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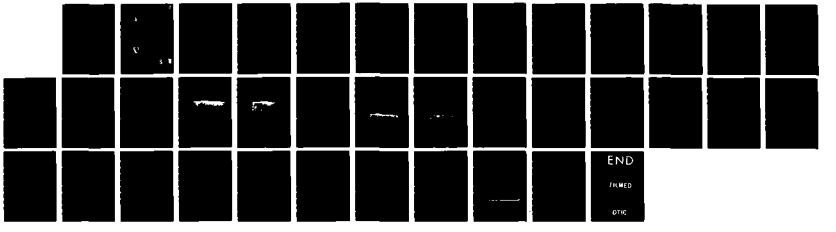

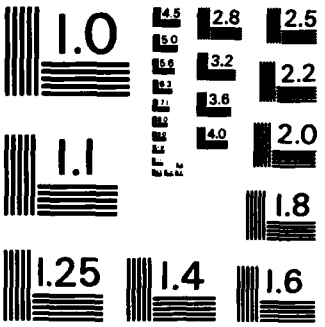

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TECHNICAL REPORT RT-85-6

ELECTROMAGNETIC SHIELDING MEASUREMENTS - NMR ENCLOSURE, UNIVERSITY OF ALABAMA AT BIRMINGHAM

Birtha L. Hooks
Daniel W. Aughinbaugh
Test and Evaluation Directorate
US Army Missile Laboratory

21 DECEMBER 1984

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

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MIL-STD 285
Attenuation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

These are the results of an EMI (Electromagnetic Shielding Measurements) shielding effectiveness test of the screened enclosure to be used for the Nuclear Magnetic Resonance Chamber at the University of Alabama in Birmingham.

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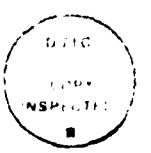

I. BACKGROUND

The Nuclear Magnetic Resonance (NMR) is a powerful new probe of the body's internal anatomy. Since its development in 1946, NMR has been used to examine the chemical environment of nuclei in a wide range of materials. This is done by utilizing the very precise relationship between resonant frequency and magnetic field experienced by the nucleus. It uses no ionization radiation and appears to be essentially without any biological hazard. These facets of the instrument make it a very important diagnostic tool. It can be very useful in detecting a wide spectrum of disorders including the spread and degree of treatment of tumors.

The University of Alabama makes use of a large magnet that has a primary frequency of 21.5 MHz in normal operation and a secondary frequency of 84 MHz when operated at higher powers.

The NMR is very sensitive to interference at its operating frequencies. Therefore, the University of Alabama at Birmingham Medical Department requested that the Army Missile Labs Electromagnetic and Nuclear Effects group conduct tests to obtain information regarding the shielding effectiveness of the room in which it was to be installed. These tests were conducted on 20 and 21 November 1984 in Birmingham, AL.

II. TEST OBJECTIVE

The purpose of this test was to determine the shielding effectiveness of the materials used in construction of an EMI shielding room for the Nuclear Magnetic Resonance Chamber using the requirements of MIL-STD 285 as a guideline.

III. TEST ITEM

The room tested was shielded with copper screening in 4 foot widths that were soldered together on the walls. Screening was also used in the ceiling, but copper plating was used in the floor and soldered to the walls.

At the time of this test, the room was not in its finished state. Copper screen was used to cover all points that were to be entry ports or windows when completed. For this test, screen was used to cover wooden frames which were used to close the doorways. These were then grounded to the walls with four straps of copper screen, approximately 6 inches wide, which were soldered to the walls on each side of the doors. One extension cord was brought inside under a door.

The only other point of entry was the air duct. The duct inside of the room was isolated from the outside duct and grounded to the screen by soldering. The duct inside of the room had a divider in its entrance to provide an aperture that was intended to attenuate most of the undesirable signals entering the duct. The walls had not been plastered, but the concrete had been poured for the floor. A diagram of the perimeter of the room is shown in Figure A-1.

IV. TEST PROCEDURE

The following procedures were used to determine the levels of attenuation in the frequency range of interest, 2 MHz to 100 MHz.

A. Reference Level Determination

Two antennas with approximately the same frequency gain characteristics were set up inside the screened room with a 1.0 meter separation. The EMCO 3104 antenna was used to transmit the amplified signal of the Hewlett Packard Model 8660 signal generator. The other biconic antenna, an EMCO 3108, was used to receive the signal for the Hewlett Packard 8566A Spectrum Analyzer to display the signal amplitude versus frequency. This information was then plotted on the Hewlett Packard 9872 plotter. The same procedure was repeated with the LP-105 loop antennas with 1.0 meter and .229 meters separation to provide an unattenuated reference level over the entire frequency range of interest.

B. Attenuated Level Determination

The receiving antennas and equipment were placed outside the screened enclosure and the attenuated signal was measured through the screen at various points around the room. The antenna separation, the resolution bandwidth of the spectrum analyzer, and the radiated power level remained the same for the reference test and the attenuated signal test. Also, the antenna used as the receiver in the reference test was used as the receiving antenna in the attenuated signal test. Therefore, the data received could be easily compared.

V. TEST RESULTS

A. Shielding Effectiveness 2.1 MHz to 30 MHz

Two reference measurements were taken in this frequency range, one at 1.0 meter and another at .229 meter. The attenuation tests conducted with the one meter separation were inconclusive because the signal received through the screen was not great enough to be seen above the internal noise level of the spectrum analyzer. This data is not presented in this report but is available upon request.

The data taken with .229 meter as the reference separation allowed the determination of the shielding effectiveness of the screen. The reference data is shown in Figures A-2, A-3, and A-4. The attenuation test data is shown in Figures A-5 through A-8. This data shows that the attenuation level is 60 decibels across the frequency band of interest. Measurements were taken at the junction of the duct and the screen at 21.5 MHz. The signal was attenuated by more than 60 dB and can be seen in Figure A-22.

B. Shielding Effectiveness 30 MHz to 100 MHz

All data was taken with the antenna horizontally polarized in this frequency band. Also, the reference level was obtained with a 1 meter separation distance and can be seen in Figure A-9. Figure A-10 displays the room ambient in this band. The following areas were tested:

1. The data taken on the south wall is shown in Figures A-12, A-13, A-14, and A-15, and the minimum level attenuation was 60 dB.

2. On the north wall, shown in Figure A-19, the minimum level of attenuation was 49 dB.

3. The console window in this frequency band, shown in Figure A-21, was found to have an attenuation level greater than or equal to 50 dB.

4. On the east wall, shown in Figure A-16, the attenuation level shows a minimum of 52 dB, and when the floor was measured the received signal was so low that it could not be discerned above the ambient levels.

Because of interference from other emitters in the 80 MHz to 100 MHz frequency band, it was not possible to determine the exact level of attenuation in that region of the spectrum.

VI. CONCLUSIONS AND RECOMMENDATIONS

The attenuation provided at all points in the 2.0 MHz to 30 MHz frequency range was 60 dB. The attenuation provided above 30 MHz was a minimum of 48 dB at the points tested. Since the primary frequency of the MFR is in the range where the room provides 60 dB attenuation, an electromagnetic interference problem is unlikely.

It is recommended that the attenuation level of the room be checked when the room is completed.

APPENDIX

DEFINITION OF TERMS

AND

EQUIPMENT LIST

DEFINITION OF TERMS

Ambient levels - The radio frequency levels in the environment before the test source begins to radiate.

Resolution Bandwidth - The 3 dB bandwidth of the radio frequency stages of the spectrum analyzer.

Attenuation - The amount the RF signal is reduced when shielding is placed between the source and the receiver.

EMI - Electromagnetic Interference.

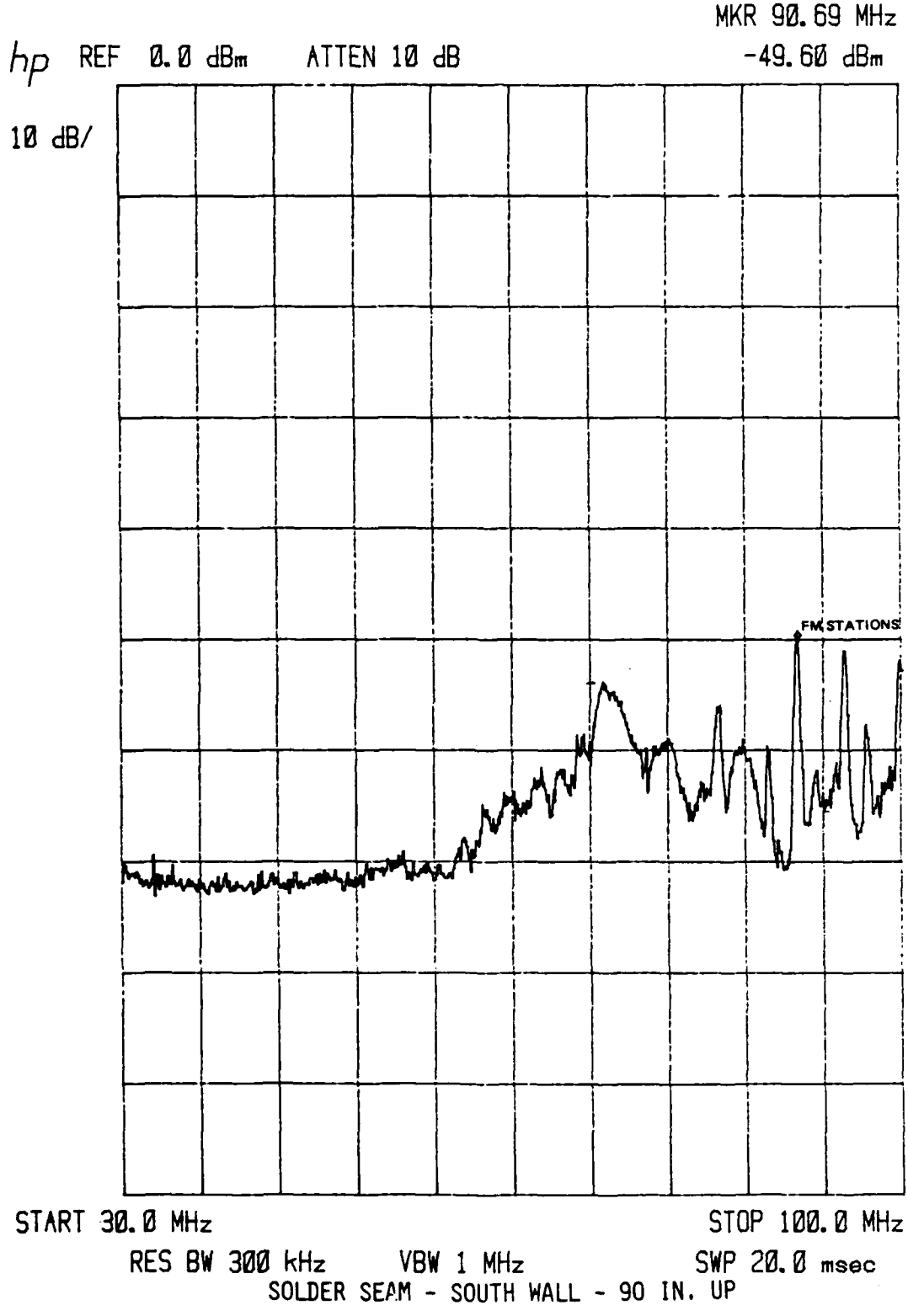

Figure A-13. Solder seam - south wall - 90 in. up.

