NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

May 5, 1992

MEMORANDUM

To : R. Hall

From : R. Norrod, R. Lacasse

Subject : RFI Tests on Magnetostrictive Position Sensors

On April 7/8 1992, preliminary RFI tests were performed at Green Bank on a magnetostrictive position sensor system on loan from RSI/PCD. These sensors have potential application on the GBT subreflector positioner and on the prime focus FRM. The preliminary tests indicated that, as delivered, the units could produce harmful RFI. It was decided to do further tests and attempt to determine what steps would be required to eliminate the problem. This memo reports on that effort. A brushless DC motor and controller were also tested and the results are reported separately.

Appended are diagrams of the test setups and test data obtained. The sensor system is manufactured by MTS Systems Co. and consists of two modules: the Linear Displacement Transducer (LDT, a.k.a. probe), and the Encoder Output Module (EOM, a.k.a. controller). On the GBT, the LDT would be located adjacent to a particular linear actuator and the EOM could be located up to 250 feet away. PCD is planning to place the EOMs in a RFI shielded cabinet located inside the receiver room. Digital electronic circuitry is present within both the EOM and the head of the LDT, and is evidently the source of the RFI.

SUMMARY: Tests showed that detectable signals are radiated to at least 1500 MHz. The most obvious component is a comb spaced at approximately 14 MHz. This comb was detected in indoor tests in the 100-200 MHz range using a YAGI antenna, a transistor preamp, and a spectrum analyzer. It was also detected at 350-400 MHz and 1300-1500 MHz using NRAO prime focus feeds and cooled receivers as preamps, and the spectrum analyzer.

The following steps were taken: The EOM and its power supply were placed in a large metal box. The cover of this box is sealed with a conductive gasket and AC power into it goes through RFI filters. The power supply and EOM were grounded to the box. A metal can was fabricated and placed around the LDT electronics head. The cable between the EOM and LDT was replaced with a 5 twisted pair cable of the type (Belden 8105) recommended by MTS. This cable has two overall shields, the inner a 100% coverage foil

shield and the outer a braided shield. The cable was introduced into the large box containing the EOM and into the can around the LDT head through Crouse/Hinds cable-grip type feedthroughs. At each end, the braided shield was folded back around the feedthrough rubber grommet and forced into contact with the metal cable-grip shell. The goal was to provide a continuous metal shield around the electronics and the interconnecting wires.

These steps appeared to be successful. The test data shows that no signals could be detected from the MTS equipment with the metal boxes closed up. It is hard to judge the absolute amount of shielding achieved because the "after" levels were below our setup's sensitivity, but it appears to be at least 40 dB near 150 MHz. Energy was being radiated both by the MTS electronics enclosures and by the cable between. Simply using the recommended twisted pair shielded cable and taking care with shield terminations reduced the detected levels by about 20 dB.

We feared that all the interconnecting leads would have to be filtered at each end, but this is probably not necessary if proper care is taken with the shielding of the electronics and the cable. The proper use of twisted pairs to transmit the differentially driven signals is important as well. A useful text is Noise Reduction Techniques in Electronics Systems by H. W. Ott.

RECOMMENDATION: Both the EOM and the LDT head should be placed in metal enclosures with RFI gaskets at all joints. The interconnecting cable should be of the proper type and care should be taken when terminating the shield at each end.

CONCLUSION: The steps we implemented are commonly recommended to fight RFI problems. The results reinforce the effectiveness of, and need for, good grounding and shielding techniques when operating digital equipment near the GBT feeds and receivers. We conclude that, if similar techniques are used, RFI levels from the magnetostrictive sensors will be acceptable. However, our test equipment is not as sensitive as the GBT data acquisition equipment, and shielding effectiveness is very implementation dependent. Therefore, we feel it would be prudent to leave some room in the PCD cabinet so that NRAO could add RFI filters to the cabling if it becomes necessary in the future. We would also be glad to review the details of the PCD design as it becomes available and make recommendations accordingly.

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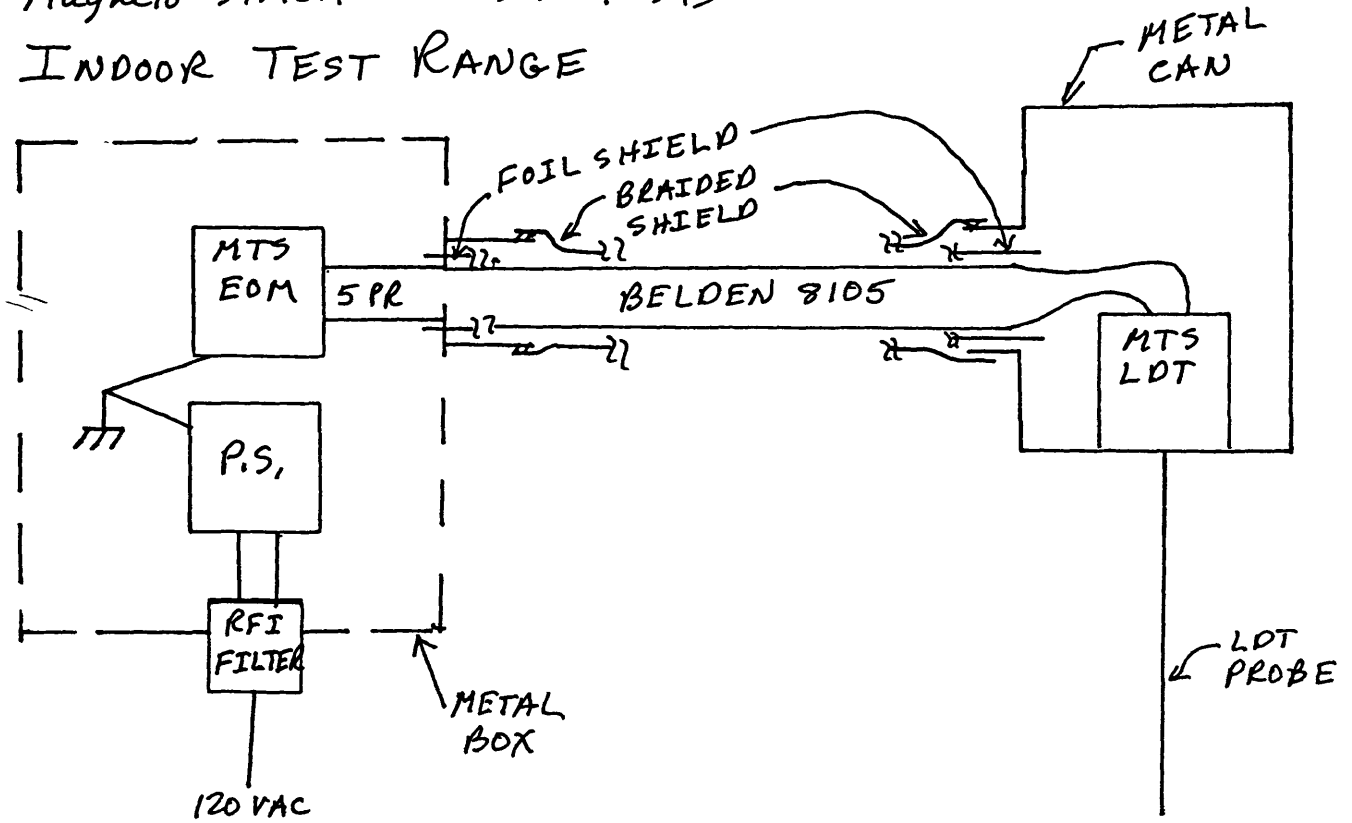
Magneto-strictive Sensor Tests

