COUNTER-TYPE DISTANCE INDICATOR FOR AIRCRAFT

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Technical Development Report No. 140

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT AND
EVALUATION CENTER
INDIANAPOLIS, INDIANA
March 1951

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Manuscript received, September 1950

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SUMMARY

This report describes the construction and the results of experience with a counter- or drum-type indicator for use with distance measuring equipment (DME). The indicator was constructed so that operating experience could be gained under actual flight conditions. It was used in numerous flights by several pilots, and its operation was witnessed by many observers in comparison with clock-face- or pointer-type indicators. Results indicate that it is to be preferred over the previously used pointer-type indicators.

INTRODUCTION

Several years of experience with distance indicators have revealed several disadvantages of pointer-type indicators, chief among which is the inability to obtain rapid and accurate readings. This fact has been recognized by all users of distance measuring equipment as well as by designers of course line computers, and others involved in aircraft cockpit instrumentation.

Special Committee No. 17, of the Radio Technical Commission for Aeronautics, sponsored extensive laboratory tests by the Psychological Branch of the Aero-Medical Laboratory, and the Communications and Navigation Laboratory; both of Air Materiel Command, U. S. Air Force, Wright Field, Dayton, Ohio. As a result of these tests, three alternative designs for distance indicators were recommended from more than 12 proposed designs.[1]

The Committee recommended a veeder-counter-type indicator for use in all aircraft, except where economic factors dictated a more simple instrument and where less accurate distance information will suffice. In such cases the use of a simple dc voltmeter was suggested. The Committee, however, suggested two types of veeder-counter-type indicators. One of these was to include a pointer rotating around a circular scale near the outer circumference of the instrument face. The pointer was to rotate once for each ten miles of distance, the speed of rotation affording the pilot an estimate of the rate of closure. The other counter indicator recommended was similar to the indicator described herein.

Since the mechanical design and construction of such a driving mechanism is quite complicated, and since the pilots and DME users at the Technical Development and Evaluation Center doubted the value of a pointer as a rate of closure indicator, it was decided that an indicator should be constructed without the pointer for these tests. Later information secured from tests conducted on the indicator described herein, and others at the Communications and Navigation Laboratory, Air Materiel Command, indicates that the so-called "rate of closure" pointer is not essential; and that laboratory has recommended that indicators for use by the USAF be procured without such pointers.[2]

This report describes indicators constructed and installed in airplanes for the purpose of a qualitative analysis of the actual utility of the counter-type indicator under conditions normally encountered at the TDEC.

DESCRIPTION

The indicator described herein is not considered a prototype of production indicators, but was constructed as a first model for the sole purpose of presenting the desired method of indication to pilots and potential users for the purpose of securing their comments and suggestions. For this reason it was constructed to operate with Hazeltine Model 1459, 100-channel DME interrogators, which were in use at the TDEC at the time of completion of the instrument. Electrically,

[1] RTCA Paper 27-50/FC-104, dated February 15, 1950, prepared by SC 17.

[2] A. P. Parker and C. S. Franklin, Air Materiel Command, Communications and Navigation Laboratory Memorandum on Distance Measuring Equipment Instrumentation, dated September 21, 1950.

