TECHNICAL DEVELOPMENT REPORT NO. 224

EVALUATION OF AIRCRAFT RADIO CORPORATION TYPE H-14 SIGNAL GENERATOR AS A LOW-COST OMNITEST FACILITY

FOR LIMITED DISTRIBUTION

by

Raymond A. Forcier

Electronics Division

December 1953

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT
AND EVALUATION CENTER
INDIANAPOLIS, INDIANA

EVALUATION OF AIRCRAFT RADIO CORPORATION TYPE H-14 SIGNAL GENERATOR AS A LOW-COST OMNITEST FACILITY

INTRODUCTION

The Office of Federal Airways requested the Technical Development and Evaluation Center to evaluate the Aircraft Radio Corporation's Type H-14 signal generator and Type H-16 standard-course checker to determine their suitability as a low-cost omnitest and monitor facility. This evaluation was to cover the accuracy, stability, power output, and reliability of the equipment over a period of several months' operation. This report gives the results of tests conducted over a period of eight months.

The Type H-14 signal generator is a test set used for testing and adjusting airborne VHF navigational receiving equipment and is manufactured by the Aircraft Radio Corporation, Boonton, N. J. The H-14 signal generator tested was a standard model and was transmitting a signal of 0 degrees FROM bearing at a frequency of 112.0 Mc. The Type H-16 standard-course checker is used for checking the 0-degree and 180-degree bearings from the signal generator.

The specific tests conducted at TDEC on the ARC Type H-14 signal generator are described in this report.

BENCH TESTS OF ELECTRICAL COMPONENTS

The circuit analysis indicated that there were several components (resistors and capacitors) that would give an erroneous bearing if their optimum value were changed by plus or minus 10 per cent. In order to determine these critical components, each resistor and capacitor was paralleled with a like component of such value that it would change the resistance or capacity of its circuit by 10 per cent.

A change of 10 per cent of the optimum value of the following components caused a bearing change as listed in the following. During this test, the course-selector switch was set at 180 degrees TO.

Only those components that are used when the signal generator is operated as a very-high-frequency omnitest facility (VOT) on 180-degree TO bearing were checked. Those components used during tone and localizer operation and for all other bearings were not checked during this test.

TABLE I

10 PER CENT CHANGE OF COMPONENT NOMINAL VALUE VS. BEARING CHANGE

Component		Value	Bearing Change (degrees)
Resistor	R-134	100K (ohms)	0.3
	R-135	100K	0.3
	R-138	100K	0.3
	R-143	20K	0.4
	R-145	15K	0.5
	R-157	100K	0.4
Capacitor	C-115	0.0043 (microfarads)	0.4
	C-118A or B	0.25	0.4
	C-119	0.0043	0.3
	C-123A or B	0.25	4.5
	C-127	0.5	0.5

SERVICEABILITY AND STABILITY

The original Type H-14 signal generator was placed in operation on March 27, 1953, and was later replaced with an improved unit supplied by the Aircraft Radio Corporation on April 15, 1953. This later model (Serial No. 369) was in continuous operation until September 7, 1953, when it was shut off for laboratory tests. After the laboratory tests were completed, the equipment was again operated as a VOT aid.

The stability tests were conducted as follows: The signal generator was set up and tuned to 112.0 Mc and transmitted a signal of 180 degrees TO (0 degree FROM) from a crossed-dipole antenna mounted on the laboratory roof. Measurements of the bearing were taken daily using a V-antenna and a Collins 51R-2 navigation receiver. After taking the bearings, the receiver was immediately calibrated with a Collins 479S audio generator and a Boonton 211A signal generator. The improved H-14 signal generator was calibrated and adjusted when first installed on April 15, and no further adjustments were made until it was shut down for the bench tests on September 7. During the bench tests, all of the tubes were checked and none were found in need of replacement. It was found necessary to replace tubes V104 (30-cps amplifier) and V114 (r-f output) on November 16 because of low tube emission.

Fig. 1a graphically portrays the stability by indicating the minimum and maximum variations of the transmitted bearings for the weeks starting on the indicated dates. The broken line (drawn midway between the weekly minimum and maximum points) does not indicate the daily measurements but only the trend of the weekly variations.

The AFC standard-course checker, Model H-16, was connected to the "demod" output of the H-14 signal generator; and the course variations as indicated by the course checker were recorded. The H-16 course checker was calibrated and adjusted in accordance with the instruction manual each time the bearing was checked. Fig. 1b shows the bearing error indicated by the course checker for those weekly maximum and minimum variations as shown in Fig. 1a.

Fig. 2a indicates the daily bearings from the signal generator for the period September 21 to November 6. Fig. 2b shows the bearing error indicated by the H-16 course checker for the same period.

