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Green Bank, West Virginia

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Active Surface Actuator RFI Problems

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Introduction

After selecting the motor we would use to drive the actuators, we had a quick look at the RFI generated by the motors. From what we saw, it looked like capacitors to ground and ferrite beads on each motor lead should suppress the RFI to an acceptable level. Unfortunately, after we received the actuators and checked them out in the field the RFI was at an unacceptable level. Figure 1 shows a baseline noise level and the noise level with 9 actuators running. We found that by grounding the shields in the actuator cable at the connector end the RFI could be reduced but not eliminated, see figure 2.

The test setup consisted of a log periodic antenna, 50 feet from the actuators, 50 feet of RG-214, an amplifier with 30 db gain and a spectrum analyzer.

RFI Filtering

Since we were still able to see the motors with the shields grounded it was necessary to investigate more filtering. The approach investigated, was to install an additional barrier inside the motor can, to shield the connector to the outside world from the RFI generated by the motor.

To be able to see the RFI generated by the motor, I used the setup as shown in figure 3. Using this setup I tried many different combinations of filters. After extensive testing, respectable results could be obtained with a simple feed-thru capacitor. It seemed that the addition of chokes or toroids to the filter didn't improve the filter enough to justify the cost.

By this time I had enough confidence in the filtering system as shown in figure 4 to do some tests in the field. For the following tests we had two actuators running and had the antenna 25 feet from the actuators. The first test was a repeat of the test described above. Figure 5 was with shields not grounded at the connector and figure 6 was with the shields grounded. As you can see the RFI is still evident with the shields grounded at the connector. The next set of tests was with the RFI filter as shown in figure 4 installed. We tried both cases, shields not grounded (figure 7) and shields grounded (figure 8) and in either case we weren't able to see the RFI.

The last step in the RFI problem was to find a way the filters could be installed easily. Using wire braid and filter plates worked but would be time consuming to implement on 2400 actuators. With the help of Dave Seaman another can was found that could be installed inside the outside can. This arrangement is shown in figure 9. While evaluating the can I also tried different methods of sealing the inside can to the outside can. I found that using a mesh gasket between the cans didn't offer any significant improvement. But, when we install the inner can it is important that the nut holding the can be as tight as possible. It probably would be good to use a large washer to distribute the pressure over a larger area on the inner can. Using the setup as shown in figure 3 we got some favorable results with the new filter system. Looking at figures 10 and 11 you can see the comparison between a filtered and unfiltered motor. To see a comparison between the background noise and the motor noise see figures 12 and 13. Although we can still see the motor in the lab setup (figure 3), I feel that with the present motor can this is the best we can do.

To do any better would require two stages of filtering.

Conclusions

With filtering and grounding the shields of the twisted pairs at the connectors we will reduce the RFI as much as is possible with our present arrangement of the actuators. The installation of the filters will take some time, rough guess of 15 to 20 minutes for each actuator. The best guess cost is listed below.

Inside can with punched holes (3) guess $3	7,275
Feed-thru capacitors, quote $0.65	3,250
Push on terminals, .39 & .36 each	1,875
Hookup wire	500
Hardware, 4-40 cap screw etc.	945
TOTAL	13,845

The only quote I had was the feed-thru capacitors all others are a good guess and we might be able to get better prices.

One other thought on the RFI problem is that maybe the retro-fitted motors (brush problem) won't be as bad as the ones we have been testing. But, relying on the motors RFI improving would be tempting fate.

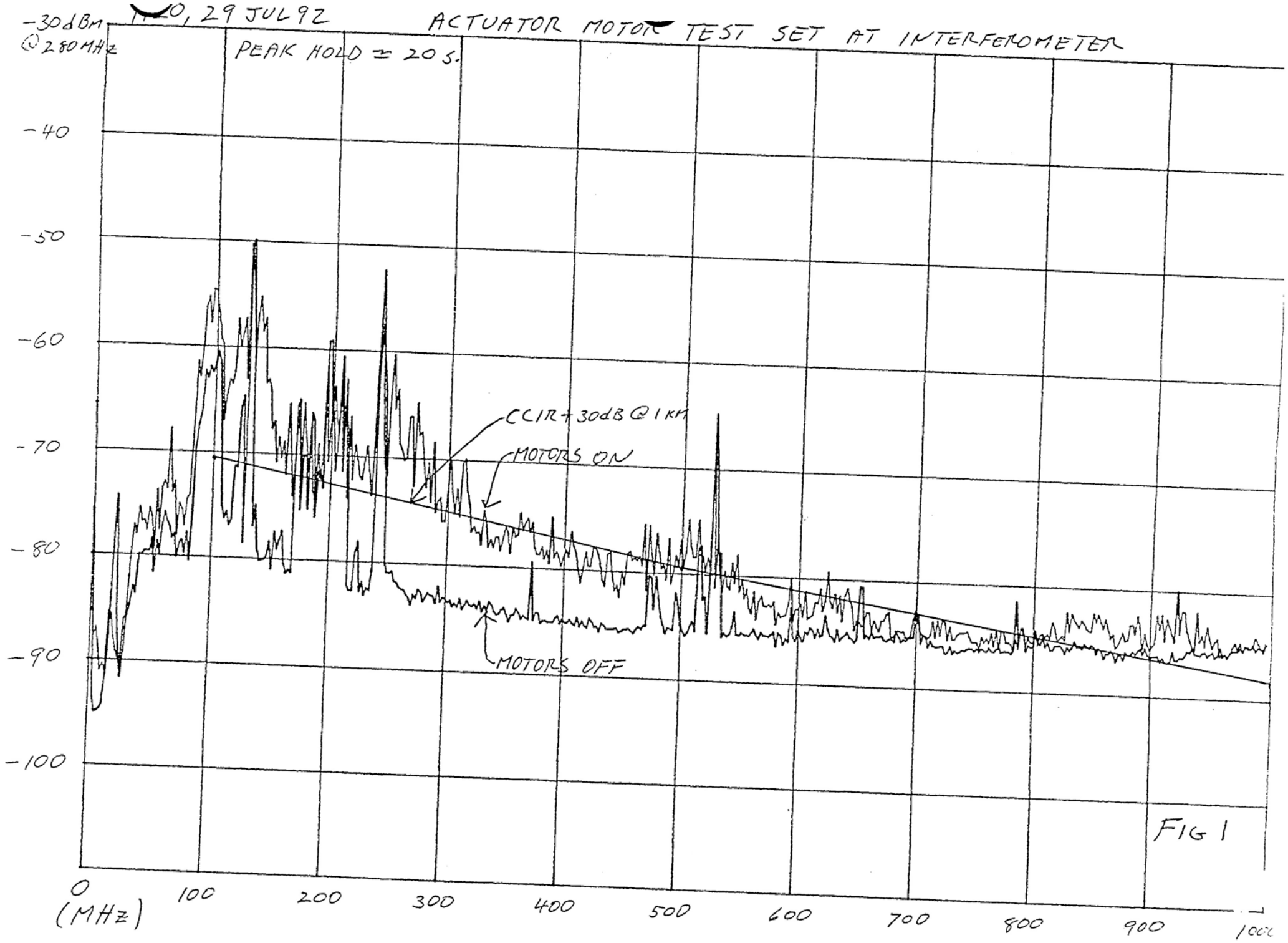

-30dBm @ 280MHz
10, 29 JUL 92
ACTUATOR MOTOR TEST SET AT INTERFEROMETER
PEAK HOLD = 20 s.
-40
-50
-60
-70
-80
-90
-100
CCIR + 30dB @ 1KM
MOTORS ON
MOTORS OFF
0
(MHz)
100
200
300
400
500
600
700
800
900
1000

