DEVELOPMENT OF A DME ANTENNA TRANSFER SWITCH

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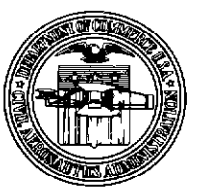

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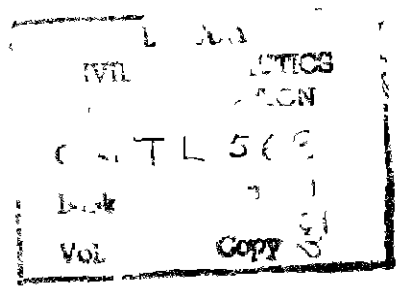

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DEVELOPMENT OF A DME ANTENNA TRANSFER SWITCH

SUMMARY

This report describes an antenna transfer switch developed at the Technical Development and Evaluation Center of the Civil Aeronautics Administration for use with airborne distance measuring equipment (DME). This switch operates with two airborne antennas and one interrogator to minimize the loss of signal caused by interruption of the line of sight by a portion of the aircraft structure during turns in areas of low field strength The locations of the aircraft antennas are chosen so that the line of sight to the ground equipment (transponder) can be maintained with at least one antenna while the aircraft is in any normal operating attitude

The switch was designed to operate with a modified Federal Telecommunication Laboratories Model DIA interrogator, but with minor changes it can be made to operate with any type of DME interrogator

INTRODUCTION

Experience has indicated that it is not feasible to locate a single DME antenna on an aircraft in such a position that the line of sight to the transponder will not be wholly or partially obstructed by a part of the aircraft structure at some time during normal flight maneuvers If the composite field-strength pattern of the interrogator and transponder antennas is relatively strong, the interrogator will usually track even though the antenna in use is partially obstructed However, there is a large zone within which the interrogator will track under line-of-sight conditions but will not track when the signal path is partially obstructed by the wing during a banking turn or by any other part of the aircraft structure It is in any of these obstructed zones that the antenna switch described in this report is particularly useful, since it automatically connects the interrogator to the unobstructed antenna.

The design of an antenna switch to perform this function was initiated in December 1950

DESCRIPTION AND THEORY OF OPERATION

The switch illustrated in Fig 1 occupies approximately 175 cubic inches (5 by 5 by 7 inches) and is shock-mounted The weight of the switch is approximately four pounds.

The circuit shown in Fig 2 is designed to operate a coaxial relay K5 in such a way as to select an antenna which is in a field strength adequate for tracking The coaxial relay does not switch antennas to select the strongest field but changes antennas only when normal tracking is interrupted The two antennas are located with one above the fuselage and one below

During memory and search 28 volts of direct current (dc) are applied to relay K1 thereby closing contacts Nos 4 and 6 which apply B+ voltage to the plates of tube V3, a free-running multivibrator [1,2] The multivibrator has unequal time constants which result in K2 being energized for about 1/2 second and de-energized for about 2 1/2 seconds Relay K3 was added to the circuit because the K2 contacts would not carry the energizing current for the stepping relay K4 and because an additional set of contacts was needed K2 energizes K3 for about 1/2 second, during which time K4 is energized and rotates one step. During the same time contacts Nos 4 and 5 of K3 ground the interrogator trigger, thus silencing the transmitter and preventing radio frequency (r-f) arcing at the coaxial relay K5 Relay K4 alternately energizes and de-energizes K5 and also alternately energizes one or the other of two pilot lamps in order to indicate which antenna is in use As shown in Fig 2 the lower one is in use, and its accompanying pilot light is energized by K4-A The pilot lights may be seen in Fig 1 below the outboard coaxial connectors

If sufficient tracking signal appears on the antenna in use, the interrogator removes the 28 volts from relay K1, thereby de-energizing the multivibrator and stopping the switching action When the power is turned off, relay K5 will connect the lower antenna The two 20-microfarad (mfd) capacitors are used to reduce contact sparking

It will be noted that this circuit changes antennas continuously during memory and search, remaining connected to each antenna approximately three seconds Another method, involving the addition of one relay and the insertion of an additional input from the interrogator, would permit antenna

[1] Memory is here defined as the continuation of airborne distance indication during short periods of signal loss

[2] Search indicates a progressive and continuous time sampling of receiver video

