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DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36360

STEBG-TD (6)

22 JUL 1966

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SUBJECT: ~~Letter Report~~, "Product Improvement Test of Engine Tail Pipe Indicator and Recorder Installed in UH-1B Helicopter, ~~RDT&E~~ Project No. _____, USATECOM Project No. 4-5-0101-05."

(11) 22 Jul 66

TO: Commanding General
US Army Materiel Command
ATTN: AMCPM-IR
Washington, D. C. 20315

(16) USATECOM-4-5-0101-05

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1. References.

a. Letter, Bell Helicopter Company, 7 April 1965, subject: "Service Evaluation of Tail Pipe Temperature Indicator and Temperature Recorder."

b. Letter, SMOSM-EEL-UH-1-19, Headquarters, US Army Aviation Materiel Command, 27 April 1965, subject: "Product Improvement Test, UH-1B Helicopter."

c. Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command, 4 May 1965, subject: "UH-1 Actions."

d. Letter, SMOSM-EAA, Headquarters, US Army Aviation Materiel Command, 19 May 1965, subject: "Service Evaluation of Tail Pipe Temperature Indicator and Temperature Recorder."

e. Plan of Test, USATECOM Project No. 4-4-0108-05, "Logistical Test (Phase F) of UH-1B Helicopter Equipped with Model 540 Rotor System," US Army Aviation Test Board, 1 June 1965.

f. Letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 1 June 1965, subject: "Test Directive, USATECOM Project No. 4-5-0101-( ), Product Improvement Test, UH-1B Items."

g. Message, AMCPM-IR-T 10132, Commanding General, US Army Materiel Command, 2 September 1965, subject: "UH-1 Test Program and Meeting at ATB, 31 August 1965, UH-1 Test Program."

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h. Letter, STEBG-TP-A, US Army Aviation Test Board, 9 September 1965, subject: "Iroquois Test Coordination Meeting."

i. Letter, SMOSM-EAA, Headquarters, US Army Aviation Materiel Command, 20 September 1965, subject: "Product Improvement Test - UH-1B Helicopter."

j. Letter, AMCPM-IR, Headquarters, US Army Materiel Command, 21 September 1965, subject: "Trip Report, United States Army Aviation Test Board."

k. Plan of Test, USATECOM Project No. 4-5-0101-( ), "UH-1B Items, Product Improvement Test," US Army Aviation Test Board, 8 October 1965.

l. Letter, STEBG-TP-A, US Army Aviation Test Board, 19 October 1965, subject: "Iroquois Test Coordination Meeting."

m. Letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 19 October 1965, subject: "Test Directive, USATECOM Project No. 4-5-0101-05, Product Improvement Test, Engine Tail Pipe Indicator and Recorder."

n. Technical Manual 55-1520-211-20, "Organizational Maintenance Manual, Army Models UH-1A and UH-1B Helicopter," Department of the Army, January 1966.

2. Objectives.

a. Purpose. To determine the suitability of the test system as a substitute for the standard exhaust gas temperature (EGT) indicator.

b. Test Objectives. To determine:

(1) Physical characteristics.

(2) Accuracy and readability.

(3) Usefulness of the test systems as an engine preventive maintenance device.

(4) Compatibility of the test systems with the UH-1B Helicopter.

(5) Durability of the test systems.

(6) Maintainability of the test systems.

3. Description of Materiel. The test system consists of:

a. The EGT indicator, P/N 102750, which is a two-inch diameter unit displaying temperatures between 0-1200° C. by means of signals obtained from the existing thermocouple system installed on the aircraft engine. The indicator scale is graduated in 100° C. increments with a vernier scale graduated in 10° C. increments.