FIG 1

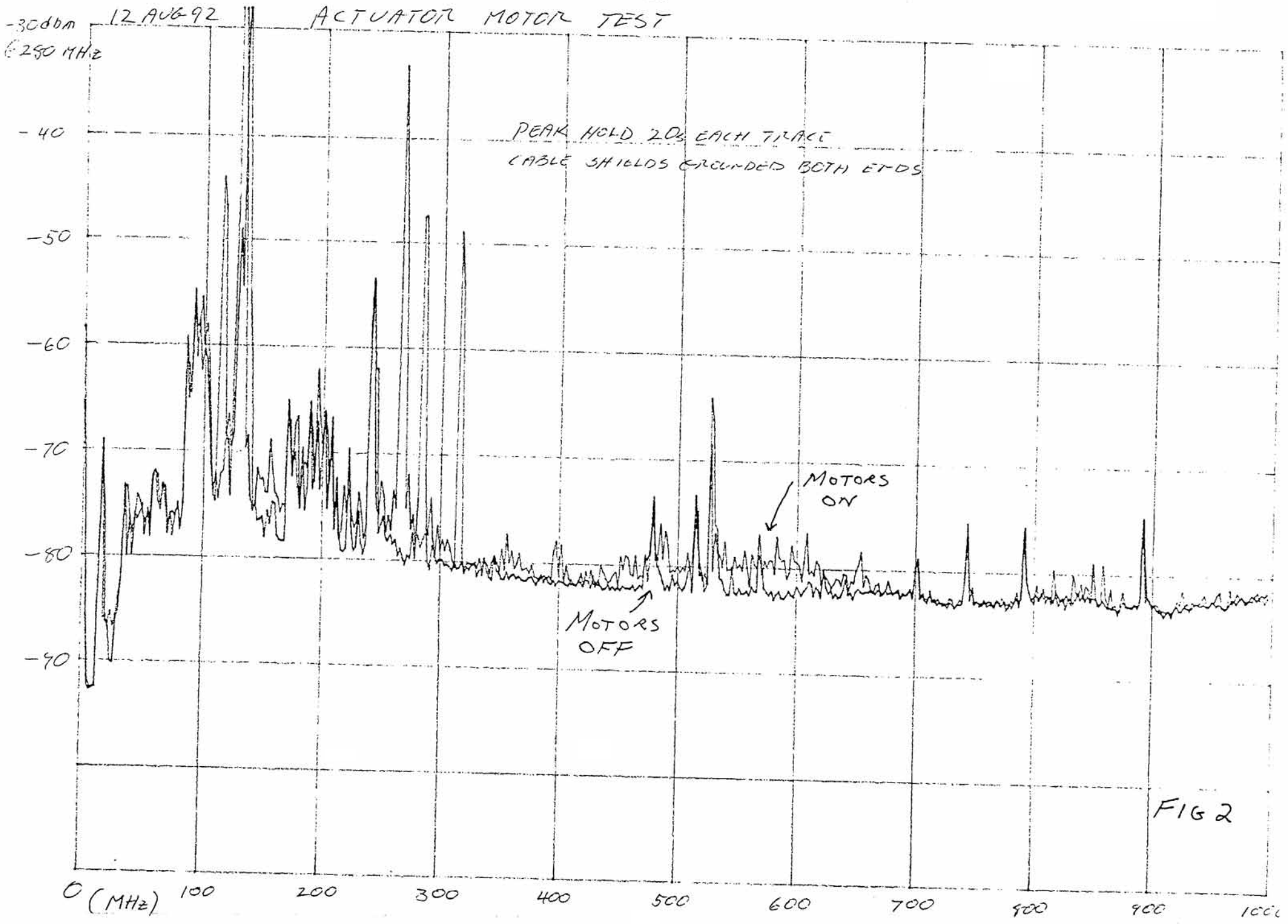

12 AUG 92
ACTUATOR MOTOR TEST
-30dbm
@ 250 MHz
PEAK HOLD 20s EACH TRACE
CABLE SHIELDS GROUNDED BOTH ENDS
MOTORS ON
MOTORS OFF
-40
-50
-60
-70
-80
-90
0 (MHz)
100
200
300
400
500
600
700
800
900