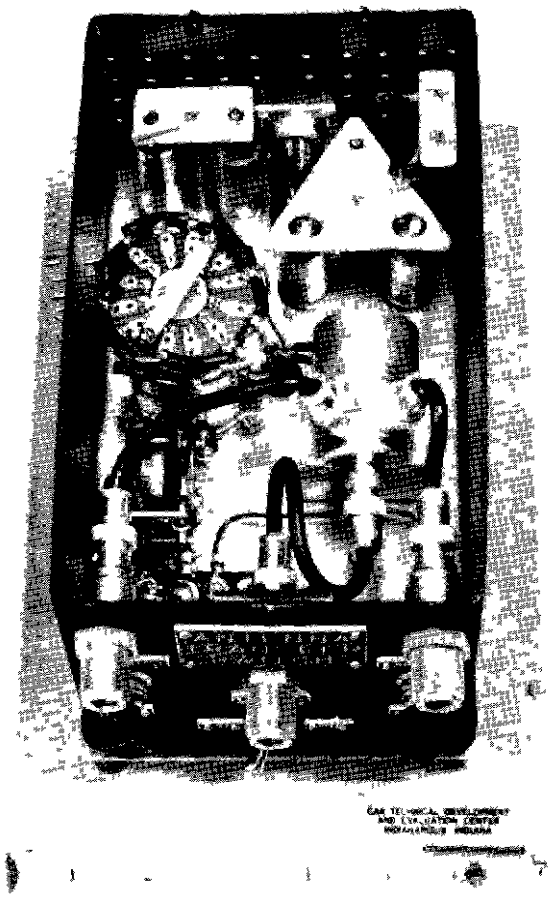

Fig 1 Transfer Switch

switching during memory only Search then could be accomplished on either the lower or the upper antenna alone The average search time for the two methods of operation is about the same Antenna switching during search tends to reduce search-time extremes, thereby increasing the reliability Flight tests have indicated the method in use to be completely satisfactory

PRELIMINARY FLIGHT TESTS

In order to record instantaneously the presence or absence of sufficient signal for proper tracking, an external circuit was designed to operate an Esterline-Angus recorder This circuit is shown in Fig 3 The circuit is designed so that the relay tube V2 conducts when the interrogator decoder output is below tracking level and so that the relay tube is cut off when normal tracking output is present The pulse transformer is used for isolation The relay applies a voltage to the recorder when the signal fails and applies ground when the signal is normal By marking the recording during a turn every 90°, the heading of the aircraft and the amount of signal loss can be determined

TABLE I

COMPARISON OF SIGNAL CONTINUITY

Distance	Altitude Above Transponder	Signal Below Tracking Level (Amount of Turn)	
(miles)	(feet)	Bottom Antenna (degrees)	Switch (degrees)
26	400	70	20
38	1,000	40	15
55	1,800	180	15

Flight No 1

The purpose of this flight was to explore the usefulness of the switch. Turns of 360° with banks of 30° were made over known ground points at altitudes of marginal-tracking signal level, and the results are shown in Table 1

These figures indicate that a substantial improvement in continuity of signal may be accomplished by the use of the switch The signal loss while using the switch was due entirely to the time required for the interrogator relays and antenna-switch relays to operate The signal was never absent or low in both antennas at the same time The weaker the general signal level, the longer the time during which the lower antenna received an inadequate signal The "out" time for the switch (the time when the switch is unable to find an adequate signal) does not increase appreciably until the unobstructed signal is below the tracking level, at which time the useful distance of the equipment has been exceeded

Flight No 2

The purpose of this flight was to determine approximately how much the switch would increase the practical working distance of the DME during turns It is recognized that several variables affect the results, but they are averaged over three trials The field pattern of the transponder could distort the results, but if transponder field patterns are similar, the same effect can be expected at the same distance and altitude, regardless of which ground station is being used