4/29/92

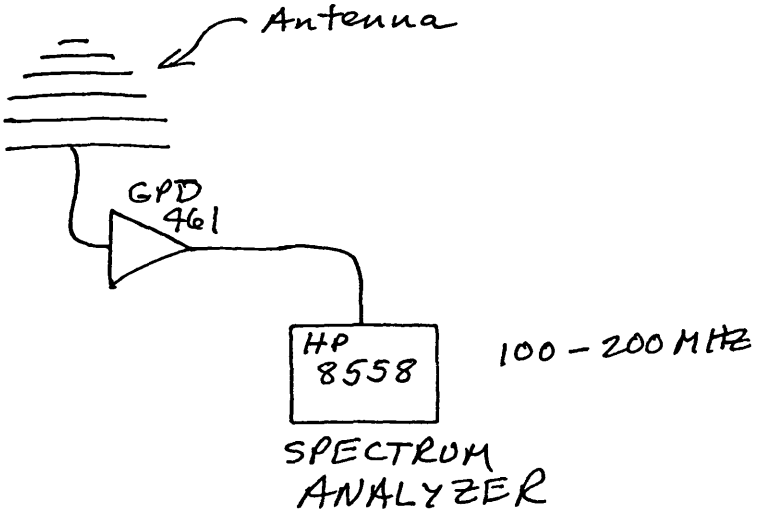
INDOOR TEST RANGE



≈ 30 ft.

EOM = MODEL EOM 515
S/N 3449 09-02-001

LDT = MODEL TTSR? L0240 R
S/N 34489-86-01



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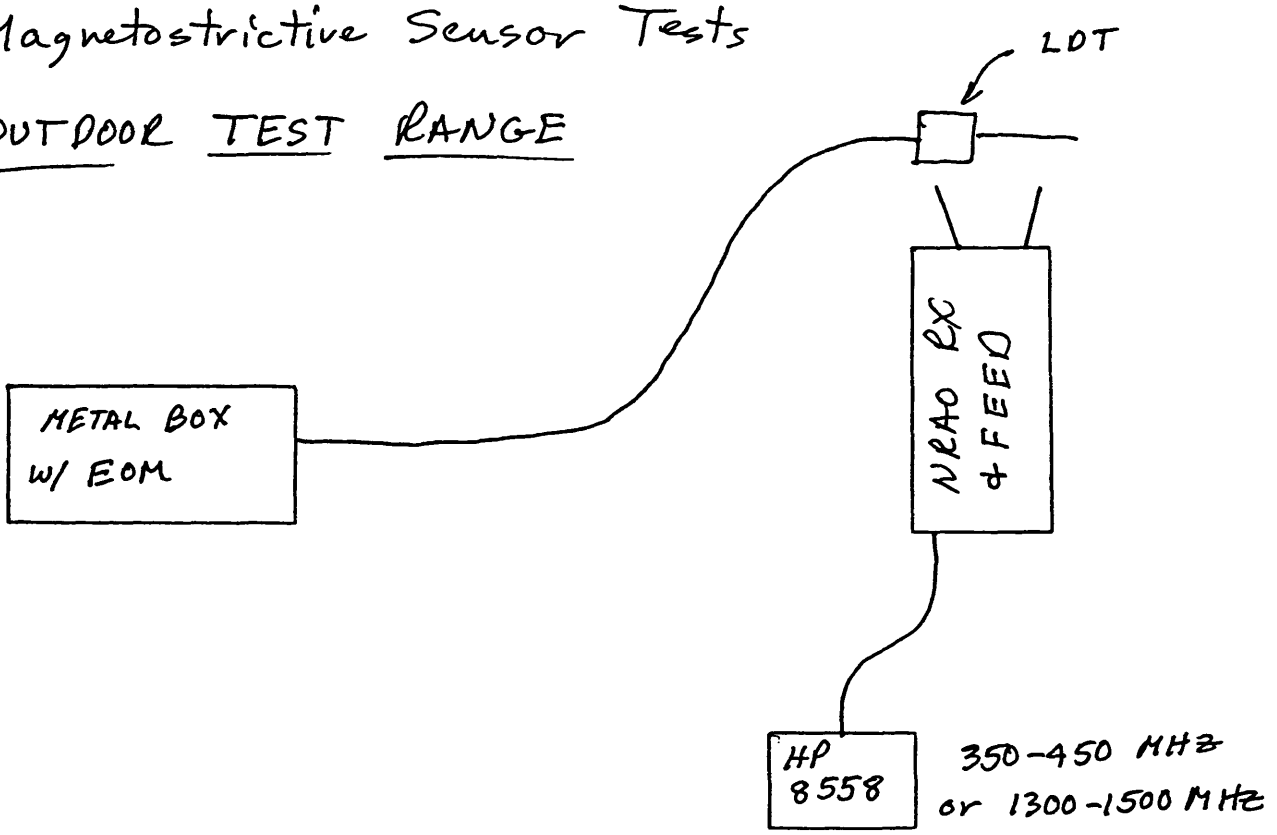
Magnetostrictive Sensor Tests

OUTDOOR TEST RANGE



FEED POINTED AT ZENITH

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TEST DATA LOG

Ⓐ - W/ 21cm Rx as preamp, EOM in front of feed. Note comb @ ≈ 14 MHz

Ⓑ - Indoor test range. All MTS equipment in metal box, cover off. Cabling as delivered.

Ⓒ - Cover placed on box & sealed. Comb not detected.

Ⓓ - Removed LOT from box, cable ran out through hole in side. Strong signals detected.

Ⓔ - Reworked cabling & shields. LOT head in can. Compare w/ Ⓑ, & Ⓓ.

Ⓕ - Put cover onto EOM box & removed LOT can.

Ⓖ - Everything closed up. No detected emission from MTS equipment. Compare w/ Ⓓ.

Ⓗ - Repeated Ⓖ.

Ⓘ - Input minus Reference display showing effect of EOM box.

Ⓙ - Input minus Reference display showing effect of can around LOT head.

Ⓚ - OUTDOOR TEST with 300-1000 Rx & 400 MHz feed. Input minus reference showing effect of cover on EOM box. Note: EOM & box were on floor about 12 ft below feed aperture which was pointed to zenith.