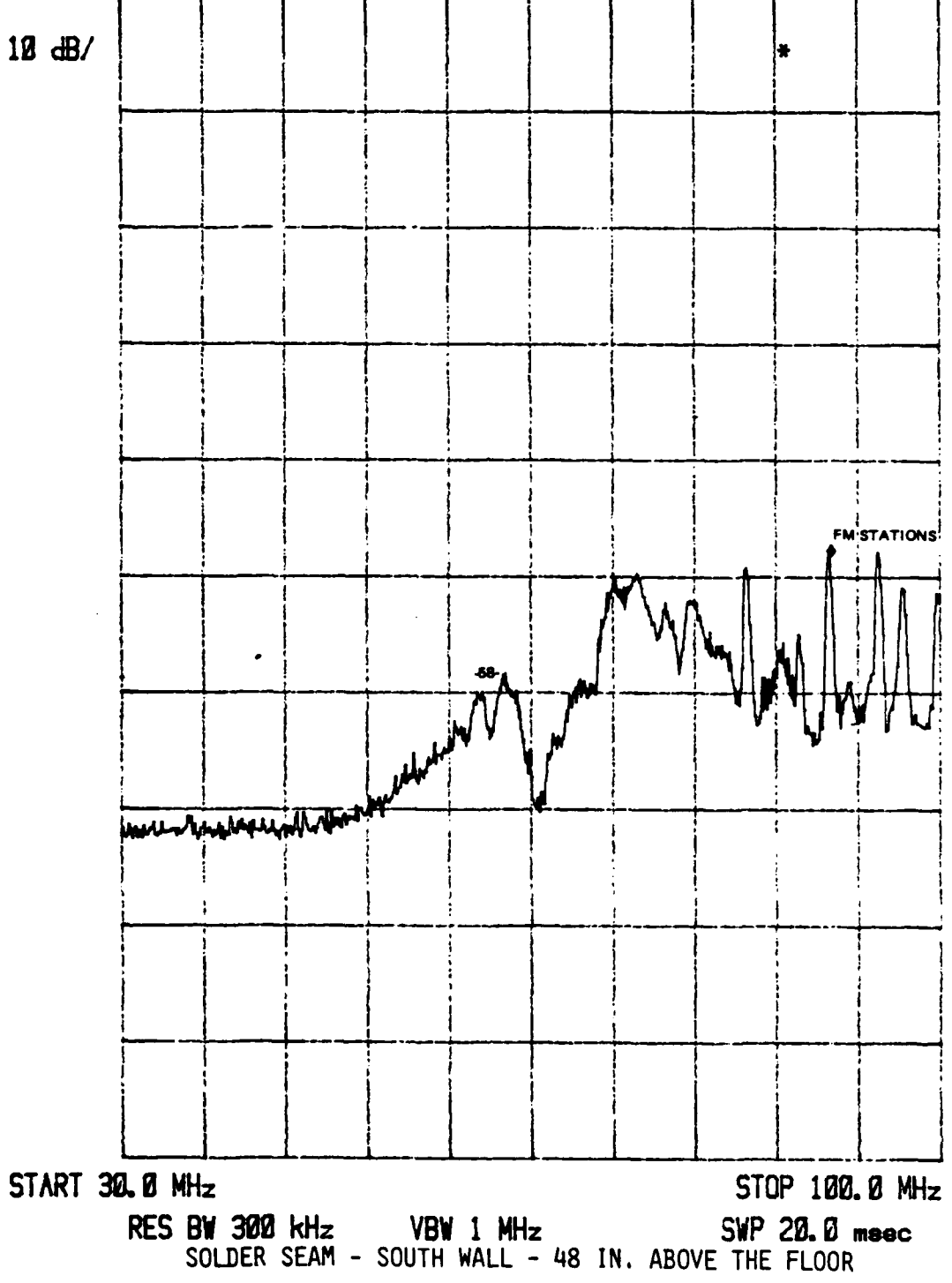

Figure A-12. Solder seam - south wall - 48 in. above the floor.

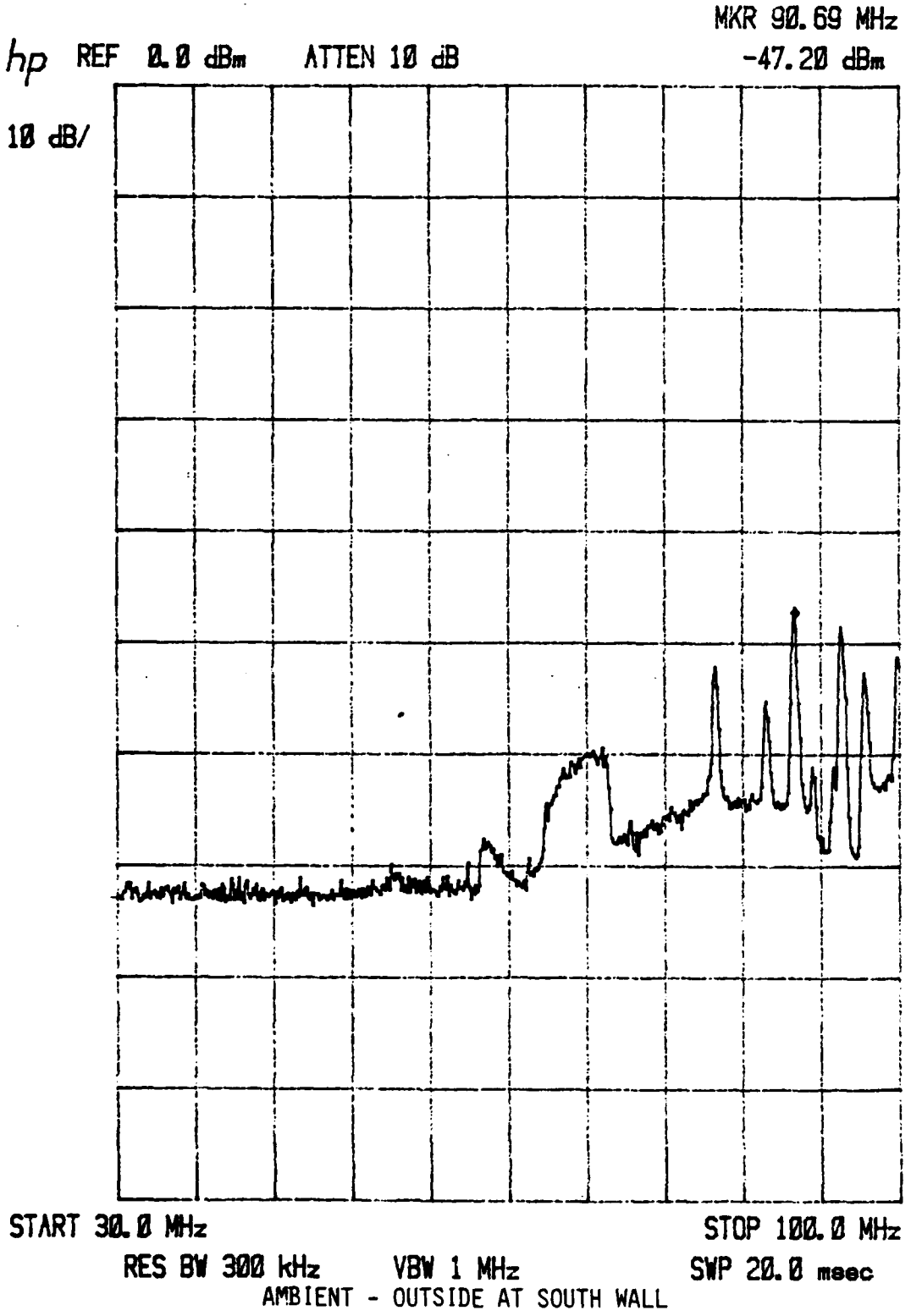

Figure A-11. Ambient - outside at south wall.