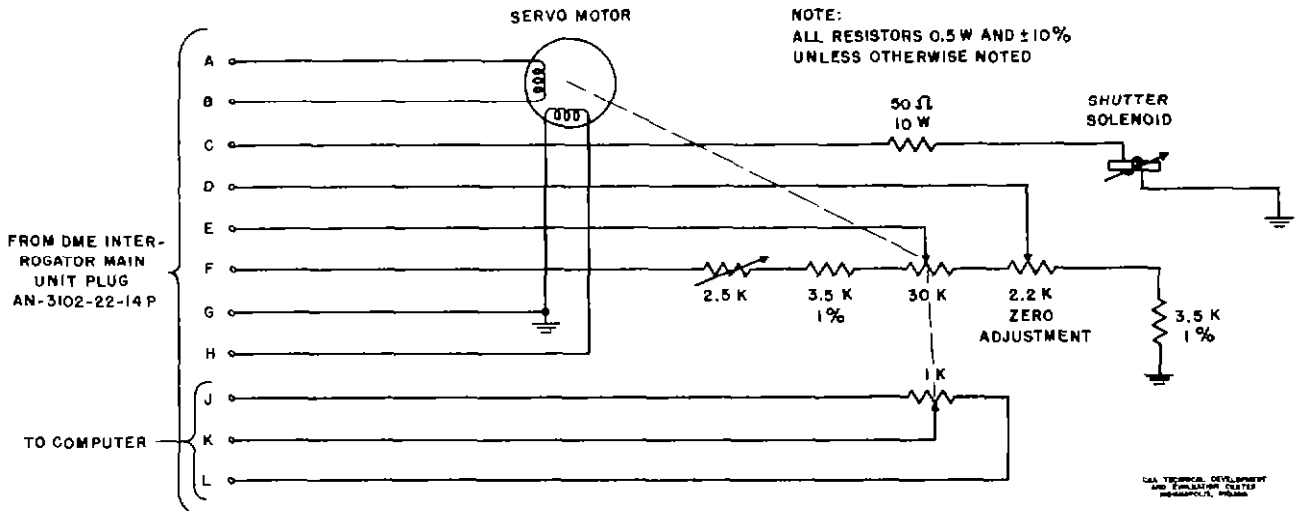


Fig. 1 Schematic Diagram, Counter-Type DME Indicator

its design is identical to the Hazeltine Model 1463 indicator (which it replaces) except that a 28-volt, dc shutter circuit has been substituted for the original 6.3-volt, 400-cps signal-light circuit. A circuit schematic diagram of the indicator is shown in Fig. 1.

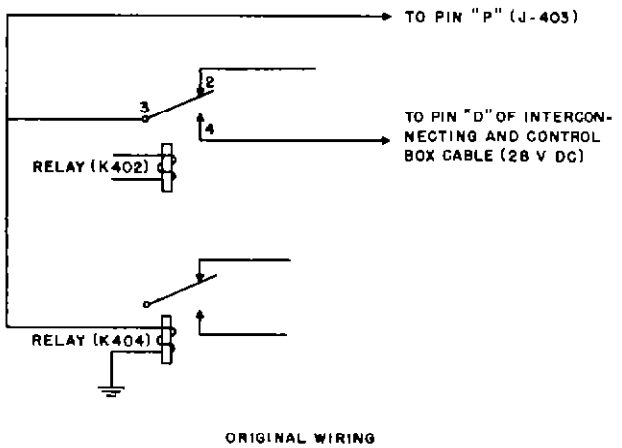
Although an effort was made to hold modification of the DME interrogator to a minimum, some circuit changes were necessary to accommodate the new indicator. It was necessary to change the connections to the search-track relay K-402 in the interrogator to allow it to furnish 24 volts dc to the indicator shutter while the distance measuring strobe is in the tracking position, and to remove it after completion of the memory period and during all conditions of search. These modifications are shown in Fig. 2.

It will be noted that the shutter circuit is connected to pin P of J-403 at the DME main unit and to pin C at the indicator plug. This arrangement allows operation of either the counter indicator or the original pointer-type indicator for comparison purposes by a simple wiring change in the aircraft junction box located between these two units.

Fig. 3 indicates the mechanical arrangement used to accomplish the counter-type rotation, employing the original servo motor and precision potentiometers as used in Hazeltine Model 1463 indicator. The counters were specially constructed by Durant Manufacturing Co. for this purpose and are composed of three drums, so that indication up to 200 miles can be displayed if desired. However, for this indicator only two drums are used, the third being covered by the indicator face. This was done because the interrogator used has a maximum tracking range of 100 miles and, consequently, only the distance from 0 to 99 miles need be displayed. Figs. 4 and 5 are views of the instrument face in the operating and nonoperating conditions, respectively. The numerals are 7/16 inch in height. This was the largest numeral size available at the time of purchase of the counter. A numeral size of one-half inch would be preferred and will be used on future models, if possible.