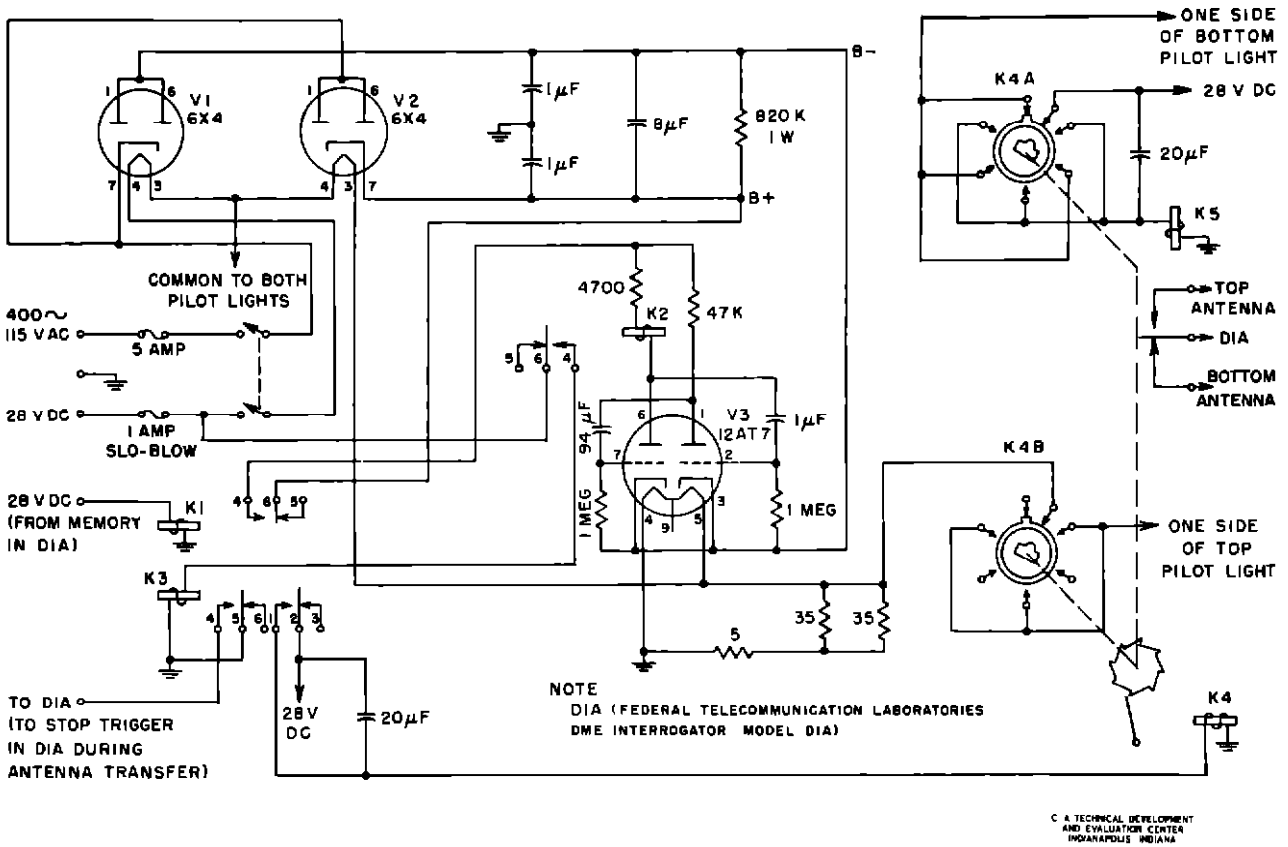

Fig. 2 Transfer Switch Circuit

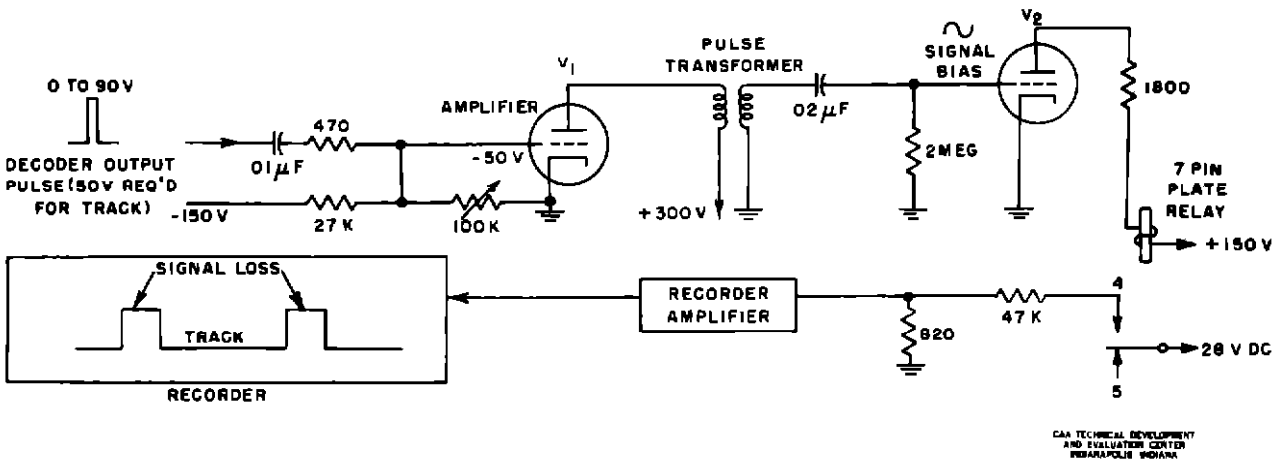

Fig 3 Recorder Circuit

All distances listed in Table II could have been increased by extending the time during which the interrogator was in memory during the turn Since it was not the purpose of these tests to determine maximum coverage, the flights were made in areas of reasonable signal level in order to increase the reliability of the results It is shown by the data in Table II that for the same amount of below-tracking signal level during a 360° turn at 30° bank, the antenna switch improved the tracking distance appreciably.

TABLE II

COMPARISON OF PERFORMANCE WITH AND WITHOUT THE SWITCH

Altitude Above Transponder (feet)	Signal Below Tracking Level (degrees)	Distance	
		Bottom Antenna (miles)	Switch (miles)
1,000	30	40	47
2,000	30	55	61
3,000	30	61	69

CONCLUSIONS

1 A small, lightweight, antenna transfer switch has been developed for automatically connecting a DME interrogator to an unobstructed antenna

2 The transfer switch will improve the continuity of distance information during normal aircraft maneuvers

3 The switching of antennas quite often reduces the length of time during which the interrogator remains in the memory mode of operation. Since it is impossible to display accurate information during memory, the switch effectively contributes to accuracy as well as to reliability