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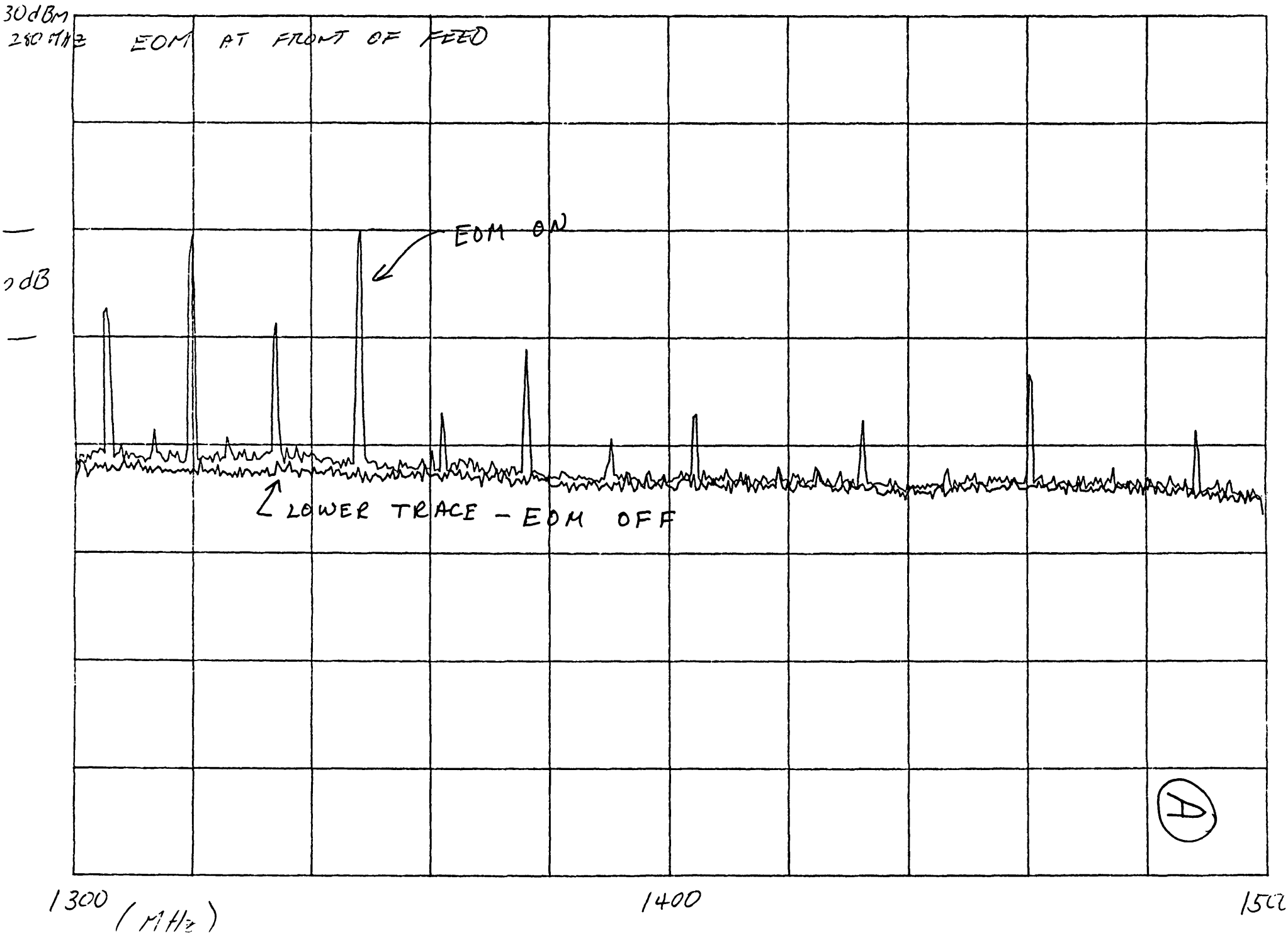
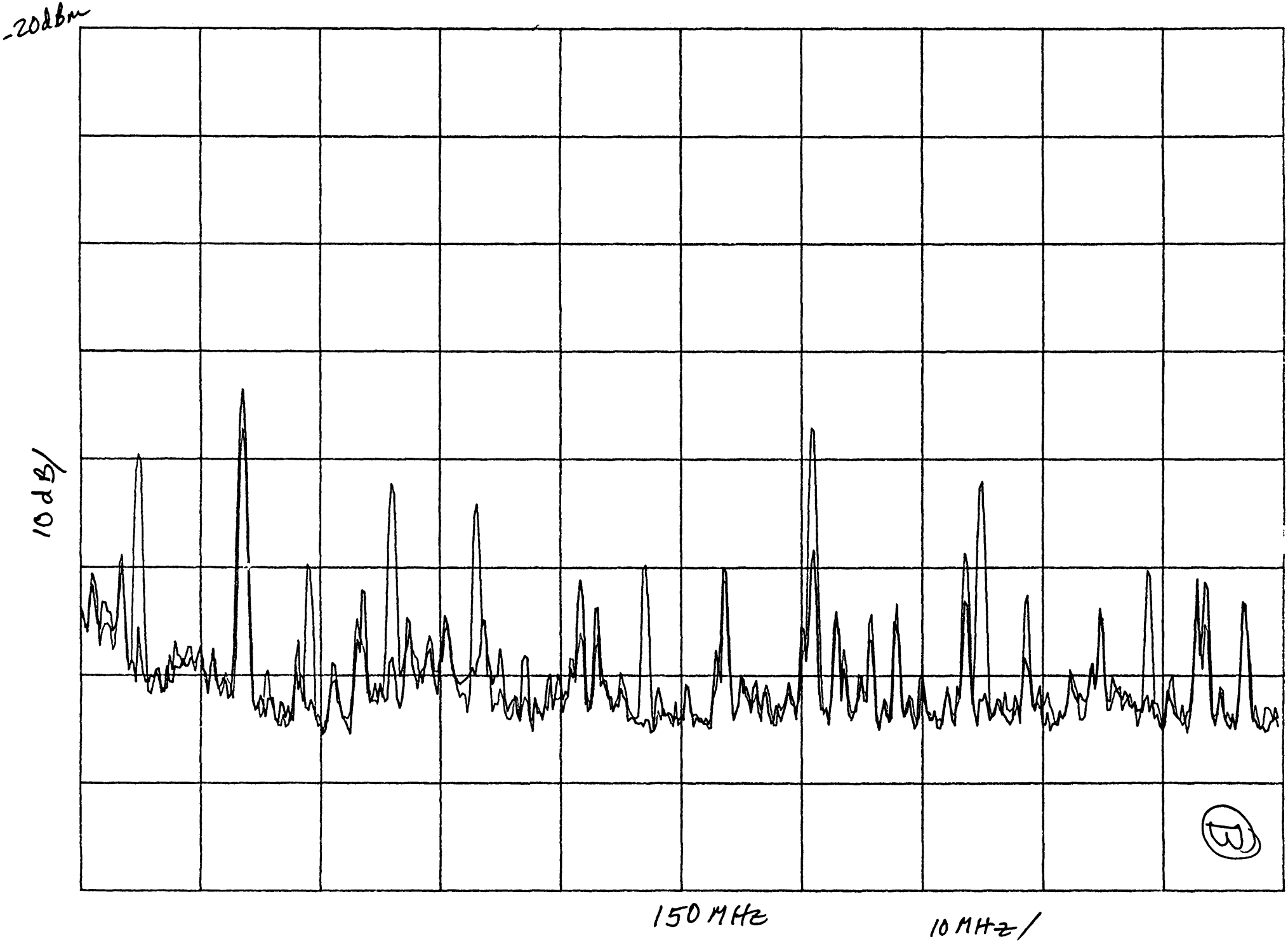