Although it is not apparent from the photographs, the shutter, which obscures the digits when the DME is not tracking or is turned off, is painted a bright red in order to provide a distinctive "out of service" indication. The shutter solenoid used in this unit is a standard Ledex rotary solenoid, which has been modified mechanically to provide an arm for securing the shutter linkage.

Since the counter used to display distance cannot continue to rotate in one direction, it was necessary to provide a stop to prevent rotation of the prime counter drive shaft more than ten turns in a single direction. In addition, a spring-loaded clutch was provided between the motor and stop to protect the motor and gears when the gear pin strikes the stop.



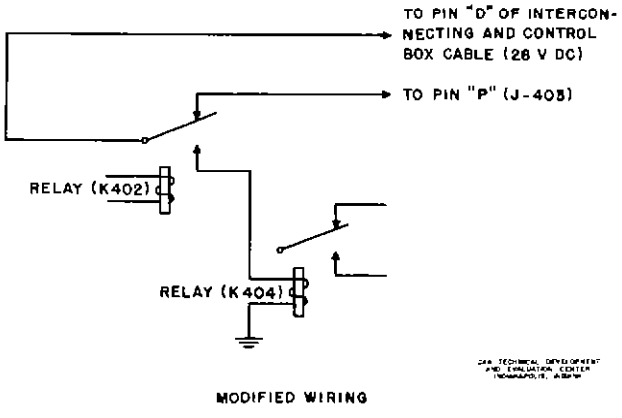


Fig. 2 Wiring Modifications to Hazeltine Model 1459 DME Interrogator for Counter-Type Indicator

The precision resistors and potentiometers, mounted on the rear plate with the cable receptacle, are used for the purpose of adjusting the zero and maximum voltages of the repeat-back circuit to correspond with the proper values of the dc range voltage generated by the strobe positioning circuit in the interrogator.

TESTS AND OBSERVATIONS

On completion of the construction of two of the indicators, they were demonstrated with DME interrogators in the laboratory to numerous engineers and pilots in comparison with clock-face- or pointer-type indicators. Subsequently, the instruments were installed in DC-3 type aircraft at the TDEC, and have been flown a total of approximately 500 hours since installation. The DME has been used in all of its normal functions during this time. These include fixed orbits around the station, approaches in instrument weather, en route navigation and accurate position reporting to radar operators. The DME is used on practically all flight tests by pilots at this Center as a routine procedure, and for this reason, the indicator actually has been used during most of the flight time.

At the outset of the tests it was anticipated that some ambiguity of reading would occur with this type of indicator whenever 1/2 of each of 2 successive numerals appeared at the face opening, (i.e., each 1/2-mile point) and especially at the 9 1/2, 19 1/2, 29 1/2, etc., points. This would occur due

