PB - 11827 PRICE #C 75

Improvements in the Type CA-1277 Vor Monitor

by
R A Forcier
and
C G Lynch
Electronics Division

TECHNICAL DEVELOPMENT REPORT NO 216

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT AND
EVALUATION CENTER
INDIANAPOLIS, INDIANA

14.0

August 1955

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, Secretary

CIVIL AERONAUTICS ADMINISTRATION
F B. Lee, Administrator
D M Stuart, Director, Technical Development and Evaluation Center

TABLE OF CONTENTS

IMPROVEMENTS IN THE TYPE CA-1277 VOR MONITOR*

SUMMARY

This report presents the results of tests conducted at the Technical Development and Evaluation Center of the Civil Aeronautics Administration to determine why the reference-channel phase-splitting stage in the Type CA-1277 VOR monitor is sensitive to tube changes and what corrective action is necessary to overcome this design deficiency The effect of incorporating filters in the reference and the variable channels of the monitor on its calibration accuracy was also determined

It is shown that the modifications to the monitor decreased the over-all spread in the calibration-error curve from 4 2° to 0 9°, almost eliminated all effects caused by aging or exchanging of tubes, and reduced the effects of a-c hum on the monitor operation

INTRODUCTION

One purpose of the monitor is to sample the transmitted very-high-frequency omnirange (VOR) signal and to give alarm at the INSAC when the bearing changes more than ±1 0° or when trouble develops in the transmitter Because of its specific use, the monitor must be extremely reliable and its indicated bearing must be unaffected by normal variations in power-line voltage or frequency, temperature, humidity, or aging tubes and other components If the indicated bearing of the monitor is affected by any of these varying conditions, the monitor may shut off the transmitter even though the station might be operating normally

During the past year, an exhaustive study was made by the Office of Federal Airways to determine new methods and test procedures for reducing station maintenance time The Office of Federal Airways requested that TDEC determine why the indicated monitor bearing changes when tube V19 (OBS input tube) is replaced and that they recommend corrective action to remedy this design deficiency This report gives details regarding the redesign of tube V19 circuitry and gives the results obtained by the incorporation of filters in the monitor circuits

TEST PROCEDURES

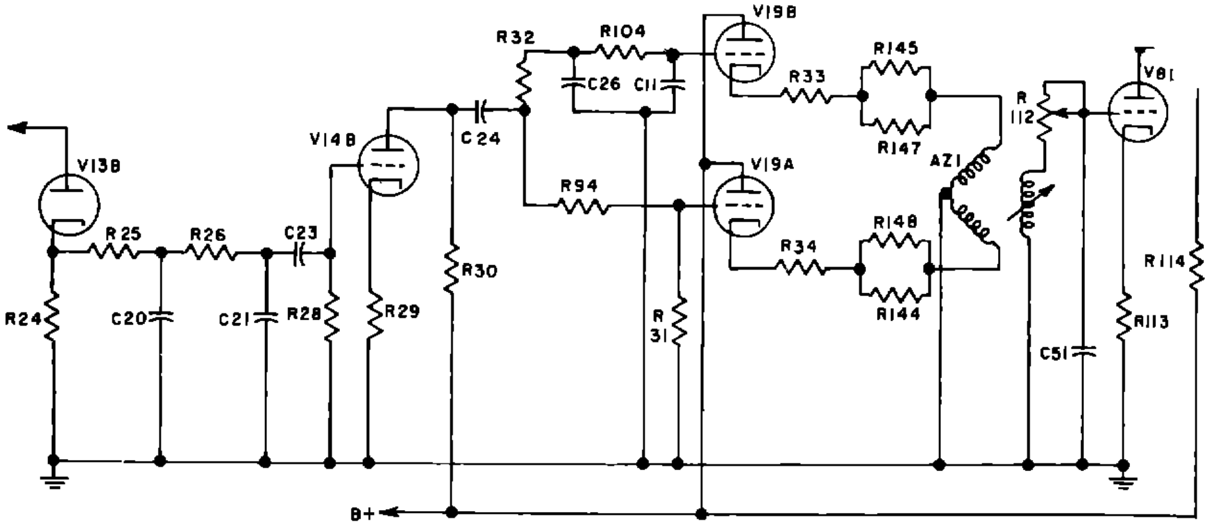
The VOR test signal from the MIXED SIG jack of the Collins Type 479S audio generator was fed to the input terminal of DET 1 in the monitor An oscilloscope was used to indicate the zero phase relationship of the test signals The vertical amplifier was connected to the cathode of tube V18A, and the horizontal amplifier was swept at a 60-cps rate with the internal sweep The omnibearing selector (OBS) in the monitor was set to the desired azimuth, and the audio-generator omnibearing dial was rotated until the two pips on the oscilloscope screen were lined up The azimuth indicated by the dial was recorded as the correct bearing

During the hum tests, tube-transconductance (Gm) tests, and variable-filament voltage tests, the power supply in the monitor was disconnected and an external hum-free power supply was substituted The a-c filament power was also supplied from this external source This was done to eliminate bearing errors due to uncontrolled hum during the tests Prior to making any tests with the internal power supply, the monitor circuitry was modified to reduce hum in accordance with Office of Federal Airways All Region Letter dated September 18, 1952, and entitled "VOR Monitor, CA-1277, Hum Reduction " All tests were conducted at room ambient conditions of temperature and humidity unless otherwise specified

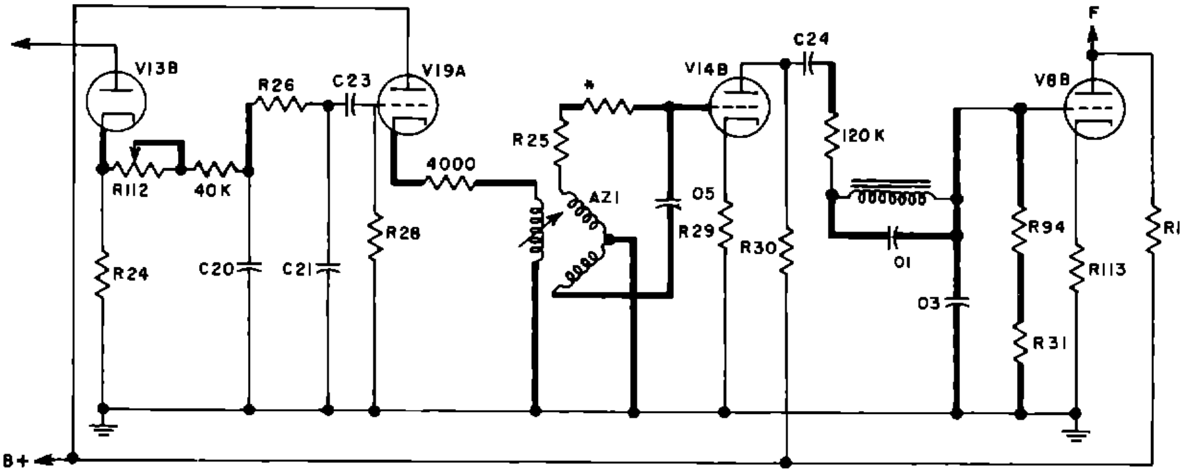
Several Type 6SN7 GT tubes were tested, and those having the highest and lowest Gm indications were selected for use during these tests The highest-Gm tube indicated a Gm of 2500 micromhos for one triode section and 2250 micromhos for the other section The lowest-Gm tube indicated 1550 and 1600 micromhos for the two triode sections

---

*Manuscript submitted for publication January 1955



(A) STANDARD REFERENCE CHANNEL CIRCUIT



* SELECT RESISTOR TO MINIMIZE QUADRANTAL ERROR
(HEAVY LINES INDICATE CHANGES)

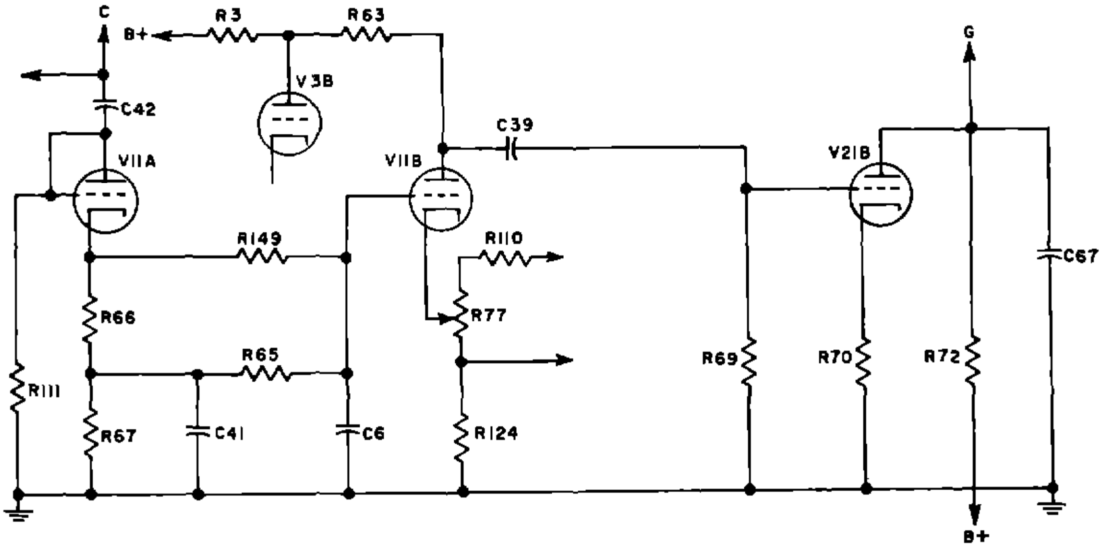
(B) MODIFIED CIRCUIT

CAA TECHNICAL DEVELOPMENT
AND EVALUATION CENTER
INDIANAPOLIS INDIANA

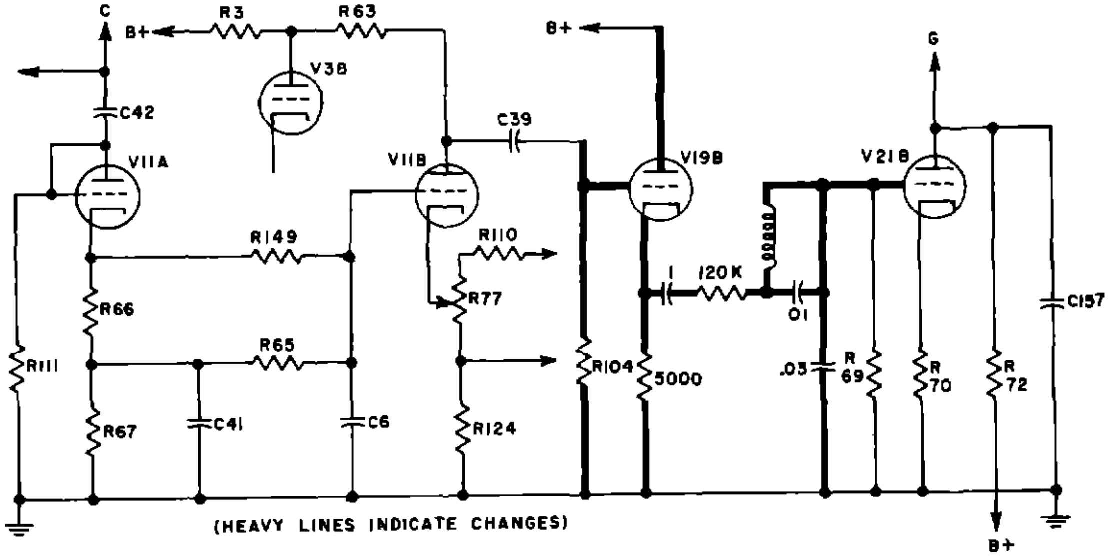
Fig 1 Schematic Diagram of Modified Portion of Reference Channel Circuit

