legends were also measured. Certain instruments, because of their nature, could not be measured by clock positions. Therefore, on the attitude indicator, omni indicator, turn-slip indicator, and the magnetic compass, measurements were made of the key features.

For the OH-58A, measurements were made inside the aircraft hangar with the aircraft covered with a black cover. All other procedures are the same.

A second set of measurements was made in the Laboratory. HEL obtained, on loan, several instruments from Kollsman Instrument Company which employ other lighting techniques. These techniques include the standard wedge, circular wedge, and center-lit. The instruments were available in both red and white lighting. The calibration and measurement procedures were the same as in the helicopters except all of the markings were measured.

An instrument employing a backlighting technique was fabricated from cannibalized equipment. Measurements were made similar to those for the Kollsman instruments.

## RESULTS AND DISCUSSION

The results of the measurements made on the UH-1H clearly indicate the problem. The type of lighting used in this helicopter is post lighting. As can be seen from the data in Tables 1 through 4, the brightest spots are at the top of the instrument and the dimmest spots are at the bottom. Figures 1 through 4 show this data in a graphical form. Either one of these clearly shows the wide variety of luminance values within any instrument; even at the lower brightness settings.

Figures 5 and 6 show the variations of contrast ratio between instruments as well as within instruments. On the other markings, the contrast ratio was approximated by using the value of the marking and the adjacent background value (1 o'clock marking and 12 o'clock background, etc.). When computing the contrast ratios of the pointers and legends, the value used for the background was the average of the background readings at the various clock positions. These ratios are shown in the center of the instrument. When two values are given, the top value is the contrast ratio of the pointer and the bottom value is that of the legend. When only one value is shown, this represents the pointer contrast ratio. The formula used for the computation of the contrast ratio was $(L_M - L_B)/LB$ where $L_M$ is the luminance of the marking and $L_B$ is the luminance of the background.

The results of the measurements made on the OH-58A are shown in Tables 5 through 8 and in graphical form in Figures 7 through 10. The contrast ratios are displayed in Figures 11 and 12. Again, as with the UH-1H, wide variations can be seen within instruments as well as between instruments.

The results of the measurements made on the instruments from Kollsman Instrument Company have not been shown in graphical form. Also, the tabular data has not been presented. Because of the large number of measurements, no comparisons can be directly applied to other systems. However, for each instrument, computations were made of the standard deviations and means and are presented in Table 10.

Photographs were taken of all of the instrument panels at each brightness level. The photographs are helpful in showing "bright spots" and areas where the dial face is so dark that it cannot be read (Figs. 13 through 15).

## CONCLUSIONS

Even though some of the instruments were lit with red light while others used white light, the color of the lighting system has no effect on the objectives of this study. As the aim of this study is to determine which of the existing lighting techniques will give the best distribution of light across the dial face. The distribution of light will not change because the color of the lighting system is changed.

It is considered that the light distributions in current helicopters are unacceptable. By examining the ratio of standard deviation to mean, as shown in Table 10, it can be seen that the circular wedge technique has the lower values and hence the best distribution. It should be noted at this point, that several lighting techniques were not investigated. These include transillumination, electroluminescent, and integral other than wedge.

Of the lighting techniques tested, circular wedge lighting has the best distribution of the individual instruments. Circular wedge lighting was then compared with the lighting systems currently in use in helicopters. The circular wedge instrument was a dual tach, so a comparison was made between this and the dual tachs in the UH-1H and OH-58A. The results are shown in Figure 18. Again, it can be seen that the circular wedge technique provides the best light distribution.

Therefore, it is concluded that, on the basis of light distribution, the circular wedge technique is better than any other system that was investigated.

TABLE 1

Illuminance Measurements (FC) UH-1H, High Brightness Level

| | | |
|---|---|---|
| Date: | 29 Nov 73 | 3 Dec 73 |
| Aircraft: | 70-16333 | 70-16333 |
| Moon: | 1/4 | 1/2 |
| Voltage: | 27.5 VDC | 27.5 VDC |
| Ambient Illumination: | | |
| Outside A/C: | .0033 | .0100 |
| Inside A/C, lights off: | .0026 | .0033 |
| Internal Illumination: | | |
| Instrument lights only: | | |
| Photopic: | .0140 | .0140 |
| Scotopic: | .0125 | .0125 |
| Instrument and control panels: | | |
| Photopic: | .0142 | .0142 |
| Scotopic: | .0127 | .0127 |
| Control panels only: | | |
| Photopic: | .0035 | .0035 |

TABLE 2

Luminance Measurements (FL) UH-1H, High Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | | Background | | | | |
| Instrument | 1 | 4 | 7 | 10 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Fuel Pressure | .96 | .17 | .096 | .87 | .11 | .061 | .033 | .097 | .93 | 1.50 |
| Eng Oil Press | 1.10 | .19 | .32 | 1.08 | .068 | .042 | .038 | .047 | .31 | 1.20 |
| Trans Oil Press | .46 | .22 | .23 | .16 | .073 | .033 | .025 | .033 | .23 | .037 |
| Fuel Quantity | .49 | .12 | .093 | 1.35 | .067 | .042 | .028 | .048 | 1.20 | 1.65 |
| Dual Tach | .72 | .16 | .093 | .19 | .046 | .050 | .035 | .033 | .21 | .72 |
| Torque | .55 | .13 | .33 | .77 | .063 | .080 | .040 | .062 | .97 | .58 |
| Gas Tach | .54 | .18 | .29 | .53 | .052 | .041 | .039 | .072 | .93 | .24 |
| Exh. Gas Temp | .49 | .78 | .19 | .14 | .013 | .064 | .053 | .042 | .33 | .53 |
| Airspeed | 1.20 | .18 | .32 | .92 | .070 | .050 | .045 | .063 | .88 | .34 |
| Radio Compass | 1.25 | .60 | .70 | 1.40 | .11 | .090 | .083 | .097 | 1.60 | |
| Altitude | .27 | .46 | .26 | .48 | .10 | .050 | .050 | .050 | .72 | .95 |
| Vertical Speed | .40 | .10 | .21 | .21 | .16 | .040 | .070 | .060 | .41 | .56 |
| Clock | .18 | .19 | .21 | .36 | .050 | 050 | .060 | .045 | .20 | |

TABLE 2 (con't)

Luminance Measurements (FL) UH-1H, High Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | Background | | | | | |
| Instrument | 12 | 3 | 6 | 9 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Main Gen Load | .34 | .083 | | 1.15 | .042 | .023 | | .11 | 1.05 | .85 |
| Standby Gen Load | .54 | .50 | | .64 | .105 | .047 | | .12 | 1.07 | .77 |
| Eng. Oil Temp | .58 | | .34 | .88 | .073 | | .037 | .048 | .90 | |
| Trans Oil Temp | .94 | | .77 | .82 | .067 | | .058 | .12 | 2.05 | |
| DC Volts | .92 | .57 | | .46 | .078 | .095 | | .057 | .51 | .89 |
| AC Volts | 1.50 | .67 | | .43 | .12 | .064 | | .056 | .39 | 1.65 |

TABLE 2 (con't)

Luminance Measurements (FL) UH-1H, High Brightness Level

| | |
|---|---|
| Special instruments: | |
| Turn-slip indicator | Attitude indicator |
| Index - .22 | Sky - .49 |
| Pointer - .29 | Ground - .071 |
| Ball race - .13 | A/C symbol - 1.17 |
| Ball - .035 | Legend - .65 |
| Background - .045 | Sky line - .15 |
| Legend - .092 | Ground line - .21 |
| | Horizon - .34 |
| | Roll index - .45 |
| Omni indicator | Magnetic compass |
| One o'clock position - .97 | Numerals - .93 |
| Eleven o'clock position - .82 | Index - 8.30 |
| Elevation - .78 | Compass card - .0065 |
| Azimuth - .92 | |
| Index - .51 | |
| Flag - .63 | |
| Background - .095 | |
| Lower numerals - .19 | |
| Left quadrant marking - .046 | |
| Right quadrant marking - .074 | |

TABLE 3

Illuminance Measurements (FC) UH-1H, Low Brightness Level

| | | |
|---|---|---|
| Date: | 6 Dec 73 | 10 Dec 73 |
| Aircraft: | 70-16333 | 70-16333 |
| Moon: | 3/4 | Full |
| Voltage: | | |
| Engine: | 14 VDC | 14 VDC |
| Flight: | 18 VDC | 18 VDC |
| Ambient illumination: | | |
| Outside A/C: | .0037 | .0125 |
| Inside A/C, lights off: | .0028 | .0053 |
| Internal illumination: | | |
| Instrument lights only: | | |
| Photopic: | | .0034 |
| Scotopic: | | .0058 |
| Instrument and control panels: | | |
| Photopic: | | .0040 |
| Scotopic: | | .0060 |
| Control panels only: | | |
| Photopic: | | .00[illegible]0 |
| Scotopic: | | .0067 |

It should be noted that the moon was rising during the scotopic readings.