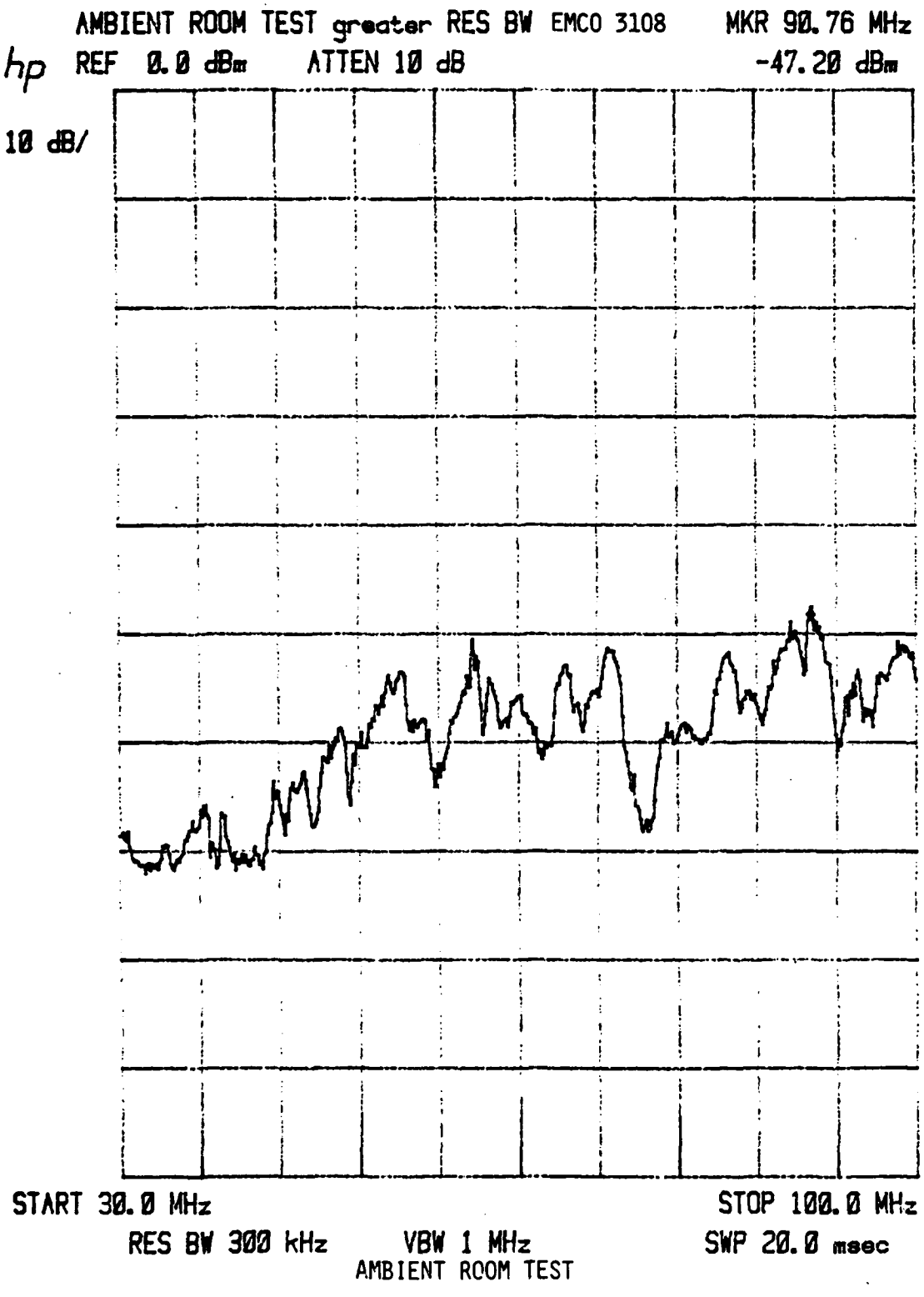

Figure A-10. Ambient room test.

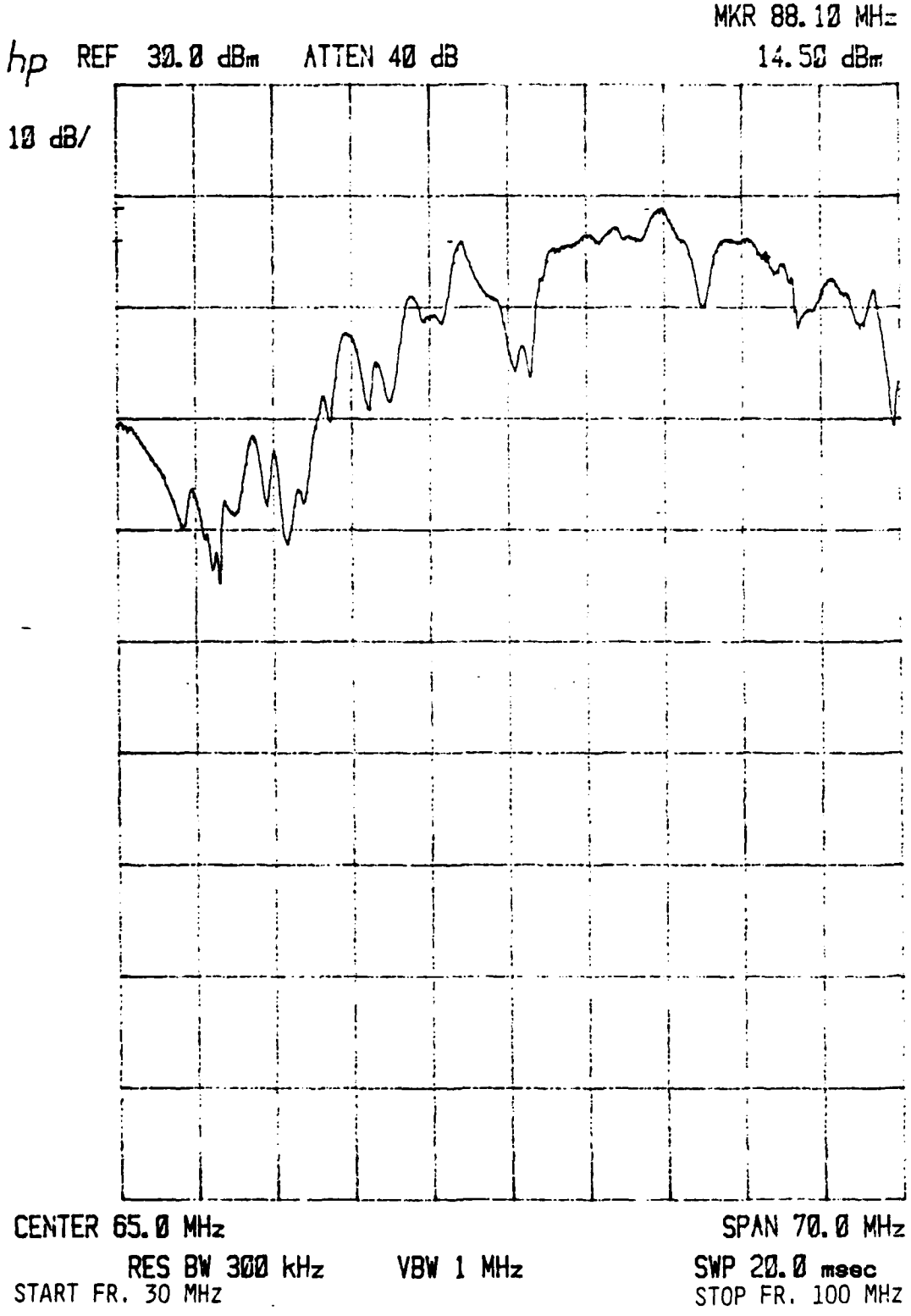

Figure A-9. One meter reference.

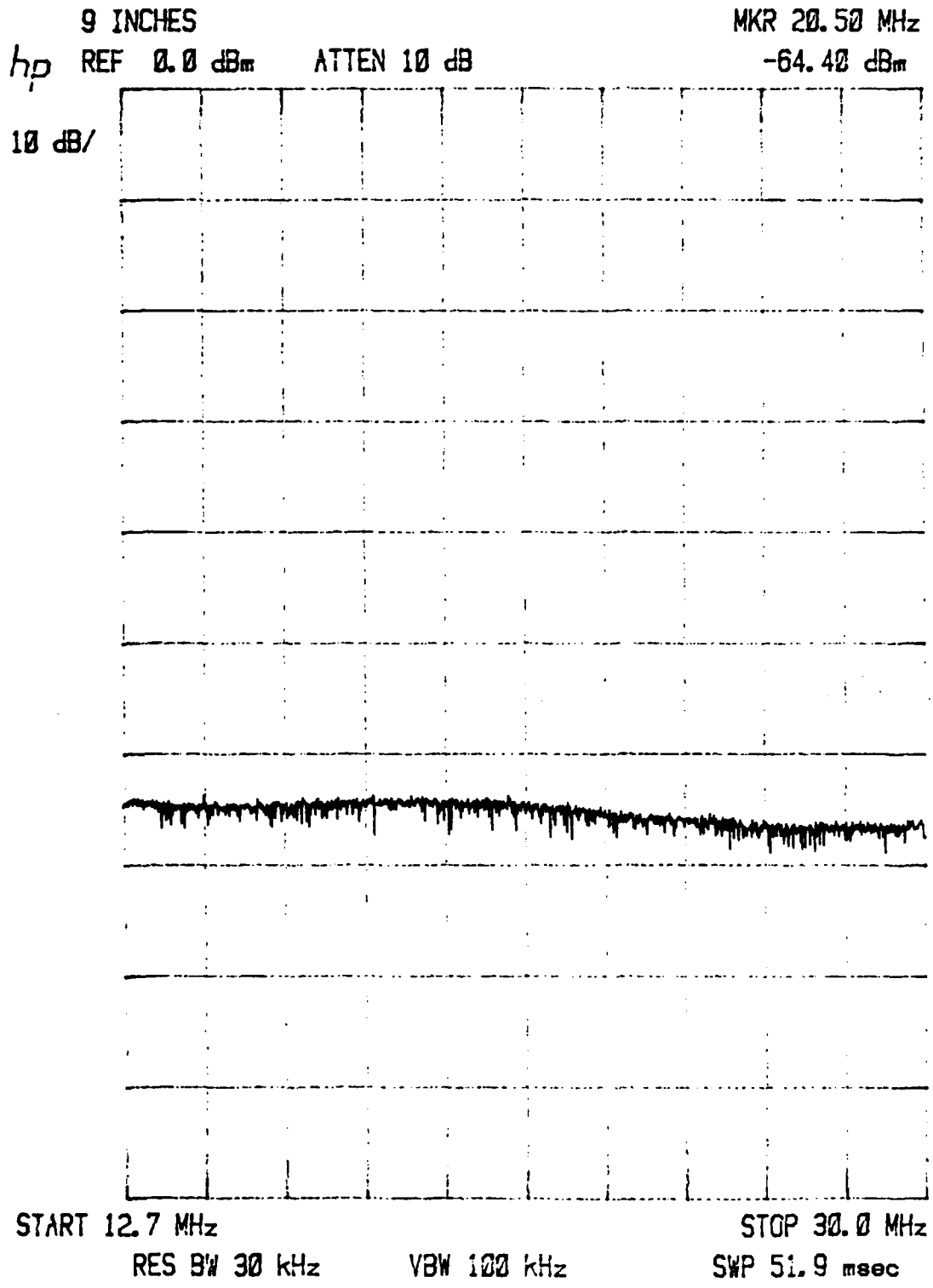

Figure A-8. West wall, 10 ft from southwest corner - .229 meter.