POWER-LINE FREQUENCY-STABILIZATION TESTS

The H-14 signal generator was connected to a variable-frequency power supply, and the input-line frequency was varied from 58 to 62 cps in one-cps steps. A Collins 51R-2 receiver was used to indicate the change in bearing due to the change in line frequency. For a comparison of the change in bearing, a similar test was made by varying the line frequency to a Collins 479S audio generator. The comparative data for these two generators are shown in Fig. 3. Previous to this time, data had been obtained to determine the effects on various types of receivers when the line frequency to a tone wheel was varied between 58 and 62 cps. The following is a summary of the data taken at that time.

TABLE II

RECEIVER BEARING ERROR CAUSED BY
CHANGE OF POWER-LINE FREQUENCY TO SIGNAL GENERATOR

Receiver Type	Error 58 cps (degrees)	59 cps (degrees)	60 cps (degrees)	61 cps (degrees)	62 cps (degrees)
Bendix MN-85BA	- 1.3	- 0.7	0	+ 0.2	+ 0.9
Collins 51R-2	- 1.0	- 0.7	0	+ 0.7	+ 1.7
Collins 51R-1	- 0.4	- 0.2	0	+ 0.2	+ 0.8
ARC 15A	+ 5.0	+ 2.7	0	- 4.2	- 6.8
Narco VTR1	+ 1.9	+ 0.8	0	- 1.3	- 3.6

Table II indicates that the amount of bearing error caused by power-line frequency variation to the tone wheel is dependent upon the type of receiver used.

GENERAL STABILITY WITH CHANGE OF TEMPERATURE

The signal generator was placed in the temperature chamber with a room ambient humidity of approximately 60 per cent, and the temperature was varied from -13 degrees C. to +50 degrees C. The change in bearing was measured with a Collins 51R-2 receiver and calibrated with a Collins 479S audio generator and a Boonton 211A signal generator. The change in bearing over the temperature range was 0.7 degree as indicated in Fig. 4.

Ground Checks

The r-f output from the H-14 signal generator was 22 milliwatts when measured with a 51-ohm Bird Termaline load and a GR Model 1800A vacuum-tube voltmeter. The power delivered to the antenna through 150 feet of RG-8/U transmission line was 11 milliwatts.

Ground checks were made at several locations on Indianapolis Weir Cook Airport for the following stations: (1) Indianapolis VOR located at a distance of 7.0 miles; (2) Tilden VOR, a TDEC experimental station, located at a distance of 10.5 miles; and (3) ARC Model H-14 signal generator fed into a crossed-dipole antenna located on the airport. The height of the crossed-dipole antenna was 40 feet above ground, and it was located at a distance of 4,750 feet from the take-off position on runway 36. A Bendix MN-85BA navigation receiver connected to the hatch antenna of the aircraft was used during these tests. Bearing checks were taken on all of the foregoing stations with the aircraft located on the hangar ramp with engines not running. The next test was made in the same location but with the engines running at 1,450 rpm. The plane was then taxied to the take-off position on runway 36, and bearings were taken on all stations with the engines running at 1,470 rpm. The plane was then taxied to take-off position on runway 31, and bearings were taken with engines running at 1,470 rpm. The plane's heading was then changed 90 degrees, and bearings from all stations were observed.

Table III indicates the field strength of the VOT and VOR stations when measured in an aircraft located at take-off position on runway 36.

TABLE III

RELATIVE FIELD STRENGTH OF SIGNALS RECEIVED
ON THE GROUND AT WEIR COOK AIRPORT

Station	Frequency In Mc	Receiving Antenna	Field Strength (Equivalent to Boonton 211A Through 6-db Pad) Aircraft Heading			
			North (Microvolts)	West (Microvolts)	South (Microvolts)	East (Microvolts)
Indianapolis VOR	116.3	Tail	7.5	6.5	3.7	10.0
Indianapolis VOR	116.3	Hatch	8.8	7.5	8.2	12.0
Tilden VOR	115.7	Tail	4.0	6.2	3.1	9.2
Tilden VOR	115.7	Hatch	9.3	6.2	5.0	3.9
ARC H-14 VOT	112.0	Tail	9.3	3.9	11.8	6.7
ARC H-14 VOT	112.0	Hatch	8.4	6.2	5.9	7.3

The results of these tests can be summarized as follows: The bearings obtained at all of these locations were accurate to within one degree. No trouble due to prop modulation when the engines were running from 1,450 to 1,470 rpm was experienced. Aircraft flying in the local area would occasionally cause the course deviation indicator to oscillate when tuned to a VOR station. When tuned to the omnitest signal, the fluctuation of the course deviation indicator was very much less.