TABLE 4

Luminance Measurements (FL) UH-1H, Low Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | Background | | | | | |
| Instrument | 1 | 4 | 7 | 10 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Fuel Pressure | .068 | .059 | .054 | .074 | .053 | .048 | .046 | .045 | .060 | .111 |
| Eng Oil Press | .092 | .065 | .069 | .072 | .049 | .047 | .058 | .054 | .065 | .096 |
| Trans Oil Press | .074 | .067 | .065 | .063 | .058 | .058 | .048 | .047 | .068 | .076 |
| Fuel Quantity | .062 | .056 | .055 | .110 | .053 | .055 | .050 | .047 | .058 | .096 |
| Dual Tach | .165 | .037 | .078 | .115 | .0145 | .0044 | .0036 | .0041 | .097 | .200 |
| Torque | .165 | .0063 | .093 | .125 | .0125 | .0036 | .0041 | .0043 | .041 | .145 |
| Gas Tach | .360 | .102 | .091 | .185 | .0130 | .0110 | .0075 | .0078 | .205 | .145 |
| Exh. Gas Temp | .112 | .067 | .049 | .350 | .0093 | .0071 | .0041 | .0053 | .089 | .155 |
| Airspeed | .215 | .043 | .074 | .230 | .0150 | .0084 | .0054 | .0110 | .205 | .069 |
| Radio Compass | .130 | .048 | .086 | .098 | .0120 | .0120 | .0084 | .0160 | .200 | |
| Altitude | .108 | .068 | .063 | .107 | .0110 | .0047 | .0059 | .0073 | .165 | .160 |
| Vertical Speed | .165 | .052 | .049 | .115 | .0120 | .0110 | .0046 | .0054 | .140 | .185 |
| Clock | .026 | .028 | .030 | .021 | .0042 | .0042 | .0029 | .0041 | .034 | |

TABLE 4 (con't)

Luminance Measurements (FL) UH-1H, Low Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | Background | | | | | |
| Instrument | 12 | 3 | 6 | 9 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Main Gen Load | .092 | .078 | | .100 | .077 | .075 | | .075 | .120 | .115 |
| Standby Gen Load | .088 | .105 | | .098 | .072 | .098 | | .084 | .120 | .110 |
| Eng Oil Temp | .084 | | .063 | .073 | .055 | | .061 | .054 | .078 | .082 |
| Trans Oil Temp | .112 | | .077 | .089 | .093 | | .063 | .072 | .078 | .085 |
| DC Volts | .102 | .096 | | .092 | .080 | .081 | | .074 | .097 | .088 |
| AC Volts | .130 | .097 | | .081 | .092 | .079 | | .072 | .079 | .115 |

TABLE 4 (con't)

Luminance Measurements (FL) UH-1H, Low Brightness Level

Special instruments:

Turn-slip indicator

- Index - .052
- Pointer - .099
- Ball race - .036
- Ball - .0046
- Background - .0068
- Legend - .013

Attitude indicator

- Sky - .064
- Ground - .0072
- A/C symbol - .265
- Legend - .140
- Sky line - .035
- Ground line - .032
- Horizon .057
- Roll index - .125

Omni indicator

- One o'clock position - .22
- Eleven o'clock position - .20
- Elevation - .165
- Azimuth - 190
- Index - .125
- Flag - .170
- Background - .0094
- Lower numerals - .00-2
- Left quadrant marking - .0048
- Right quadrant marking - .041

Magnetic compass

- Numerals - .28
- Index - .66
- Compass card - .0067

TABLE 5

Illuminance Measurements (FC) OH-58A, High Brightness Level

| | |
|---|---|
| Date: | 12 Feb and 14 Feb 74 |
| Aircraft: | 70-15641 |
| Moon: | Inside hangar with black cover |
| Voltage: | 28.5 VDC |
| Ambient Illumination: | |
| Outside A/C: | N/A |
| Inside A/C, lights off: | $2 \times 10^{-5}$ |
| Internal illumination: | |
| Instrument lights only: | |
| Photopic: | .0078 |
| Scotopic: | .00036 |
| Instrument and console panels: | |
| Photopic: | .0115 |
| Scotopic: | .00065 |
| Control panels only: | |
| Photopic: | .0048 |
| Scotopic: | .00028 |

TABLE 6

Luminance Measurements (FL) OH-58A, High Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | | Background | | | | |
| Instrument | 1 | 4 | 7 | 10 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Torque | .315 | .175 | .205 | .59 | .020 | .029 | .016 | .028 | .46 | .69 |
| Turb. Out. Temp. | | .195 | .265 | .69 | .0195 | .043 | .0143 | .036 | .46 | .81 |
| Gas Tach | .105 | .265 | .305 | .255 | .019 | .036 | .021 | .029 | .56 | .235 |
| Airspeed | 1.09 | .19 | .23 | .81 | .029 | .027 | .017 | .046 | .63 | .29 |
| Dual Tach | .67 | .18 | .175 | .46 | .023 | .017 | .013 | .015 | .74 | .64 |
| Course Indicator | 3.80 | .36 | .36 | 2.45 | .24 | .054 | .026 | .064 | 2.70 | |
| Altitude | .74 | .31 | .34 | .63 | .035 | .032 | .018 | .023 | .67 | .63 |
| Vertical Speed | .29 | .49 | .41 | .34 | .037 | .039 | .036 | .024 | .89 | .76 |
| Clock | 1.15 | .77 | 1.11 | .21 | .052 | .048 | .030 | .019 | 1.80 | |

TABLE 6 (con't)

Luminance Measurements (FL) OH-58A, High Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | Background | | | | | |
| Instrument | 12 | 3 | 6 | 9 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Eng. Oil Press. | .93 | | .45 | .47 | .097 | | .076 | .069 | .34 | 2.35 |
| Trans. Oil Press | .38 | | .41 | .51 | .045 | | .061 | .056 | .38 | 1.60 |
| DC AMPS | .28 | | .26 | .36 | .051 | | .053 | .044 | .29 | 1.75 |
| Fuel Quantity | .42 | | .22 | .34 | .047 | | .047 | .049 | .39 | 1.45 |

Special Instruments:

Attitude indicator

- Sky - .32
- Ground - .042
- A/C Symbol - .30
- Legend - .105
- Horizon - .50
- Roll index - .059
- Roll index pointer - .28

Turn-slip indicator

- Index - .057
- Pointer - 1.04
- Ball race - .145
- Ball - .019
- Background - .023
- Legend - .165

TABLE 7

Illuminance Measurements (FC) OH-58A, Low Brightness Level

| | |
|---|---|
| Date: | 19 Feb 74 |
| Aircraft: | 70-15641 |
| Moon: | Inside hangar with black cover |
| Voltage: | 18 VDC |
| Ambient illumination: | |
| Outside A/C: | N/A |
| Inside A/C, lights off: | $2 \times 10^{-5}$ |
| Internal illumination: | |
| Instrument lights only: | |
| Photopic: | .00037 |
| Scotopic: | $.42 \times 10^{-4}$ |
| Instrument and control panels: | |
| Photopic: | .00056 |
| Scotopic: | $.51 \times 10^{-4}$ |
| Control panels only: | |
| Photopic: | .00018 |
| Scotopic: | $.25 \times 10^{-4}$ |

TABLE 8

Luminance Measurements (FL) OH-58A, Low Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | | Background | | | | |
| Instrument | 1 | 4 | 7 | 10 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Torque | .089 | .033 | .043 | .093 | .0125 | .0092 | .0074 | .0087 | .097 | .145 |
| Turb. Out. Temp. | | .071 | .058 | .098 | .0093 | .0097 | .0094 | .015 | .135 | .098 |
| Gas Tach | .056 | .076 | .072 | .125 | .0135 | .0104 | .0091 | .0115 | .235 | .089 |
| Airspeed | .265 | .036 | .041 | .215 | .0015 | .0093 | .0066 | .0315 | .145 | .049 |
| Dual Tach | .185 | .061 | .041 | .145 | .0094 | .0097 | .0073 | .0086 | .205 | .145 |
| Course Indicator | 1.50 | .106 | .089 | .240 | .058 | .0235 | .0086 | .0145 | .78 | |
| Altitude | .23 | .077 | .086 | .135 | .0145 | .0115 | .0069 | .0072 | .084 | .112 |
| Vertical Speed | .068 | .125 | .067 | .102 | .011 | .012 | .0115 | .011 | .091 | .096 |
| Clock | .295 | .195 | .255 | .082 | .0225 | .0135 | .0115 | .0195 | .365 | |

TABLE 8 (con't)

Luminance Measurements (FL) OH-58A, Low Brightness Level

| | Clock Position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Markings | | | | Background | | | | | |
| Instrument | 12 | 3 | 6 | 9 | 12 | 3 | 6 | 9 | TIP | LEGEND |
| Eng. Oil Press. | .165 | | .116 | .118 | .0235 | | .0245 | .0195 | .098 | .44 |
| Trans. Oil Press. | .104 | | .114 | .125 | .0165 | | .0155 | .0165 | .097 | .78 |
| DC Amps | .079 | | .037 | .086 | .0150 | | .0145 | .0155 | .067 | .365 |
| Fuel Quantity | .092 | | .073 | .089 | .0125 | | .0155 | .0155 | .103 | .335 |

Special Instruments:

Attitude indicator:

Sky - .078

Ground - .0105

A/C Symbol - .074

Legend - .035

Horizon - .113

Roll index - .0195

Roll index pointer - .069

Turn-slip indicator

Index - .0165

Pointer - .295

Ball race - .0285

Ball - .0063

Background - .015

Legend - .0165

TABLE 9

Illuminance Measurements (FC) AH-1G

| | Scotopic | Photopic |
|---|---|---|
| Ambient illumination: | .00125 | .00128 |
| Internal illumination: | | |
| High level: | | |
| Instrument lights only: | .0093 | .0157 |
| Control panels only: | .0027 | .0026 |
| Instrument and control panels: | .0115 | .0168 |
| Dim level: | | |
| Instrument lights only: | .00135 | .00152 |
| Control panels only: | .00035 | .00041 |
| Instrument and control panels: | .00155 | .00190 |

TABLE 10

Standard Deviation and Mean of Luminance Measurements of Individual Instruments at Rated Voltage of Lamps

| Technique | S.D. | $\bar{X}$ | S.D./$\bar{X}$ |
|---|---|---|---|
| Red lighting: | | | |
| Circular-Edge | .054 | .517 | .104 |
| Wedge #1 | .177 | .736 | .240 |
| Wedge #2 | .650 | 1.322 | .491 |
| Center - lit | .095 | .243 | .390 |
| White lighting: | | | |
| Circular-Edge | .298 | 2.113 | .141 |
| Wedge #1 | .584 | 2.293 | .254 |
| Wedge #2 | .539 | 1.199 | .449 |
| Backlighting | .099 | .158 | .626 |

Wedge #1 and #2 refer to two different instruments illuminated by the wedge technique.