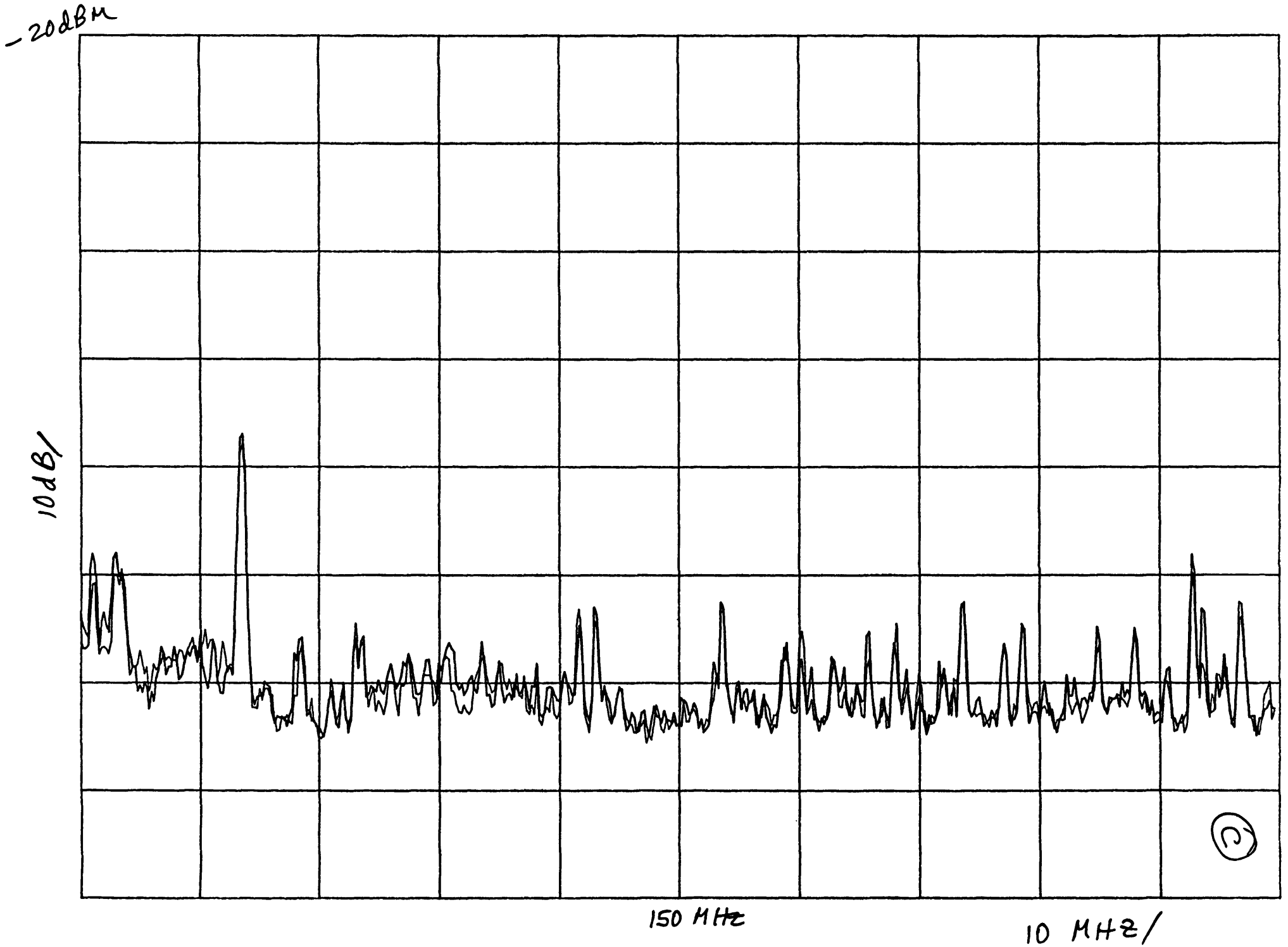
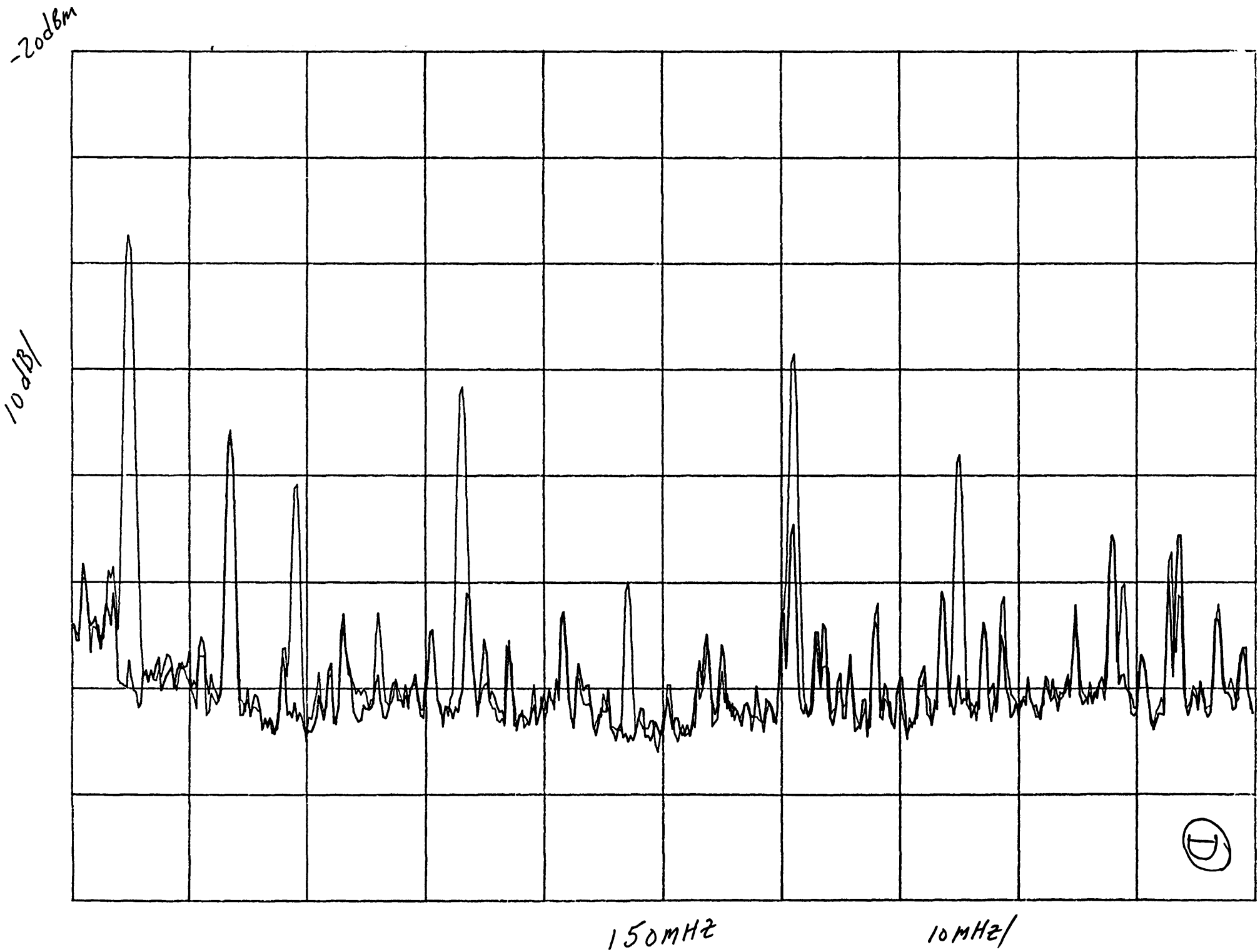
TEST DATA LOG (cont'd)