FLIGHT TESTS

The flight tests were made under two specific conditions: (1) A crossed-dipole antenna was mounted on the laboratory roof (40 feet above the ground) and the signal was fed through 150 feet of RG-8/U transmission line to the antenna, and (2) the I-14 signal generator was installed in an instrument panel truck and was operated from a motor-generator unit mounted in the truck. The r-f signal was fed through ten feet of RG-8/U transmission line to a V-antenna mounted on the truck roof and about seven feet above the ground. The relative field strengths were measured while flying at 1,000, 5,000, and 10,000 feet altitude and using the tail V-antenna on the aircraft.

Fig. 5 indicates that a relative field strength of two microvolts may be obtained at distances of 16 miles at 1,000 feet altitude, 35 miles at 5,000 feet altitude, and 50 miles at 10,000 feet altitude when using the crossed-dipole antenna mounted 40 feet above ground.

Fig. 6 indicates the distance range of the VOT signal when using a V-antenna mounted seven feet above the ground. A relative field strength of two microvolts was obtained at distances of 8 miles at 1,000 feet, 13 miles at 5,000 feet, and 20 miles at 10,000 feet.

All microvolt readings are referred to the Boonton 211A signal-generator attenuator and represent relative field strength at the antenna for perfect matching conditions. The signal levels at the receiver would then be one-half of the values given in Figs. 5 and 6.

IDENTIFICATION OF VOT SIGNAL

It was believed desirable to have some kind of modulation on the test signal to aid in tuning the signal when using a tunable receiver such as the ARC and Narco types. A 1,600-cps oscillator keyed at a rate of approximately 5 cps by a neon-lamp relaxation oscillator was built and installed inside of the generator case. The power to operate this circuit was taken from the signal generator, and its output was fed to the external modulation terminals of the generator. This oscillator-keyer was operated continuously since May 1 and is satisfactory at temperatures between -13 degrees C. and +50 degrees C. A schematic of this circuit is shown in Fig. 7.