CIRCUIT MODIFICATIONS

A careful analysis of the standard V19 tube circuitry, Fig 1a, shows that replacement of tube V19 with another tube having a different Gm will cause a phase shift in the OBS circuit Likewise, a change of Gm caused by aging of a tube will also cause a change in the indicated bearing Accordingly, it was decided to redesign the circuitry of tube V19 to eliminate the phase change with a change in tube characteristics and to incorporate filters in both the reference and variable channels to reduce the error caused by hum The redesigned circuits are



(A) STANDARD VARIABLE CHANNEL CIRCUIT



(HEAVY LINES INDICATE CHANGES)

(B) MODIFIED VARIABLE CHANNEL CIRCUIT

CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 2 Schematic Diagram of Modified Portion of Variable Channel Circuit shown in Figs 1b and 2b The complete modification follows

Reference Channel (See Fig 1)

After several preliminary tests, it appeared desirable to operate the OBS circuitry at a lower signal-input level to prevent overloading and distortion in the OBS circuit Therefore it was decided to move tube V19A and the OBS circuitry one stage ahead of its present location

1 Resistors R144, R148, R145, and R147 were disconnected from the OBS stators Nos 1 and 2 Resistors R33 and R34 were removed from the cathodes of tubes V19A and V19B

2 The grid of tube V14B was disconnected from the junction of C23 and R28 The grid of V19A was disconnected from the junction of R94 and R31 and was reconnected to the junction of C23 and R28

3 Resistor R25 was removed from between the cathode of tube V13B and the junction of R26 and C20 and was reconnected between the output of the OBS stator No 1, in series with another resistor, to the grid of tube V14B

4 An 0 05-mfd capacitor was connected between the output of the OBS stator No 2 and the grid of tube V14B

5 A 4000-ohm wire-wound resistor was connected between the cathode of tube V19A and the input to the OBS rotor

6 The phase-adjustment-vernier potentiometer R112 was moved from the input of tube V8B and was reconnected as a variable resistor in series with a 40,000-ohm wire-wound resistor between the cathode of tube V13B and the junction of C20 and R26

7 Capacitor C51 was removed from the grid of tube V8B Resistor R94 was disconnected from the junction of R32 and C24 and was reconnected in series with R31 between the grid of tube V8B and ground

8 Resistor R32 was opened at its junction with C24 The 30-cps filter, consisting of a 120,000-ohm resistor, a 704-henry choke, and four 704 0 01-mfd capacitors, was connected between C24 and grid of tube V8B

Variable Channel (See Fig 2)

1 Resistor R32 and capacitors C26 and C11 were disconnected from R104 (Fig 1a) R104 was reconnected between the grid of V19B and ground

2 The junction of C39 and R69 was opened, and C39 was reconnected to the grid of tube V19B

3 A 5000-ohm resistor was connected between the cathode of V19B and ground

4 An 0 1-mfd coupling capacitor was connected from the cathode of V19B to the input of the 30-cps filter The output of the filter was connected to the grid of tube V21B

COMPARATIVE TESTS OF STANDARD AND MODIFIED CIRCUITS

Change in Calibration After Hum Modification

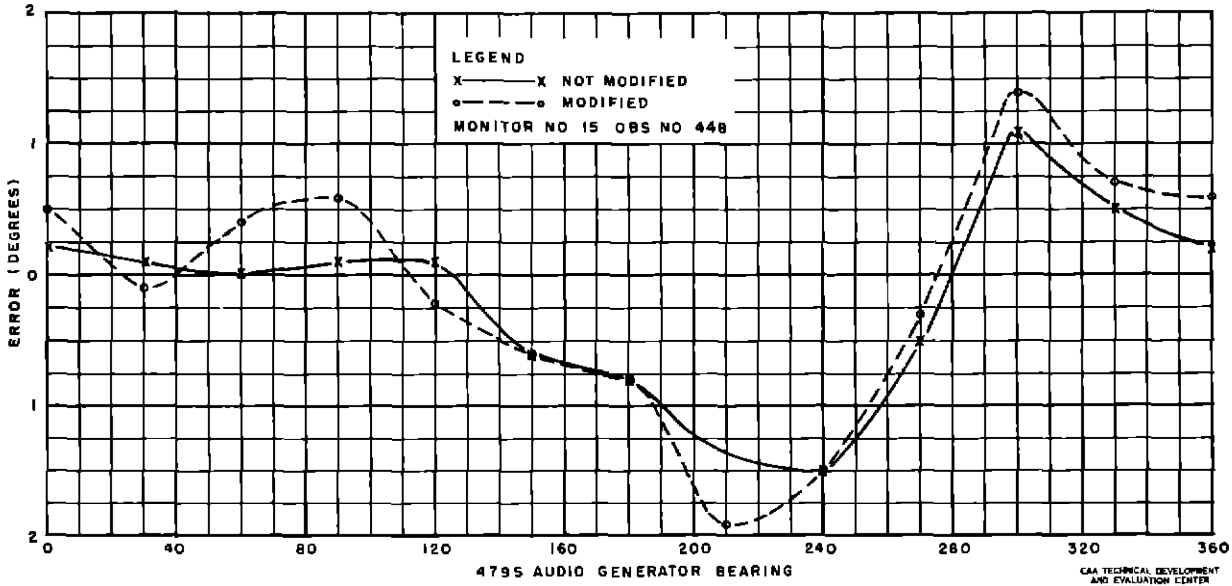
Monitor Serial No 15 was the only monitor available at the Center that had not been modified for the reduction of a-c hum Prior to modifying the equipment, it was decided to obtain a calibration-error curve so that a comparison could be made of the over-all effect of the modification Figure 3 indicates the change of the calibration-error curve due to the hum modification Prior to the modification, the maximum error spread was 2 6°, and, after the modification, it was 3 3° No measurements were made of the actual hum levels before or after the modification

Change in Calibration With a Change of Tube V19

The filament voltage was set at 6 3 volts, and the high voltage was 250 volts d-c from the external power supply Tests were conducted using a high-Gm tube and a low-Gm tube in the standard and modified OBS circuits The 30-cps filters were not used during this test

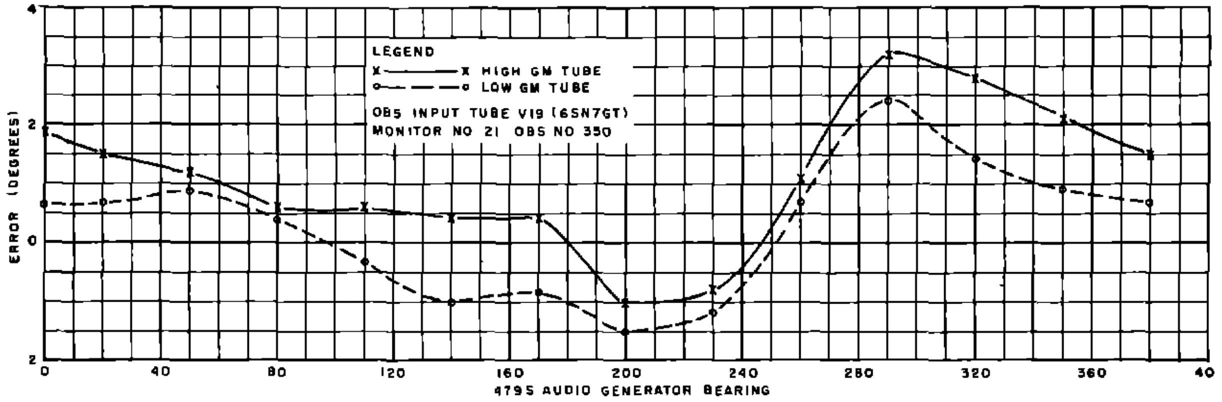
Upon reference to Fig 4a, it will be noted that in the standard OBS circuit the maximum spread between the two calibration-error curves is 1 40° and occurs at a dial setting of 320° In the modified OBS circuit, the maximum difference between the two curves is 0 3° and occurs at 290°, as shown in Fig 4b It is evident that there will be less change in the indicated bearing in the modified OBS circuit when the Gm of tube V19 varies between wide limits

Figure 5 indicates the results of the data taken to determine the value of the cathode resistor for use in series with the OBS rotor so that the phase shift between a high- and low-Gm

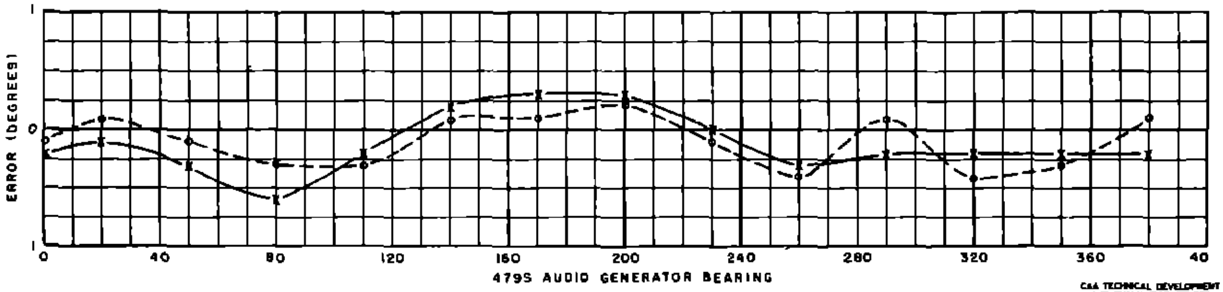


CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 3 Change of Calibration-Error Curve After Hum Modification and Prior to OBS Modification