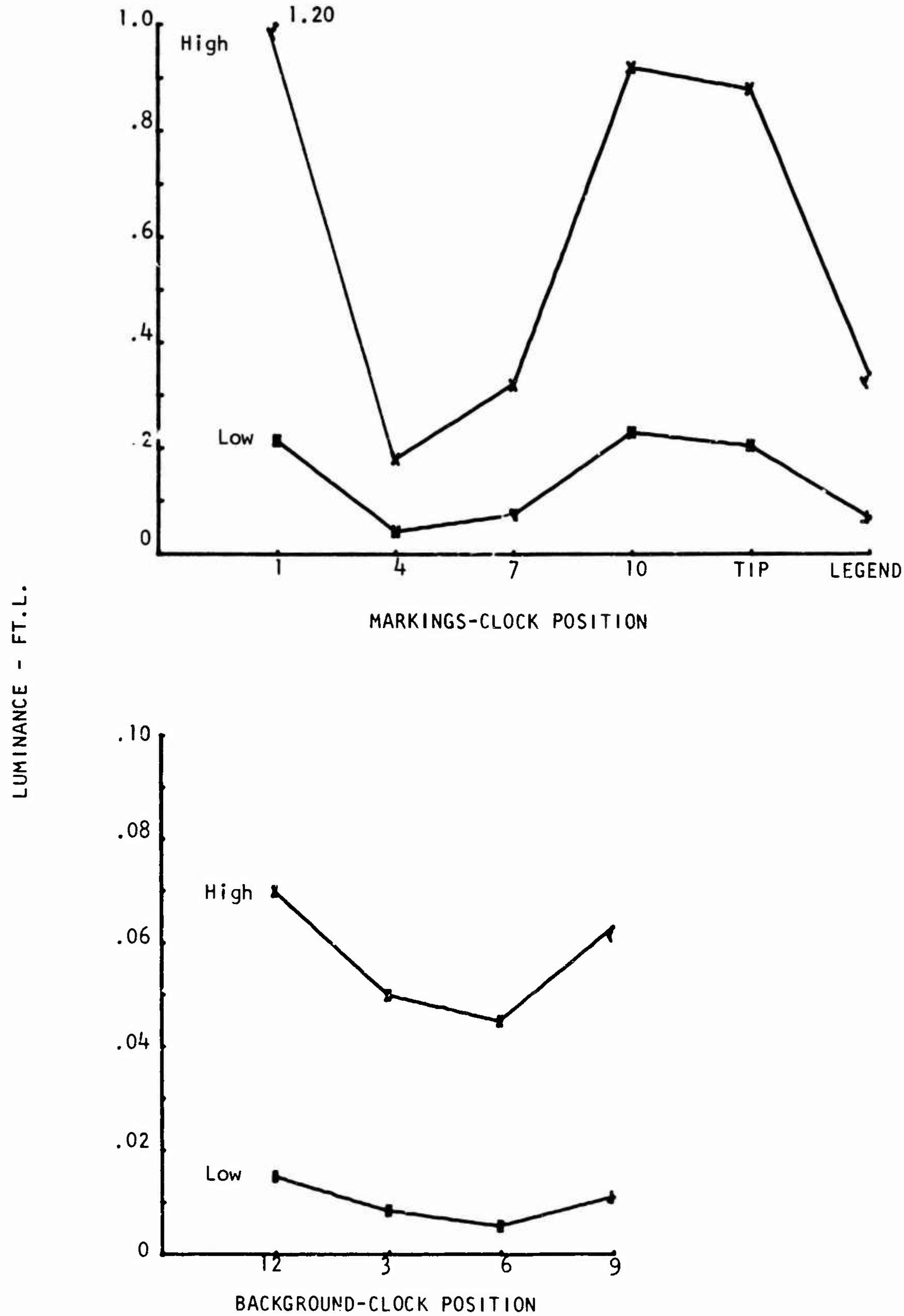


Fig. 1. UH-1H airspeed.

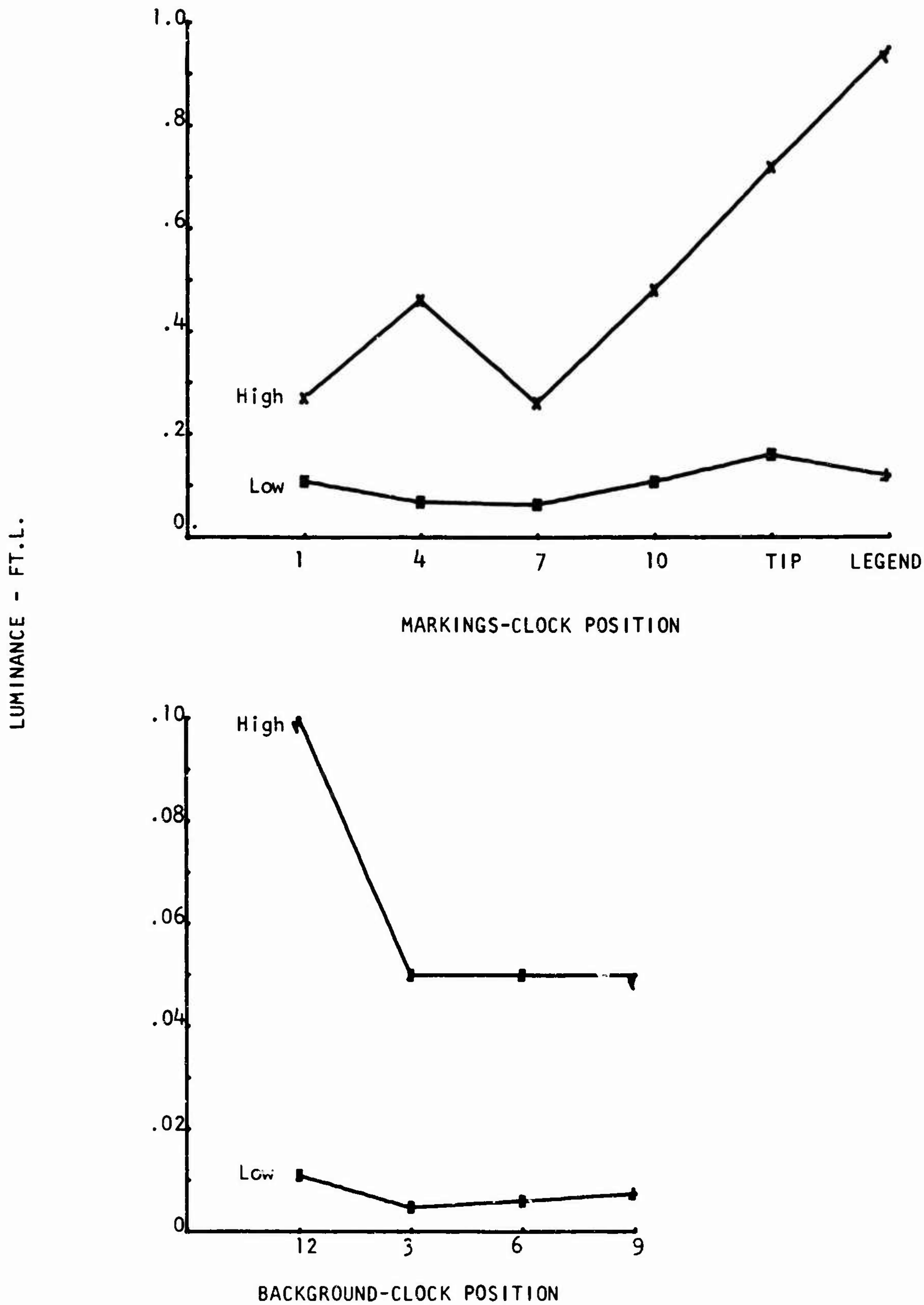


Fig. 2. UH-1H altimeter.

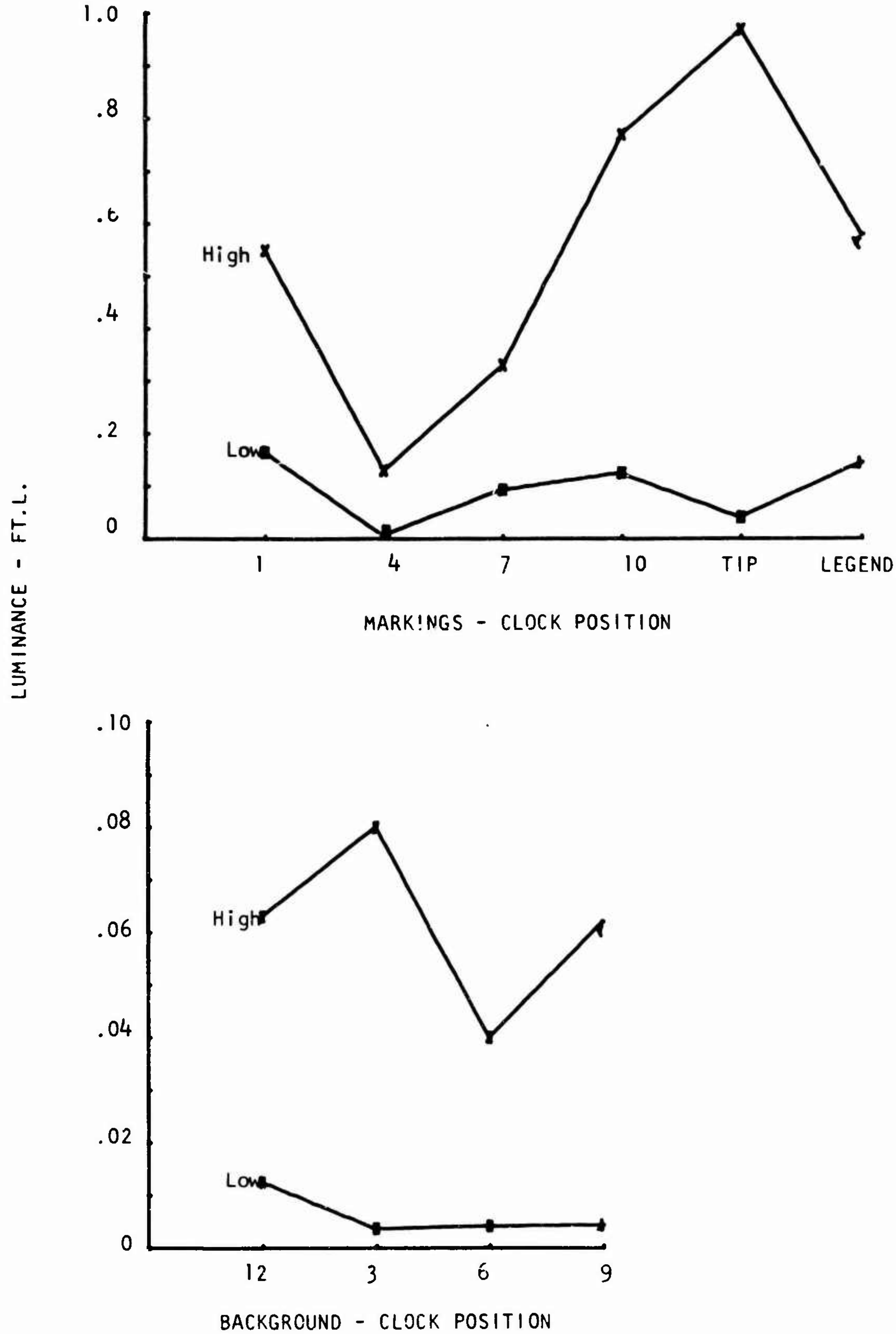


Fig. 3. UH-1H torque.