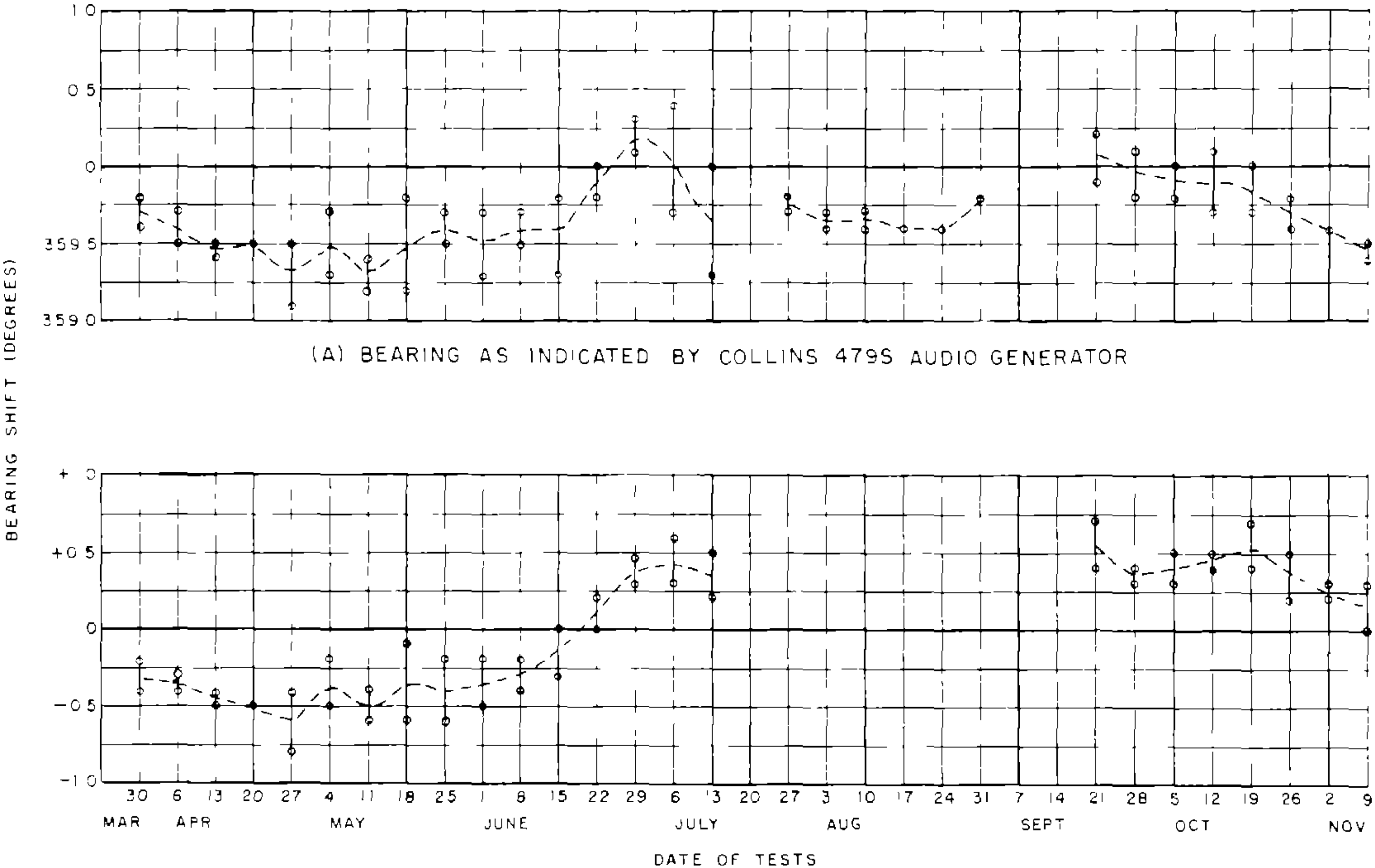
CONCLUSIONS

1. The component parts (tubes, capacitors, resistors, etc.) are operated at or below their nominal ratings. This insures long life, as indicated by approximately 5,000 hours of operation to date with no replacement of parts except two tubes and with no radical change in indicated bearing.

2. The signal generator will maintain an accuracy of plus or minus 0.5 degree over long periods of time without maintenance or adjustment.

3. The change in bearing from the generator due to variations in the power-line frequency is comparable to the Collins 479S or Wedd audio-signal generators.

4. Use of this equipment for ground-receiver checks prior to take-off provides accuracy checks within one degree, and fluctuation of the course deviation indicator caused by flying aircraft is very much less than when using a VOR for checking the receiver. The service range at 1,000 feet altitude is 8 miles when the antenna is 7 feet above ground and 16 miles when mounted 40 feet above ground.