② - Input minus reference showing effect of can around LDT head.

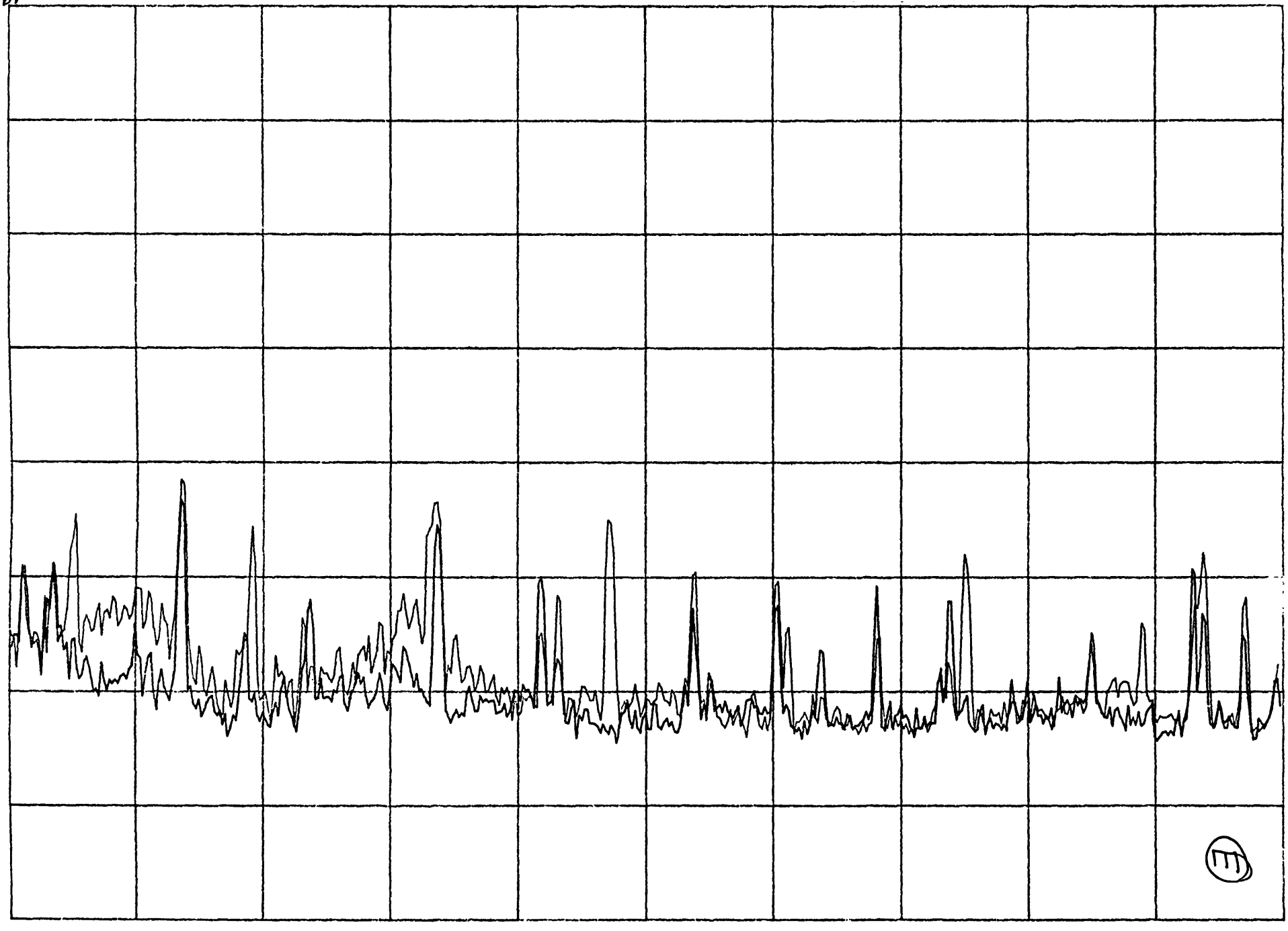

30dBm
250 MHz
EOM AT FRONT OF FEED
EOM ON
dB
LOWER TRACE - EOM OFF
A
1300
(MHz)
1400
150

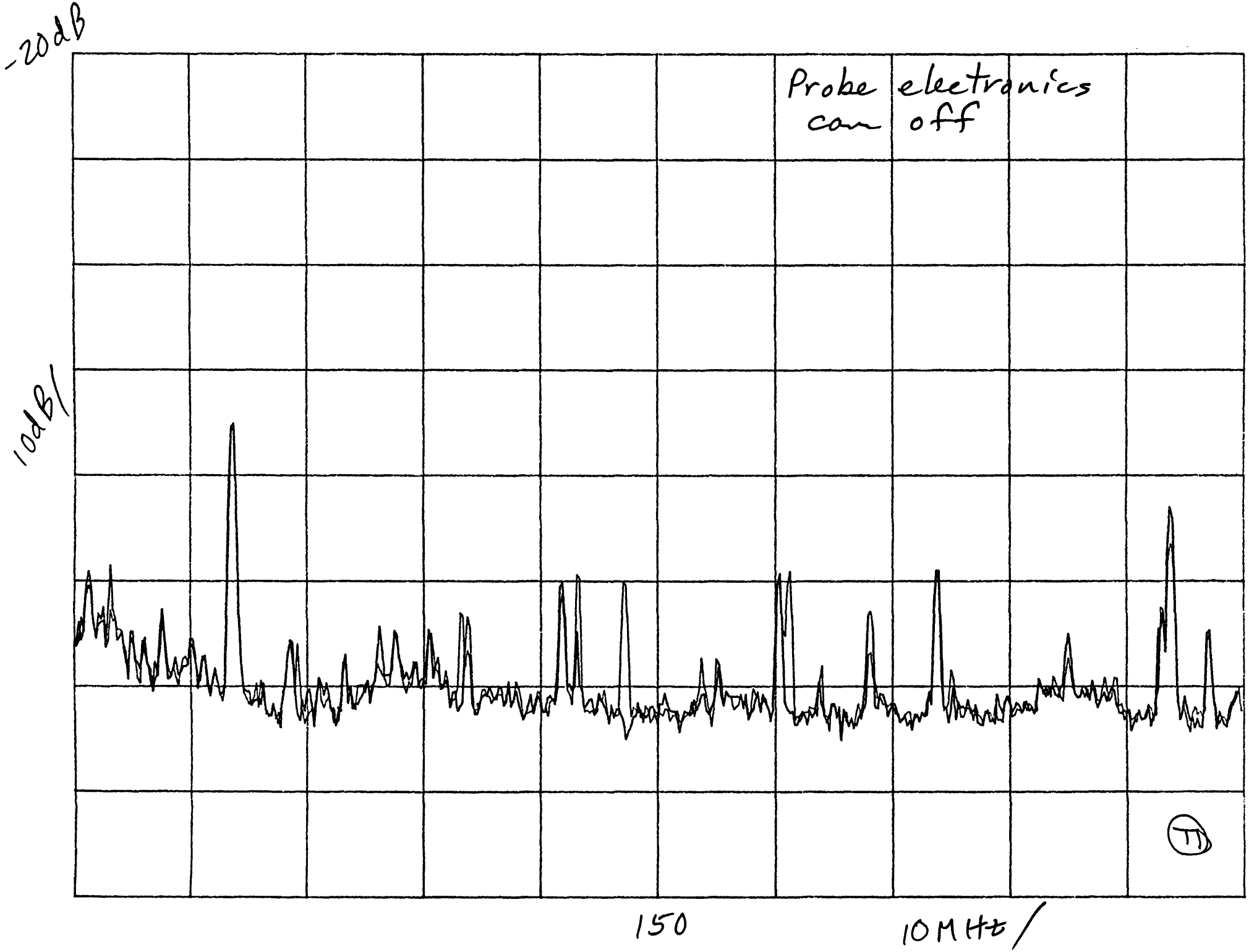

-20dBm
10dB/
150 MHz
10 MHz/

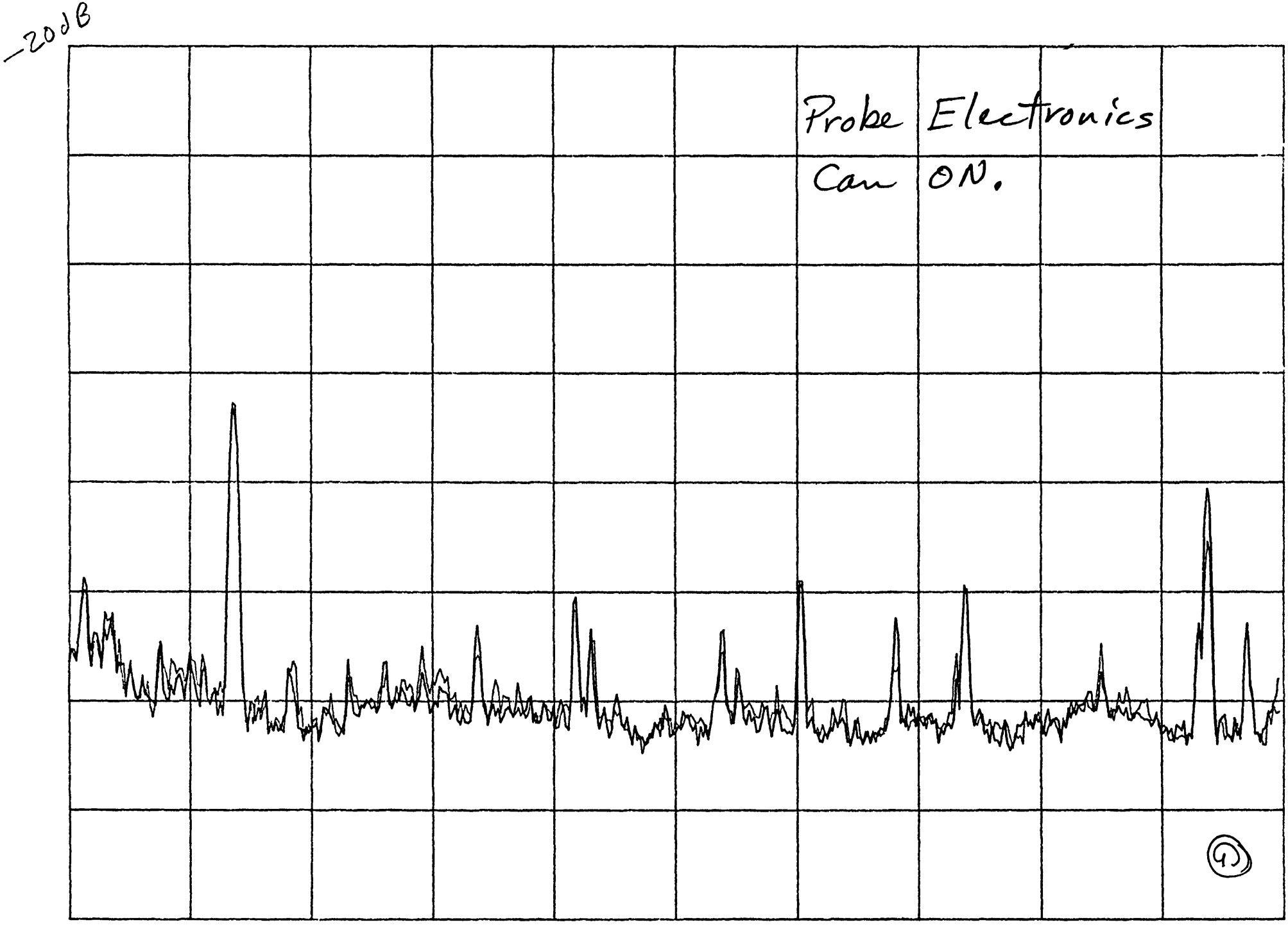

-20dBm
10dB/
150 MHz
10 MHz/