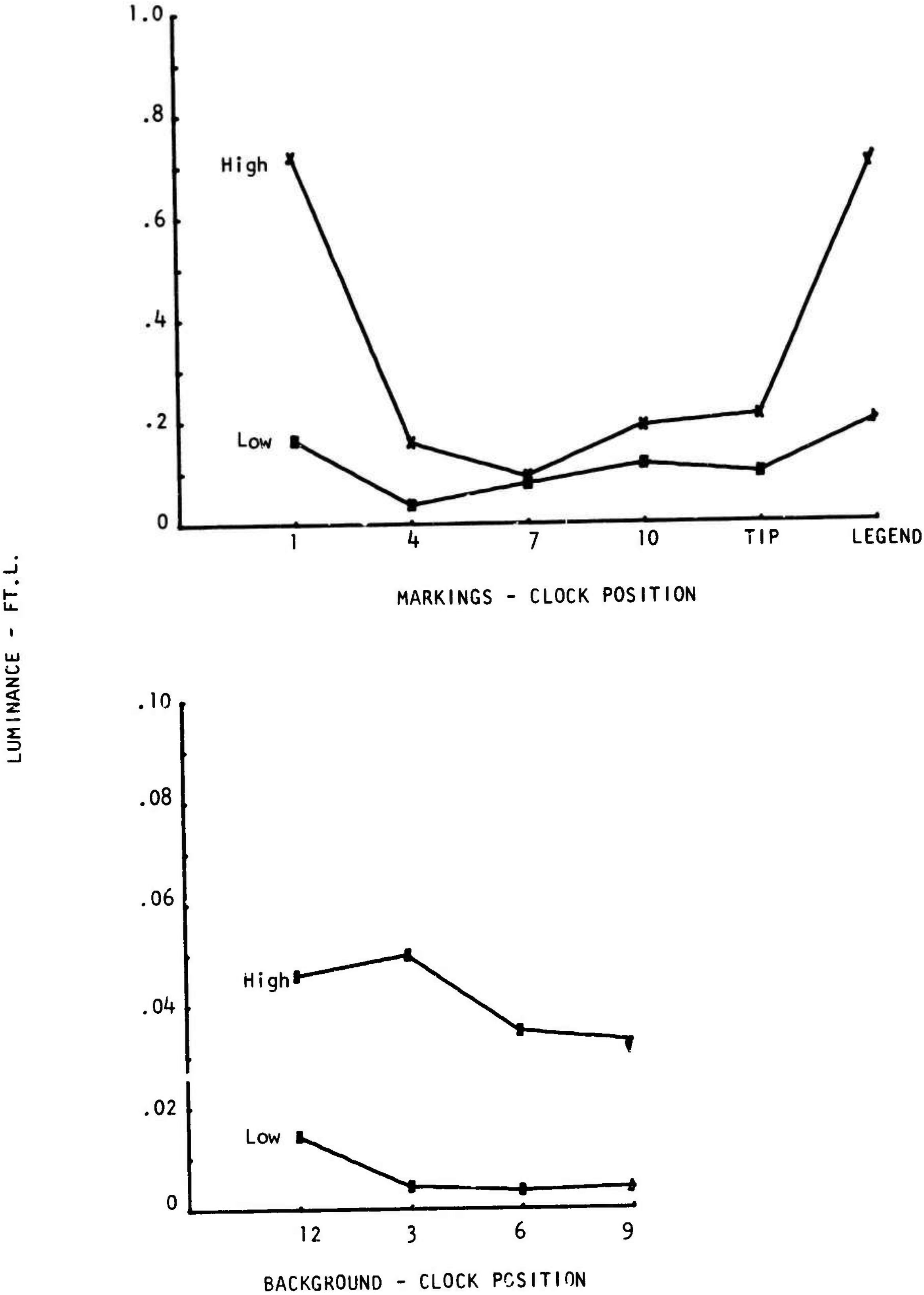


Fig. 4. UH-1H dual tach.

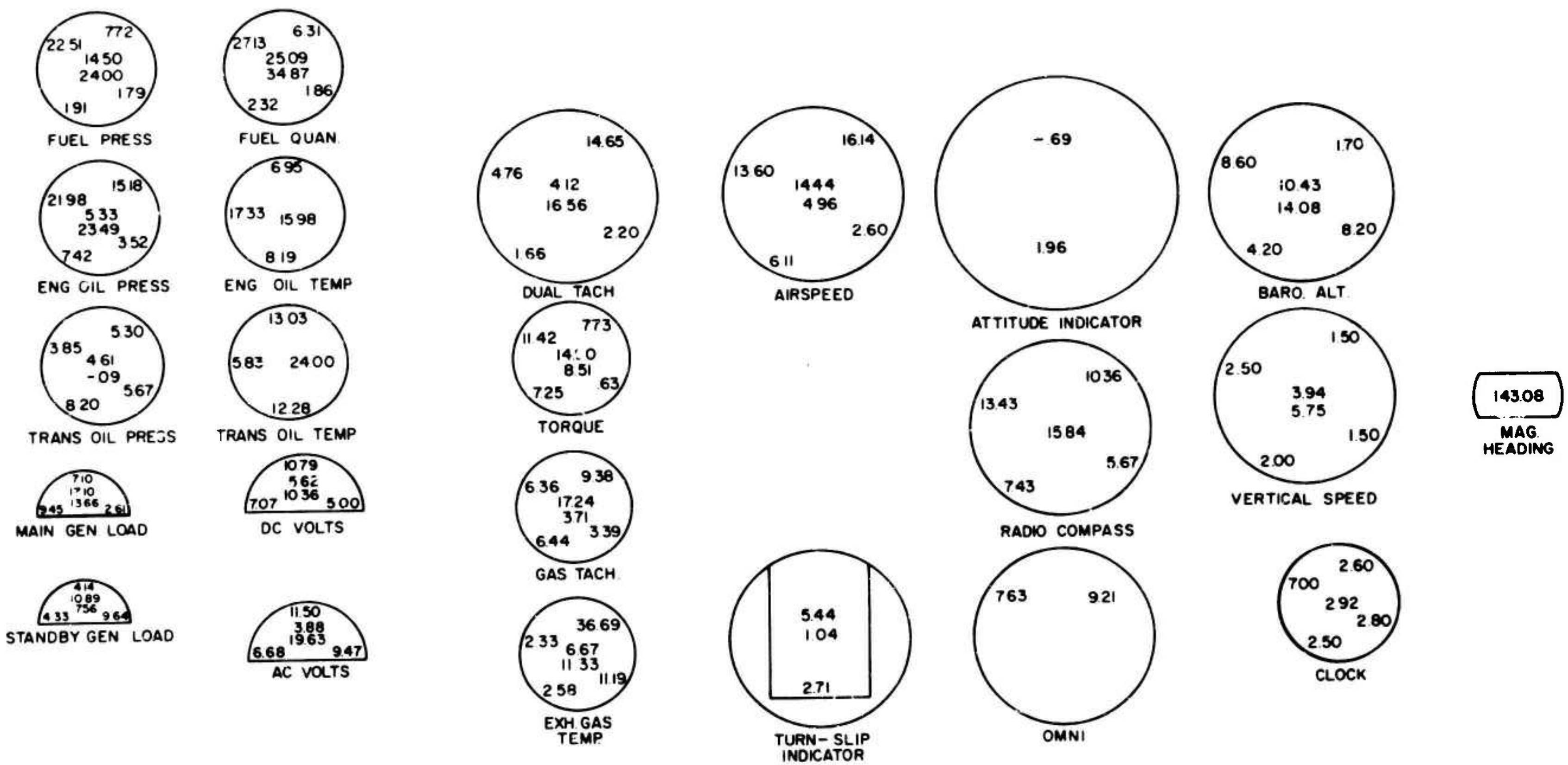


Fig. 5. UH-1H contrast ratio, high brightness level.

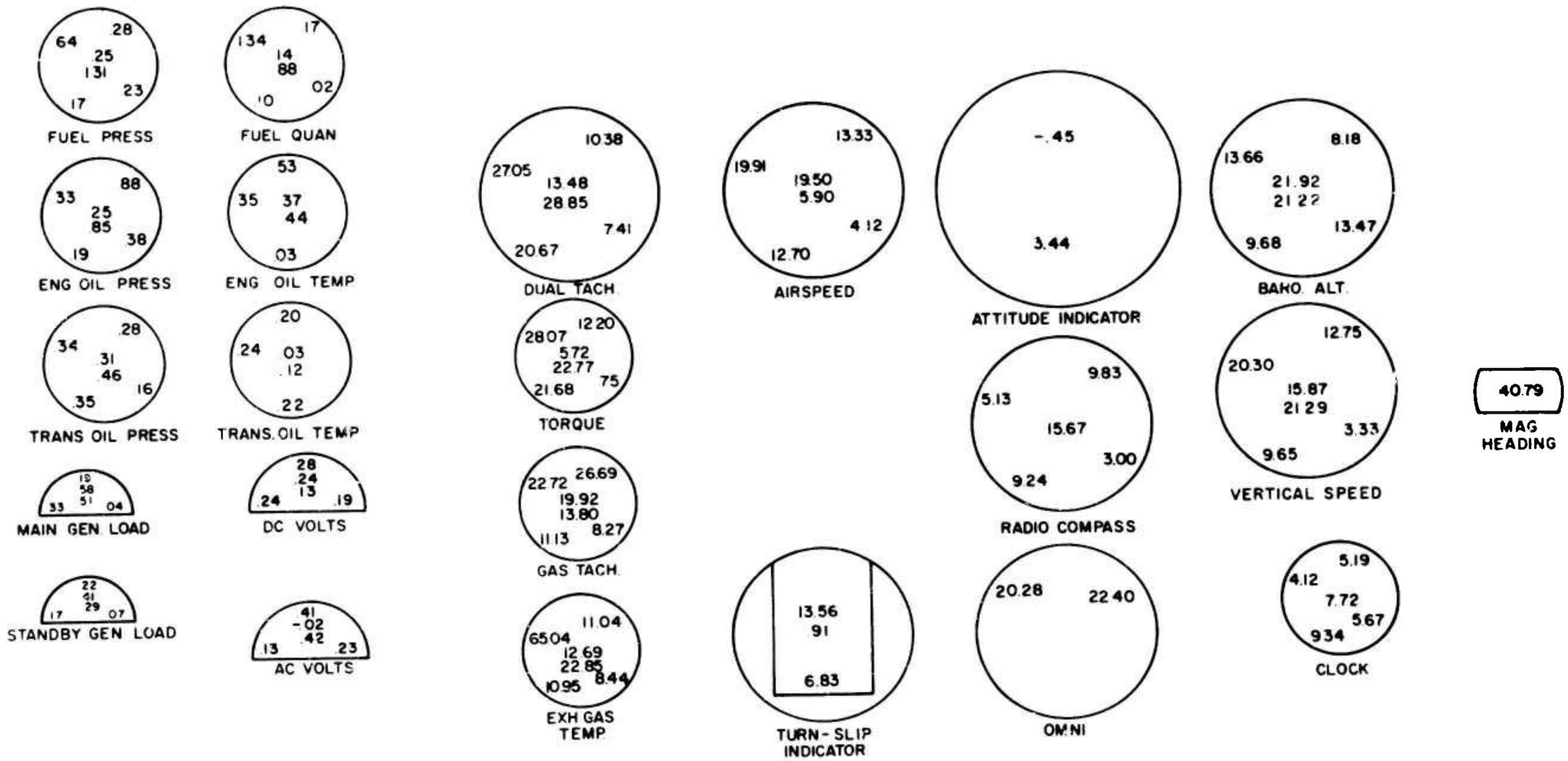


Fig. 6. UH-1H contrast ratio, low brightness level.