FIG 2

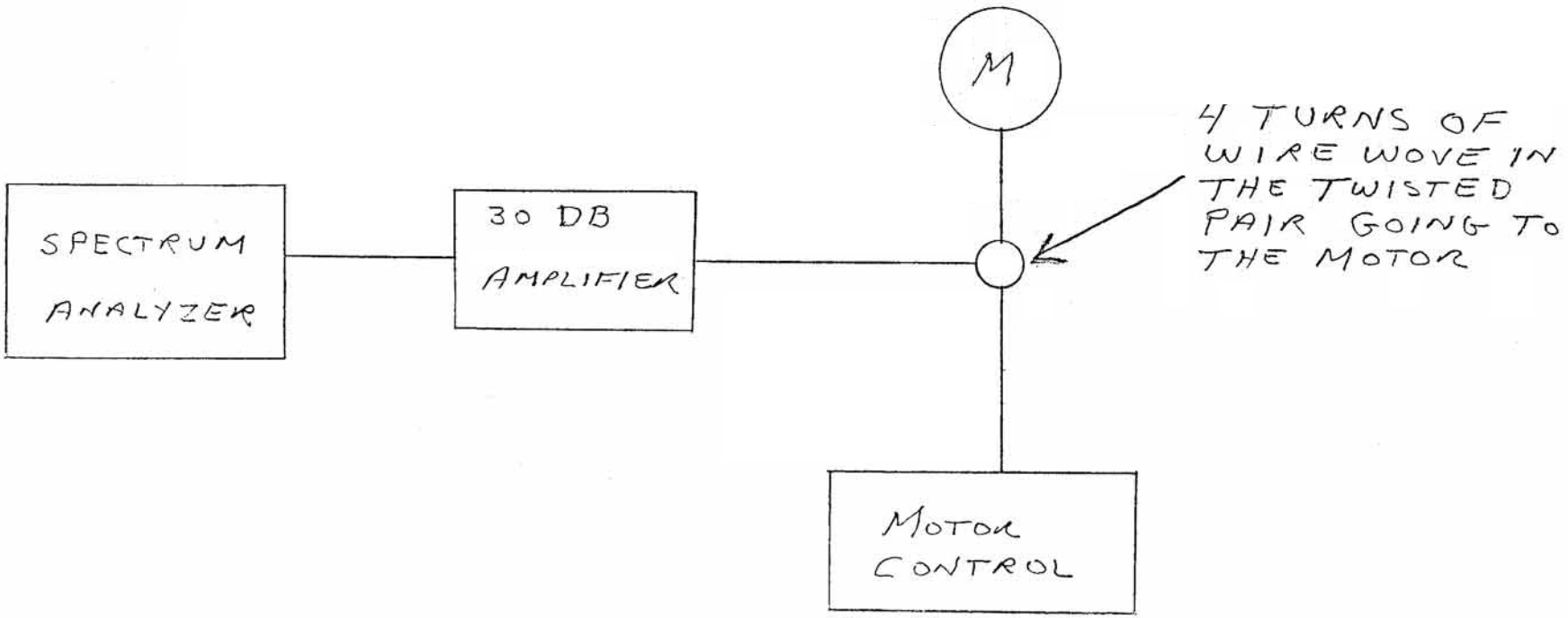

M
4 TURNS OF WIRE WOVE IN THE TWISTED PAIR GOING TO THE MOTOR
SPECTRUM ANALYZER
30 DB AMPLIFIER
MOTOR CONTROL

FIGURE 3

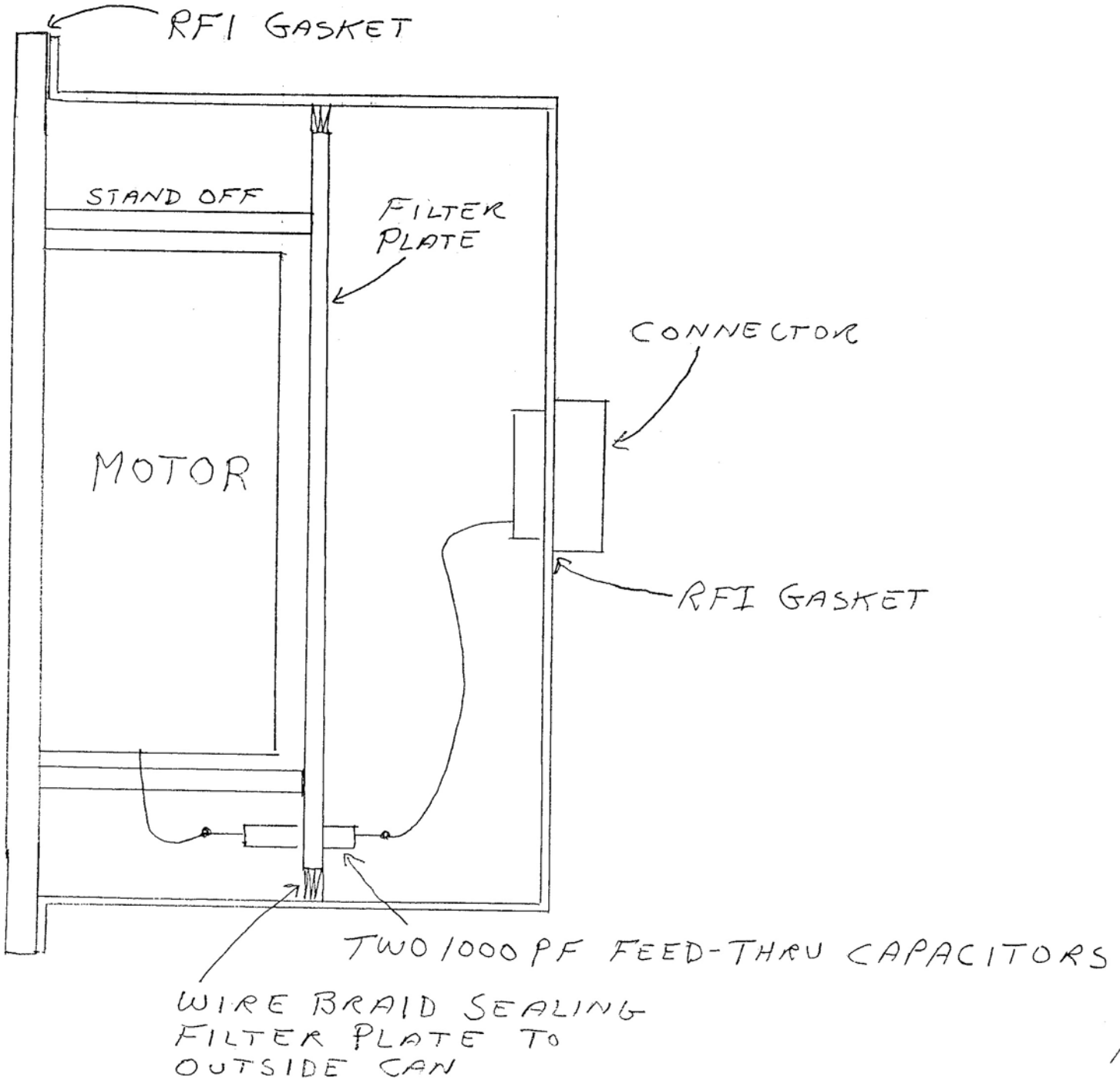
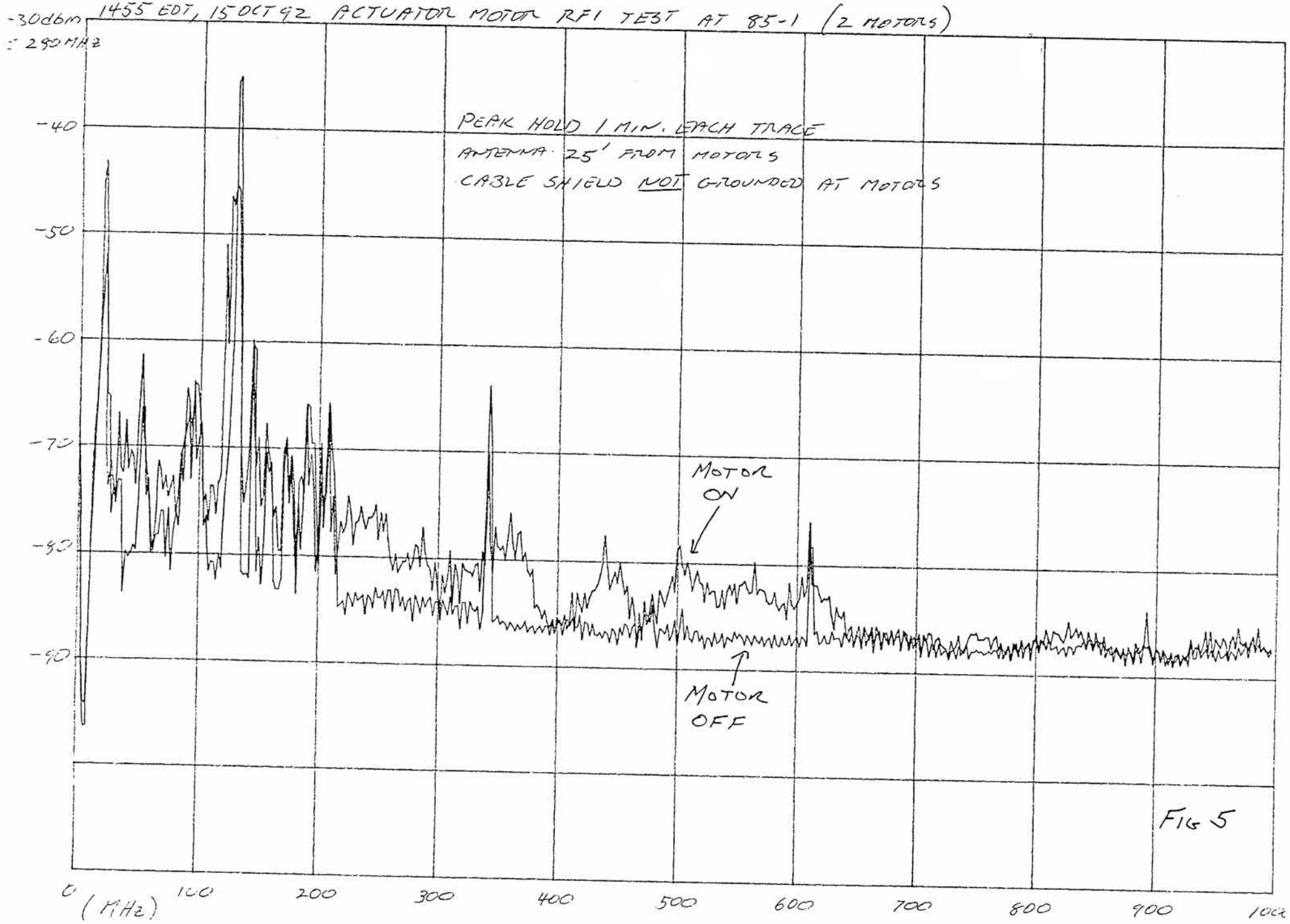