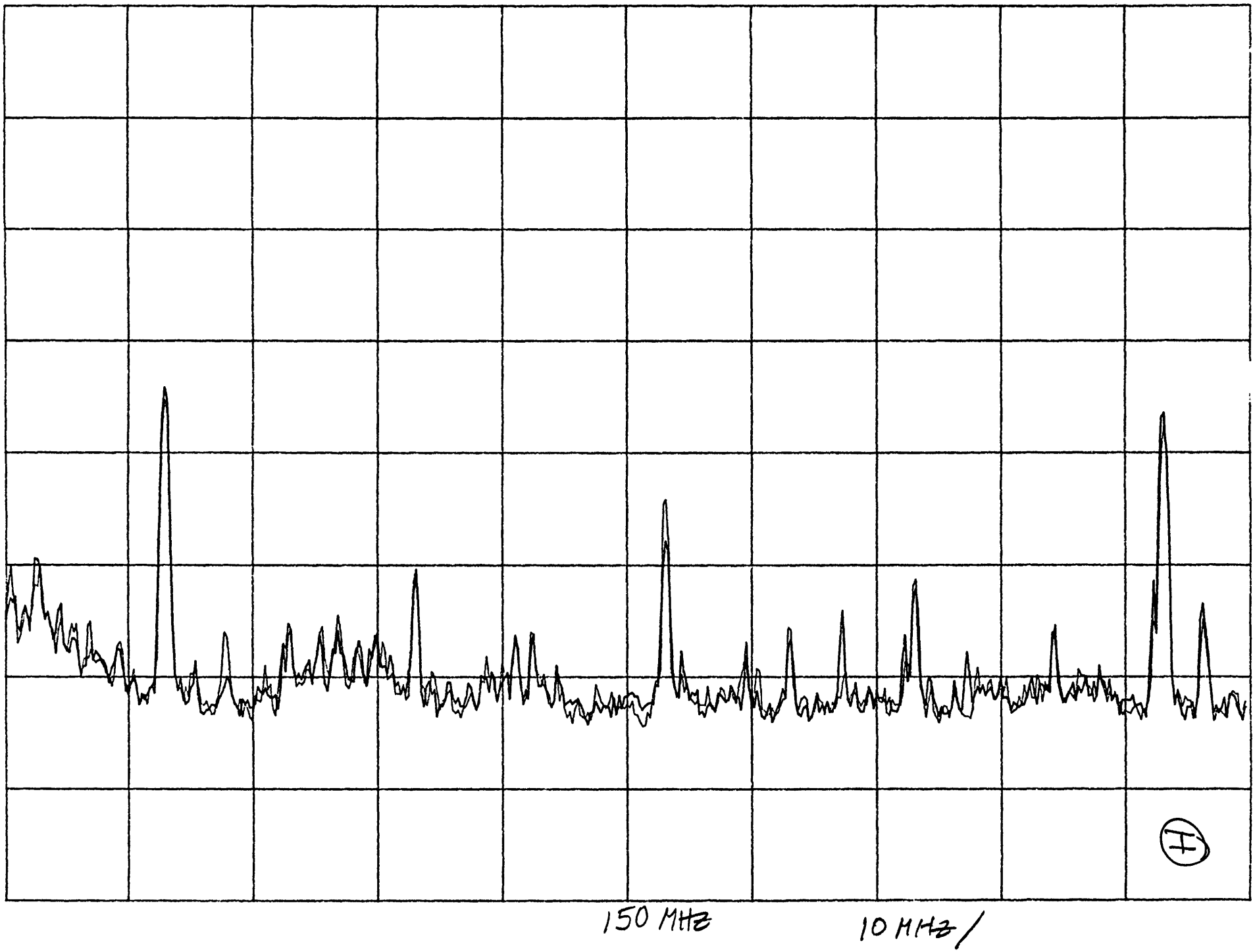

-20dBm
10dB/
150MHz
10MHz/

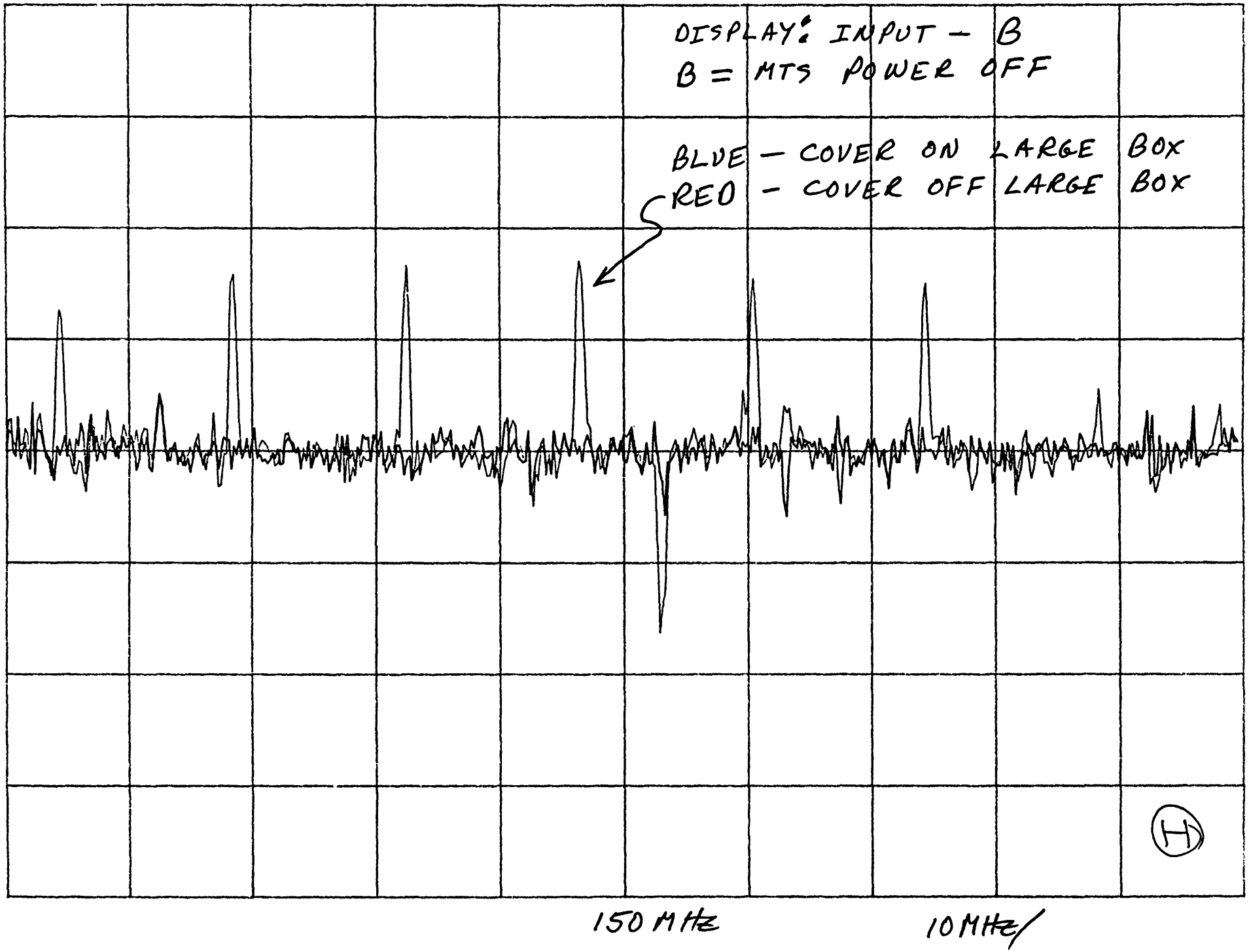
-2816-

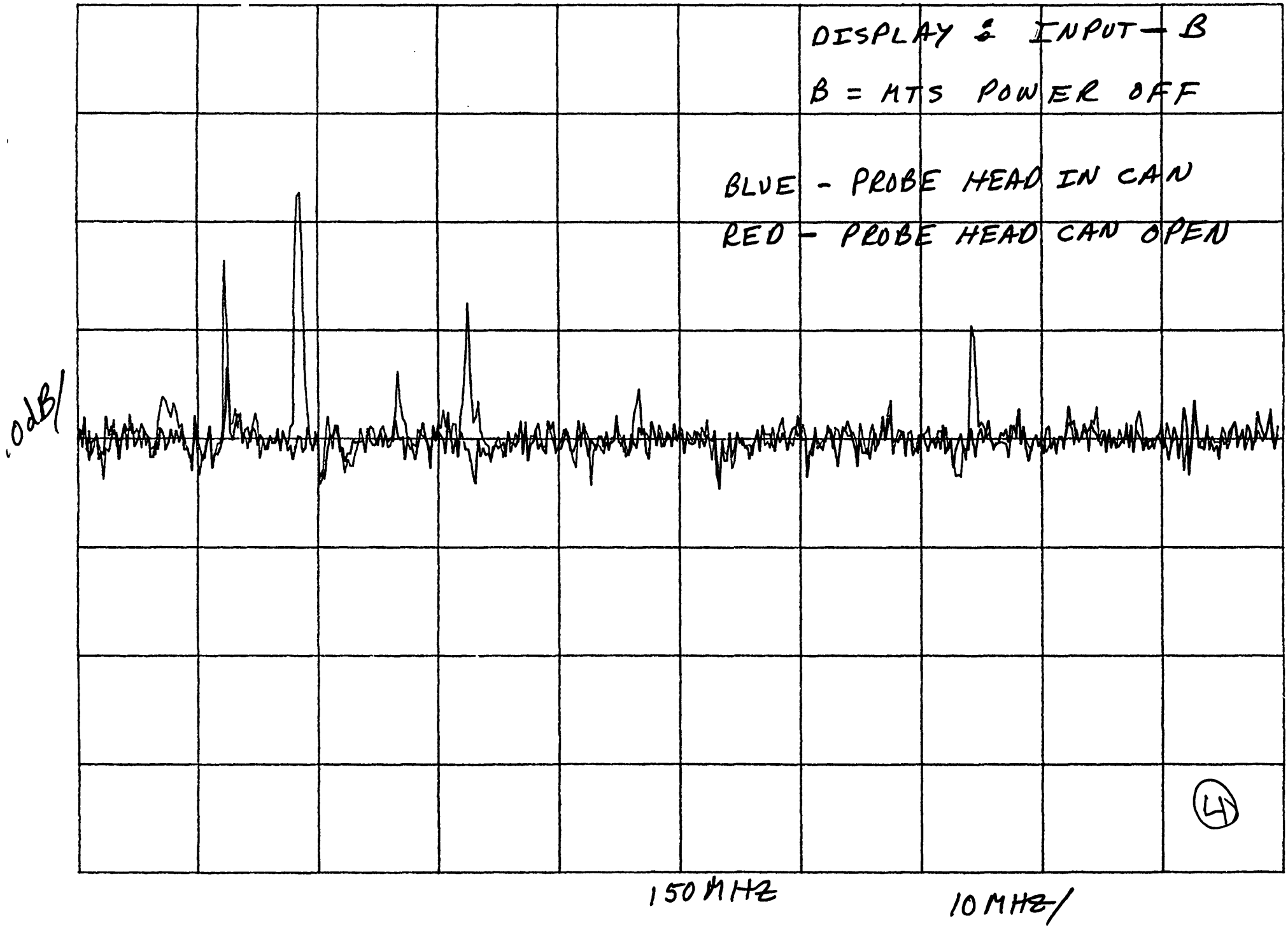



-20dB
Probe electronics
can off
10dB/
150
10MHz/


-20dB
Probe Electronics
Can ON.
9


150 MHz
10 MHz/
H


DISPLAY: INPUT - B
B = MTS POWER OFF
BLUE - COVER ON LARGE BOX
RED - COVER OFF LARGE BOX
10 dB/