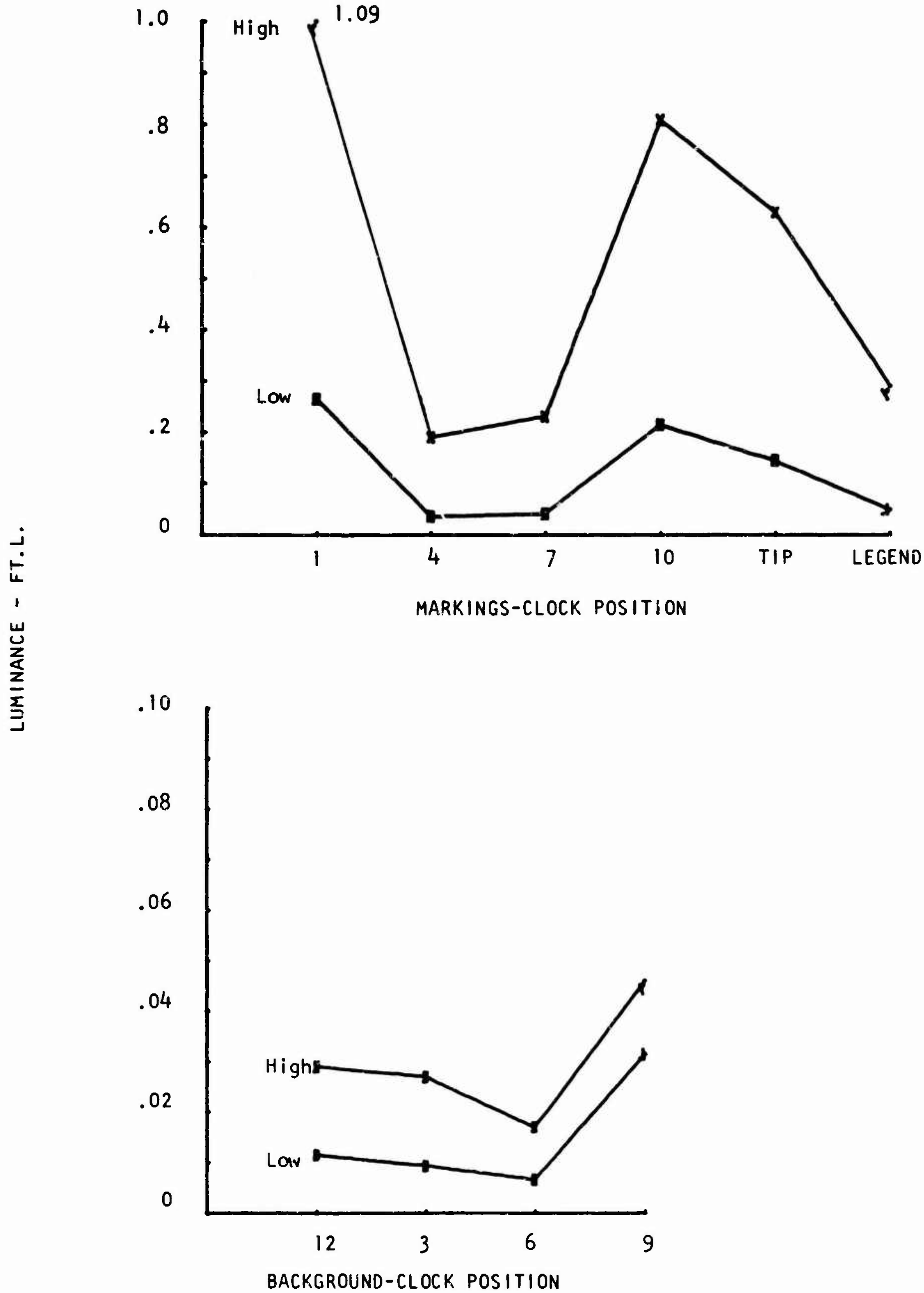


Fig. 7. OH-58A, airspeed.

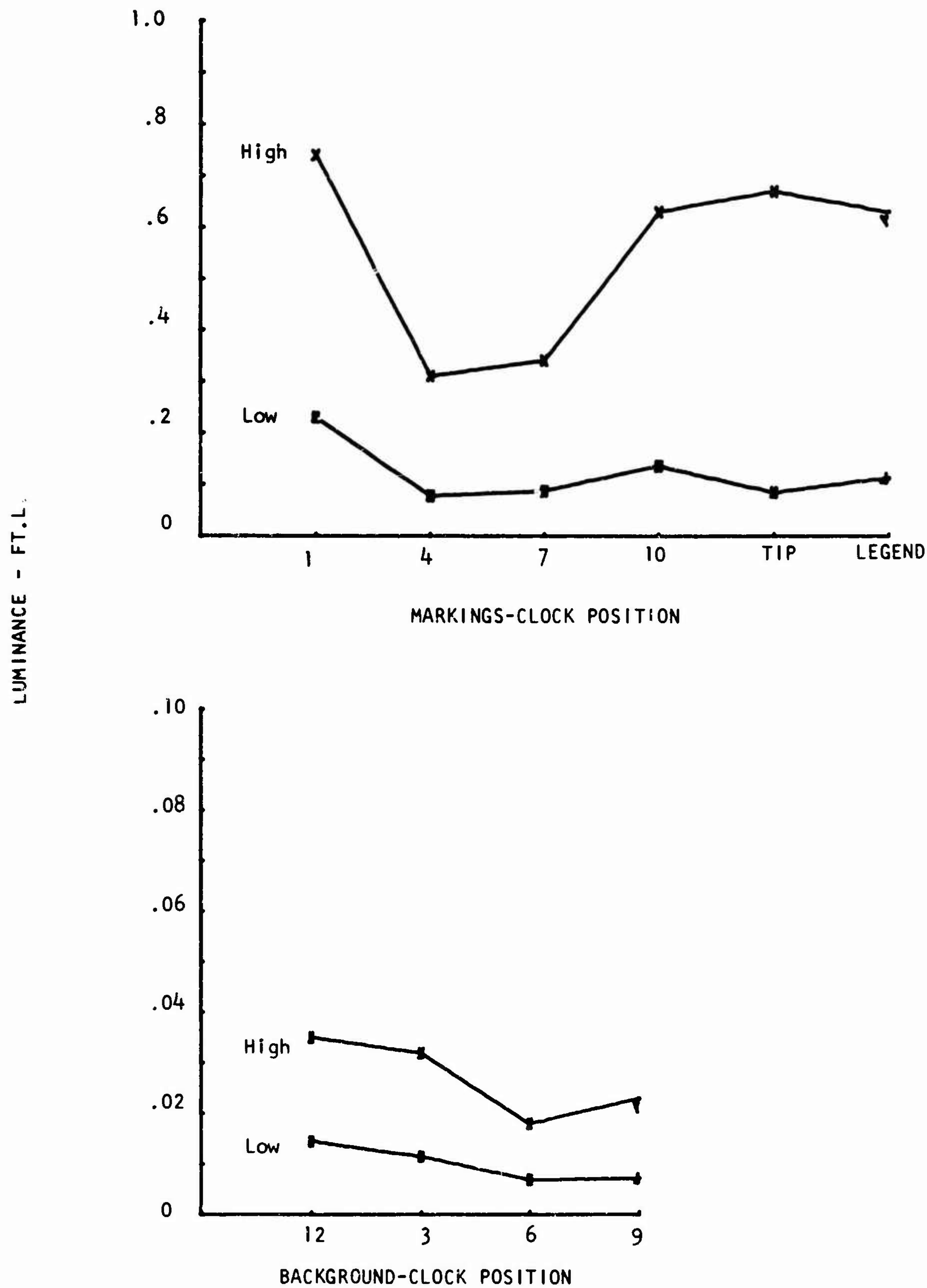

Fig. 8. OH-58A, altimeter.