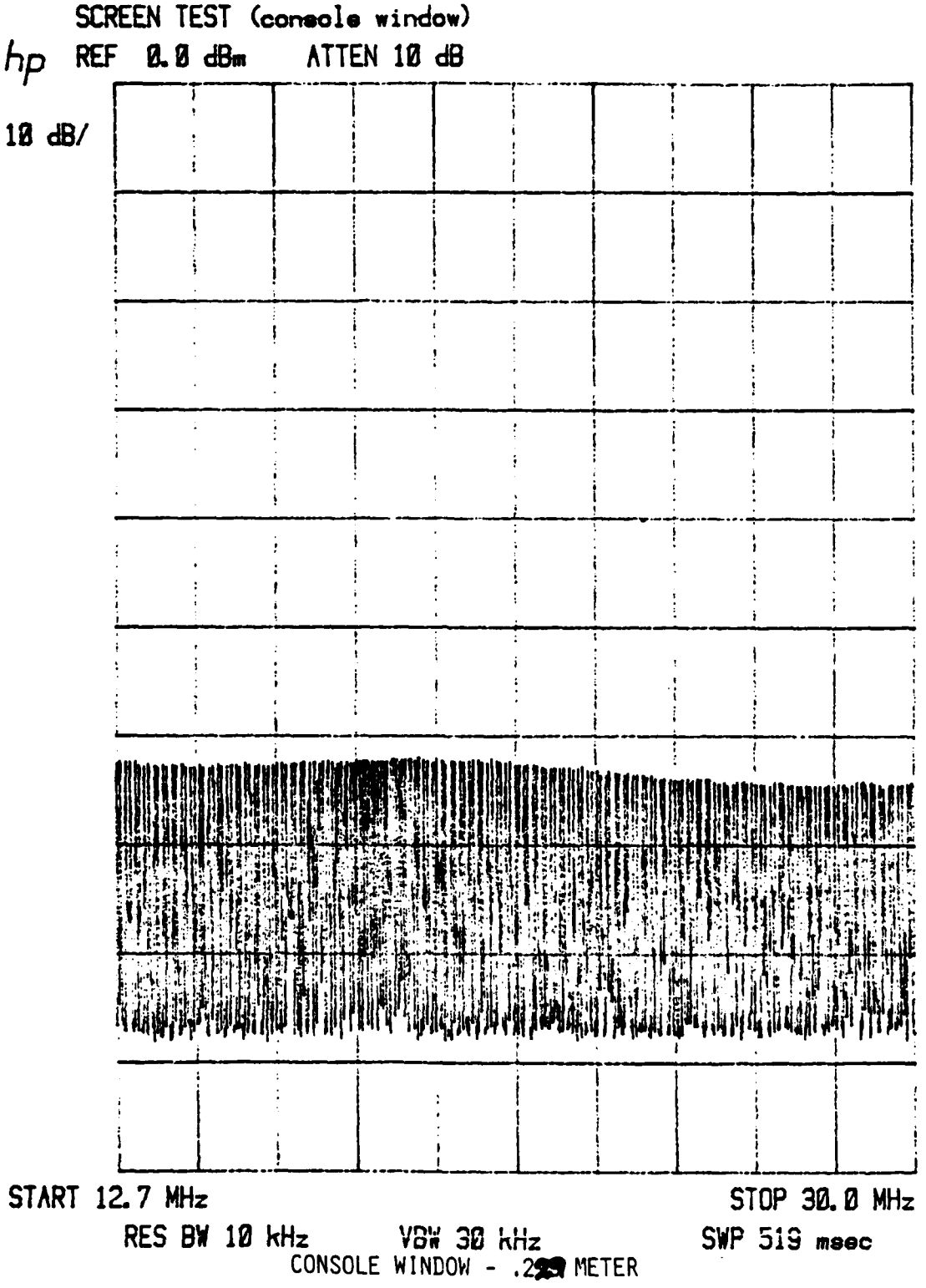

Figure A-7. Console window - .229 meter.

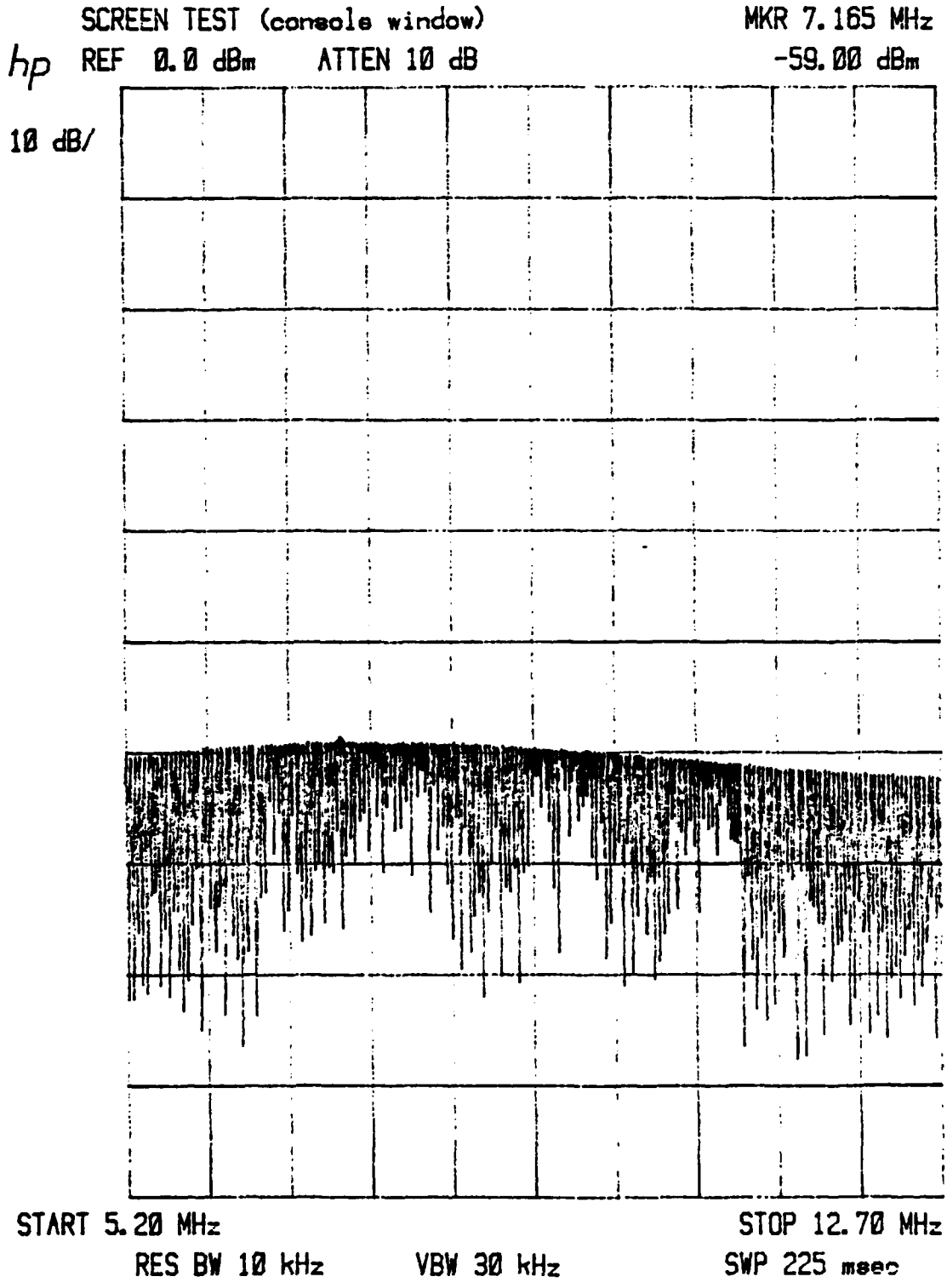

Figure A-6. Console window - .229 meter.

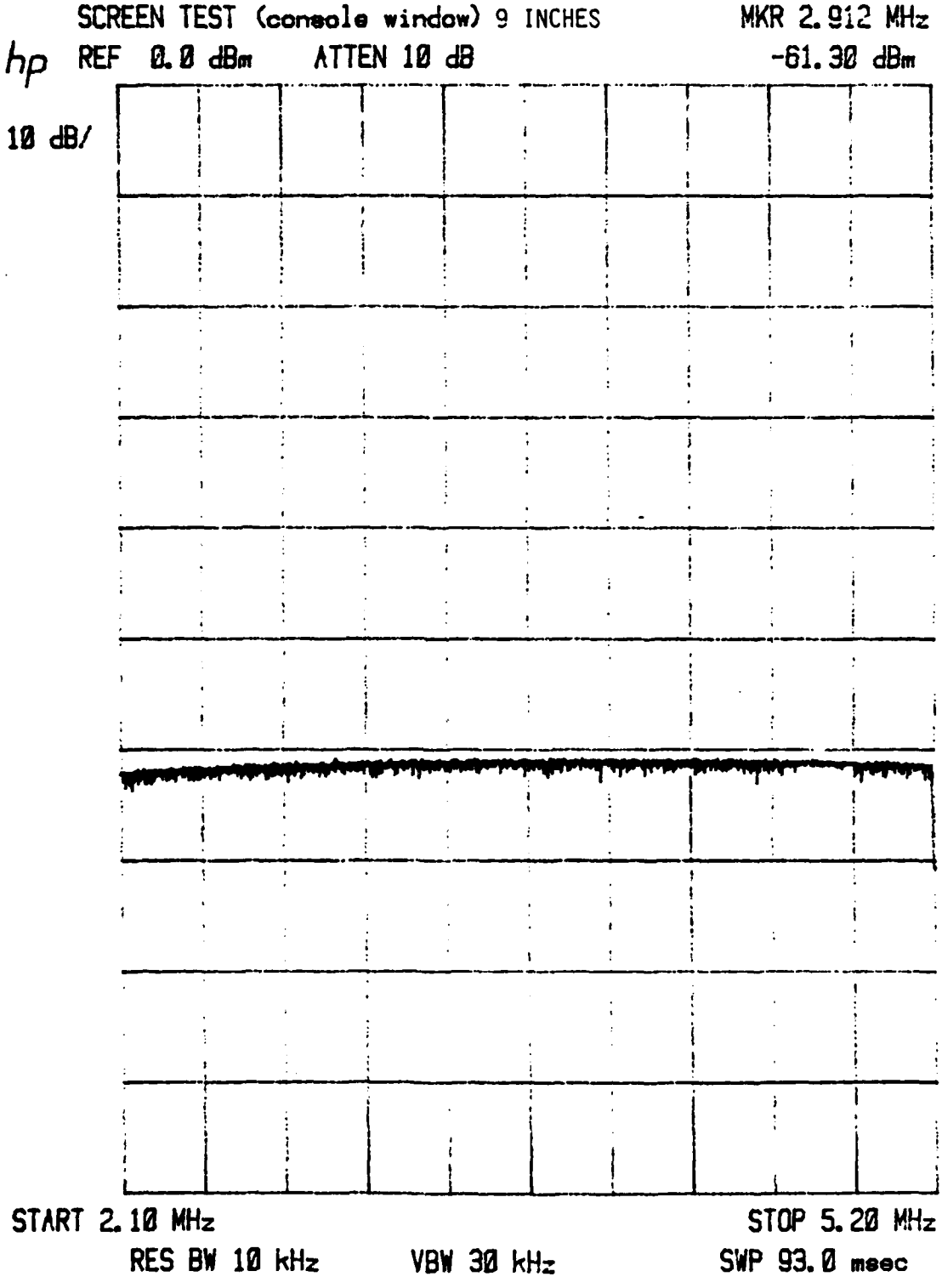

Figure A-5. Console window - .229 meter.

