BRISTOL AIRCRAFT (WESTERN) LIMITED

ENGINEERING REPORT NO. 2675

INVESTIGATION RADIO COMPASS INTERFERENCE - EXPEDITOR A/C

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CONTENTS

(List Photos) see next page.

LIST OF PHOTOS

1. PURPOSE

The purpose of this report is to record the Engineering investigation carried out on Expeditor aircraft to determine the cause and rectification of Radio Compass inverter interference. This investigation was carried out by authority of AMC letter 1038JU-8 (LC/RO4) 5 Dec. 57 and DDP letter B18-38-JU-5, 9 Dec. 57.

2. DESCRIPTION OF TESTS

2.1 Tests on HB-120

In order to properly identify the referenced noise problem listening tests were performed on Exp. HB-120 both on the ground and in the air. These listening tests were then followed by noise measurements tests using recording oscilloscope, vacuum tube voltmeter and Output Impedance matching unit. The test equipment was hooked up as shown in Fig. I Page 8 .

Then with all radio equipment turned ON and a 600 ohm terminating impedance across the pilot's phone jack the noise figure was recorded for the two systems which had the most inverter interference (interphone and VHF). The antenna was removed from the VHF in order to eliminate noise entering the equipment from local noise sources. The VHF volume control was turned all the way UP and the interphone press to talk button on the T-17 mic. was depressed during the noise tests.

2.1.1 The listening tests indicated that the unwanted signal from the inverter was also present on the ground and that it showed up to the greatest extent on INTERPHONE and VHF. It was then decided to design an audio filter to create a low impedance path to ground near the source of emination. The trial filter unit was designed to mount outboard of the existing MG-149 radio noise filter and incorporated a switch so that measurements could be carried out with the filter IN or OUT of circuit. The filter circuit is shown in Fig. II Page 9 . All tests were photographed with a recording Oscilloscope.

2.2 Tests on EXPEDITOR 1384

Due to necessity of returning HB-120 to service and also to the fact that the inverter interference was not critically affecting the telecommunications equipment, it was decided to continue the final testing on Expeditor 1384. This decision proved fortunate since 1384 was found to have a large amount

of inverter interference. The noise voltage in this aircraft was two times that in HB-120. The aircraft had a 778 Type inverter installed on arrival, and the hash created by this type of inverter was compared with that of the Eclipse Pioneer Type 2N and MG-149F. All results were recorded in Tables II, III, IV pages 3 & 4. . In these tests no filter was used but an attempt was made to examine the extent of noise induced into the audio lines by the emination of the noise field from the combination of input and output wiring to the inverter. At present the Inverter primary picks up 28 volts from the 35 amp Inverter circuit breaker in the main Radio Control panel and via cable R28-12 thru Connector No. 1 on the main panel. pin A to cable code. R522-12 or R53-12 runs parallel to and interspersed with audio wires thru the main radio cable bundle in the cabin to terminal #9 in #10 junction box thence by wire R467-12 to the inverter starting relay where the wire code is changed to R460-12 and runs directly to the positive input terminal of the inverter. Using a completely separate power source of 24 volts to power just the inverter alone several types of tests were made to evaluate the inductive effect of noise field because of the proximity of the inverter power and audio cables. The results of these tests are shown in table III and IV. Test were also conducted to examine the difference in noise radiation from various types of inverters viz Type 778, MG-149F and Eclipse Pioneer Type 2N or No. 12143-2-A.

3. RESULTS

3.1 TABLE I

NOISE MEASUREMENTS

EXP. HB-120

Equipment on Controls per Para 2.1	Background Noise Level Filter Out	Background Plus Inverter Filter Out	Background Plus Inverter Filter In
Interphone Only	11 Mv	135 Mv	25 Mv
V.H.F. Only	110 Mv	130 Mv	120 Mv

3.2 TABLE II
NOISE MEASUREMENTS EXP. 1384

Following Equipment on All Audio Off Inverter Off	778 Inverter & A/C Wiring	778 Inverter & Ext. Wiring	2N Inverter & Ext. Wiring	2N Inverter & A/C Wiring	MG-149 & External Wiring
Compass	4Mv	4 Mv	4 Mv	4 Mv	4 Mv
MHF	4 Mv	4.5 Mv	4.5 Mv	4.5 Mv	5 Mv
VHF	4 Mv	4 Mv	4 Mv	4 Mv	5 Mv
Marker	4 Mv	4 Mv	4 Mv	4 Mv	4 Mv
Interphone	4 Mv	4 Mv	4 Mv	4 Mv	4 Mv
I.L.S.	4 Mv	4 Mv	4 Mv	4 Mv	4 Mv
All ISO Selector Switches ON	5 Mv	5 Mv	4.5 Mv	5 Mv	