(A) BEARING AS INDICATED BY COLLINS 479S AUDIO GENERATOR

(B) BEARING AS INDICATED BY ARC MODEL H-16 STANDARD-COURSE CHECKER

FIG WEEKLY MINIMUM AND MAXIMUM BEARING SHIFT OF SIGNAL FROM MODEL H-14 SIGNAL GENERATOR

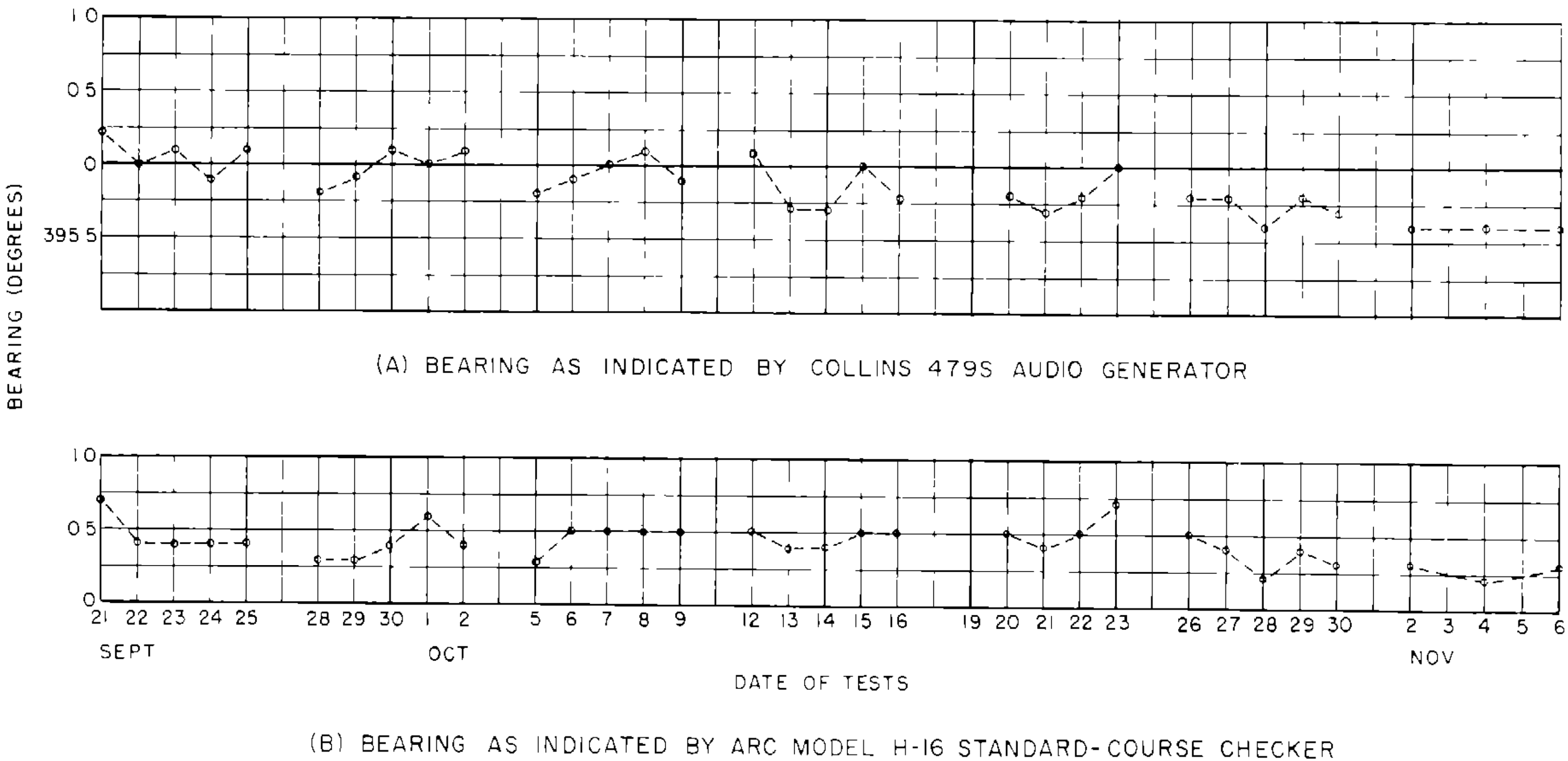