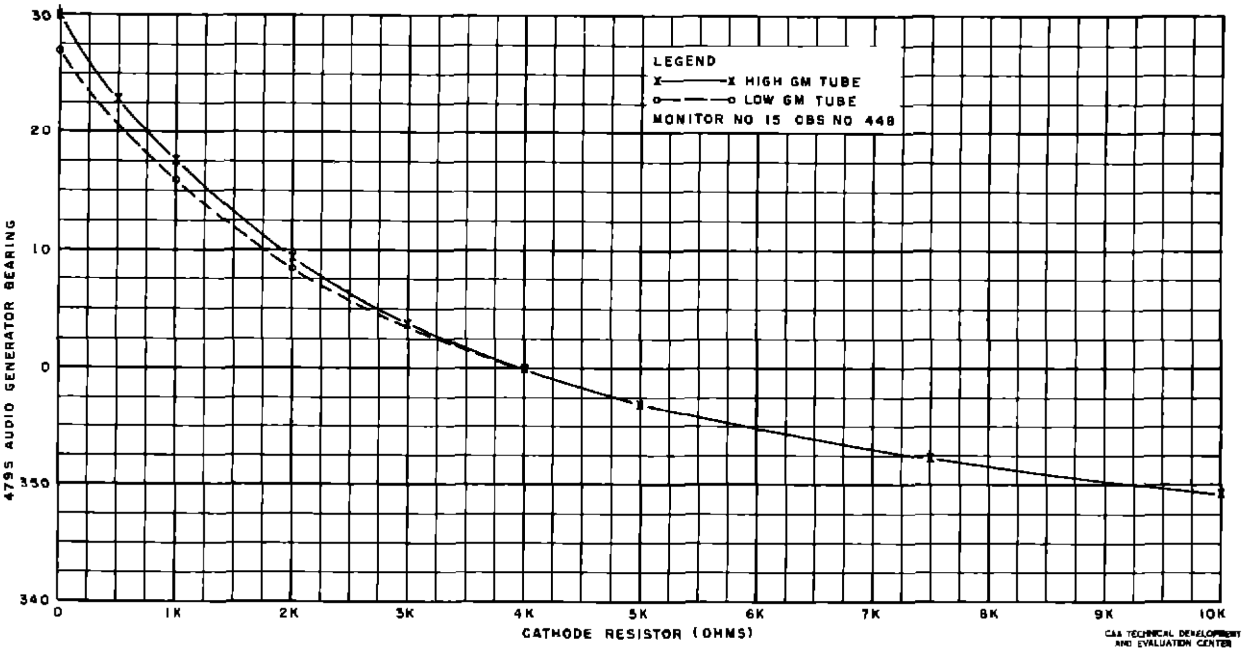
(A) STANDARD OBS CIRCUIT



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

(B) MODIFIED OBS CIRCUIT

Fig 4 Change in Calibration-Error Curve With Change of Tube



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 5 Change of Indicated Bearing With Change of Tube V19B Cathode Resistor for High- and Low-Gm Tubes

tube would be negligible The 4000-ohm value for the cathode resistor was selected to provide the maximum level of the 30-cps signal with no phase shift between high- and low-Gm tubes

Effects of Filament Voltage on Monitor Operation.

The filament voltage was recorded while the a-c line voltage was varied ±10 per cent When the line voltage was 110 volts, the filament voltage was 6.3 volts, at 121 volts, it was 7 0 volts, and at 95 volts, it was 5 5 volts The high-voltage d-c supply in the monitor remained constant because of the voltage regulators The cathode d-c bias voltage and the a-c OBS voltage from each triode section of tube V19 were measured at each filament-voltage setting The change of the transconductance of the tube with a change in the filament voltage was measured with a Hickok Model 533 tube checker.

TABLE I

EFFECT OF FILAMENT VOLTAGE ON THE D-C BIAS OF TUBE V19

	Low-Gm Tube Cathode d-c Bias			High-Gm Tube Cathode d-c Bias		
Filament (volts)	Triode A (volts)	Triode B (volts)	Difference (volts)	Triode A (volts)	Triode B (volts)	Difference (volts)
5 4	7 15	6 9	0 25	8 35	8 7	0 35
6.3 (ref)	8 3	8.6	0.3	8.5	8.9	0 4
7 0	8.6	9 0	0 4	8 65	9.0	0 35
Maximum Cathode-Bias Change	1 45	2 1		0 30	0 30	

TABLE II

EFFECT OF FILAMENT VOLTAGE ON A-C OUTPUT OF TUBE V19

	Low-Gm Tube a-c Output			High-Gm Tube a-c Output		
Filament (volts)	No. 1 Stator (volts)	No. 2 Stator (volts)	Rotor (volts)	No. 1 Stator (volts)	No. 2 Stator (volts)	Rotor (volts)
5.4	1.0	0.9	1.3	1.2	1.19	1.5
6.3 (ref)	1.2	1.2	1.5	1.2	1.2	1.5
7.0	1.2	1.2	1.5	1.2	1.2	1.52
Maximum a-c Output Change	0.2	0.3	0.2	0	0.01	0.02

TABLE III

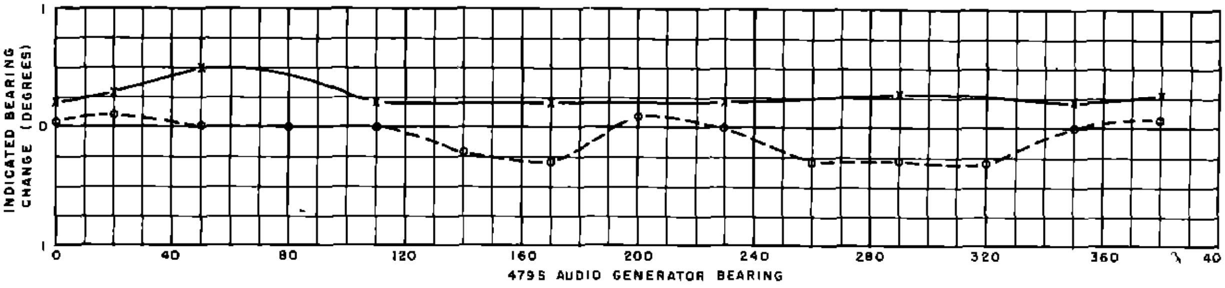
EFFECT OF FILAMENT VOLTAGE ON THE GM OF TUBE V19

	Low-Gm Tube Gm			High-Gm Tube Gm		
Filament (volts)	Triode A (μ mhos)	Triode B (μ mhos)	Difference (μ mhos)	Triode A (μ mhos)	Triode B (μ mhos)	Difference (μ mhos)
5.4	1000	950	50	2200	2400	200
6.3 (ref)	1550	1600	50	2250	2500	250
7.0	2250	2300	50	2350	2550	200
Maximum Gm Change	1250	1350		150	150	

An examination of Tables I, II, and III shows that the cathode d-c bias voltage, the a-c cathode output voltage, and the tube Gm vary between the two triode sections with a change in filament voltage. It is noted that the Gm, the a-c output, and the tube impedance of the low-Gm tube all vary more than those of the high-Gm tube for the same change in filament voltage.

In the original monitor circuit, Fig. 1a, the impedance of each triode section was in series with one of the OBS stators. Any change of impedance in either of the cathode circuits would cause a phase shift in the OBS circuitry and a resultant shift in the indicated bearing. A close correlation of the data contained in Tables I, II, and III is indicated in Figs. 6a and 6b, which show the resultant phase shift with change in tube impedance. Figure 6a (high-Gm tube) indicates the change in bearing when the filament voltage is changed from 6.3 to 5.4 and to 7.0 volts. These new bearings are referenced to the bearing obtained with a filament voltage of 6.3 volts. Figure 6b shows the same data except that the low-Gm tube was used. The maximum change in the indicated bearing was 0.5° for the high-Gm tube and 5.0° for the low-Gm tube.

Data for Figs. 7a and 7b were obtained after the OBS circuit had been modified. These curves indicate the change of bearing, referenced to the bearing obtained with a filament voltage of 6.3°, when the filament voltage was changed to 5.4 and to 7.0 volts. The maximum change in the indicated bearing was 0.4° for the low-Gm tube and 0.2° for the high-Gm tube.



(A) HIGH GM TUBE

CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

(B) LOW GM TUBE

Fig 6 Change of Indicated Bearing With Change of Filament Voltage Using Standard OBS Circuit

Effect of Resistance in the Stator Output Circuit

It will be noted in Fig. 1b that the value of a resistor in the stator output circuit is selected to reduce the quadrantal error This is necessary because of tolerances of the OBS unit and the resistance and the capacitance of the stator circuitry. Figures 8a, 8b, and 8c graphically show the effects of this resistor when used with different OBS units Figure 8a shows that a maximum calibration error of 2 0° obtained with an 8500-ohm resistor may be reduced to a maximum error of 0 4° by replacing that resistor with a 4500-ohm resistor Figures 8b and 8c indicate the errors obtained when other OBS units were used in the same monitor before and after selecting the correct resistance for the particular OBS

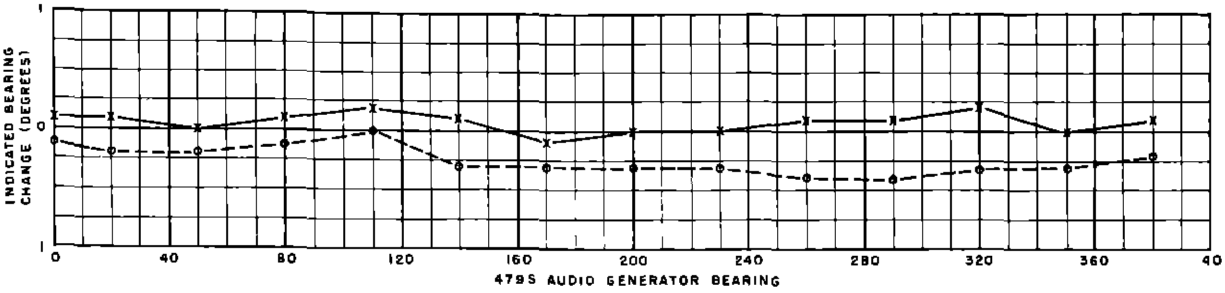
Hum Levels in the Modified Monitor.

Hum measurements using the monitor power supply were taken after all modifications were completed, and the results are indicated in Table IV.