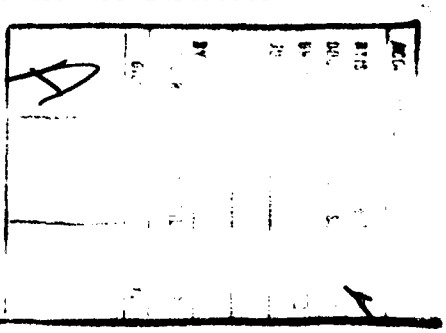
b. The engine over-temperature recorder-timer (EGT recorder), P/N 102800, which provides six counters for recording and displaying the number of times and the amount of time that the three preselected temperature values (625° C.,650° C., and 760° C.) have been exceeded. The counters are housed in a small metal box.

c. The inverter, which is a 115-volt a.c., 400-Hertz unit mounted in the helicopter nose compartment and wired to the primary bus. This inverter furnishes a constant level of power to the EGT indicator and recorder for accurately recording temperatures during start.

4. Background.

a. Frequent, prolonged over-temperature events will severely limit the service life of any gas turbine engine and may result in catastrophic failure. Occasionally, these over-temperatures are not recorded accurately on the aircraft maintenance forms. An accurate, lightweight, automatic system for recording over-temperature events would provide valuable information for the proper maintenance of gas turbine engines, and for the timely removal of engines which have been subjected to temperatures beyond allowable limits.

b. A test system was developed to provide a record of the frequency and duration of over-temperature events in addition to providing the pilot with an EGT indicator. The EGT recorder was designed to record the occurrence of temperatures above three significant, preselected values: 625° C. during the starting cycle only and 650° C. and 760° C. during flight operations. The United States Army Aviation Test Board (USAAVNTBD) was directed (~~reference a~~) to test two EGT indicator-recorders installed in UH-1B/540 helicopters.



5. Scope.

a. The USAAVNTBD conducted product-improvement testing of two EGT indicator-recorders in UH-1B/540 helicopters from 3 September 1965 to 8 June 1966 at Fort Rucker, Alabama, and Yuma Proving Ground, Arizona. During this period, the two test systems were operated for a total of 1,766 hours. The test systems were scheduled to operate for 1,100 hours each or until failure of both systems; however, the Iroquois Project Manager gave approval to conclude the test at 1,766 total hours.

b. During the test, the physical characteristics were determined by weighing, measuring, and photographing the test system. During installation, compatibility of the test item with the UH-1B Helicopter was annotated. The system was calibrated at 300-hour intervals and the results were recorded. Comparative comments on the readability of the test system were obtained from numerous aviators. A list of all over-temperature events detected by the test system was maintained in order to determine its usefulness as an engine preventive maintenance device. Durability and maintainability were determined as a result of day-to-day operation of the test item.

6. Summary of Results.

a. Physical Characteristics. The physical characteristics for the test system (figure 1) and for the standard EGT indicator (figure 2) were:

	Test System	Standard EGT Indicator
Dimensions:		
Indicator	2" dia. x 6.4" long	2" dia. x 3" long
Recorder	4.5" x 5.5" x 3.12"	None
Inverter	2" x 4"	None
Weight	4 lb.	0.75 lb.
Volume	109 cu. in.	9 cu. in.

b. Accuracy and Readability. Throughout the test, the EGT indicator was determined to be accurate using standard calibration procedures, and the recorder was determined to be accurate in recording the number of events and duration at all three preselected temperature values. The readability of the EGT indicator was more satisfactory than that of the standard indicator because of the small vernier scale, which was graduated in 10° C. increments (figure 3). The events-duration counters on the recorder also were easy to read.

c. Usefulness as an Engine Preventive Maintenance Device. The system was useful as an engine preventive maintenance device. The following two situations occurred in which the EGT recorder provided indications that the engines were not functioning normally:

(1) One helicopter experienced an engine failure. No over-temperature events above 650° C. occurred; however, the EGT recorder indicated the engine had been exposed to temperatures between 625° C. and 650° C. for extended periods of time during the starting cycle. Operation between 625° C. and 650° C. increased from 17 seconds in 23 events on 28 March 1966 to 457 seconds in 60 events on 29 March 1966. None of the over-temperature events exceeded allowable engine limitations. The helicopter was operated for 83 additional hours prior to the engine failure with the readings on the recorder remaining fairly constant. Engine inspection confirmed that hot-end damage had occurred from excessive heat.