3.3 TABLE III
NOISE MEASUREMENTS EXP. 1384

Following Equipment on All Audio Off Inverter ON	778 Inverter & A/C Wiring	778 Inverter & External Wiring	2N Inverter & External Wiring	2N Inverter & A/C Wiring	MG-149 With External Wiring
Compass	6 Mv	4 Mv	4 Mv	4 Mv	4 Mv
MHF	20 Mv	5 Mv	5 Mv	20 Mv	4.5 Mv
VHF	11 Mv	4.5 Mv	4.5 Mv	5 Mv	4 Mv
Marker	4 Mv	4 Mv	4 Mv	4 Mv	4 Mv
Interphone	5 Mv	4 Mv	4 Mv	4 Mv	4 Mv
I.L.S.	5 Mv	4.5 Mv	4 Mv	4 Mv	4 Mv
All ISO Selector Switches ON	39 Mv	5 Mv	5 Mv	25 Mv	

3.4 TABLE IV
NOISE MEASUREMENTS EXP. 1384

VHF and Inter only on Controls per Para 2.1	778 Inverter & Internal Wiring	MG-149 Inverter & External Wiring	2N Inverter & Internal Wiring	778 Inverter & External Wiring
Inverter OFF	18 Mv	18 Mv	18 Mv	18 Mv
Inverter ON	210 Mv	77 Mv	50 Mv	22 Mv

4. DISCUSSION OF RESULTS

4.1 Results of Filter Unit

The tests conducted on HB-120 using two 2000 MFD. Condensers as hash filters and the existing MG-149 inverter indicated a very effective noise reduction could be obtained by this method. The listening tests also proved that the filter reduced the unwanted signal to below pre-ceptable level. The noise was identified as a 3000 cycle interference modulated by 400 cycle. of lower voltage. Both tones were annoying but the 3000 cycle was very disturbing while airborne.

4.2 Results of External Power Source for Inverter

The tests conducted on EXP 1384 using a variety of inverters and a special external test cable indicated that an effective noise reduction could be obtained by either changing inverter type or/and relocating the inverter power cables away from the existing main radio cable bundle. It may be seen from Table IV by comparing the last two columns that a greater noise reduction was effected by re-routing wiring than by changing inverters alone. Also that there is only a small advantage in using the Eclipse Pioneer Type 2N over the Holtzer-Cabot MG-149F.

4.3 Interpretation of Results

Tables I and IV have been prepared from tests on two different aircraft, but using the same settings for all switches and controls therefore the variation in results is the difference in noise value between the two aircraft i.e. with the Inverter ON 210 Mv/135Mv or approx. 2:1, twice the noise voltage. While voltage alone does not give a true expression of noise level, the power or volume may be calculated from:

$$W = \frac{E^2}{R}$$ where

R in this case was 600 ohms. approx.

Noise in HB-120 $= \frac{.135^2}{600} = \frac{30.5}{\text{Microwatts}}$

Noise in 1384 $= \frac{.210^2}{600} = \frac{73.3}{\text{Microwatts}}$

Tables II and III have been prepared from test on the same aircraft but different runs of inverter cables and different power sources.

Noise level induced into audio cables only with the 778 Inverter

Noise $\frac{E^2}{R} = \frac{.039^2}{600} =$ 2.6 Microwatts

From Eclipse Pioneer 2N inverter

$N = \frac{.025^2}{600} =$ 1.04 Microwatts

This noise power may appear very small but it has been established that the human ear can detect .0001 micromicrowatts, and experience extreme discomfort at 100 microwatts.

4.4 Cause of Noise

The cause of the inverter interference was established as a 3000 cycle signal modulated at 400 cycles eminating from the motor winding or input terminal of the radio compass inverter MG-149F; or a 6000 cycle modulated at 400 cycles as in the case of the 2N inverter. The difference in frequency is the result of inverter speed. The MG-149 rotates at 5700-6300 RPM while the 2N turns at 12,000 RPM. The back voltage generated in the motor section appears to be 1/2 the frequency of rotation.

4.5 Effectiveness of Filter

The Reactance of the bulked capacitance may be calculated from

$X_c \frac{1}{2\pi fc}$ where C is in FARADS

For 400 cycles & 4000 Mfd.

$$X_c = \frac{1}{6.28 \times 400 \times .004 \text{Fds.}}$$

X_c = .1 ohms at

For 3000 cycles & 4000 Mfd.

$$X_c = \frac{1}{6.28 \times 3000 \times .004 \text{ Fds.}}$$

X_c = .013 ohms.