RFI GASKET
STAND OFF
FILTER PLATE
CONNECTOR
MOTOR
RFI GASKET
TWO 1000 PF FEED-THRU CAPACITORS
WIRE BRAID SEALING FILTER PLATE TO OUTSIDE CAN

FIG 4


-30dBm
1455 EDT, 15 OCT 92 ACTUATOR MOTOR RFI TEST AT 85-1 (2 MOTORS)
= 280 MHz
PEAK HOLD 1 MIN. EACH TRACE
ANTENNA 25' FROM MOTORS
CABLE SHIELD NOT GROUNDED AT MOTORS
-40
-50
-60
-70
-80
-90
MOTOR ON
MOTOR OFF
0
100
200
300
400
500
600
700
800
900
1000
(MHz)
FIG 5

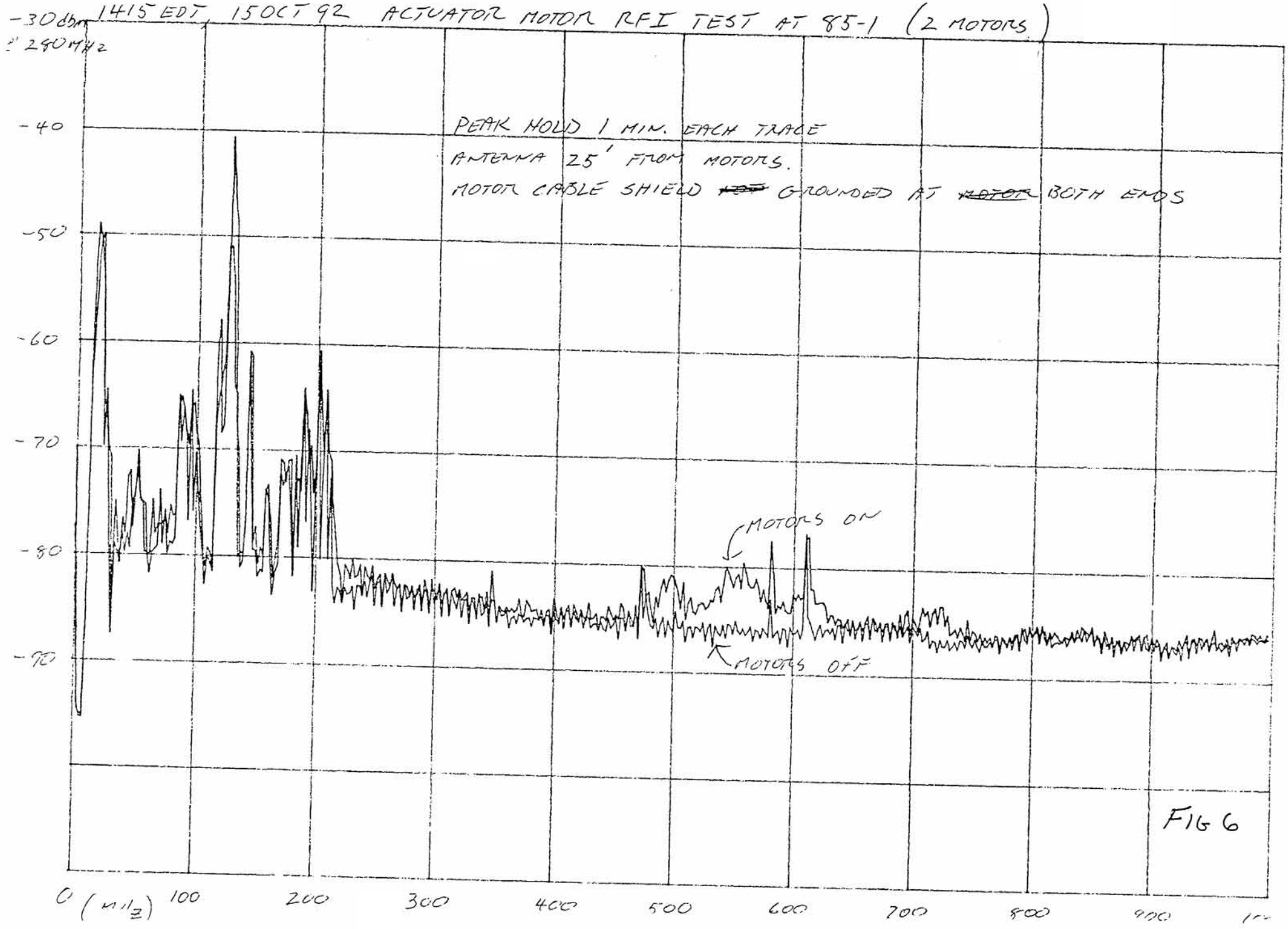
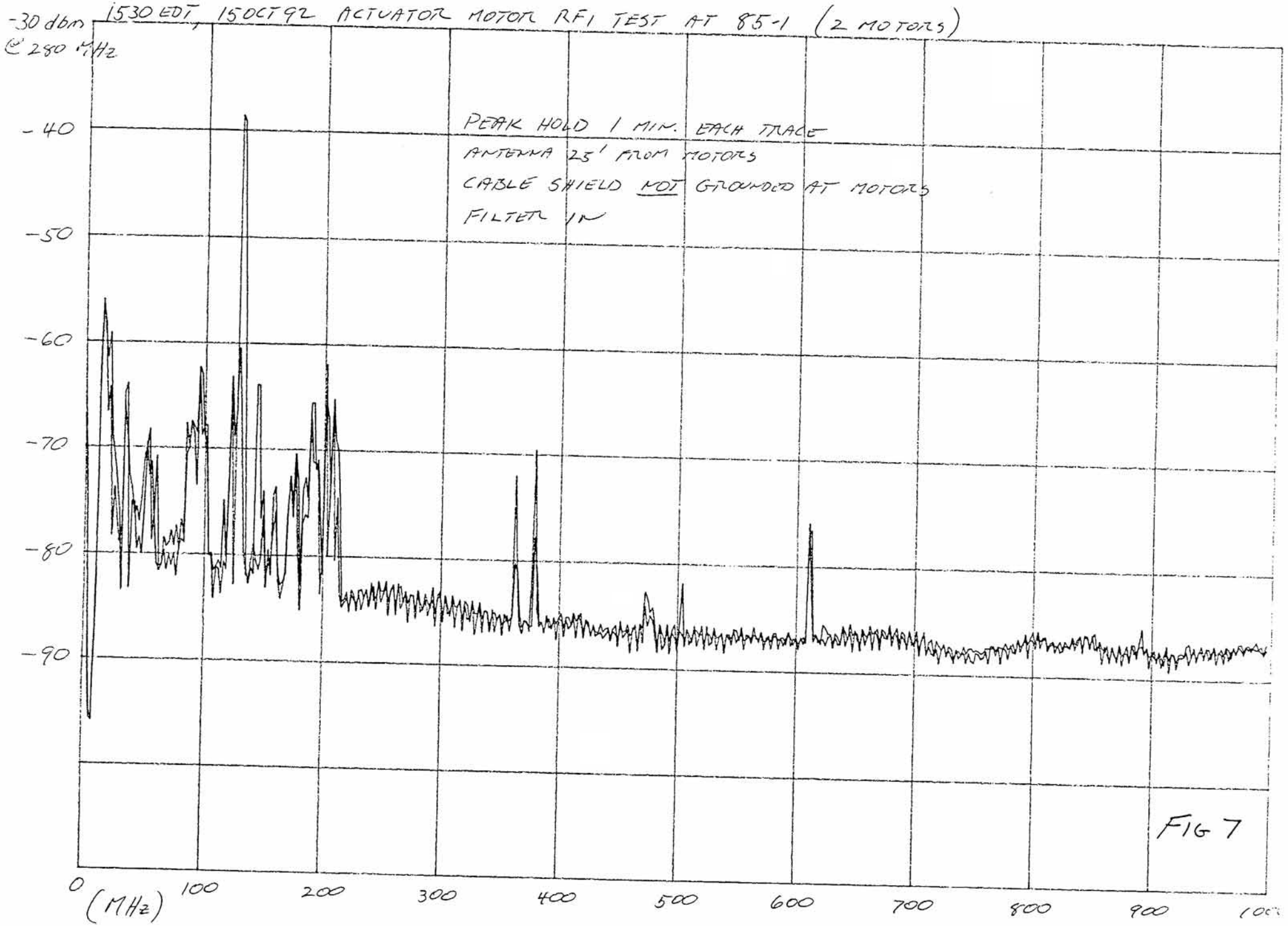
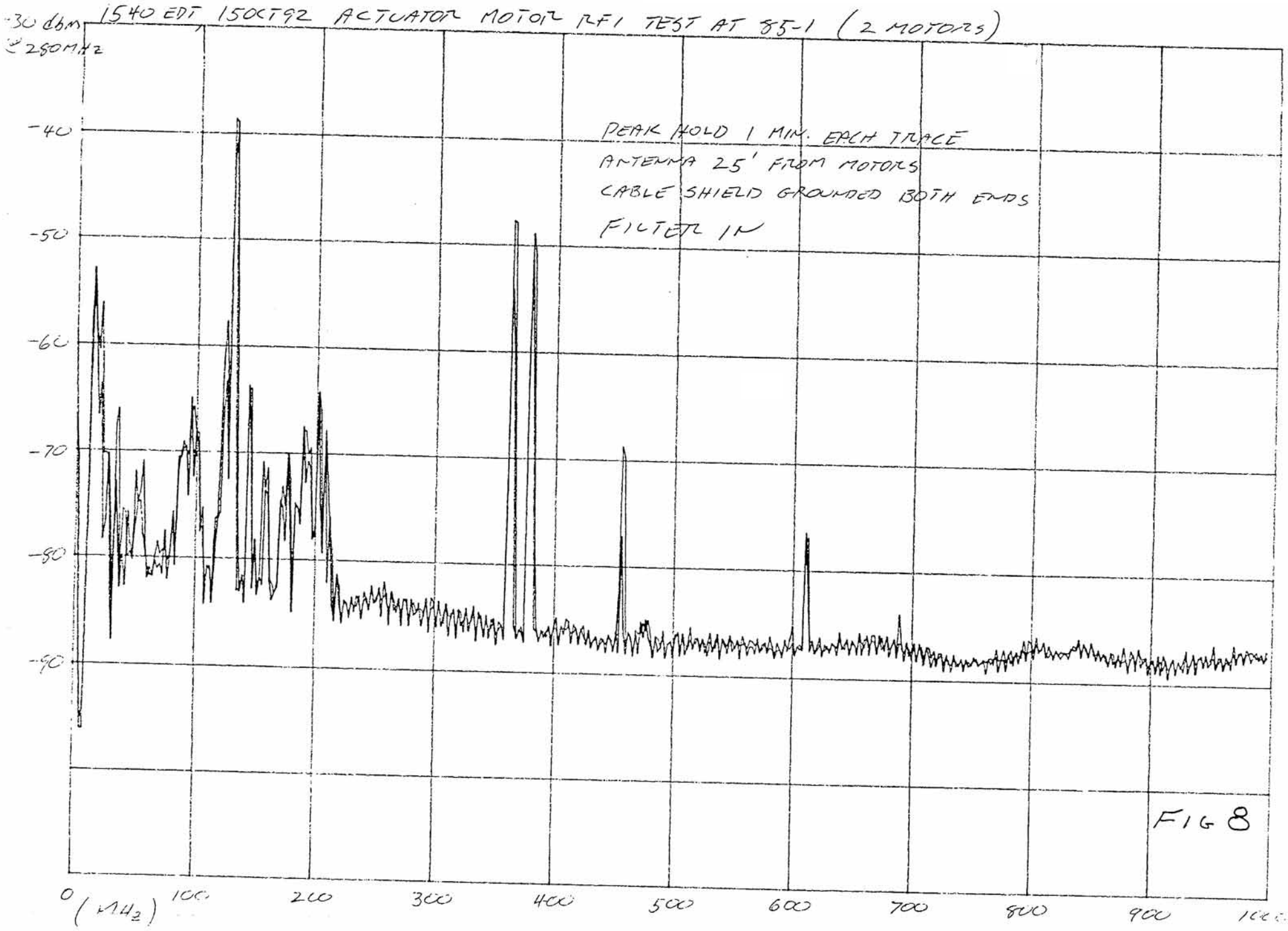

1415 EDT, 150CT92 ACTUATOR MOTOR RFI TEST AT 85-1 (2 MOTORS)
-30dbm
240MHz
-40
-50
-60
-70
-80
-90
PEAK HOLD 1 MIN. EACH TRACE
ANTENNA 25' FROM MOTORS.
MOTOR CABLE SHIELD GROUNDED AT BOTH ENDS
MOTORS ON
MOTORS OFF
0 (MHz)
100
200
300
400
500
600
700
800
900