(2) The EGT recorder installed in the second helicopter indicated an increase in engine start temperatures between 625° C. and 650° C. from 5 seconds in 8 events on 26 March 1966 to 184 seconds in 198 events on 12 May 1966. The temperatures between 650° C. and 759° C. also increased from 3 seconds in 2 events to 77 seconds in 62 events during this same period. A scheduled hot-end inspection was performed on 24 May 1966. During this inspection, the exhaust diffuser was found to be burned beyond allowable limits and the gas-producer turbine nozzle was burned and corroded excessively.

d. Compatibility of Test Systems with UH-1B. There were no problems encountered during the installation of the test systems. The EGT indicator was mounted in the same manner as the standard indicator. The recorder was mounted under the pilot's instrument panel on the center console (figure 4). The inverter was mounted in the avionic nose compartment. The test system required a 115-volt a.c., 400-Hertz inverter because the standard helicopter inverters are OFF during engine start. The addition of the 115-volt a.c., 400-Hertz inverter wired to the primary

bus and a pickup wired to the gas-producer tachometer were the only changes required in the airframe electrical system. No changes were required in the thermocouple harness.

e. Durability. The two test systems operated for a combined total of 1,766 hours without malfunctioning. However, shortly after the beginning and again at the midpoint of the test, the recorders installed in both helicopters indicated that excessive temperatures had been encountered. Subsequent engine hot-end inspections revealed nothing beyond normal patterns. The readings raised questions as to the validity of the recorder. The manufacturer checked out the test systems and determined that both systems were accurate. The explanation for the over-temperature recordings was that the test systems had not been zeroed after previous calibration checks. The mean time between failure was not computed since there were no failures during the test period and previous UH-1B reports did not indicate any replacements of the standard EGT system.

f. Maintainability. Three and one-half man-hours were required to install the test system and one-half man-hour was required to install the standard EGT indicator. Forty-five man-minutes were required to remove the test system and 25 man-minutes were required to remove the standard indicator. These times did not include any thermocouple harness removal and installation. No maintenance was performed on the test system during the test except for periodic calibration checks. A special tool was required to zero the recorder counters. This zeroing was accomplished at the organizational maintenance category. An Aircraft Electrician, MOS 68F20, was required to install the test system.

7. Discussion.

a. Although no hot starts as defined in TM 55-1520-211-20 (reference n) occurred, the engine manufacturer stated that temperatures between 625° C. and 650° C. during starting were significant. It was difficult for each pilot to monitor and record starting temperatures and duration accurately by use of the EGT indicator and a clock. The use of the EGT recorder eliminated the inaccuracies and maintained a cumulative total in seconds' duration of all temperatures exceeding 625° C. during starts. By monitoring the EGT recorder daily, maintenance personnel could detect a trend in higher starting temperatures and indications of incipient failures. Criteria for inspecting engines exposed to temperatures between 625° C. and 650° C. during starting have not been established. The proper use of the information recorded by the EGT recorder could be

a useful tool in the prevention of possible engine failures by recording temperatures higher than normally encountered.

b. Although the test system weighed more, occupied more overall space, and required more man-hours for installation than the standard EGT indicator, the easy-to-read temperature indicator and the benefits derived from use of the recorder for preventive maintenance justify the use of this system as a replacement for the standard EGT indicator.

8. Conclusion. The test system is suitable as a substitute for the standard EGT indicator.

9. Recommendations. It is recommended that:

a. The system be adopted as a substitute for the standard EGT indicator.

b. The EGT recorders be designed to eliminate the requirement for the special tool used to zero the counters.

c. TM 55-1520-211-20 be revised to include a description, theory of operation, and instructions for using the test item as an engine preventive maintenance device.

d. The UH-1B Daily Inspection Guide be revised to include monitoring daily temperatures recorded and recording temperatures in an engine log book.

e. The engine manufacturer develop criteria for inspection intervals of the engine after prolonged exposure to temperatures between 625° C. and 650° C. during the starting cycle only.