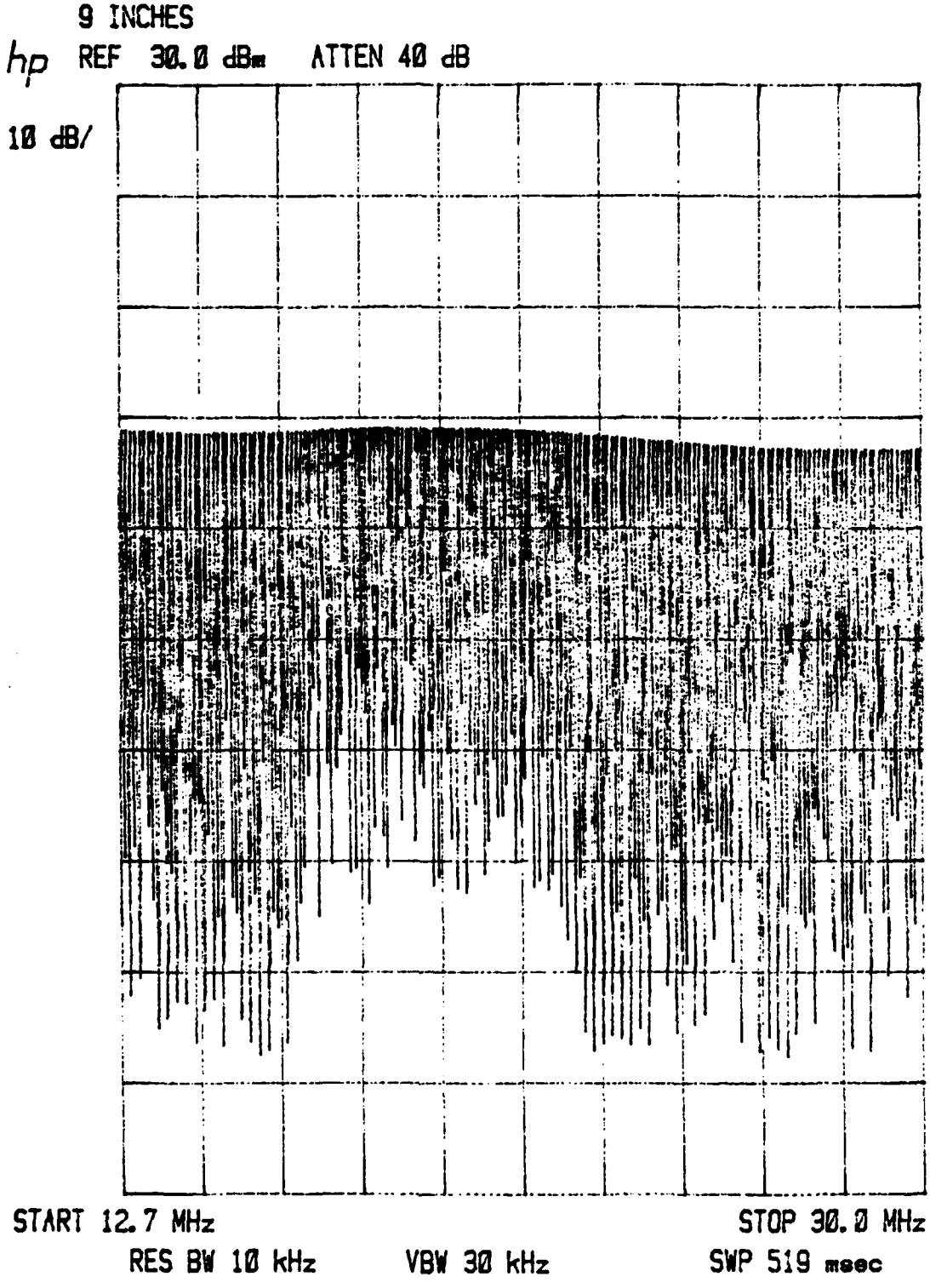

Figure A-4. .229 Meter reference.

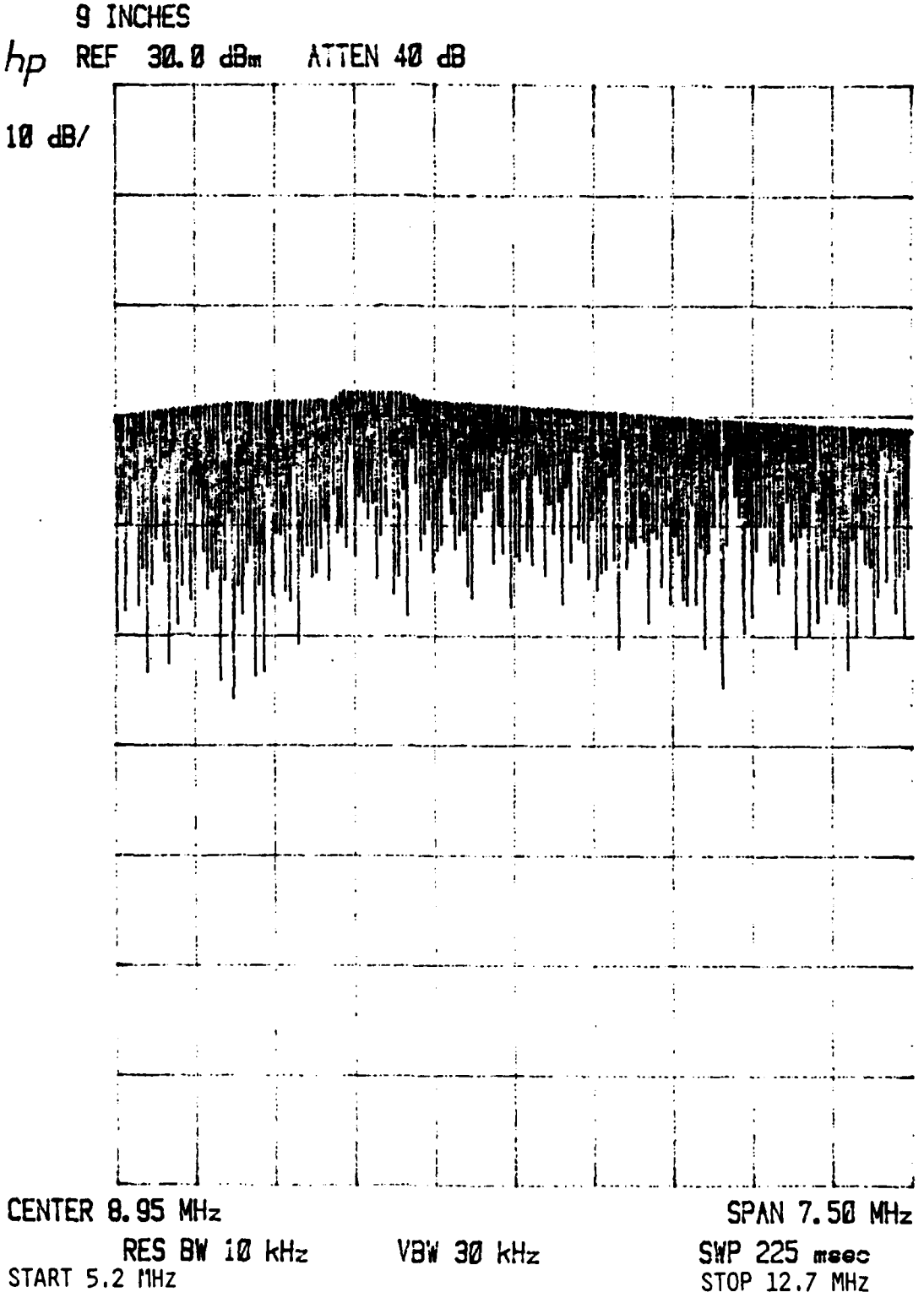

Figure A-3. .229 Meter reference.

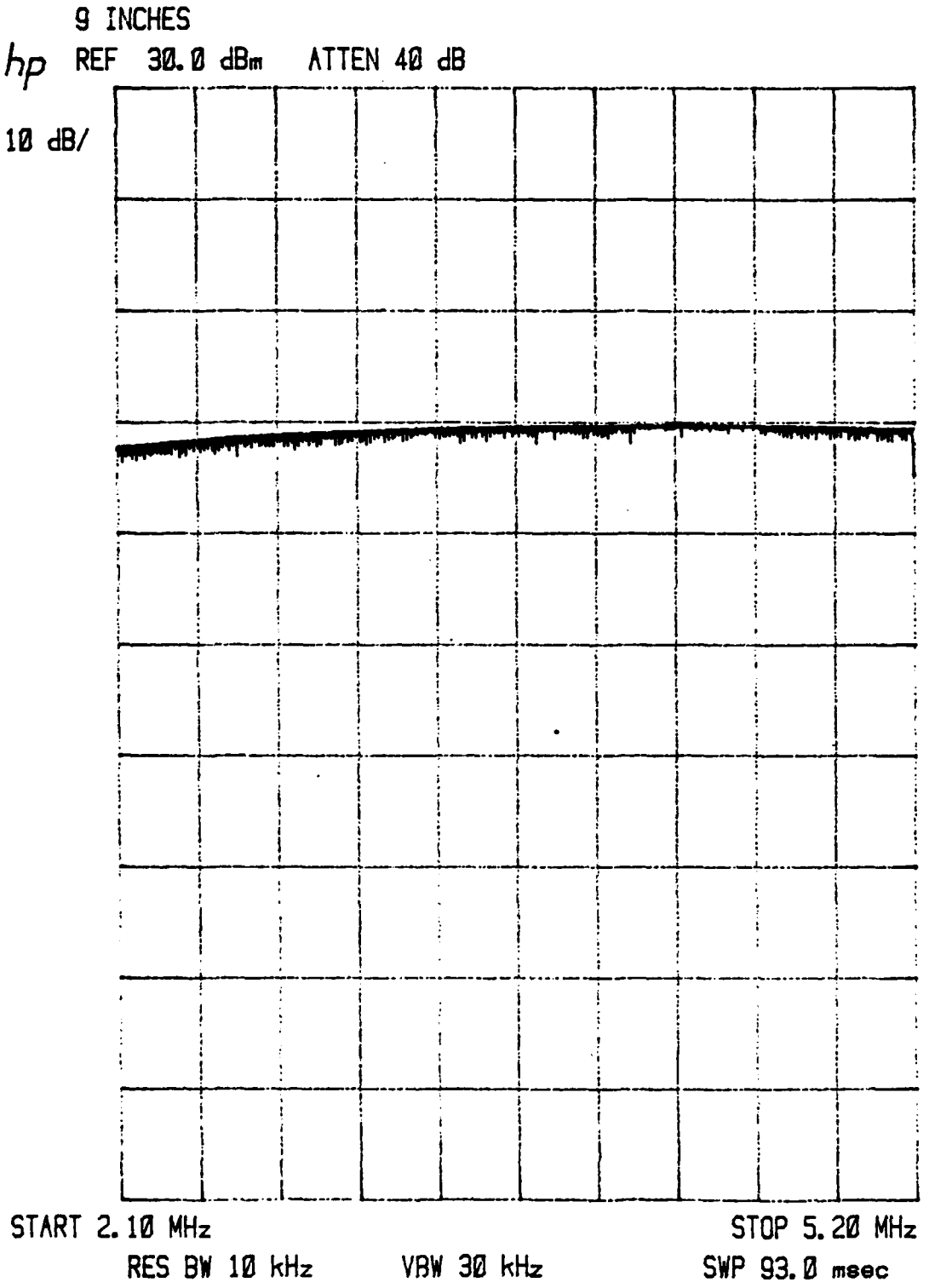

Figure A-2. .229 Meter reference.