FIG 2 DAILY BEARING OF SIGNAL FROM MODEL H-14 SIGNAL GENERATOR

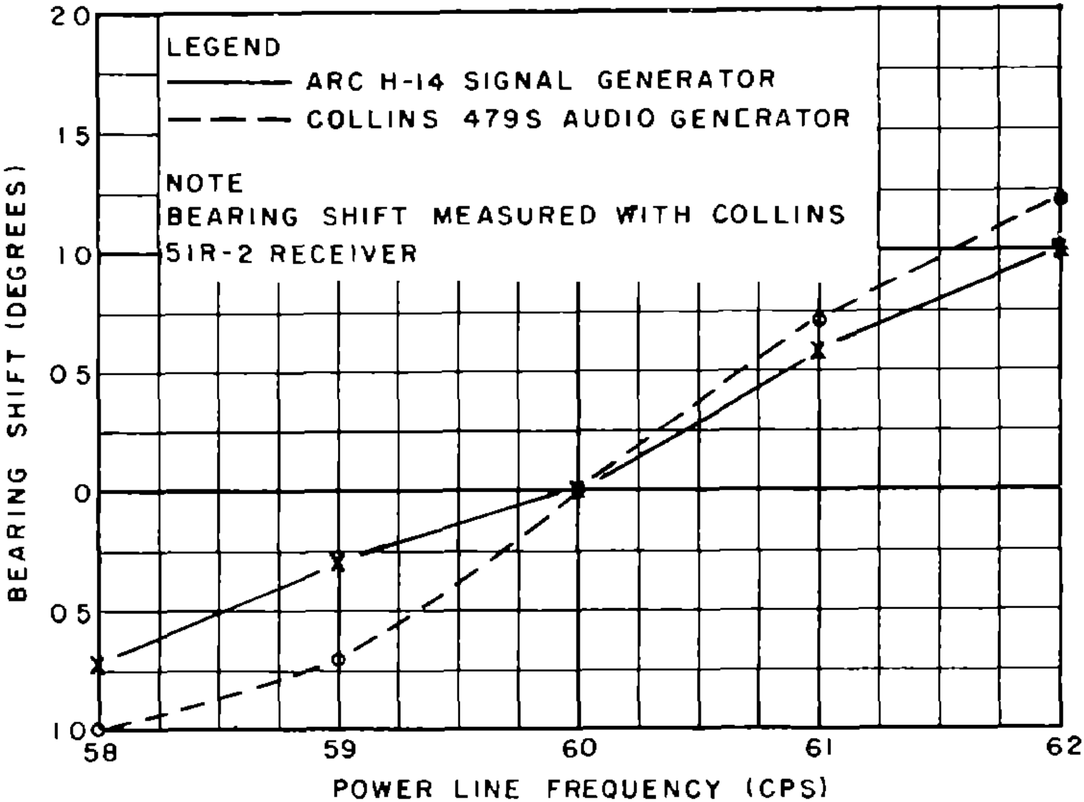


FIG.3 COMPARISON OF BEARING SHIFT VERSUS
POWER LINE FREQUENCY

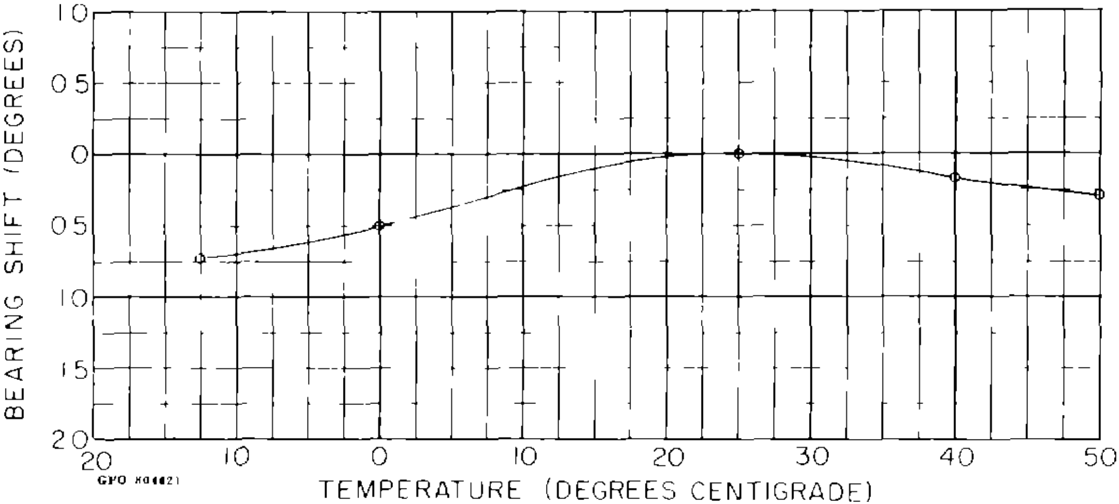


FIG 4 BEARING SHIFT VERSUS TEMPERATURE
(ARC MODEL H-14 SIGNAL GENERATOR)