FIG 6


1530 EDT, 15OCT92 ACTUATOR MOTOR RFI TEST AT 85-1 (2 MOTORS)
-30 dbm @ 280 MHz
PEAK HOLD 1 MIN. EACH TRACE
ANTENNA 23' FROM MOTORS
CABLE SHIELD NOT GROUNDED AT MOTORS
FILTER IN
-40
-50
-60
-70
-80
-90
0
(MHz)
100
200
300
400
500
600
700
800
900
FIG 7


1540 EDT 150CT92 ACTUATOR MOTOR RFI TEST AT 85-1 (2 MOTORS)
-30 dbm @ 250MHz
-40
-50
-60
-70
-80
-90
PEAK HOLD 1 MIN. EACH TRACE
ANTENNA 25' FROM MOTORS
CABLE SHIELD GROUNDED BOTH ENDS
FILTER IN
0 (MHz)
100
200
300
400
500
600
700
800
900
1000
FIG 8

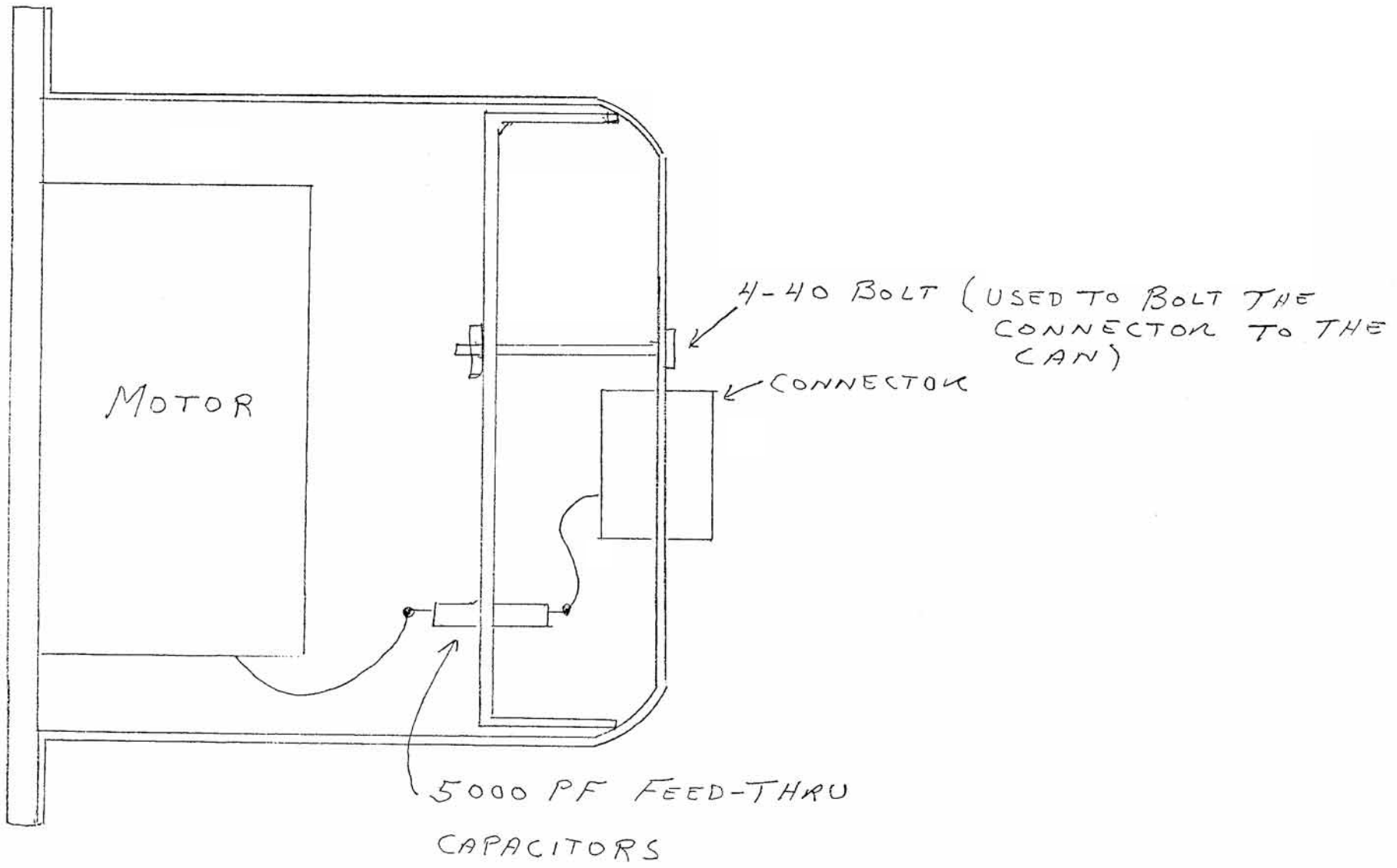

MOTOR
4-40 BOLT (USED TO BOLT THE CONNECTOR TO THE CAN)
CONNECTOR
5000 PF FEED-THRU CAPACITORS

FIG 9

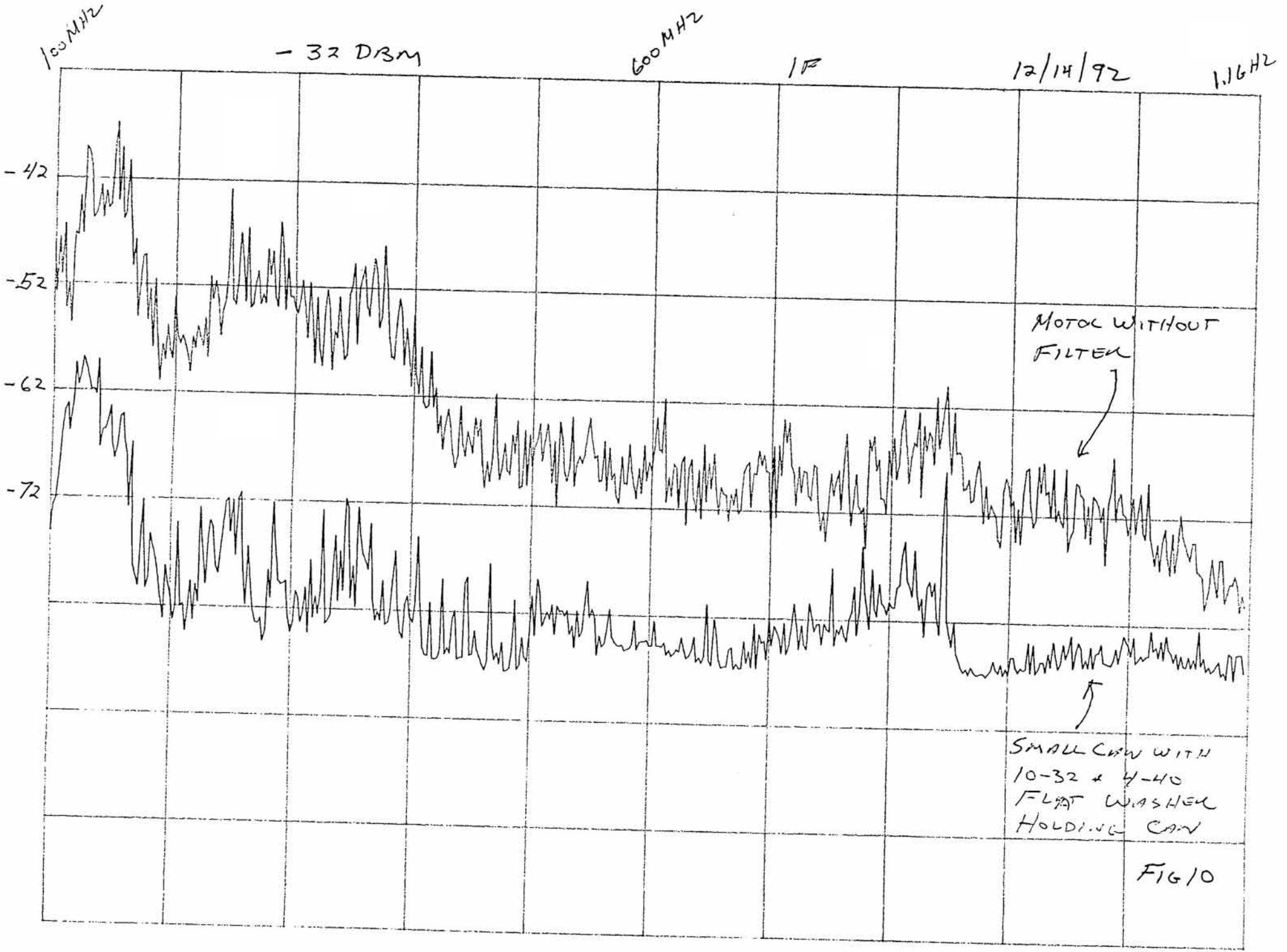

100MHz
-32 DBM
600MHz
IF
12/14/92
1.1GHz
-42
-52
-62
-72
MOTOR WITHOUT FILTER
SMALL CAN WITH 10-32 x 4-40 FLAT WASHER HOLDING CAN