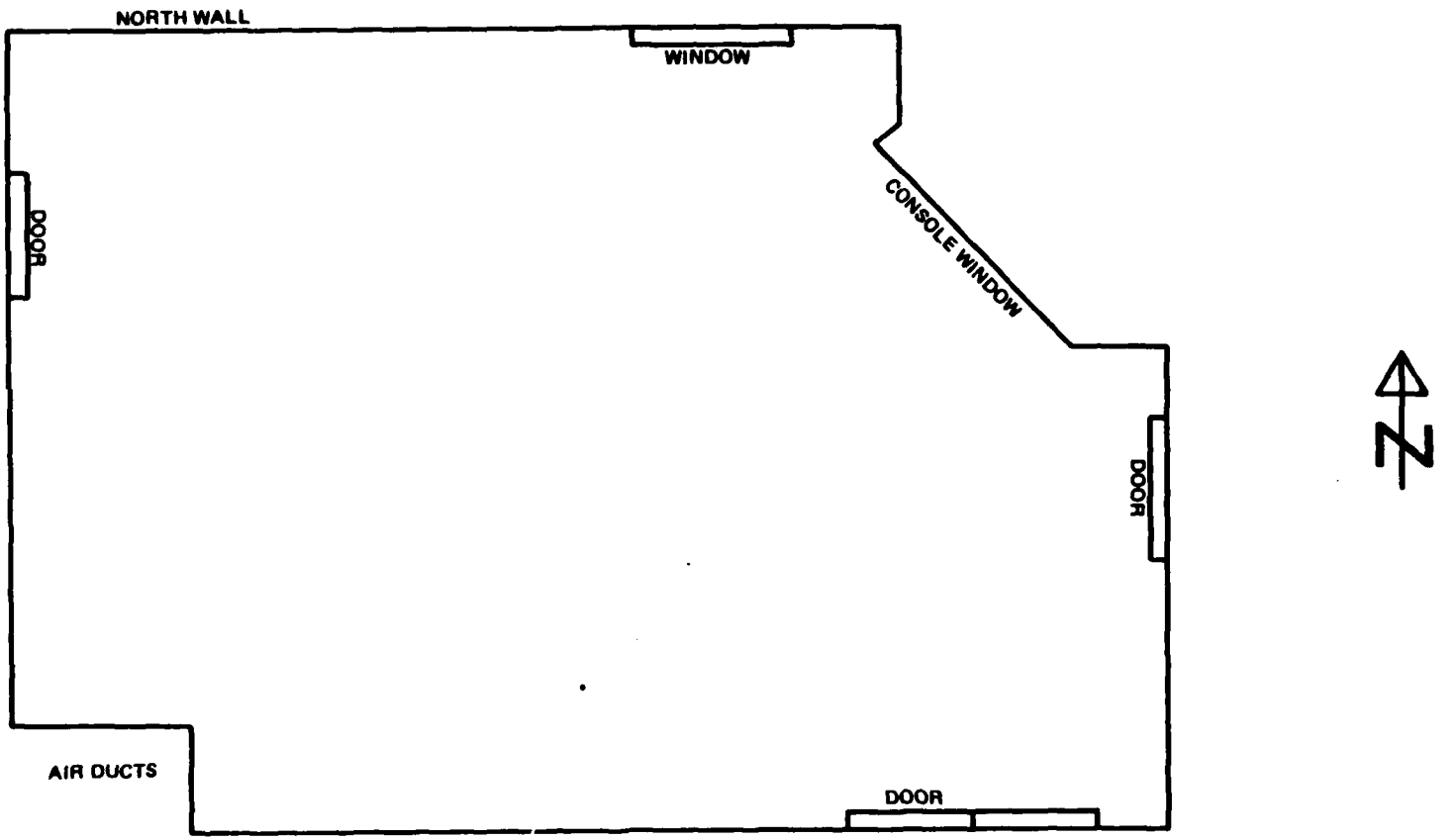

Figure A-1. The perimeter of the electromagnetic resonance (EMR) room.

EQUIPMENT LIST

Spectrum Analyzer	Hewlett Packard 8566A
Signal Generator	HP 8660 (1 to 2600 MHz plus in)
Amplifier	EIN 503L (1 - 500 MHz)
Plotter	HP 9872
Controller	HP 9825
Biconic Antennas	EMCO 3104 and EMCO 3108
Loop Antennas	LP - 105

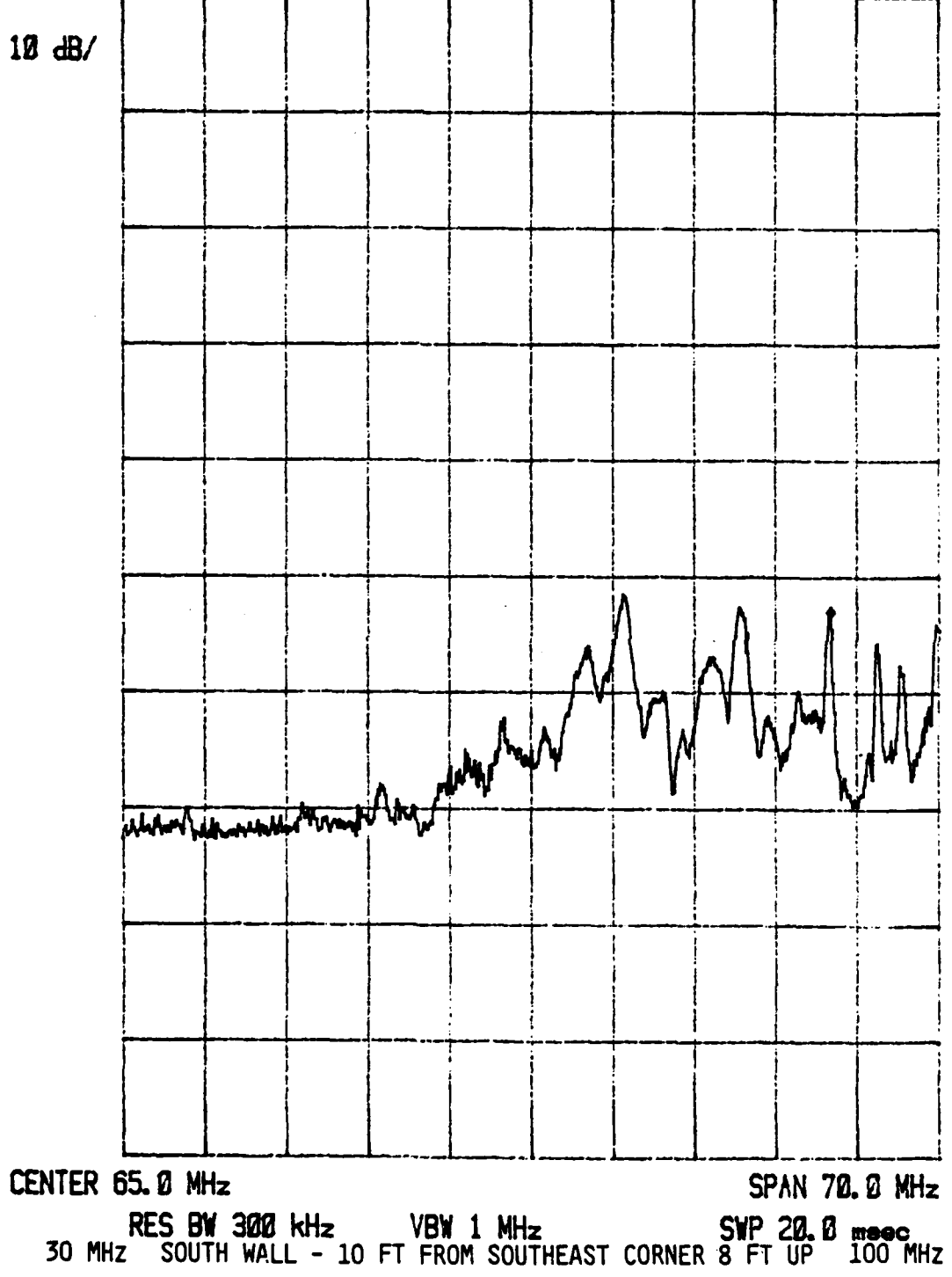

Figure A-14. South wall - 10 ft from southeast corner 8 ft up.