For 6000 cycles & 4000 Mfd

$$X_c = \frac{1}{6.28 \times 6000 \times .004}$$

X_c = .0067 ohms

The total filter inpedance will be $Z = \sqrt{R^2 + X_c^2}$

but since R is constant $Z \propto X_c$ and is always larger than X_c when some resistance is present.

This indicates that the filter is more effective on the 2N Inverter than on the MG-149. It also proves that the filter provides a very short path to ground for the annoying 3000 cycle tone generated by the MG-149F.

5. RECOMMENDATIONS

5.1 It is recommended that all Expeditor aircraft have an inverter hash filter added as a part of the aircraft telecommunications system. This filter to consist of two 4000 MDF at 30 V.DC Electrolytic Capacitor Cornell Dubilier Part FB-3040. The filter unit should be enclosed in a dural box with a rubber grommet for the input lead and a 3/4" Breeze fitting for the

output lead. The filter unit should be located between Bulkheads #10 and #11 and mounted upside down below the bottom radio shelf to the rear of the inverter unit. All cables going to the inverter should pass through the filter box. The cable from the filter unit to the inverter should be enclosed in Breeze. With this filter installed any of the three types of inverters may be used viz Type 778, Type 2N or MG-149-F.

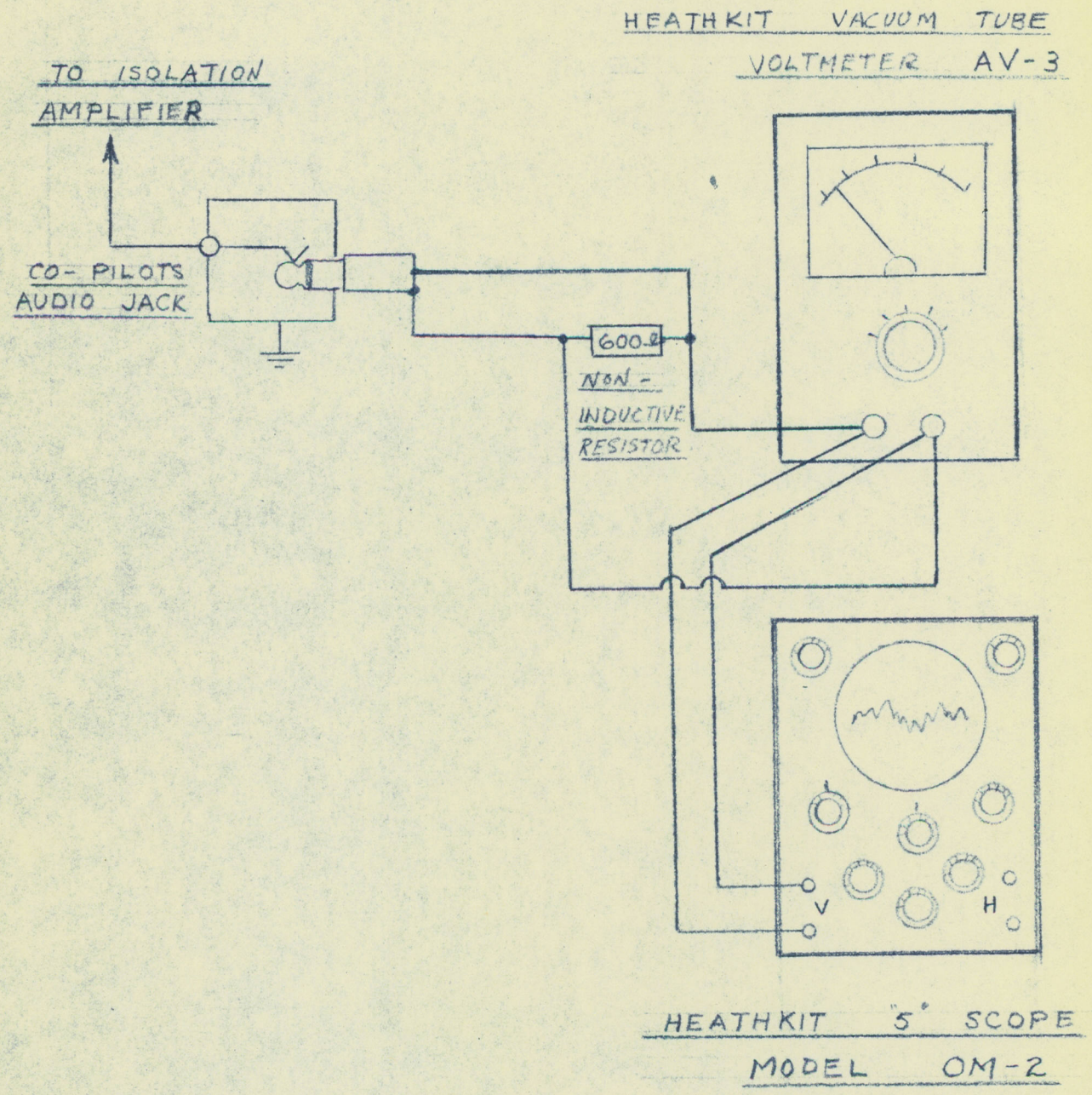

FIG I

INVERTER NOISE INVESTIGATION

TEST SET UP

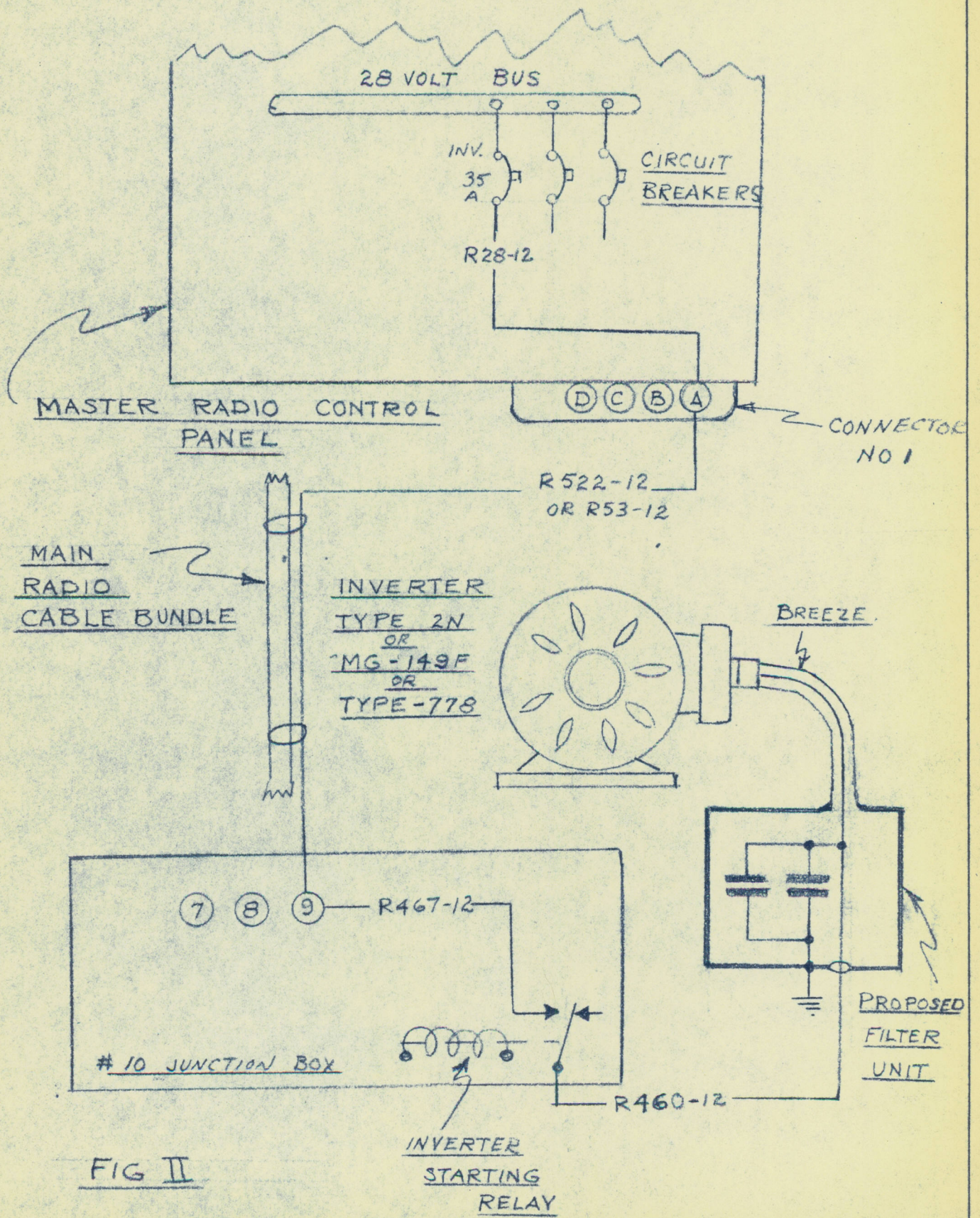

FIG II

INVERTER LOW VOLTAGE INPUT CIRCUIT