150 MHz
10 MHz/
H

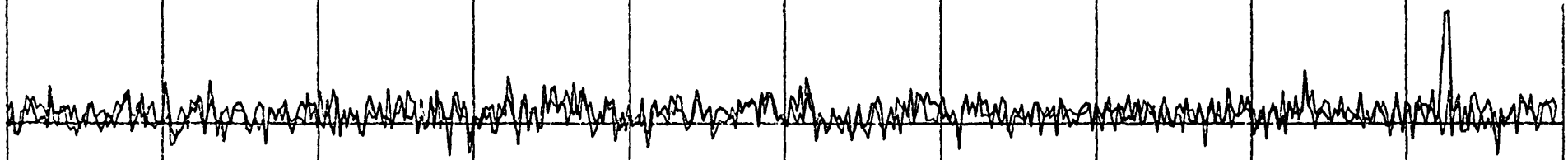

DISPLAY & INPUT – B
B = MTS POWER OFF
BLUE - PROBE HEAD IN CAN
RED - PROBE HEAD CAN OPEN
.0dB/
150 MHz
10 MHz/
4

DISPLAY : INPUT – B

B = MTS OFF

BLUE – COVER OFF LARGE BOX

RED – COVER ON LARGE BOX



10 dB/

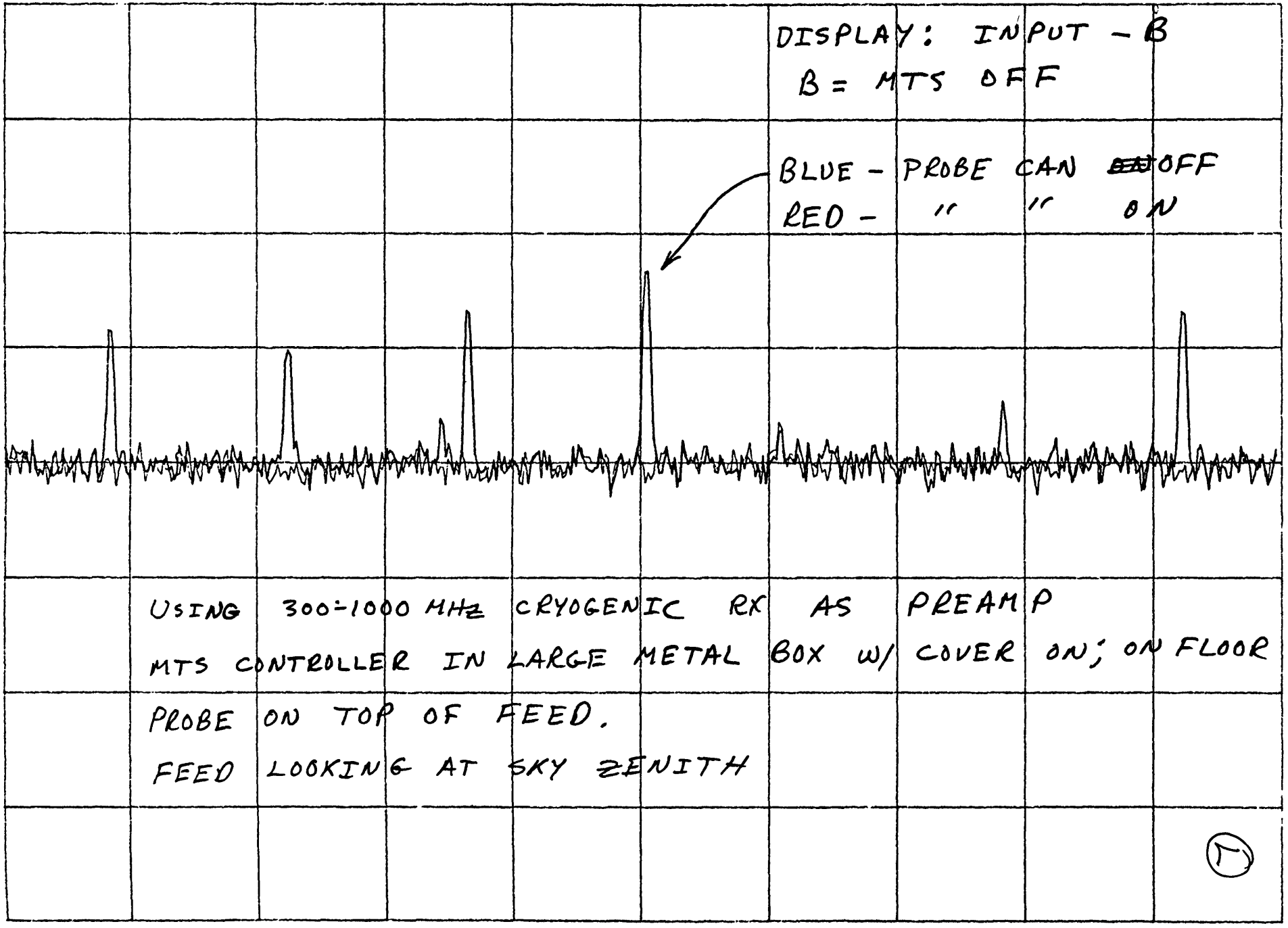
USING 300–1000 RX AS PREAMP. FEED @ ZENITH

MTS CONTROLLER IN LARGE METAL BOX ~~OF~~ ON FLOOR.

PROBE ON TOP OF FEED WITH ITS CAN ON.

400 MHz

10 MHz/


DISPLAY: INPUT - B
B = MTS OFF
BLUE - PROBE CAN OFF
RED - " " ON
10 dB/
USING 300-1000 MHz CRYOGENIC RX AS PREAMP
MTS CONTROLLER IN LARGE METAL BOX W/ COVER ON; ON FLOOR
PROBE ON TOP OF FEED.
FEED LOOKING AT SKY ZENITH
400 MHz
10 MHz/