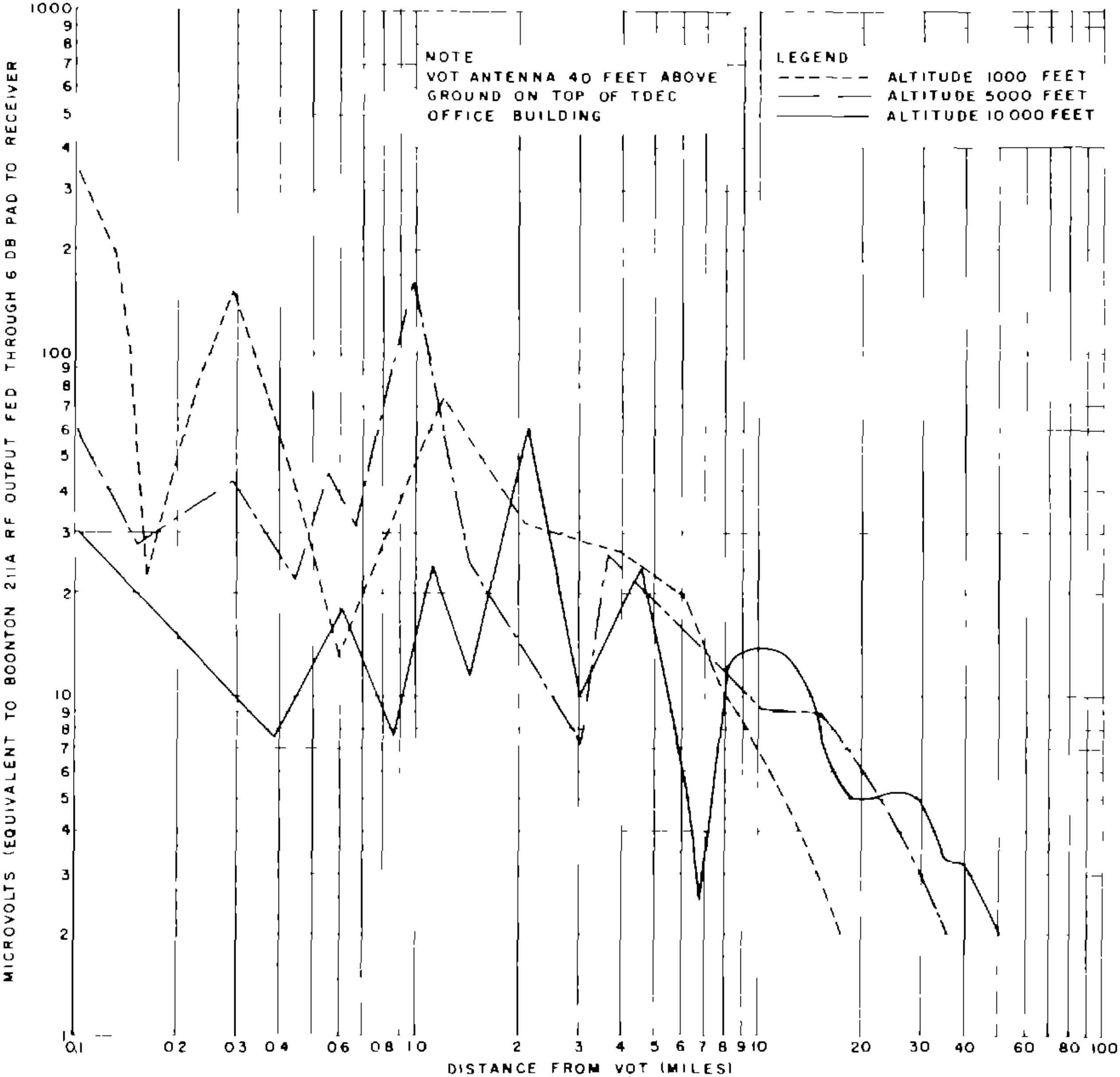


FIG 5 RELATIVE FIELD STRENGTH VERSUS DISTANCE

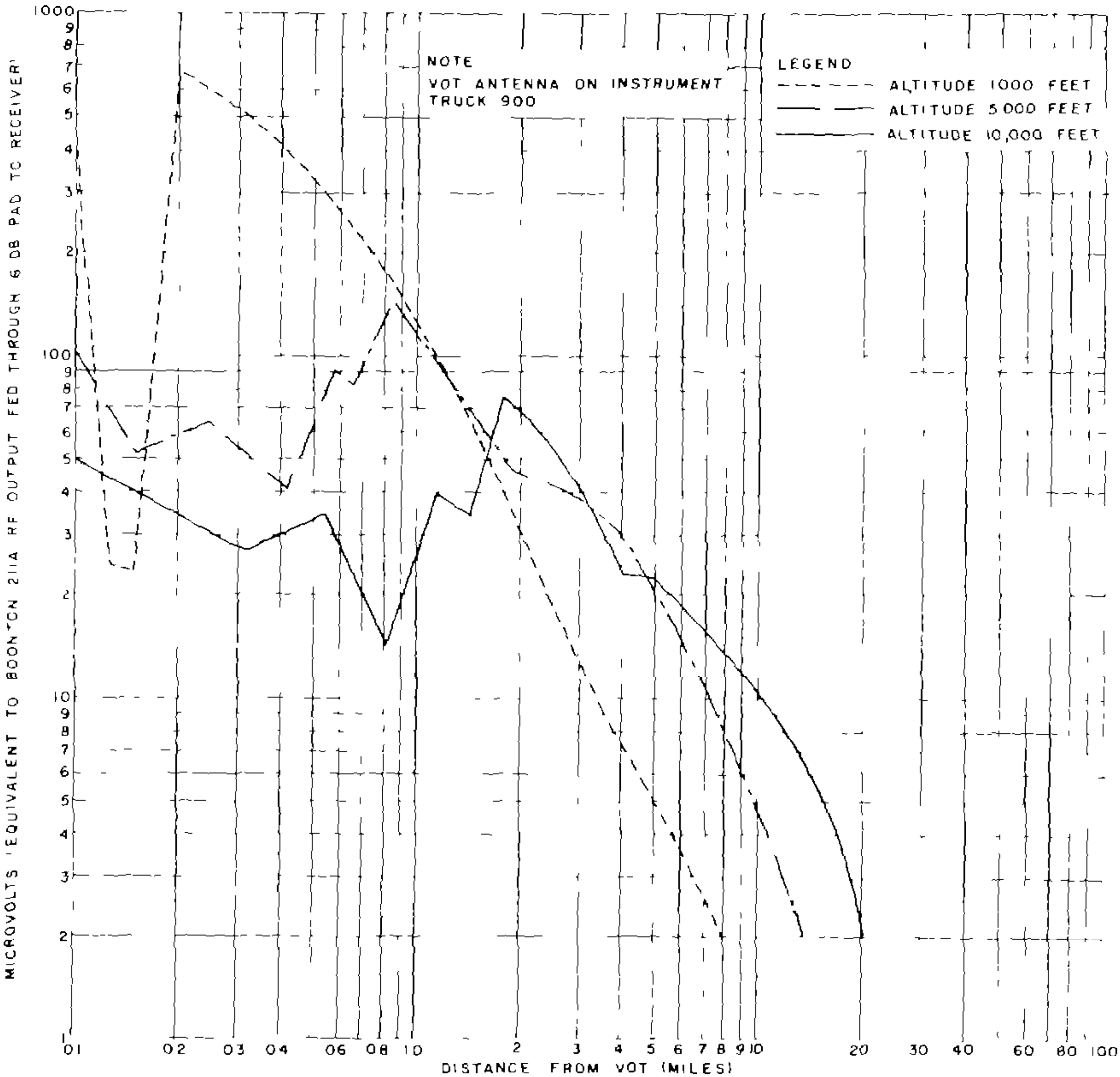


FIG 6 RELATIVE FIELD STRENGTH VERSUS DISTANCE