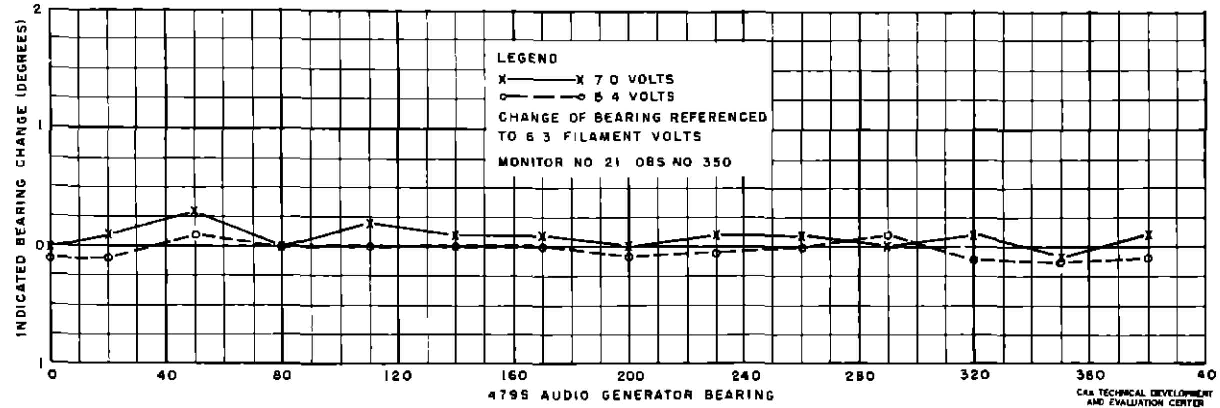
The hum level measured at tube V12-2 in the variable channel was 33 0 volts without the filter unit connected and 7 0 volts with the filter connected

Effect of Filters on a 60-cps Interfering-Signal Level.

These tests were made using the monitor power supply In the reference channel, the normal 30-cps signal was measured at the grid of tube V8B The 30-cps signal was then removed, and an interfering signal of 60-cps was injected at R112 through a one-megohm resistor. The amplitude of the interfering signal was adjusted to a level of 10 per cent of the 30-cps level measured at the grid of tube V8B.



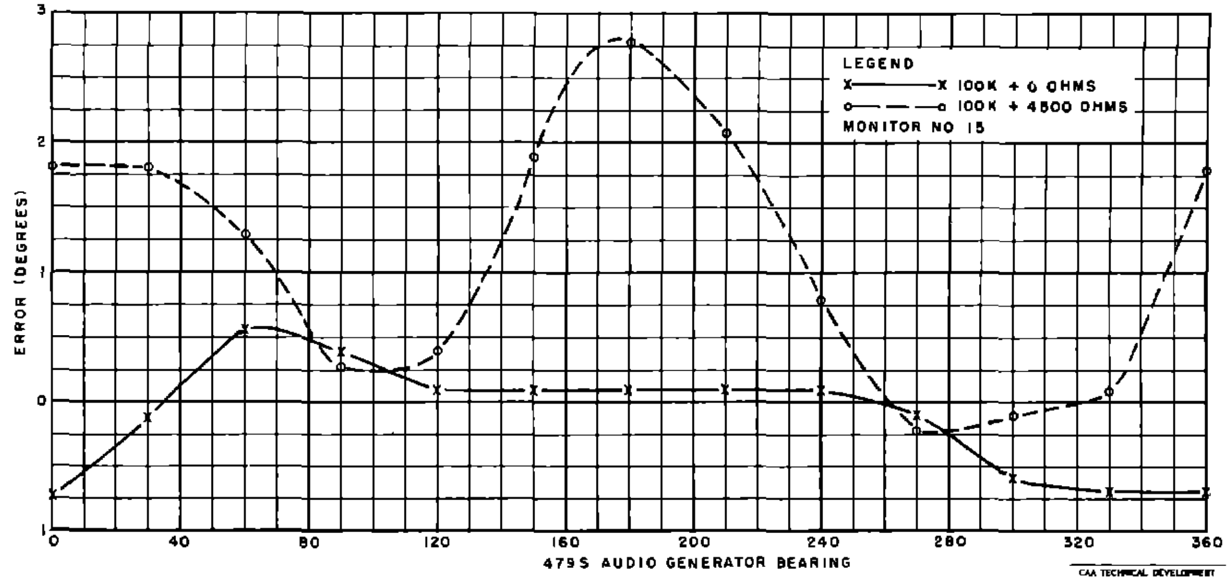
(A) LOW GM TUBE



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

(B) HIGH GM TUBE

Fig. 7 Change of Indicated Bearing With Change of Filament Voltage Using Modified OBS Circuit



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

(C) OBS SERIAL NO 305

Fig. 8 Change of Calibration-Error Curve With Change of Resistance in Stator Output Circuit

TABLE IV

HUM LEVELS IN THE REFERENCE CHANNEL

Tube	Azimuth Selector (degrees)	Hum Level Filter Out (volts)	Hum Level Filter In (volts)
V12-5	10	30.0	4.8
V12-5	90	49.0	5.3
V12-5	180	34.0	4.5
V12-5	270	45.0	6.6
V12-5	340	20.0	4.8

TABLE V

INTERFERING-SIGNAL LEVEL AT GRID OF TUBE V8B

Azimuth Selector (degrees)	30-cps Level (volts)	Interfering 60-cps Signal Level Filter Out (volts)	Interfering 60-cps Signal Level Filter In (volts)
240	1.4	0.18	
240	1.1		0.005
280	1.4	0.14	
280	1.1		0.0035
340	1.4	0.1	
340	1.1		0.003

During the variable-channel test, the normal 30-cps signal was measured at the grid of tube V21B. The 30-cps signal was then removed and the 60-cps interfering signal was connected to the junction of R50 and C31 through a one-megohm resistor. The amplitude of the interfering signal was adjusted to a level of 10 per cent of the 30-cps level measured at the grid of tube V21B. When the 30-cps level was 1.2 volts, the interfering-signal level was 0.12 volt with the filters not connected. With the filters in the circuit, the 30-cps level was 1.1 volts and the interfering-signal level was 0.0035 volt.

Errors Caused by 60-cps Hum in a Standard Monitor

A standard dehummed monitor with its internal power supply was used for these tests. The 60-cps interfering signal was fed through a one-megohm resistor to the junction of R25 and C20 in the reference channel, and the level was measured at the cathode of tube V14B. The amplitude of the 60-cps interfering signal was adjusted to produce 5 per cent of the level of the 30-cps signal at tube V14B. It will be noted in Fig. 9 that the monitor had a maximum error spread of 3.3° when operated under normal conditions. When an interfering signal having an amplitude of only 5 per cent of the 30-cps level was introduced in the reference channel, the maximum calibration-error spread changed from 3.3° to 10.7°.

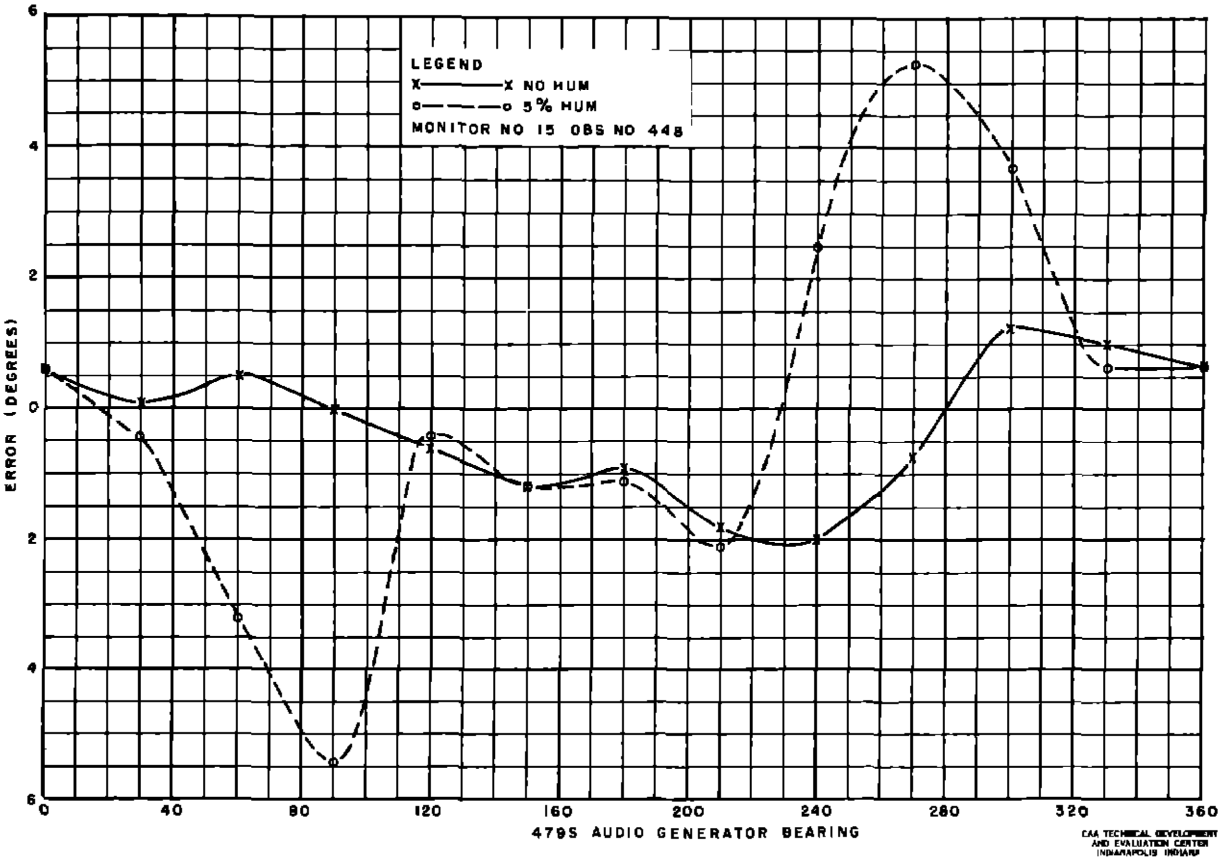


Fig 9 Change in Calibration-Error Curve of a Standard Dehummed Monitor Caused by 5 Per Cent of Interfering 60-cps Signal

Errors Caused by 60-, 90-, and 120-cps Signals in the Modified OBS Circuit

During these tests, the monitor was operated from a hum-free external power supply. Signals of 60, 90, and 120 cps were used; and the amplitude of each signal was adjusted to produce 5 per cent of the level of the reference and variable 30-cps signals The signals were fed into the reference channel through a one-megohm resistor at the junction of C20 and R26, and the amplitude was measured at the cathode of tube V14B The signals for the variable channel were inserted at the junction of R50 and C31 (input to tube V1A) through a one-megohm resistor, and the amplitude was measured at the cathode of V3B The tests were first run without the filter units and then were repeated with the filter units inserted in their proper circuits Figures 10, 11, 12, and 13 indicate the change in error caused by the interfering signals. Figures 10 and 11 show the change of error when signals of 60 and 90 cps with an amplitude of 5 per cent of the reference-signal level are superimposed in the reference channel Figure 10 (no filters) shows a total change of error spread of 36.2° for the 60-cps signal and 18 0° for the 90-cps signal. Data for the 120-cps signal (not shown) indicated a change of error spread from +4 4° at 50° bearing to -5 3° at 230° bearing for a total spread of 9.7°.