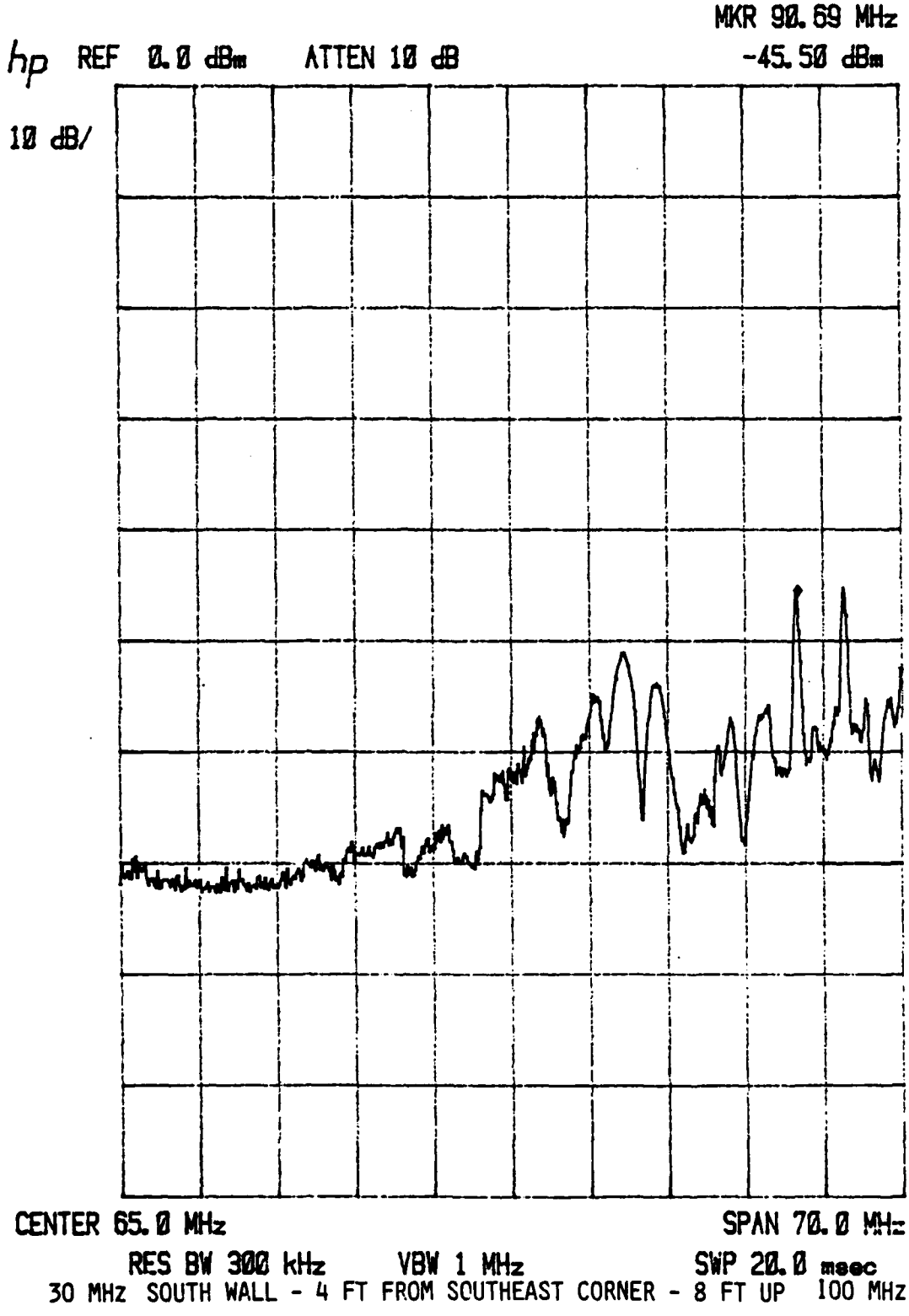

Figure A-15. South wall - 4 ft from southeast corner - 8 ft up.

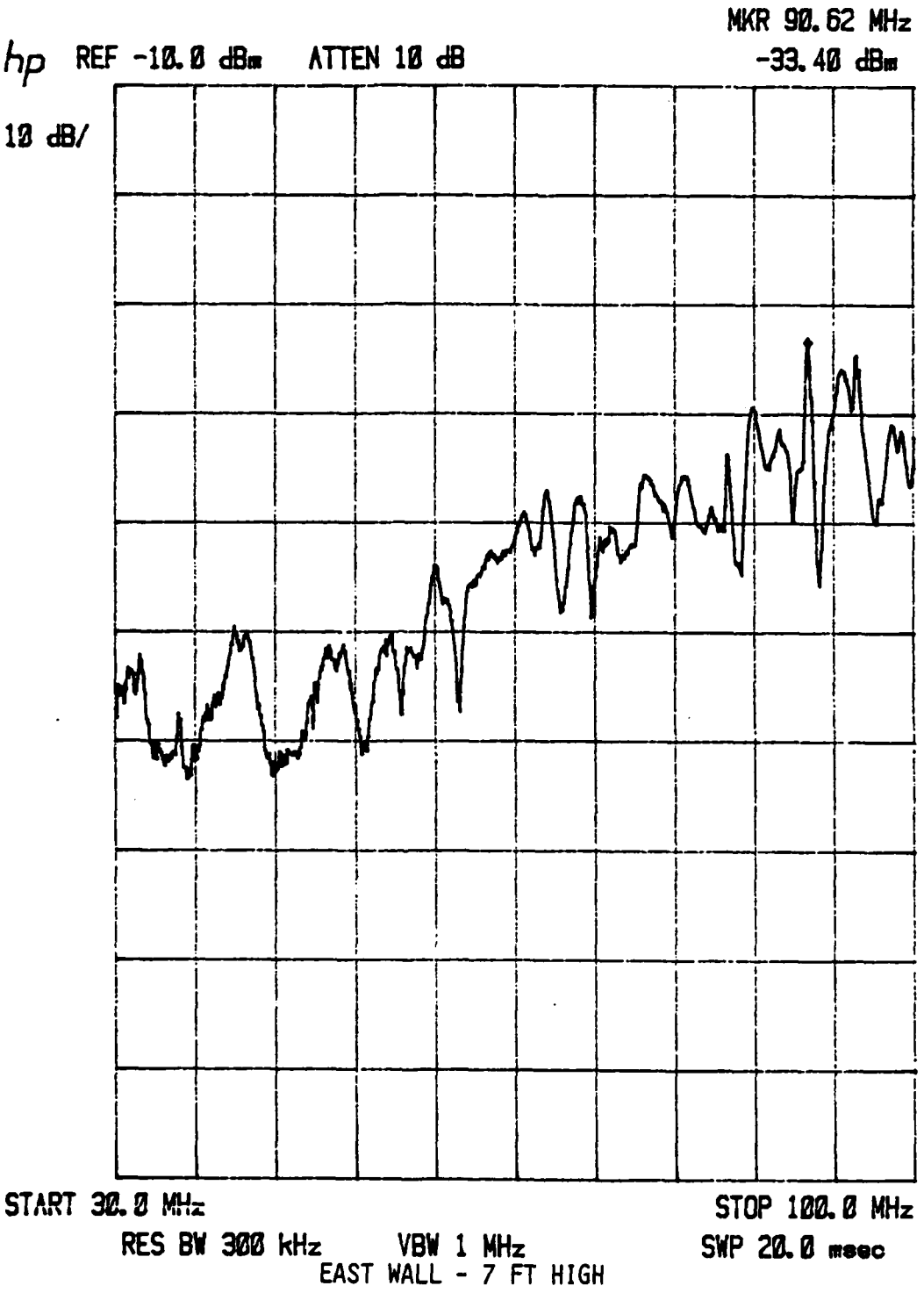

Figure A-16. East wall - 7 ft high.

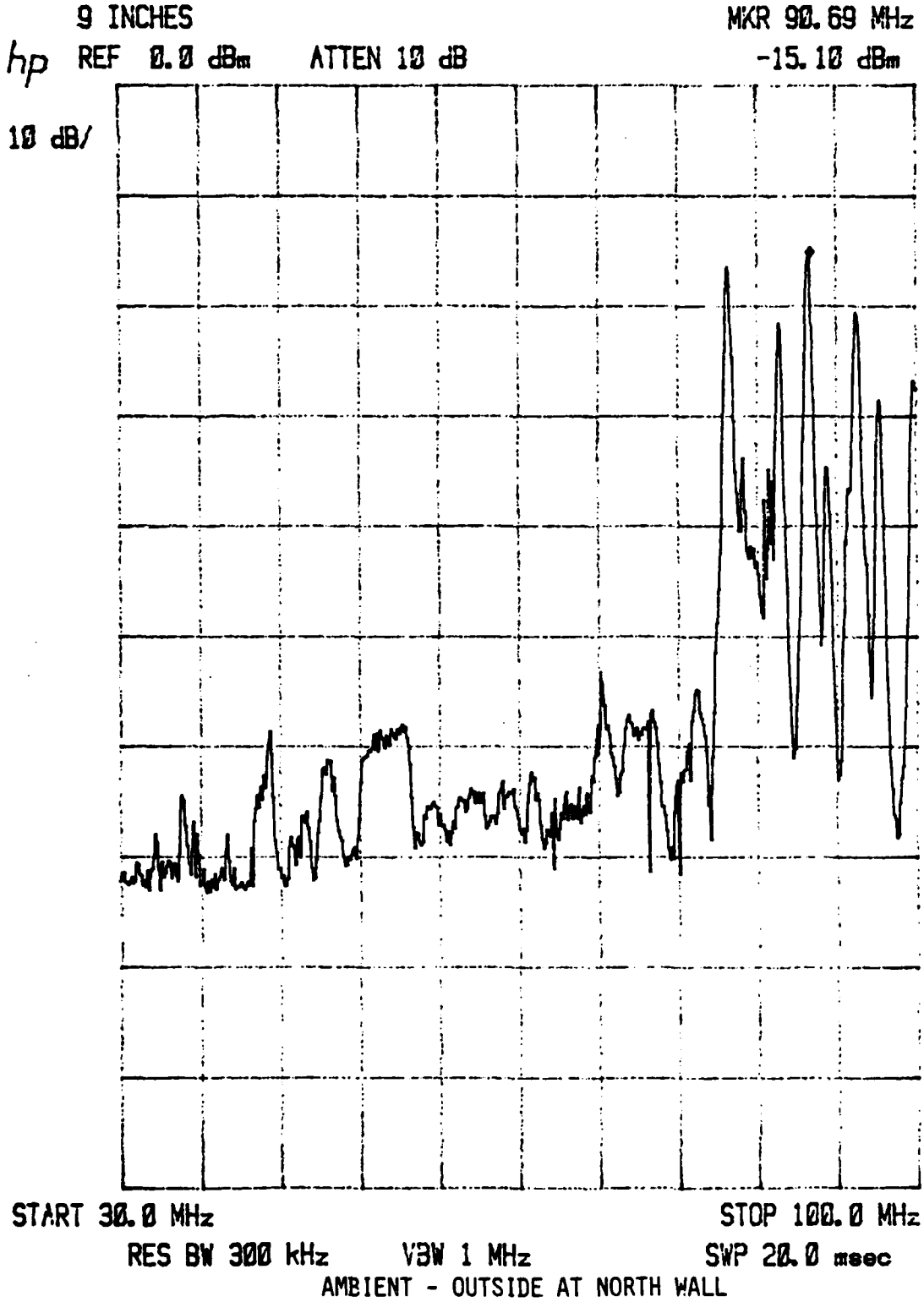

Figure A-17. Ambient - outside at north wall.