Raymond E. Johnson

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Photographs

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INCLOSURE 1

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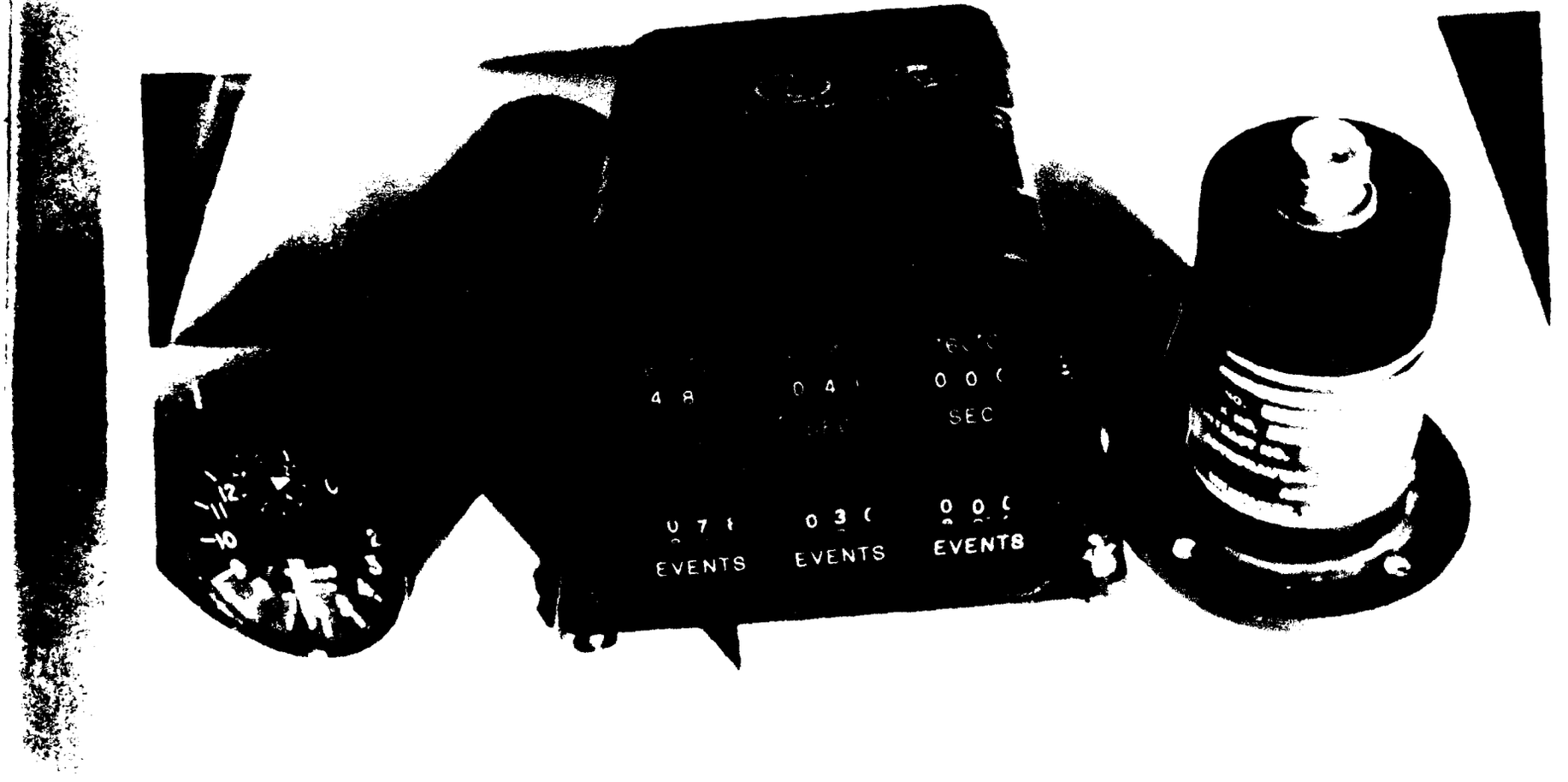
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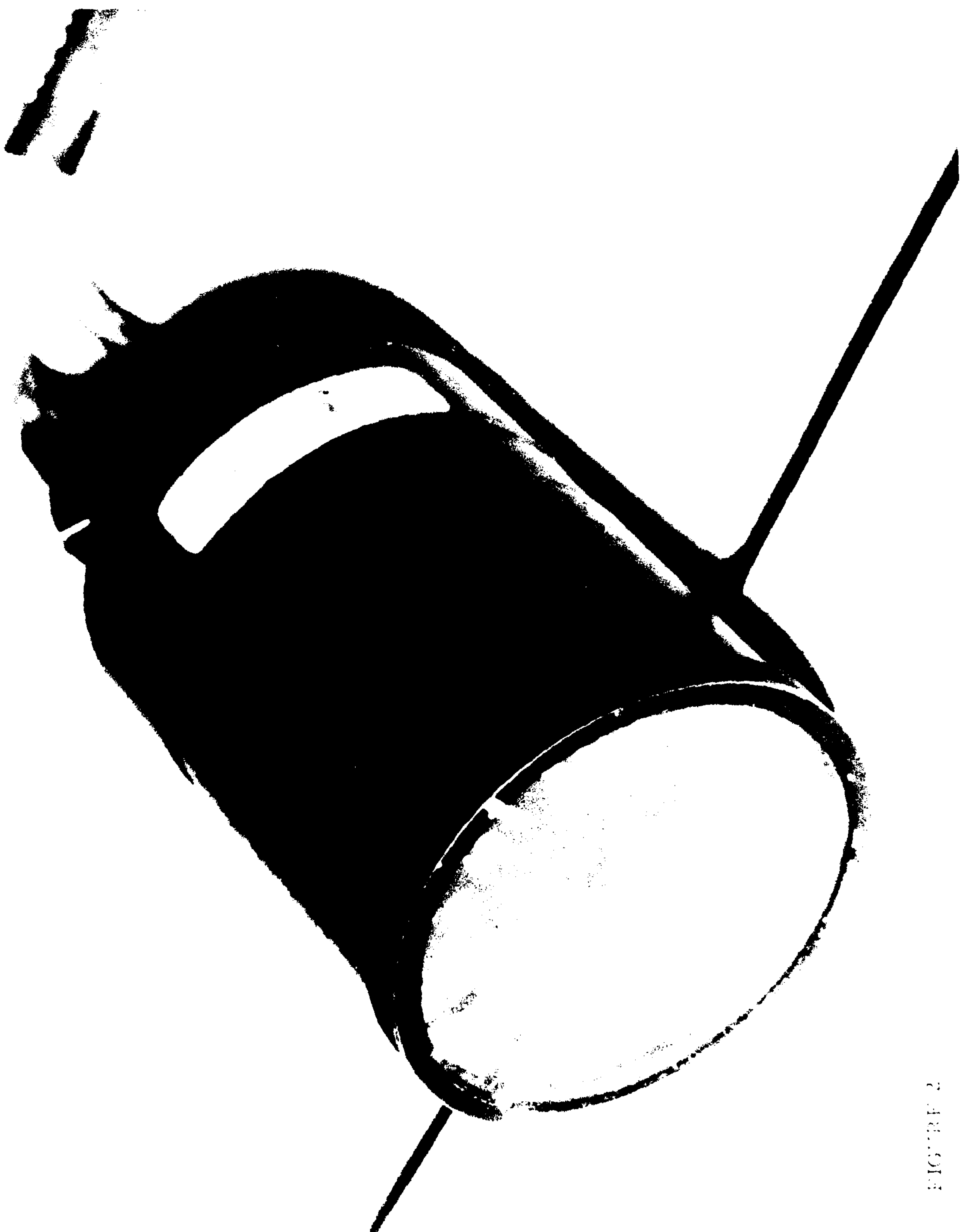