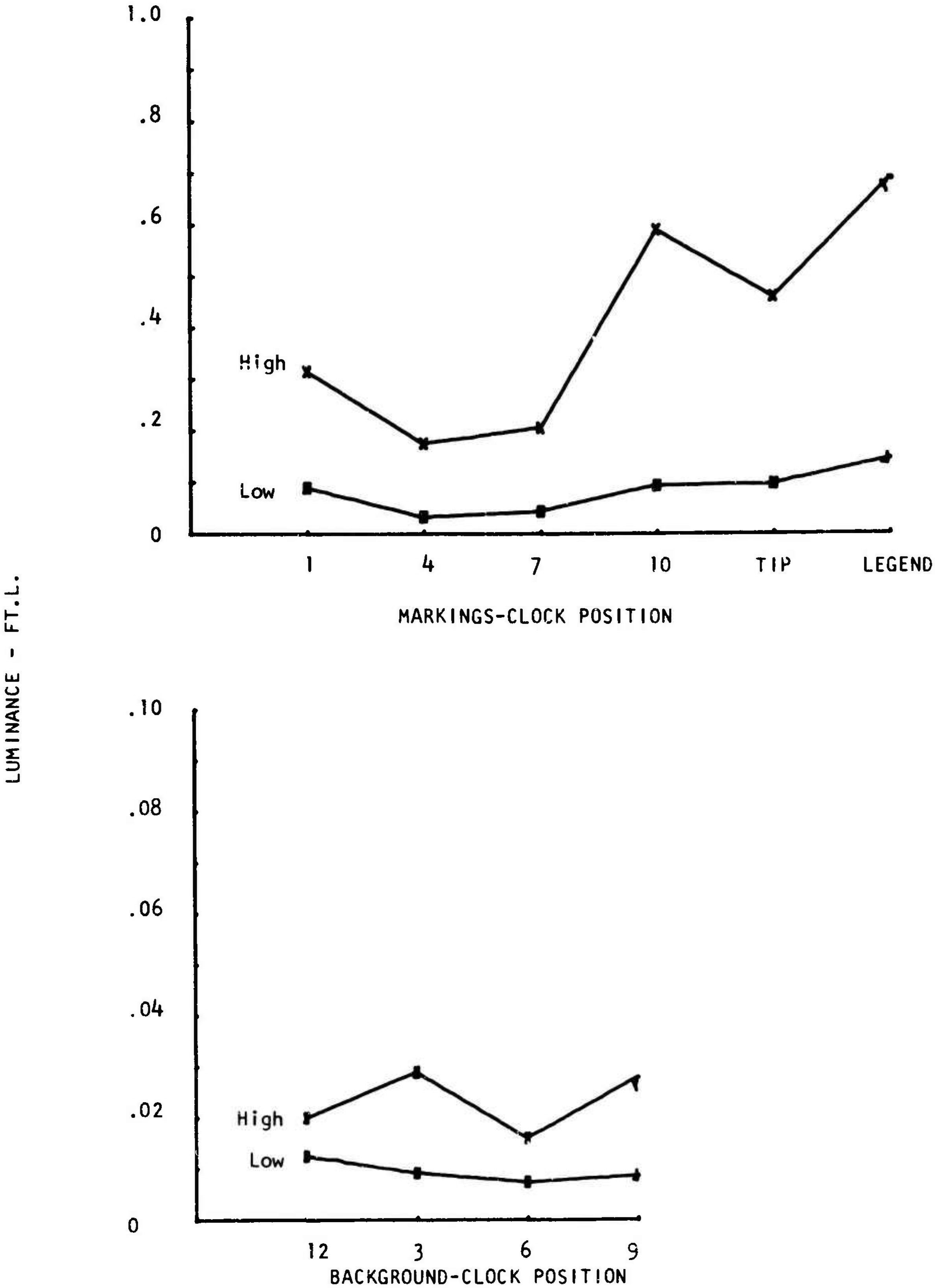


Fig. 9. OH-58A, torque.

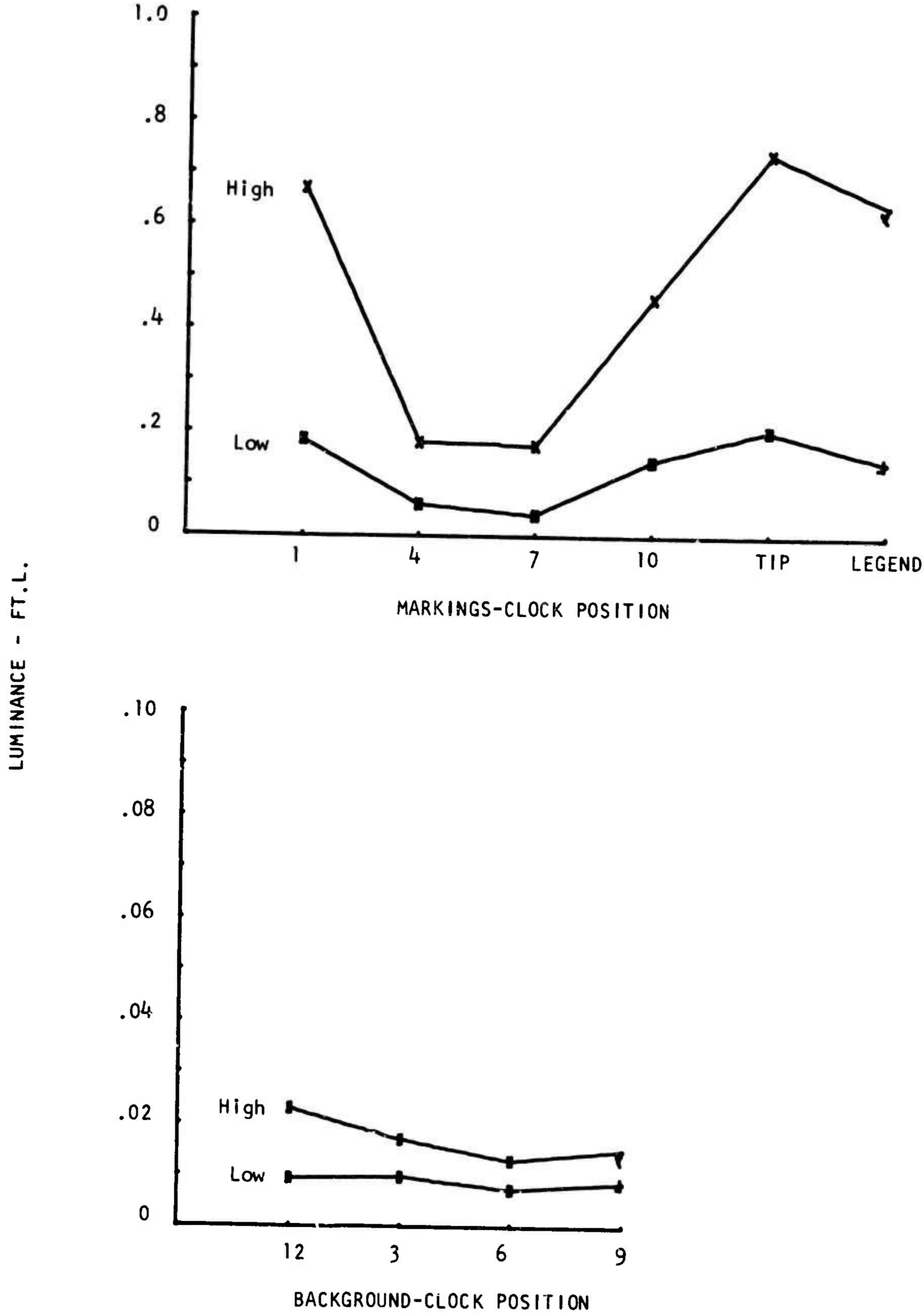


Fig. 10. OH-58A, dual tach.

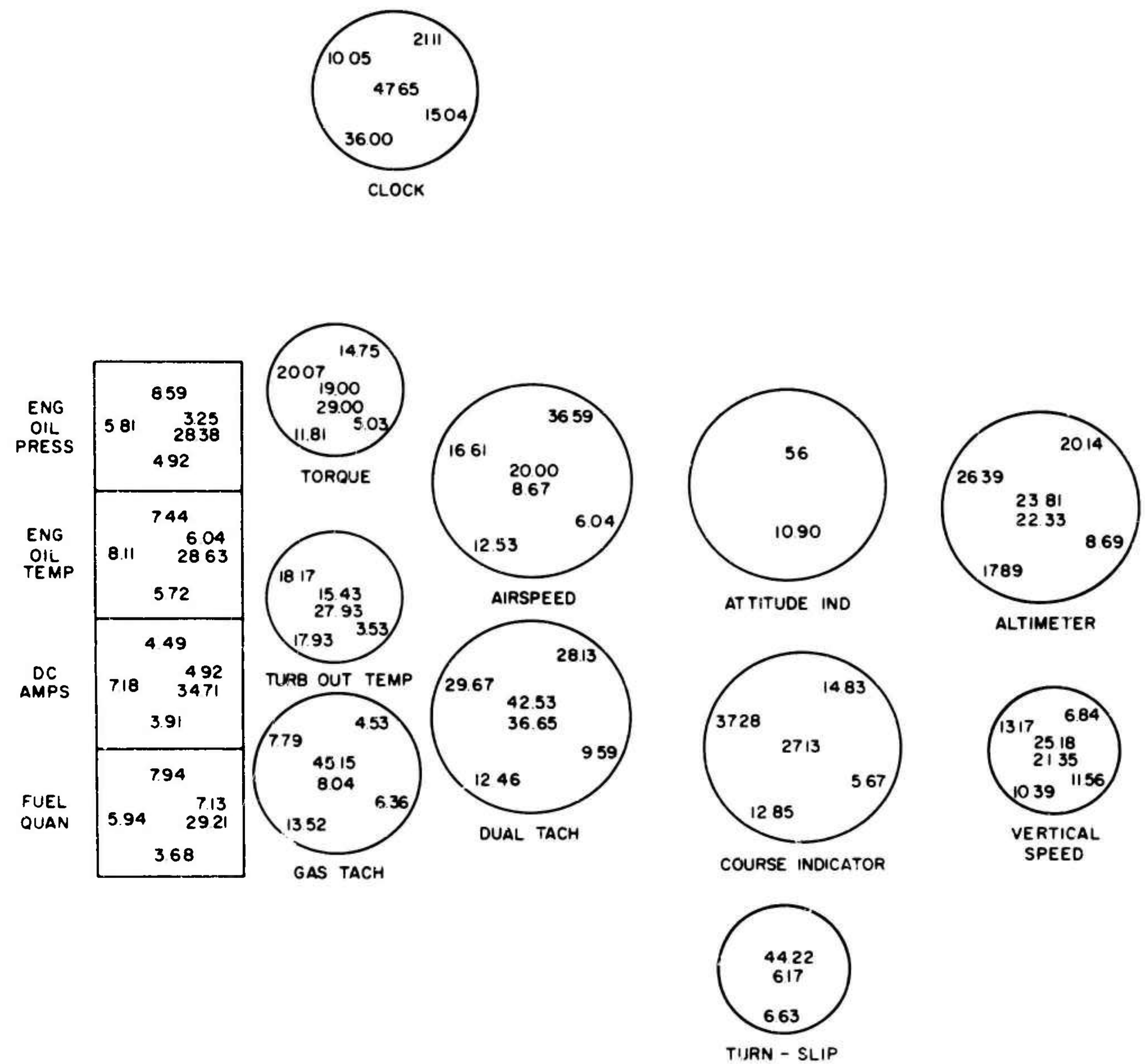


Fig. 11. OH-58A contrast ratio, high brightness level.