FIG 10

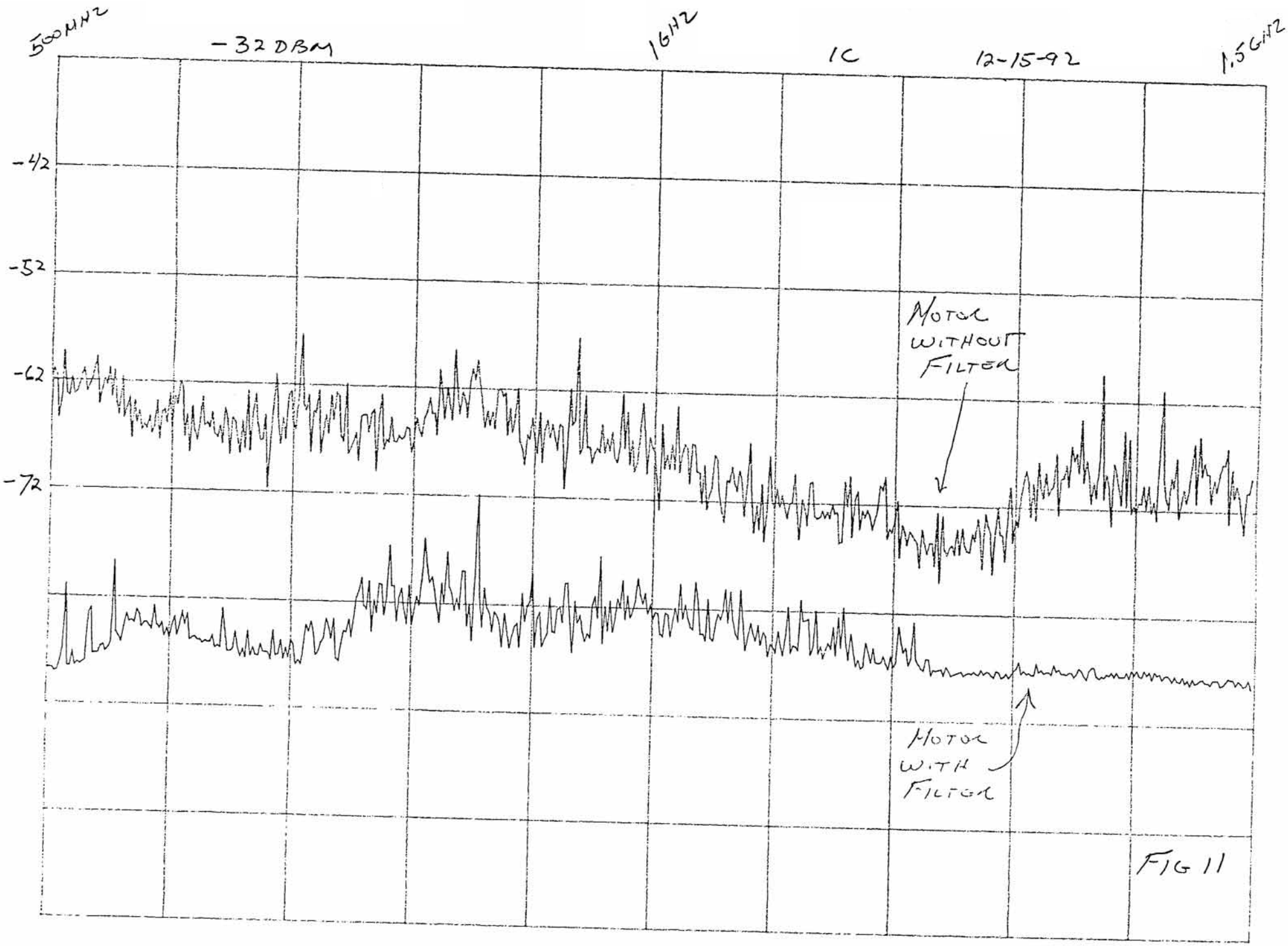

500MHZ
-32 DBM
1GHZ
1C
12-15-92
1.5GHZ
-42
-52
-62
-72
MOTOR WITHOUT FILTER
MOTOR WITH FILTER

FIG 11

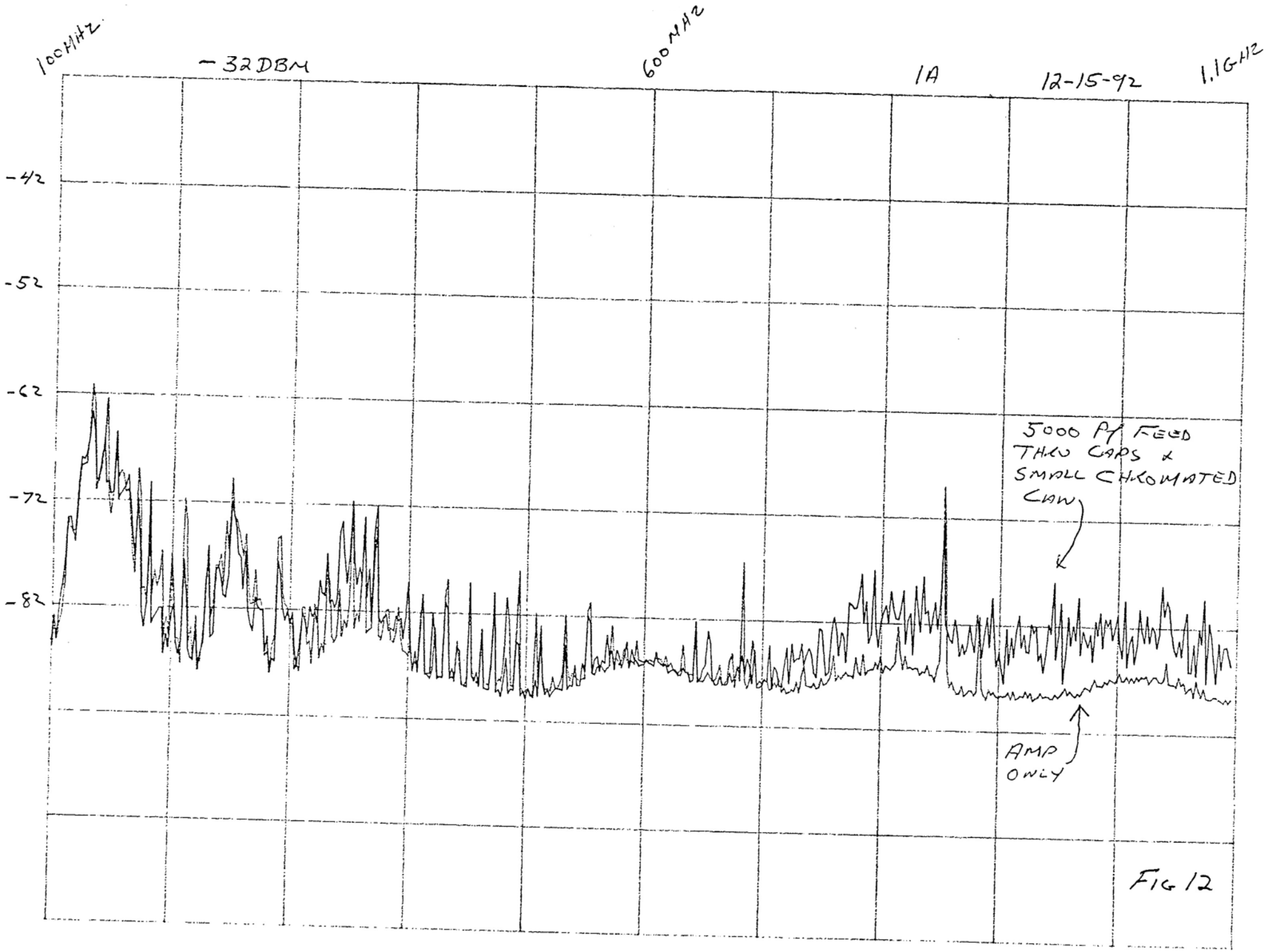

100MHz
-32DBM
600MHz
1A
12-15-92
1.1GHz
-42