Figure 11 shows the change of calibration error when the filter is used. A total change of error spread of 1 2° for the 60-cps signal and 3 0° for the 90-cps signal was shown Data for the 120-cps signal gave a changed error spread of +0 7° at 290° bearing to -1 0° at 110° bearing for a total spread of 1 7° Incorporation of the filter unit in the reference channel gave an improvement in the OBS error curve of 35 0° on the 60-cps signal, 16.0° on the 90-cps signal, and 8 0° for the 120-cps signal

Figure 12 shows the effect of 5 per cent of 60- or 90-cps signal in the variable channel when no filters are used. These data show a total change of error spread of 7.2° for the 60-cps

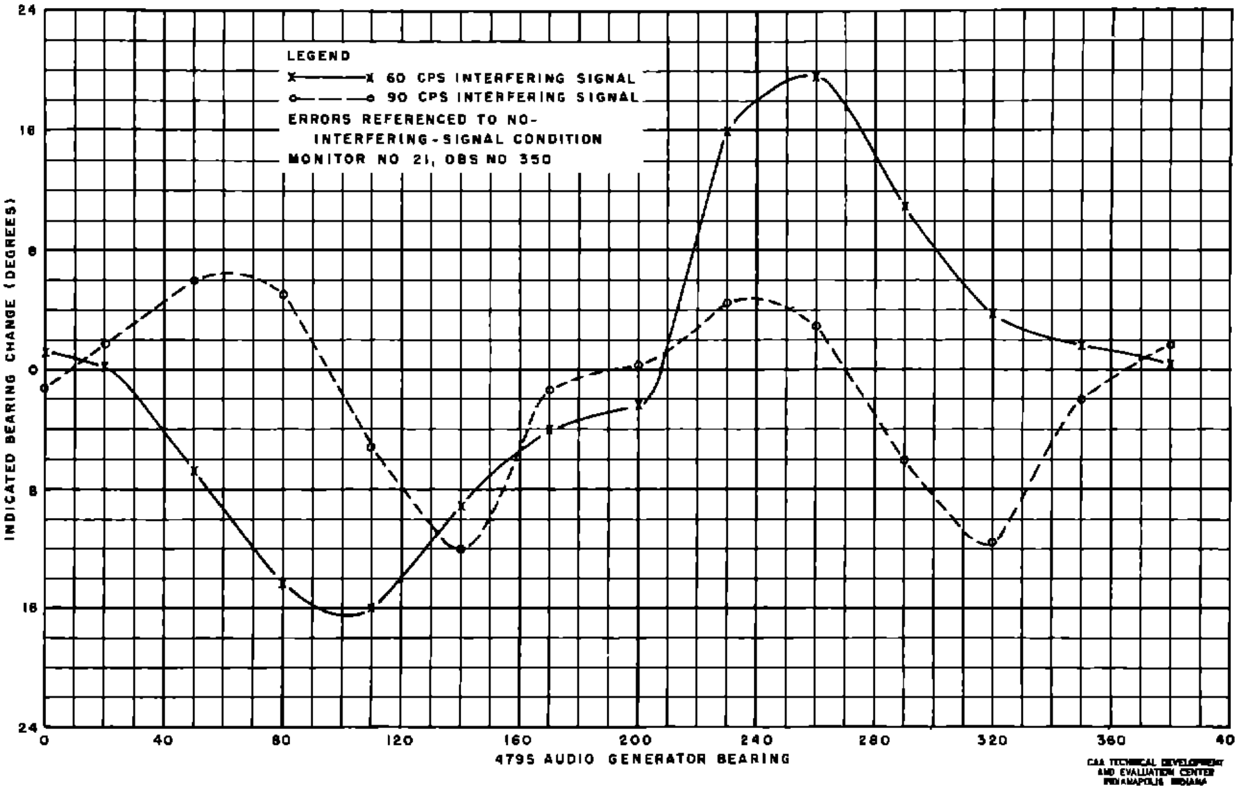


Fig 10 Change in Indicated Bearing Caused by 5 Per Cent Interfering Signal in Reference Channel Using Modified OBS Circuitry Without Filters

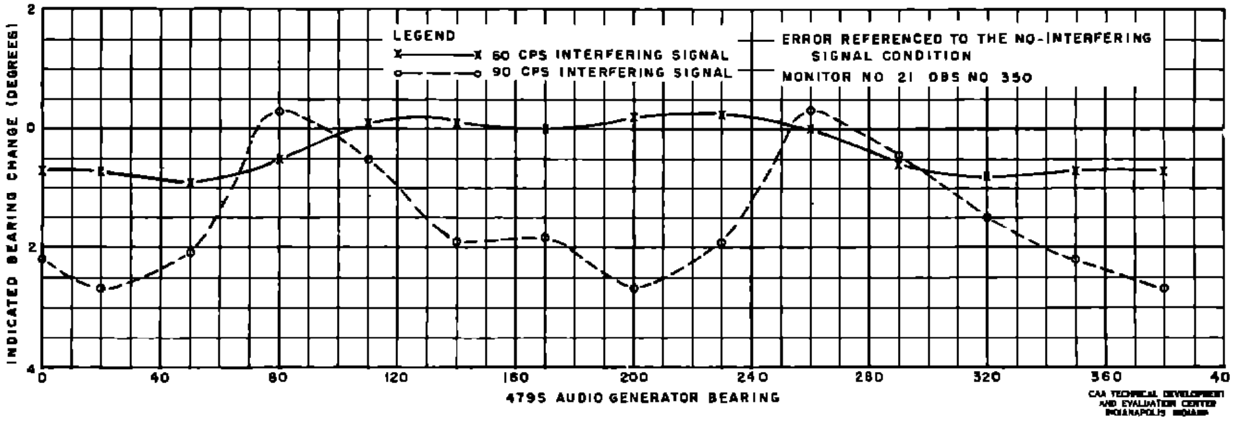


Fig 11 Change in Indicated Bearing Caused by 5 Per Cent Interfering Signal in Reference Channel Using Modified OBS Circuitry With Filters

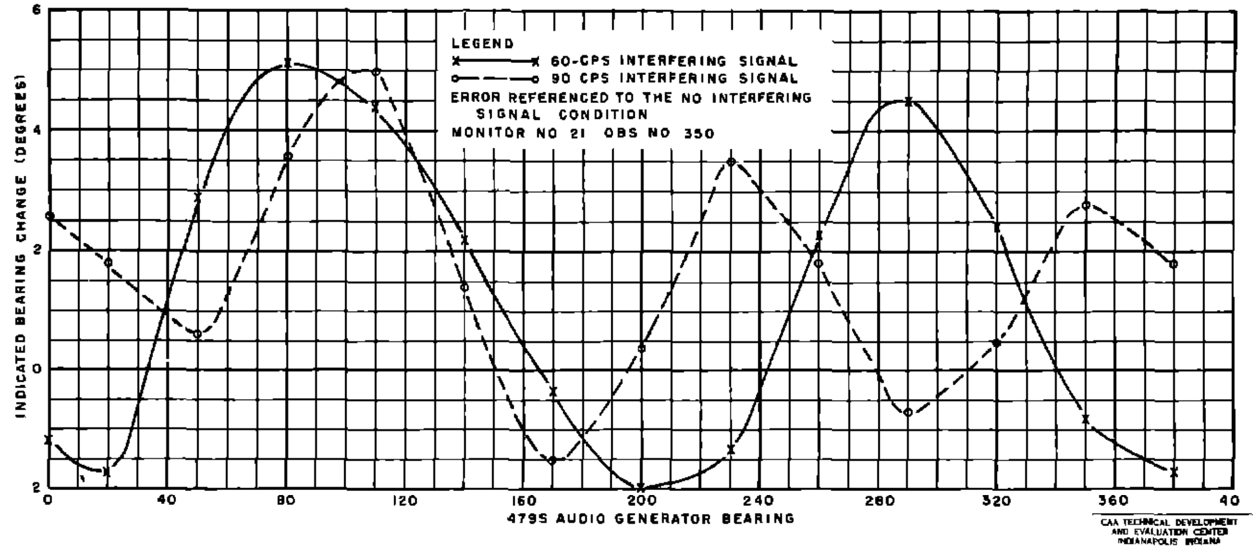


Fig. 12 Change in Indicated Bearing Caused by 5 Per Cent Interfering Signal in the Variable Channel Using Modified OBS Circuitry Without Filters