FIGURE 7

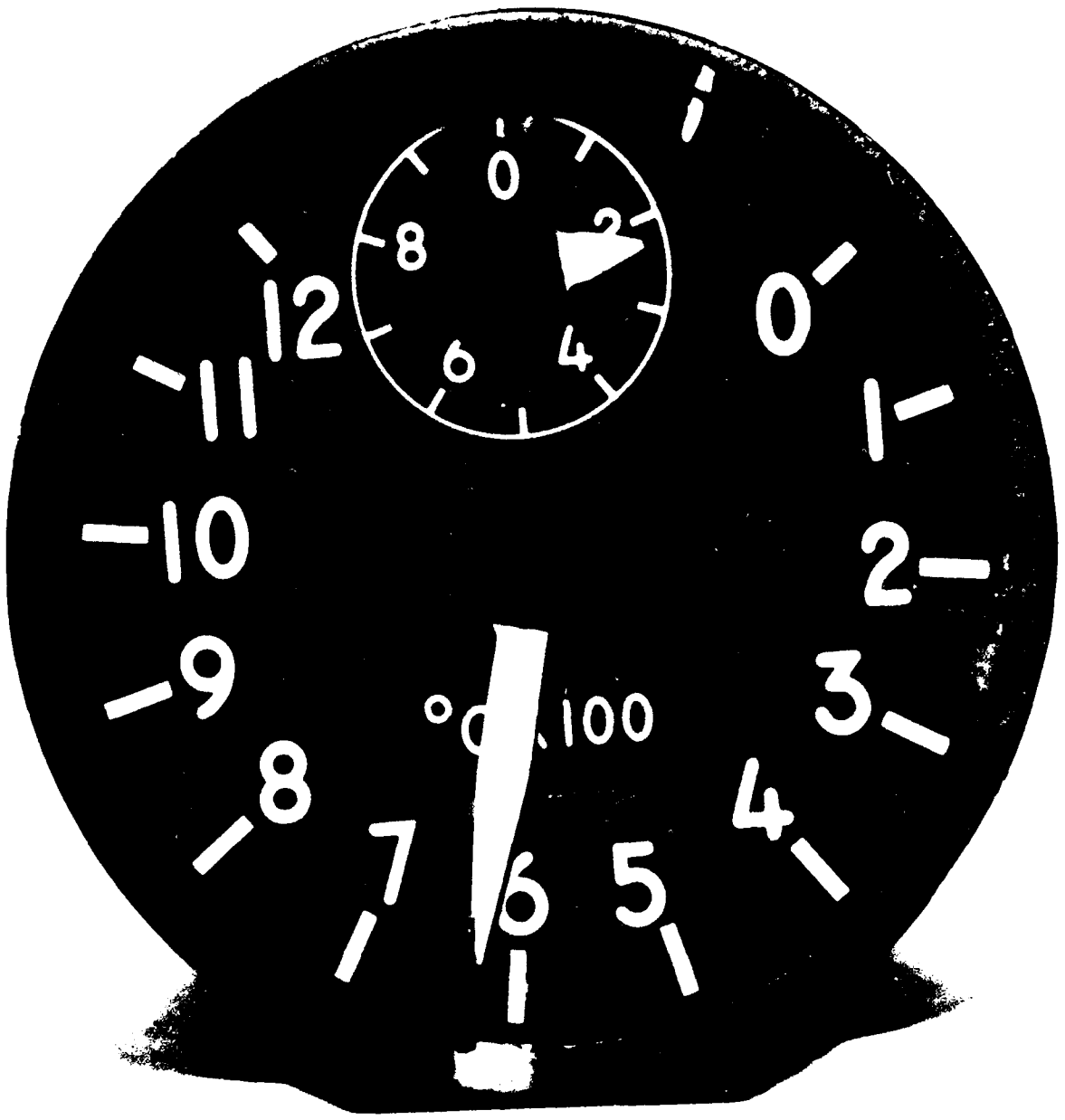

FIGURE 3