-52
-62
-72
-82
5000 PF FEED THRU CAPS & SMALL CHROMATED CAN
AMP ONLY

FIG 12

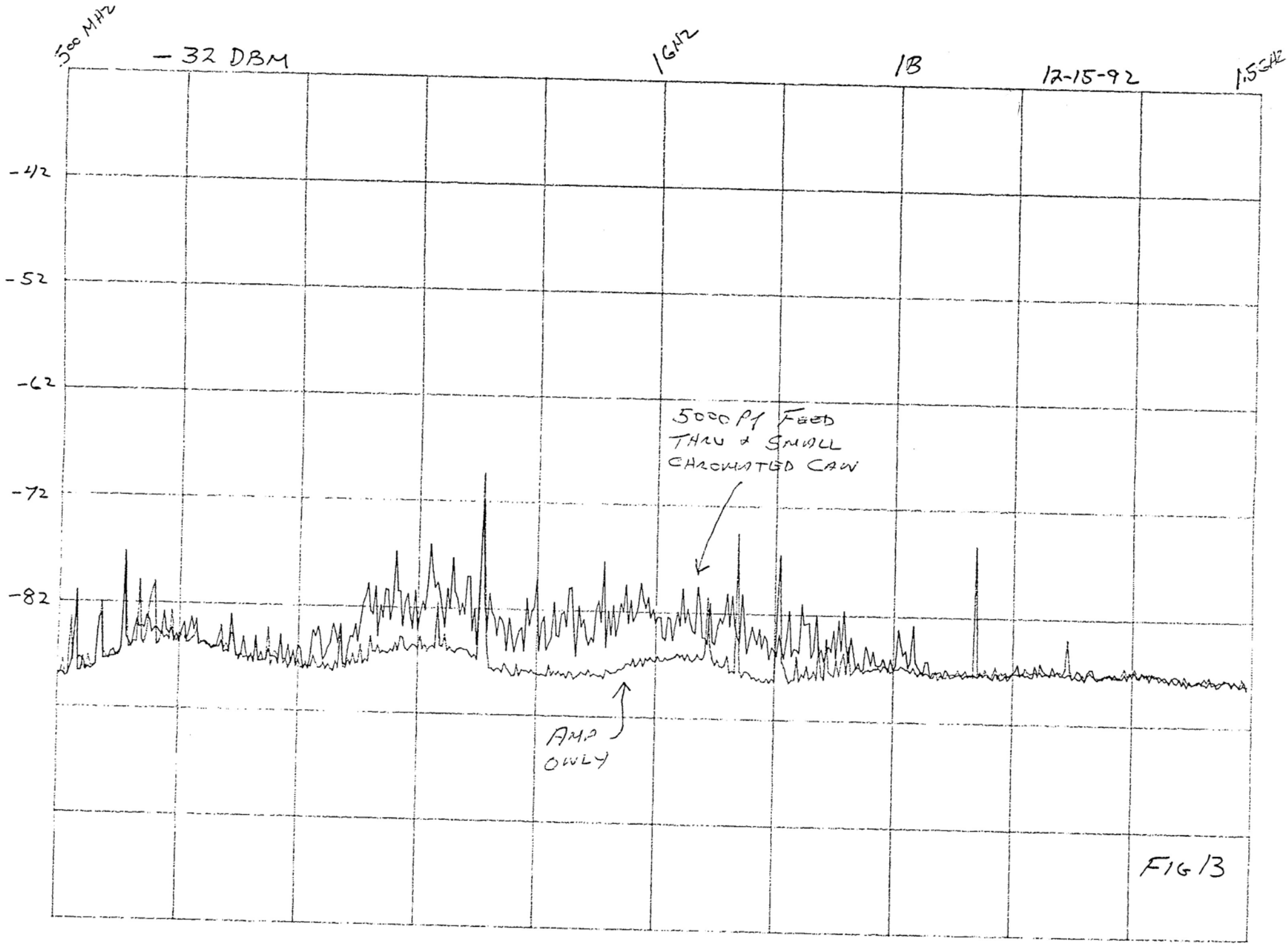

500 MHz
-32 DBM
1GHz
1B
12-15-92
1.5GHz
-42
-52
-62
-72
-82
5000 Pf Feed
THRU & SMALL
CHROMATED CAN
AMP
ONLY

FIG 13