Fig. 3 Counter Indicator, Cover Removed, Top View

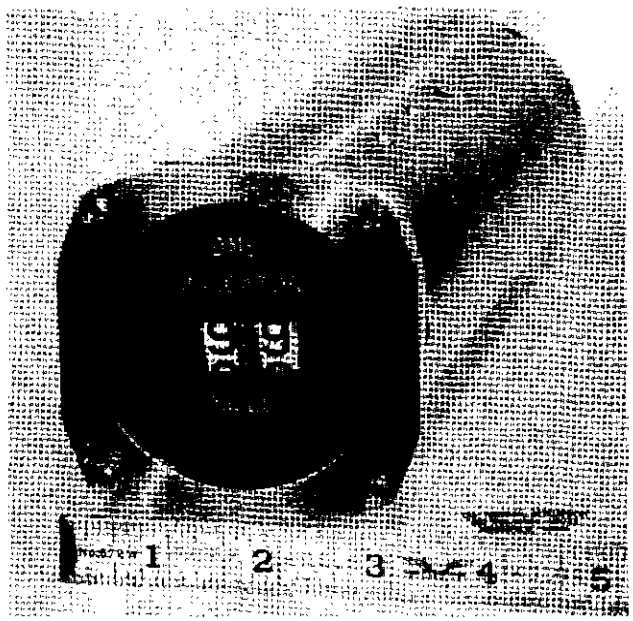


Fig. 4 Counter Indicator, Shutter Open

to the fact that, with the arrangement used, the units drum rotates in proportion to the speed of the aircraft to or from the ground station. In addition, the units drum carries the tens drum with it at the same speed for one-tenth turn between nine and zero. This condition could be eliminated almost entirely by the use of a snap action for advancing the tens digits; but if accuracy of readings of less than one mile were to be secured this could not be accomplished with the units drum. It was decided, therefore, that, since no suitable mechanism was available for advancing the tens digits by a snap or momentary action, the available counter mechanism would be employed and, if serious misreadings or difficulty of readings did occur due to this cause, further effort would be made to incorporate an improved mechanism providing such a snap action. No adverse comments, however, have been received for this reason from either pilots or observers during flight tests or in the laboratory. This condition has been alleviated by constructing the face opening slightly larger than that required to make one numeral visible, thus allowing enough of the succeeding or preceding numeral to be seen to determine the correct distance.

No attempt has been made to collect quantitative data, since a psychological evaluation of the indicator was beyond the scope of the project. However, the indicator has been used by 6 pilots during actual instrument flight conditions, and viewed by approximately 225 observers during flight, and the unanimous opinion of those observing its operation has been that it is a great improvement over previous indicators. It may be noted that 475 hours of the total 500 hours of flight with this instrument have been almost equally divided between four pilots at this Center, and it is their opinion that this method of presenting distance indication is preferred over other previous types.

CONCLUSIONS

As a result of experience obtained, it is concluded that the counter-type indicator is preferred for display of distance information. Although a snap or instantaneous movement for advancing the tens and hundreds digits would appear to be desirable, no difficulty was encountered with the conventional counter mechanism. A shutter or flag should be provided to obscure as large a portion of the distance indication as possible, when the distance information is not correct.

As a result of the flight tests and observations on this experimental instrument, it has been decided to equip all aircraft at

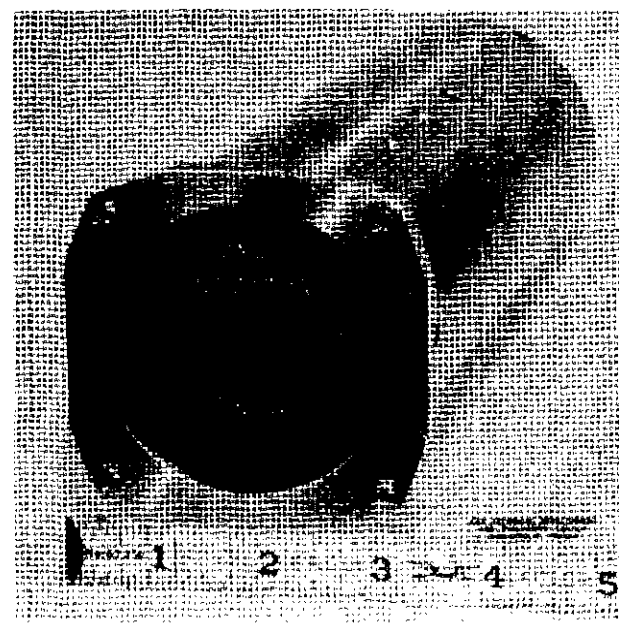


Fig. 5 Counter Indicator, Shutter Closed

the TDEC with this type of instrument, and procurement has been initiated for a quantity of indicators for this purpose.

These instruments will be designed for use as distance-to-station indicators when connected to DME, and as distance-to-waypoint indicators when connected to a course line computer.

GPO 81-103601