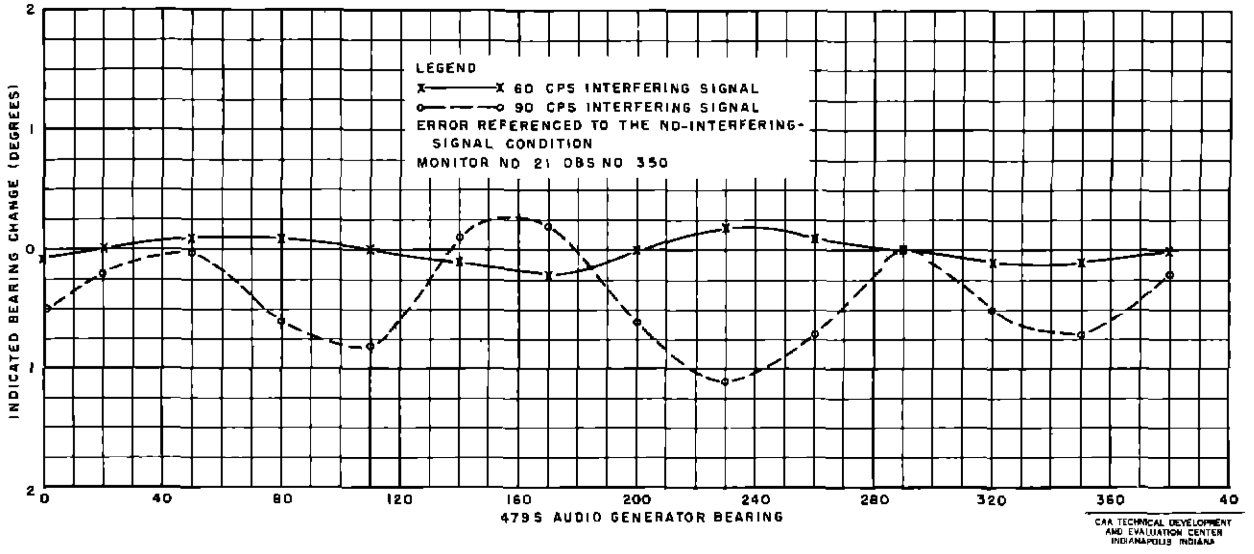
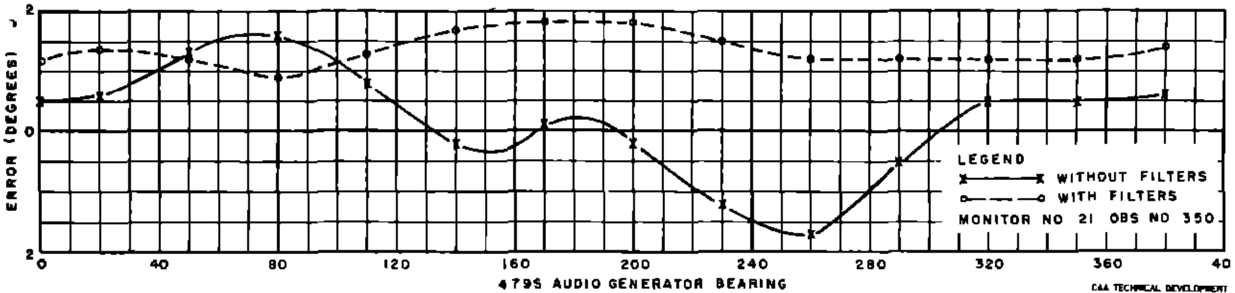
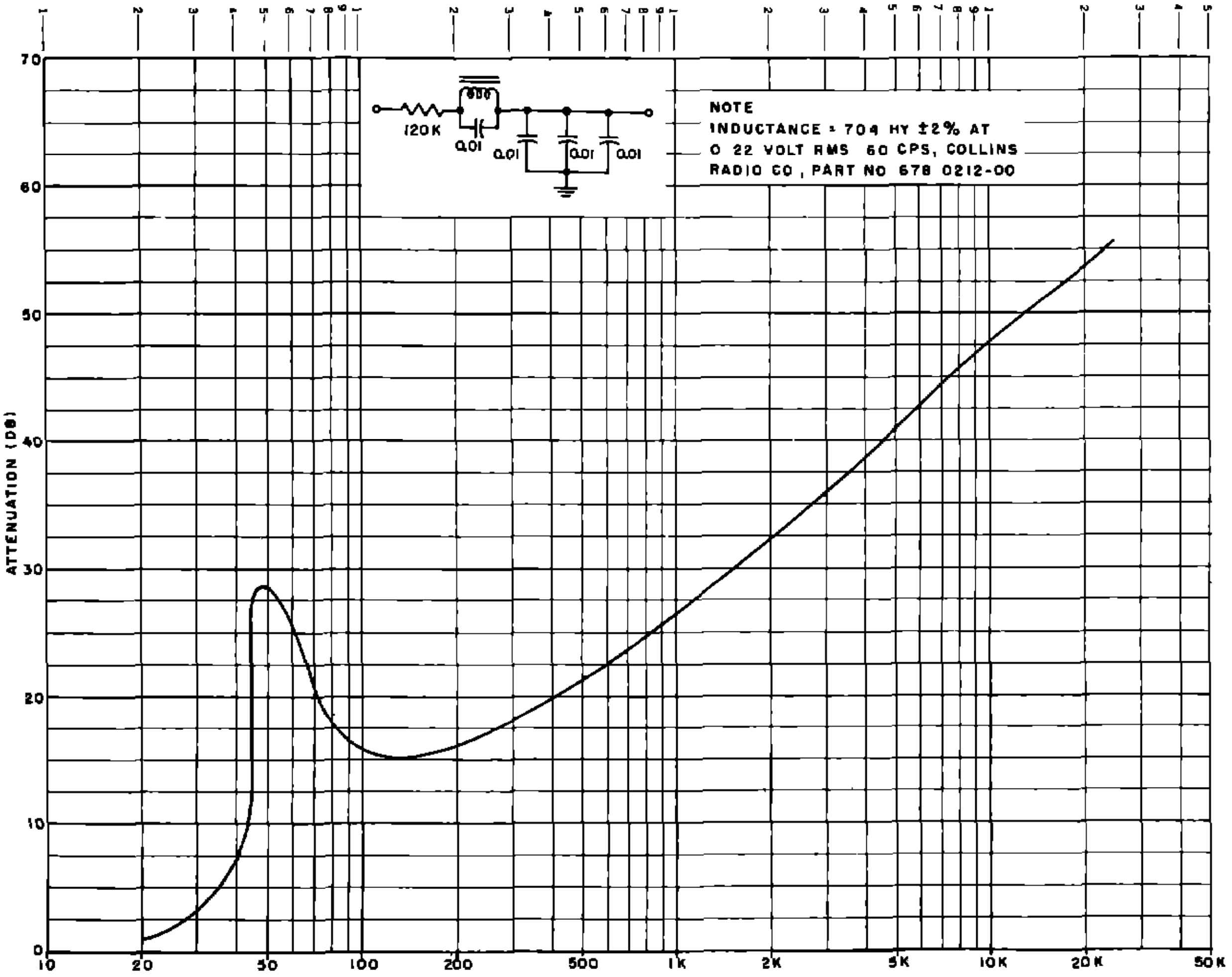


Fig 13 Change in Indicated Bearing Caused by 5 Per Cent Interfering Signal in the Variable Channel Using Modified OBS Circuitry With Filters



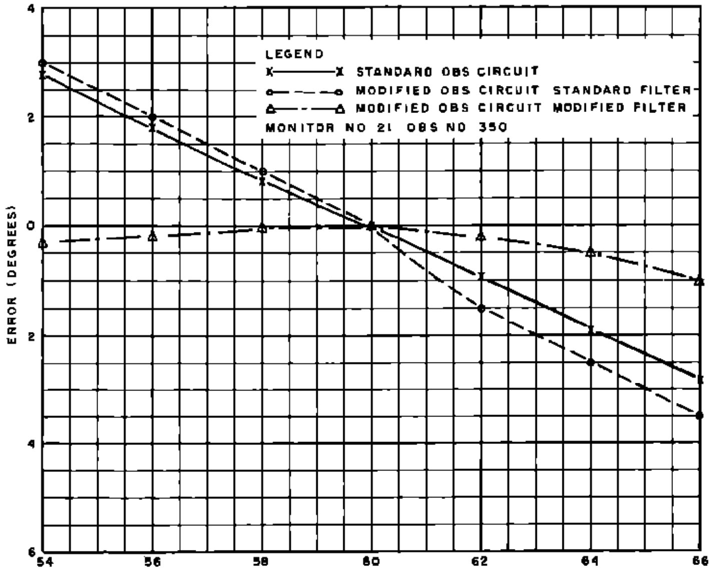
CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 14 Calibration-Error Curve of Modified OBS Circuit With and Without Filter Units



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig. 15 Frequency Response of 30-cps Filter Unit



CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 16 Errors Caused by Change in Power-Line Frequency

signal and 6.5° for the 90-cps signal Data on the 120-cps signal (not shown) showed a changed error spread of +1 4° at 320° bearing to -3 8° at 110° bearing for a total spread of 5 2°.

Figure 13 contains data compiled under the same conditions as for Fig. 12, with the exception that filters were incorporated in the variable channel A total change of error spread of 0 3° for the 60-cps signal and 1 3° for the 90-cps signal is shown The 120-cps signal data showed a spread of +0 1° at 260° bearing to -0 9° at 50° bearing for a total spread of 1 0°. Incorporation of the filter unit in the variable channel gave an improvement of the calibration-error curve of 6 9° for the 60-cps signal, 5.2° for the 90-cps signal, and 4 2° for the 120-cps signal.

OBS Calibration Error With and Without Filters

The modified OBS circuitry and the internal power supply were used during this test The 30-cps filter for the variable channel was inserted between the cathode of V19B and R69 at the input to tube V21B The filter for the reference channel was connected between C24 and the input to tube V8B The tests were first run without the filter units and were then repeated with the filters inserted Figure 14 shows the improvement that may be obtained by using 30-cps filters in both the reference and variable channels The over-all error spread is 3 3° when no filters are used and 0 9° when filters are used in both channels. The frequency response and the schematic diagram of the 30-cps filter units are shown in Fig 15.