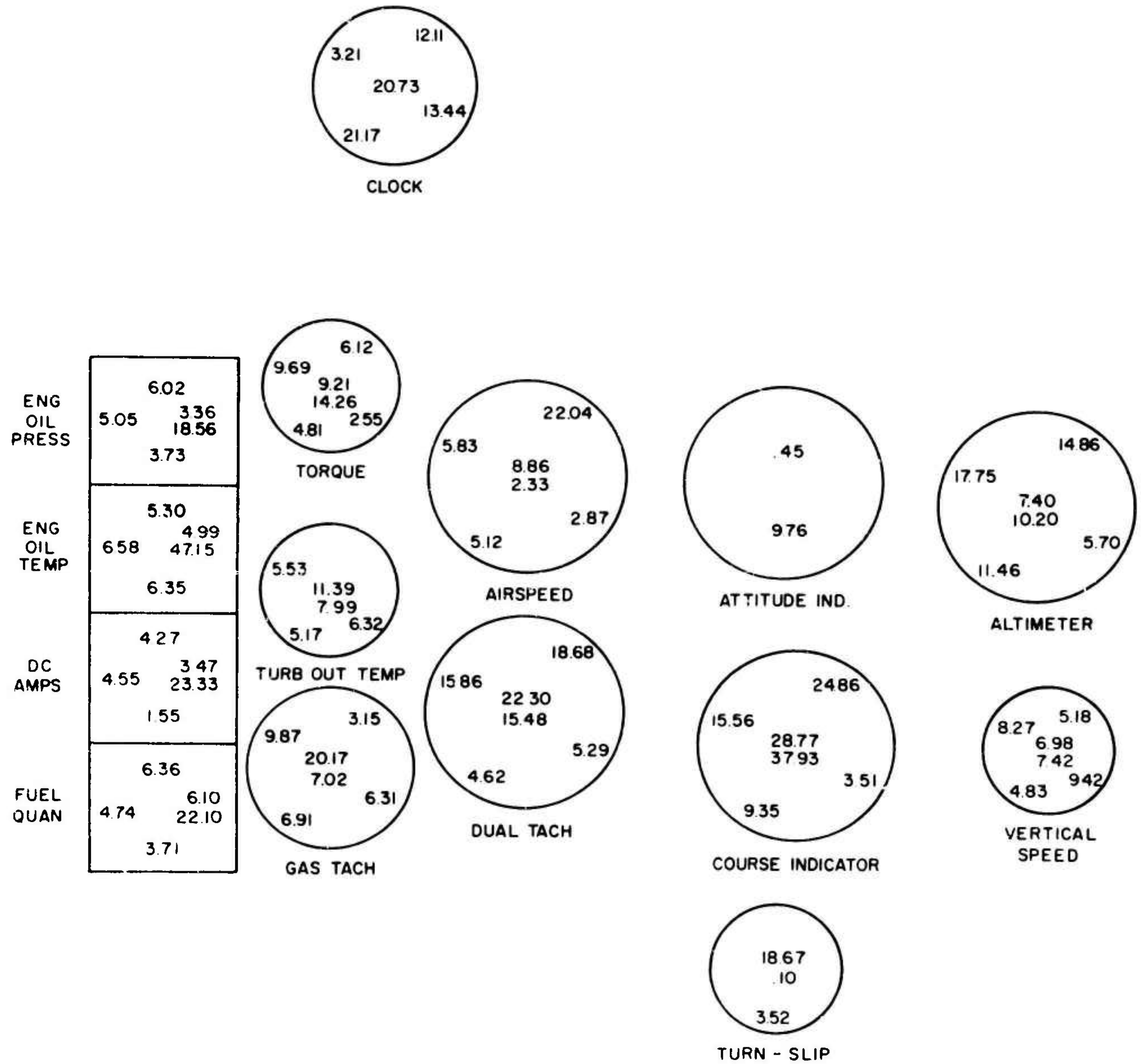


Fig. 12. OH-58A contrast ratio, low brightness level.

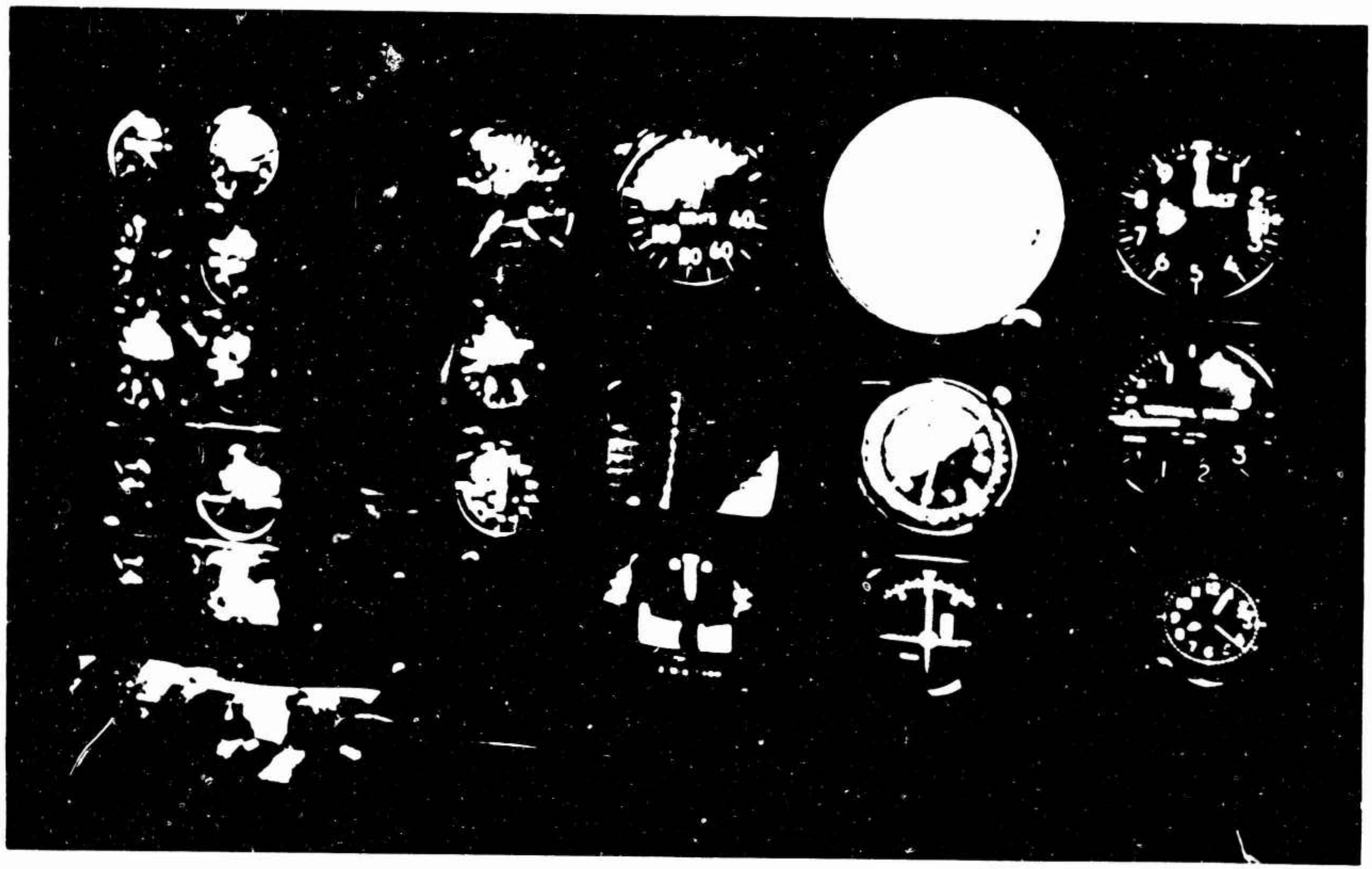

Fig. 13. UH-1H instrument panel.

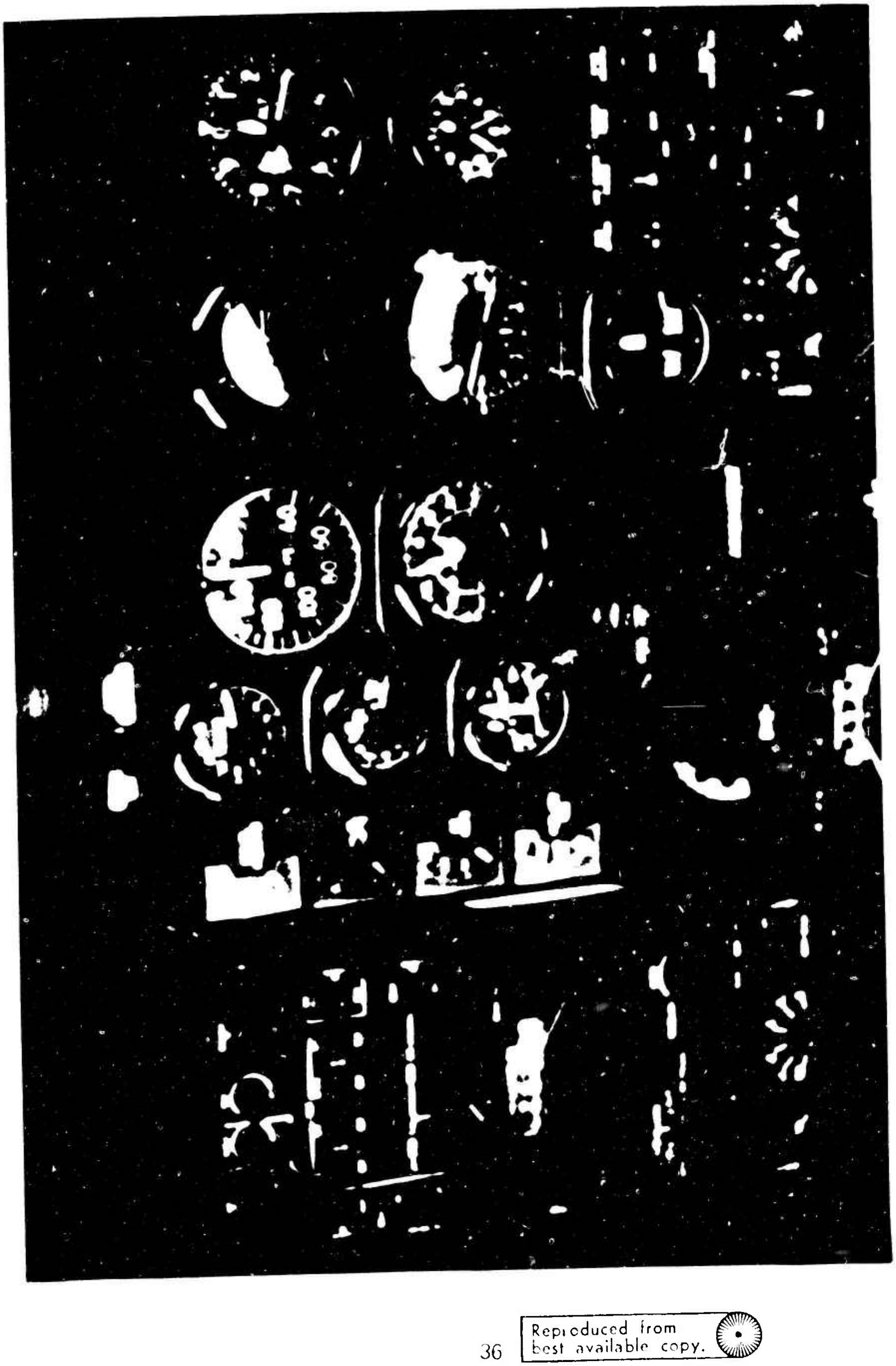

Fig. 14. OH-58A instrument panel.