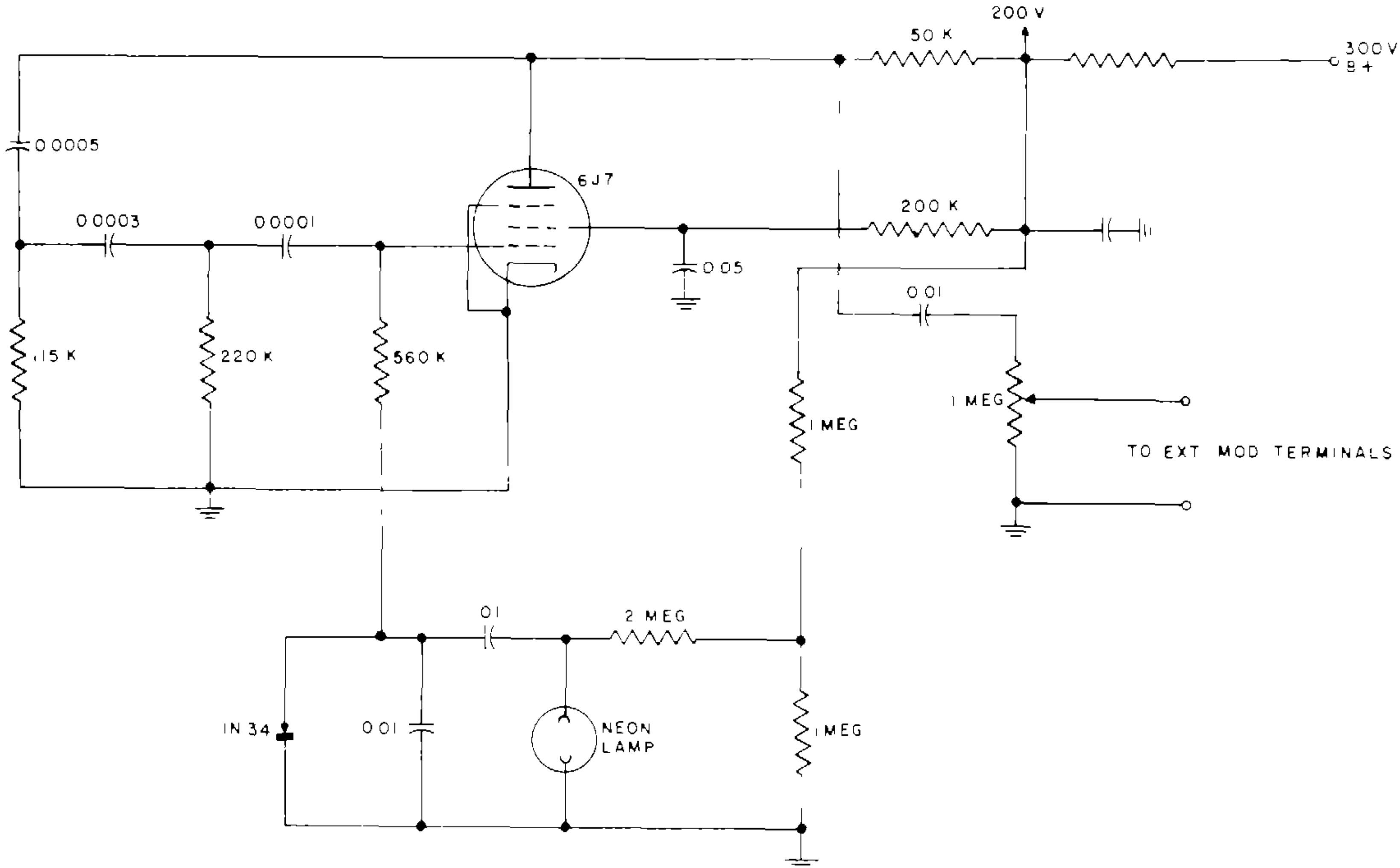


FIG 7 SCHEMATIC DIAGRAM OF OSCILLATOR KEYER USED FOR IDENTIFICATION IN H-14 SIGNAL-GENERATOR TESTS