Error Caused by Variation in Power-Line Frequency

The power-line-frequency variation was simulated by introducing a variable-frequency signal from an audio-signal generator to the DET 1 input for the variable channel and to the junction of R26 and C23 for the reference channel The variable-frequency signal was fed simultaneously to both channels and was varied in 1-cps steps from 27 to 33 cps This was equivalent to varying the power-line frequency from 54 to 66 cps A 2-megohm resistor was connected in parallel with the 120,000-ohm resistor of the filter which was used in the variable channel to improve the frequency characteristics

Figure 16 indicates the error that would result with power-line-frequency variation The errors resulting from a power-line-frequency variation of ±1 0 per cent (±0 6 cps) would be approximately ±0 3° for present monitors, ±0 4° for the modified monitor with unmodified Collins filters in both channels, and ±0 05° for the modified monitor using the modified Collins filter in the variable channel and the unmodified Collins filter in the reference channel

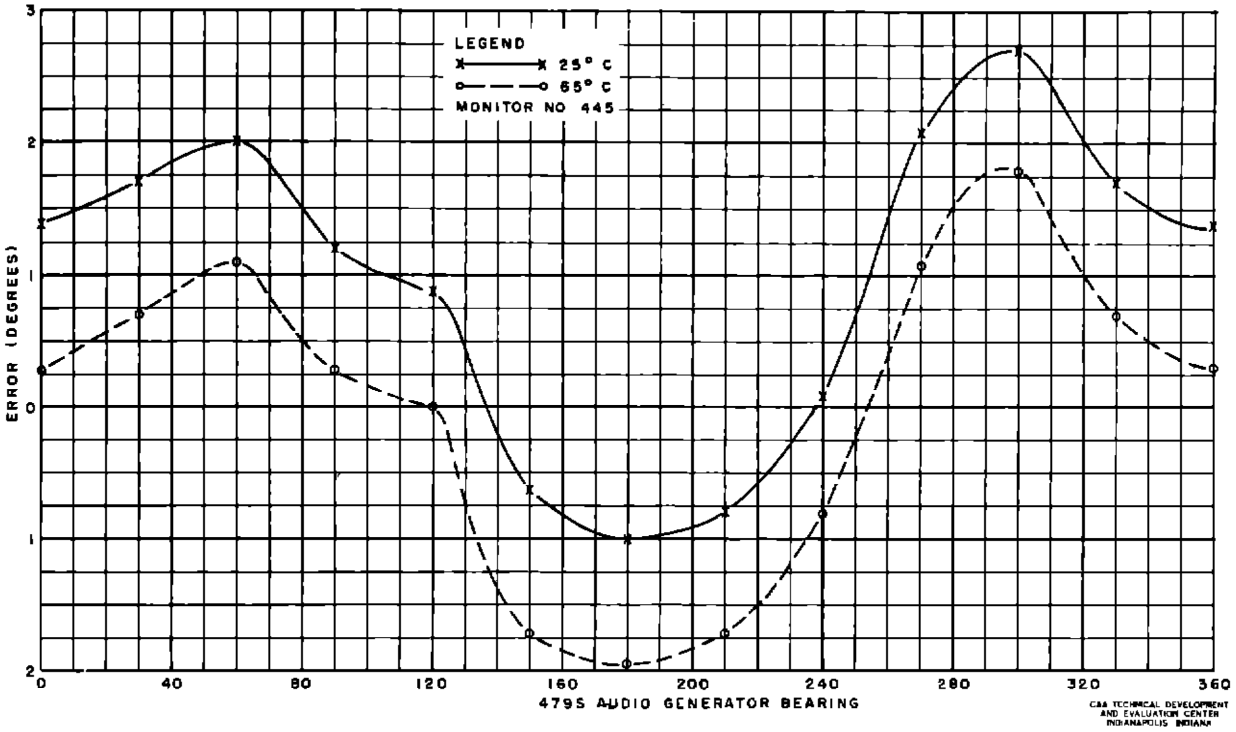


Fig. 17 Change in Calibration-Error Curve of a Standard Dehummed Monitor Caused by Change of Ambient Temperature of OBS Unit

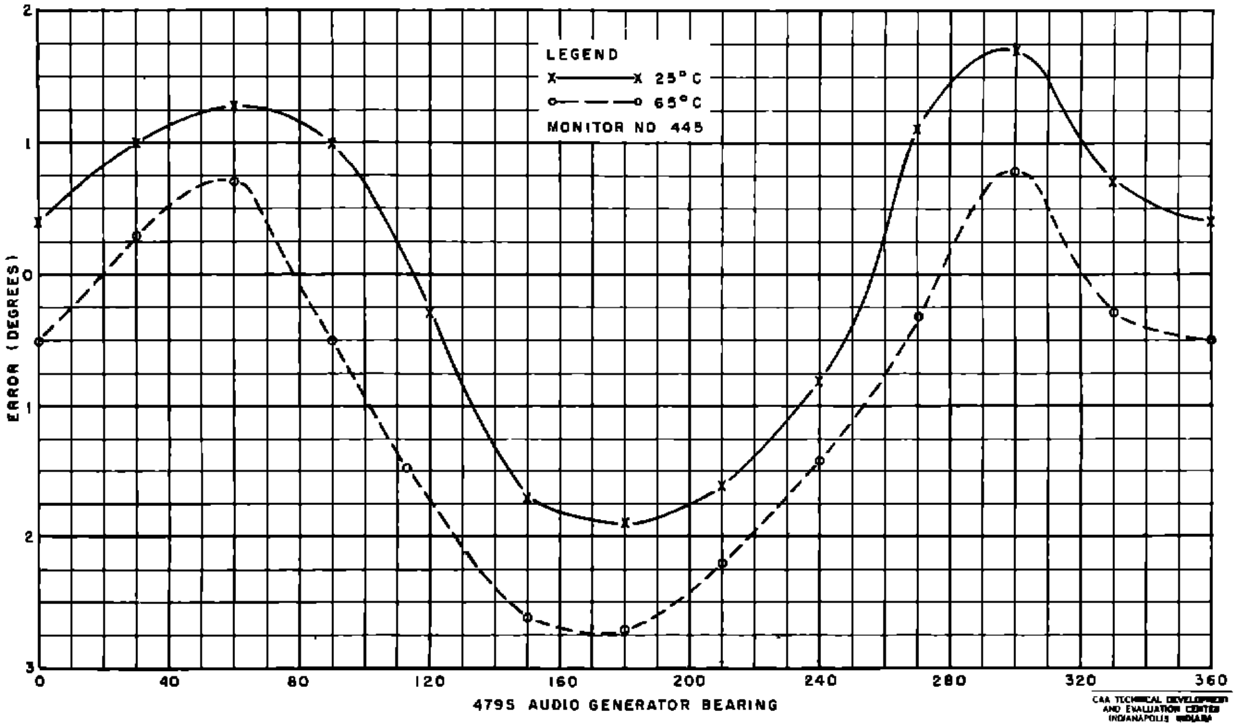


Fig 18 Change in Calibration-Error Curve of a Standard Dehummed Monitor Caused by Change of Ambient Temperature

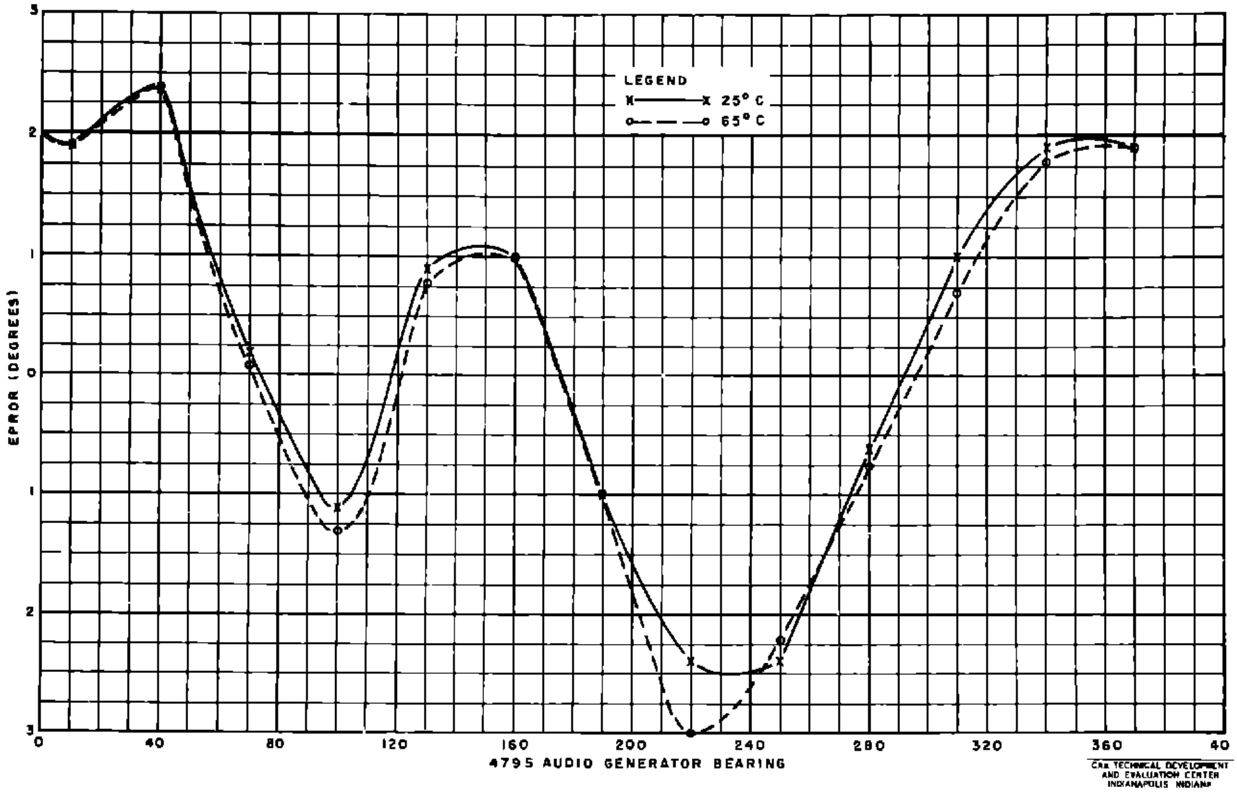


Fig 19 Change in Calibration-Error Curve of the Modified Monitor No. 15 (Without Filters) Caused by Change in Ambient Temperature

Change of Calibration Error of an OBS Unit With Change of Temperature

A standard dehummed monitor was used during this test A calibration curve was run on the monitor at a room ambient temperature of +25° C, after which the OBS was removed from the monitor and was reconnected with an extension test cable The OBS was then placed in a small heat chamber, and the temperature was raised to +65° C The monitor was operated at room ambient temperature Figure 17 indicates the change in bearing caused by the change of temperature of the OBS

Change of Calibration Error With Change of Temperature

This test was conducted on three different monitors, a standard dehummed monitor and two others that had been modified. During these tests, the complete monitors were placed in the heat chamber and a calibration error curve was run on each at room ambient temperature

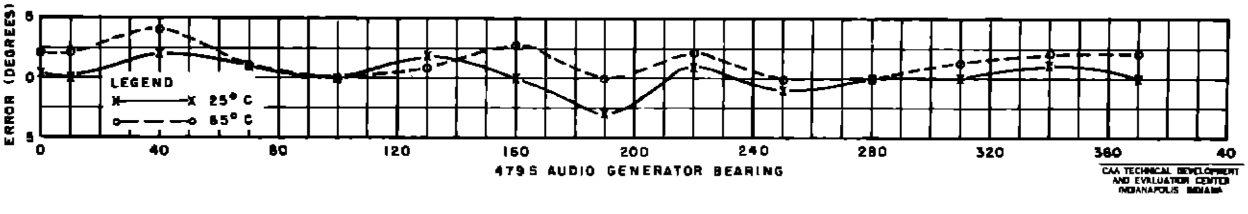


Fig 20 Change in Calibration-Error Curve of the Modified Monitor No 15 (With Filters) Caused by Change in Ambient Temperature