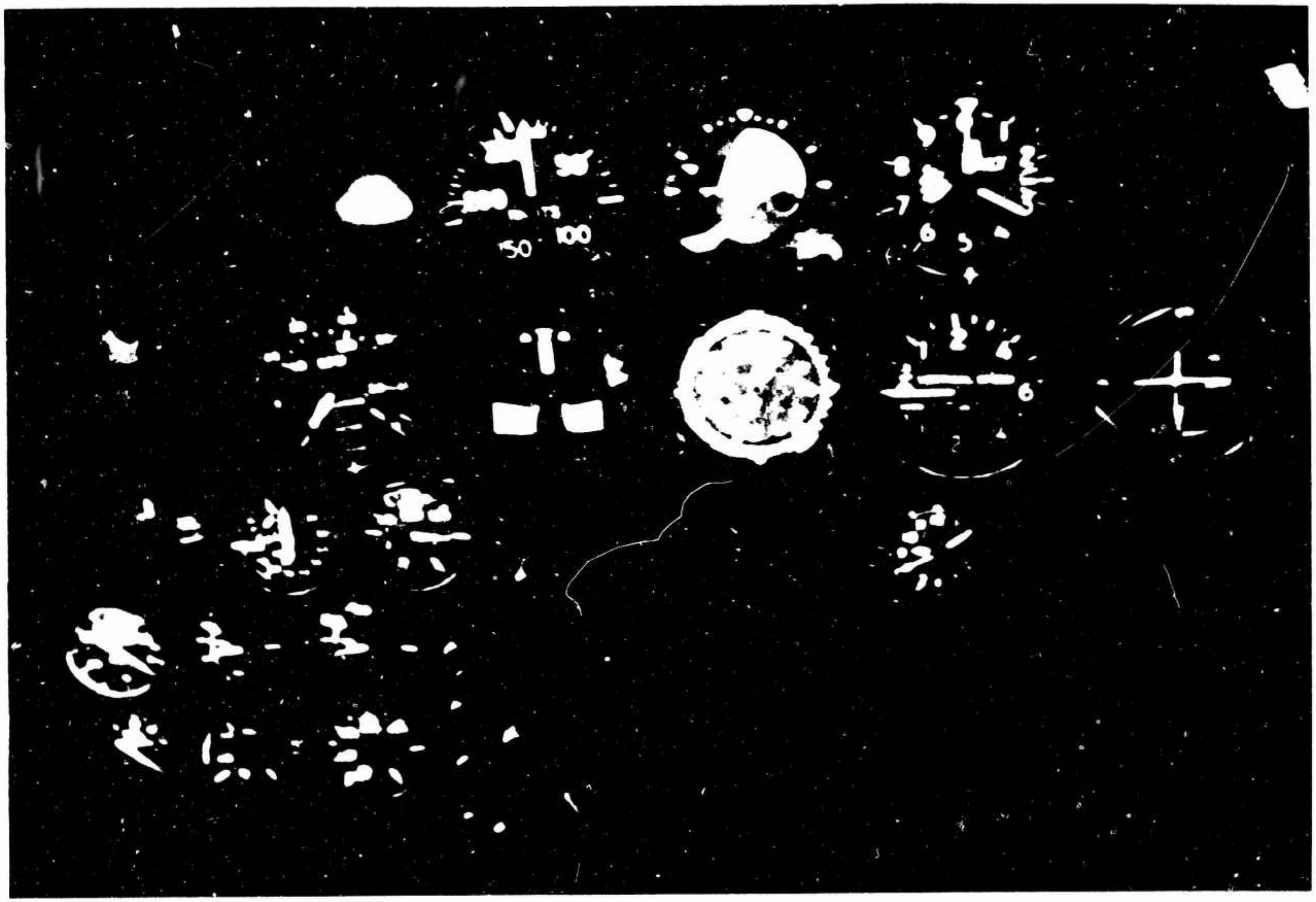


Fig. 15. AH-1G instrument panel.

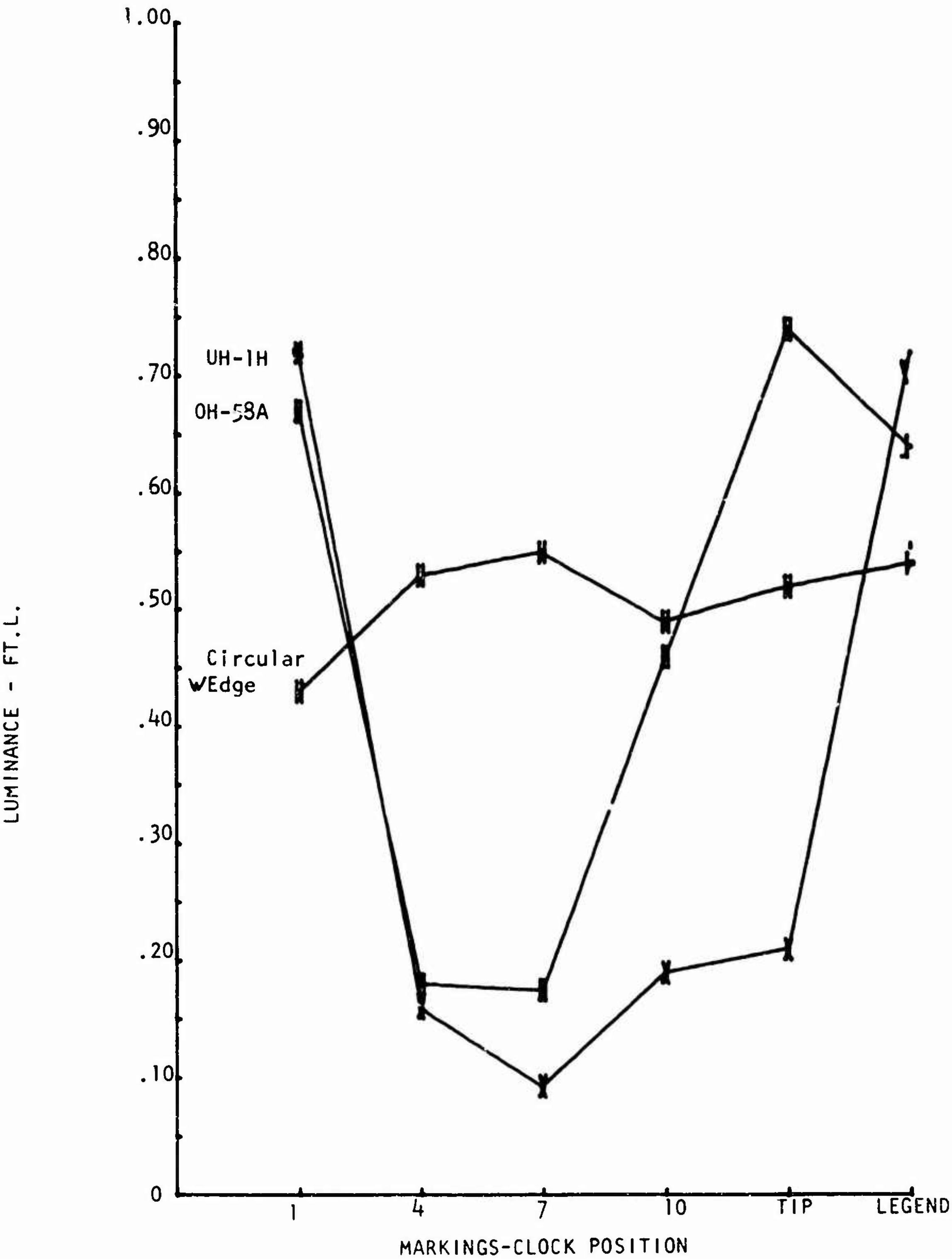


Fig. 16. Comparison of light distribution between dual tachs, red, rated voltage, UH-1H, OH-58A, and circular edge.

## APPENDIX

## CALIBRATION

1. Connect photomultiplier tube assembly by plugging into face of photometer.

2. Insert fiber optics probe in front of photomultiplier housing.

3. Connect other end of fiber optics probe to the microscope eyepiece.

4. Check to see that the photopic correction filter is inserted in the slit in front of the photomultiplier and that the lid is properly closed to prevent any light leaks.

5. Shut off all light to photomultiplier.

6. Turn on switch on the power supply.

7. Check the reference voltage as follows: Put the "Function" switch in the "Batt" position. The meter should read $100 \pm 2$ division on the main scale 0-120.

8. Turn sensitivity knob all the way counterclockwise.

9. Rotate step sensitivity control all the way counterclockwise.

10. Switch "Function" switch to "Operate."

11. Adjust "Zero" control so that meter is zeroed.

12. Switch step sensitivity control all the way clockwise, step by step, adjusting dark current to zero at each step.

13. Orient receiver to standard source and turn on standard lamp source. Open photomultiplier to light.

14. Adjust continuous variable sensitivity control for a meter deflection corresponding to the source value.

15. Shut off all light to photomultiplier and repeat Step 12, above.

16. Pull aluminum knob on top of step sensitivity control, and without changing step setting, rotate disc beneath control until appropriate full scale value is in view. Release knob to set full scale reading.

It should be noted at this point that these calibration instructions apply to the equipment from Gamma Scientific, Inc., and may vary when other equipment is used.