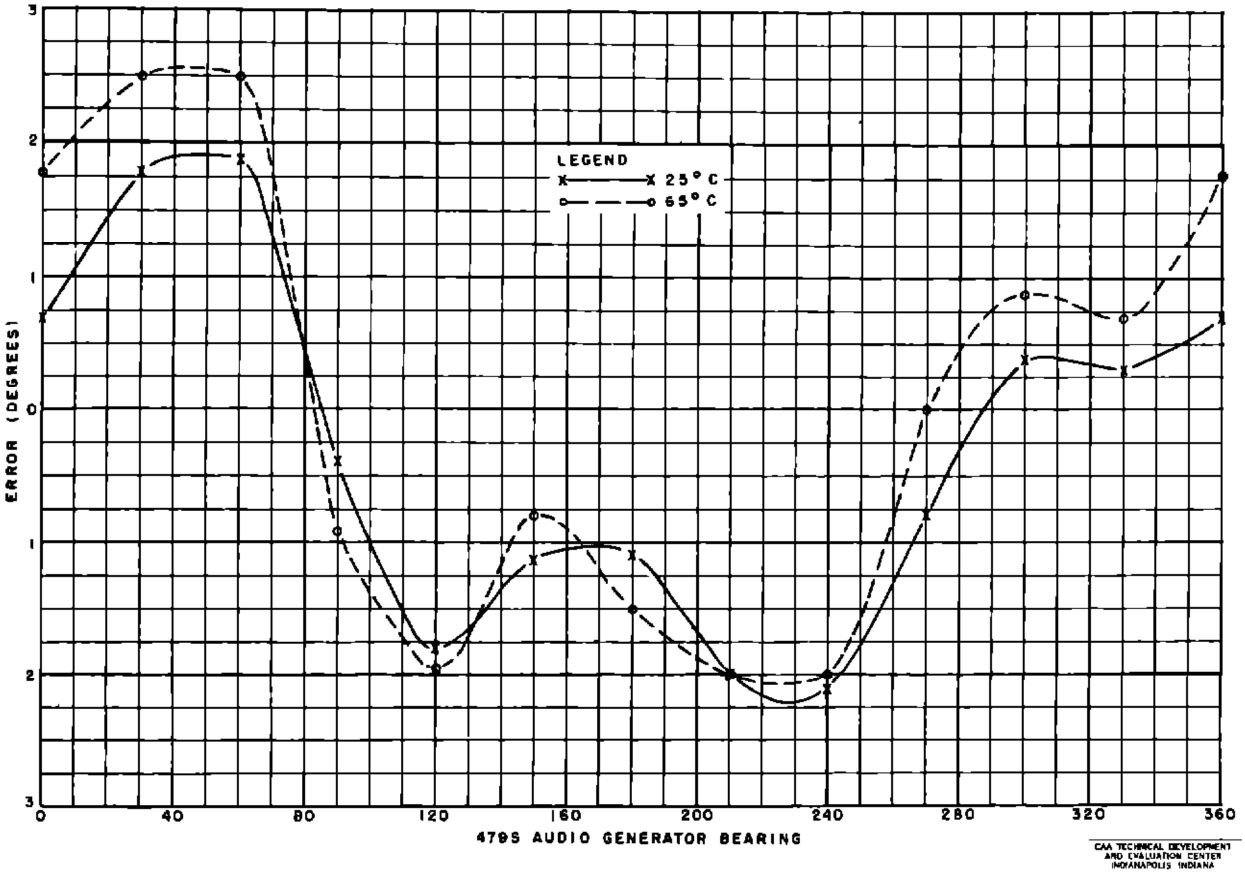


Fig. 21 Change in Calibration-Error Curve of the Modified Monitor No. 21 (Without Filters) Caused by Change in Ambient Temperature

After this run, the temperature was raised to +65° C and the equipment temperature stabilized for approximately 30 minutes before taking the calibration

Figure 18 shows the calibration-error curves, taken at +25° C and +65° C temperatures, of a standard dehummed monitor These data show that the indicated bearing of the monitor would drift approximately 1 2° with a 40° C change of temperature

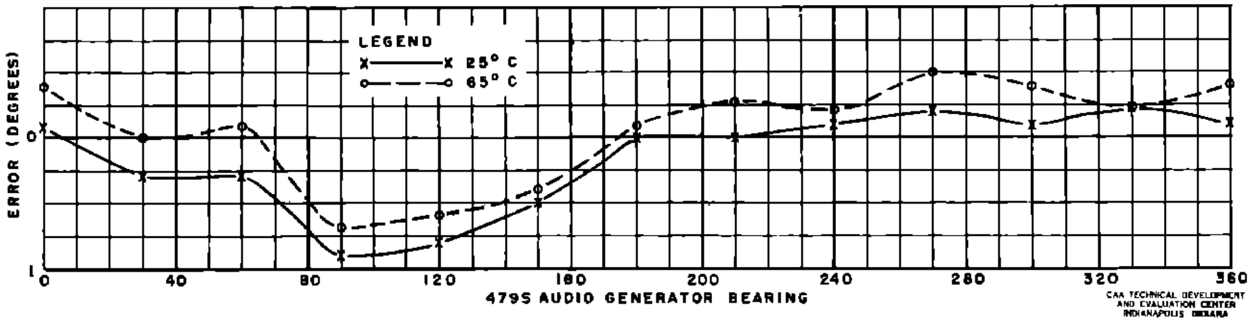


Fig 22 Change in Calibration-Error Curve of the Modified Monitor No 21 (With Filters) Caused by Change in Ambient Temperature

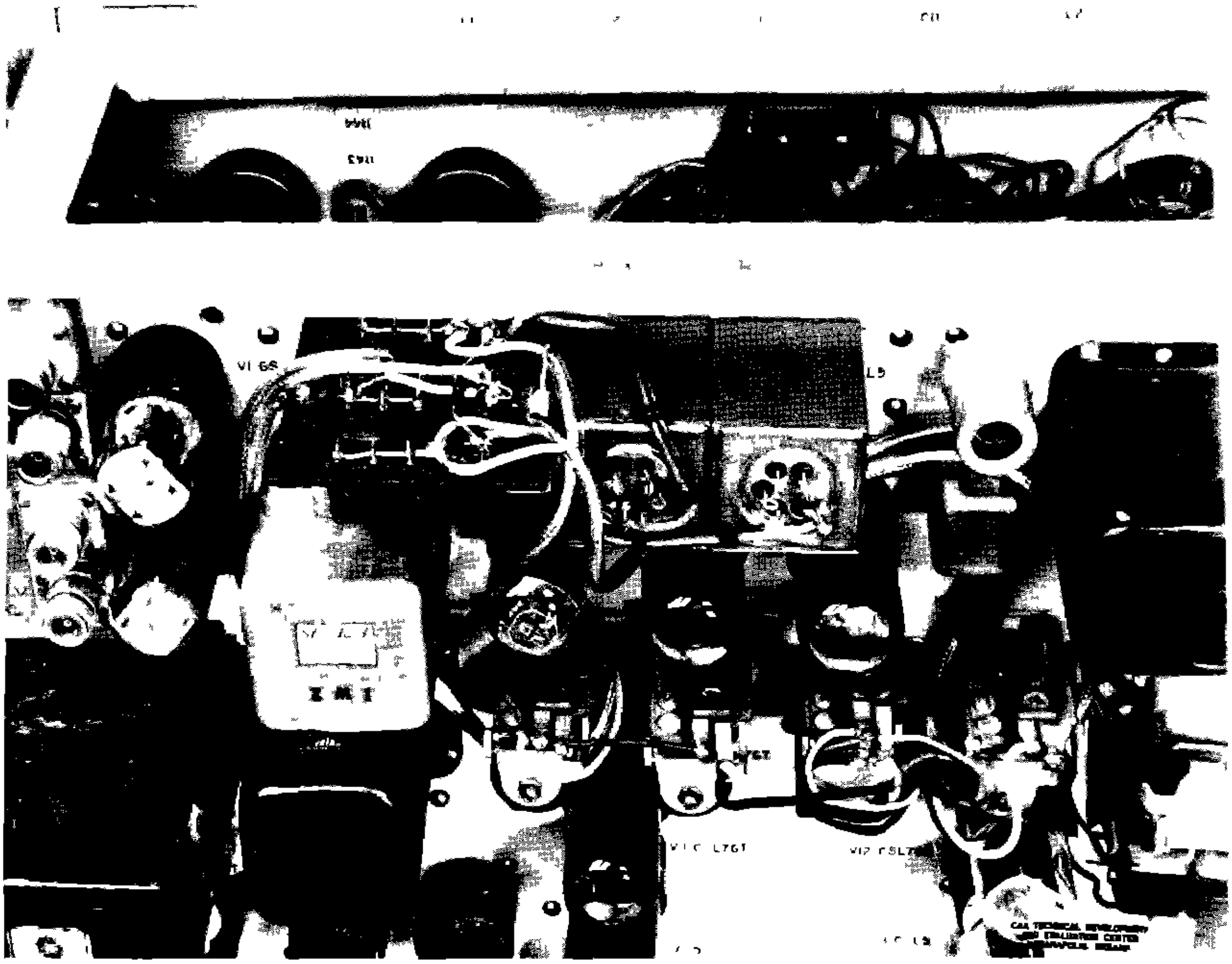


Fig 23 View of the Installation of the 30-cps Filters in Monitor Type CA-1277

Figure 19 shows the drift that occurred on a modified monitor without the filter units when the temperature was increased 40° C These data indicate that the drift would be reduced to approximately 0 2° over a 40° C temperature change.

Figure 20 illustrates the same condition as in Fig 19, except that the filters were connected in the circuits It should be noted that the incorporation of the filter units into the monitor circuits does not affect the temperature characteristics of the over-all monitor and that it does improve the calibration-error curve

Figures 21 and 22 are similar to Figs 19 and 20 except that these data were taken on another modified monitor and indicate approximately the same amount of drift with temperature change

Installation of Filter Units

Figure 23 shows the physical size of the two 30-cps filters used in the modification and also the mounting location on the monitor

CONCLUSIONS

1 The complete circuit modifications will almost eliminate the change in the OBS calibration-error curve caused by the aging or interchanging of the V19 tube in the OBS input circuit

2 The addition of 30-cps filters in the reference and variable channels greatly reduces the errors due to 60-, 90-, and 120-cps signals, improves the over-all OBS calibration-error curve, and almost eliminates errors caused by change in power-line voltage and power-line frequency

3 Incorporation of the complete modification in the Type CA-1277 monitor will reduce maintenance time and costs and will increase the monitor accuracy and reliability