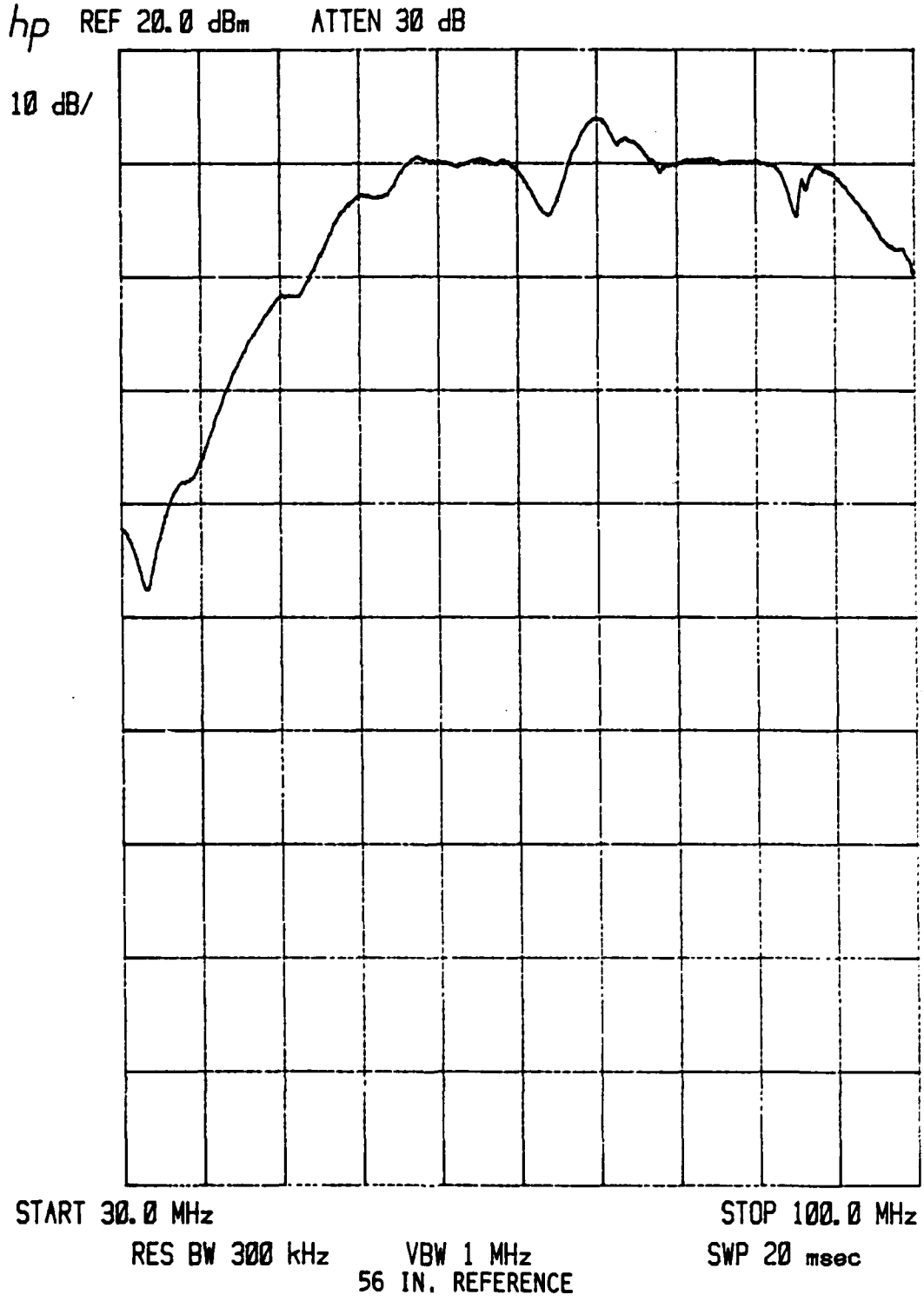

Figure A-18. 56 In. reference.

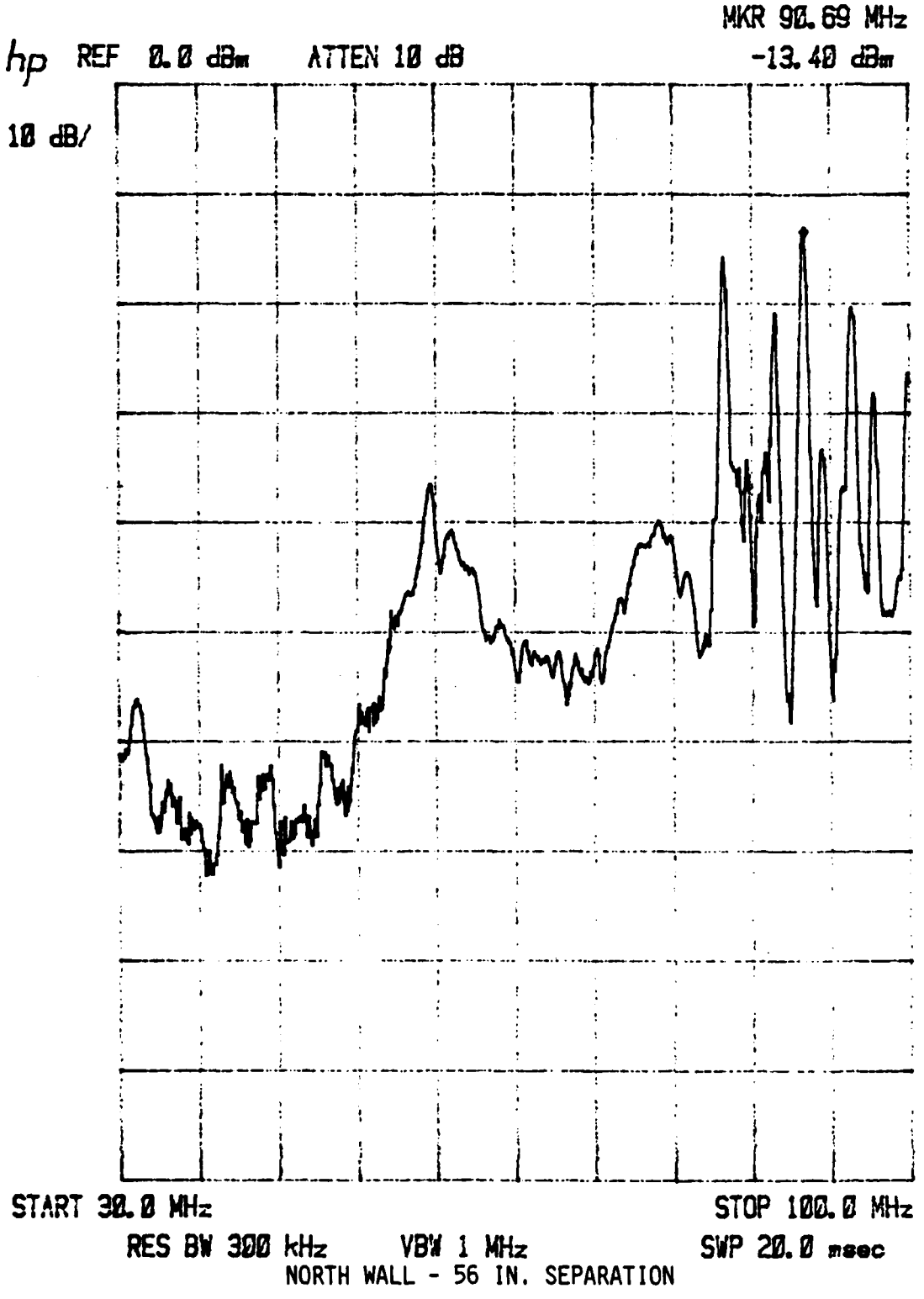

Figure A-19. North wall - 56 in. separation.

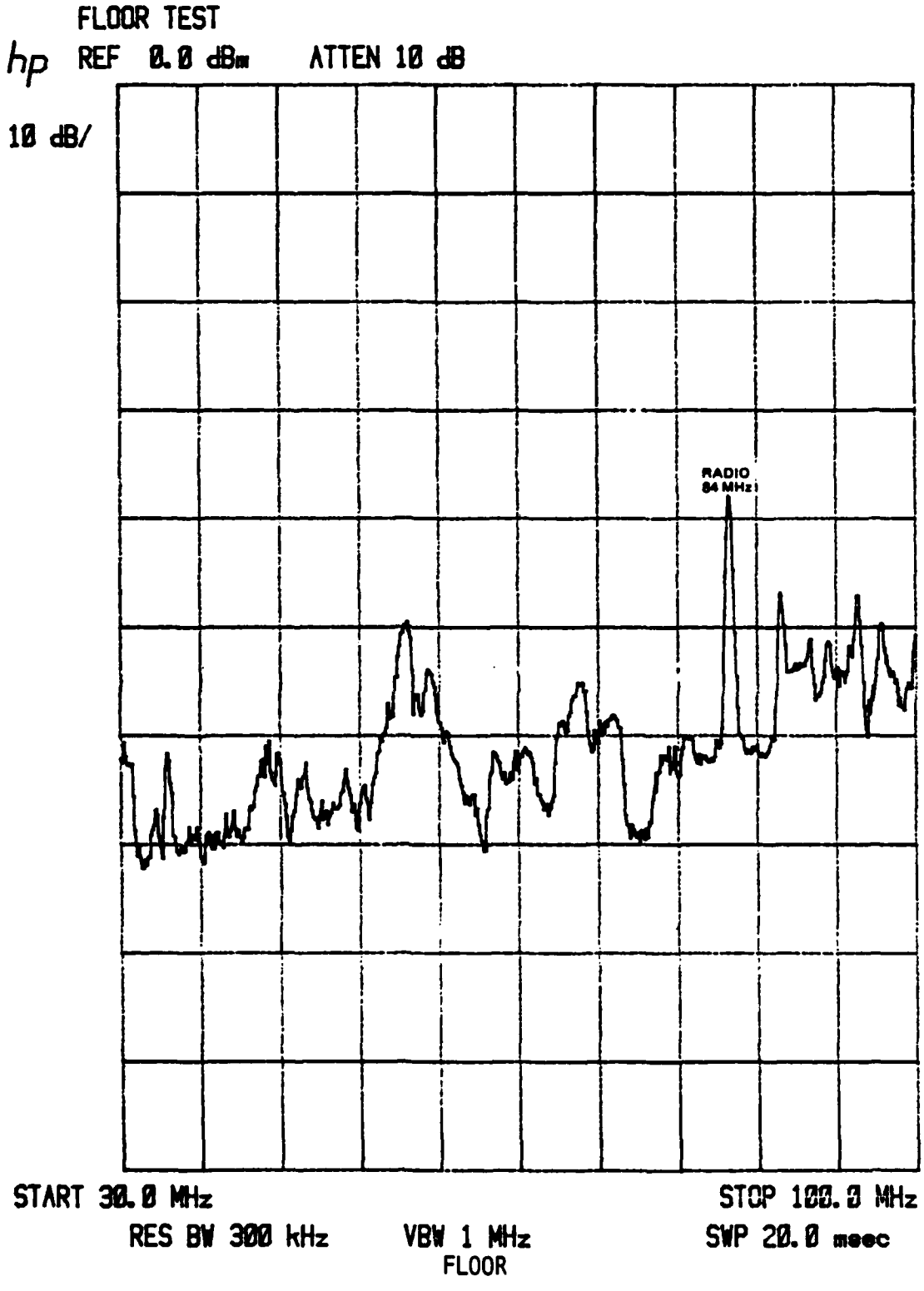

Figure A-20. Floor.

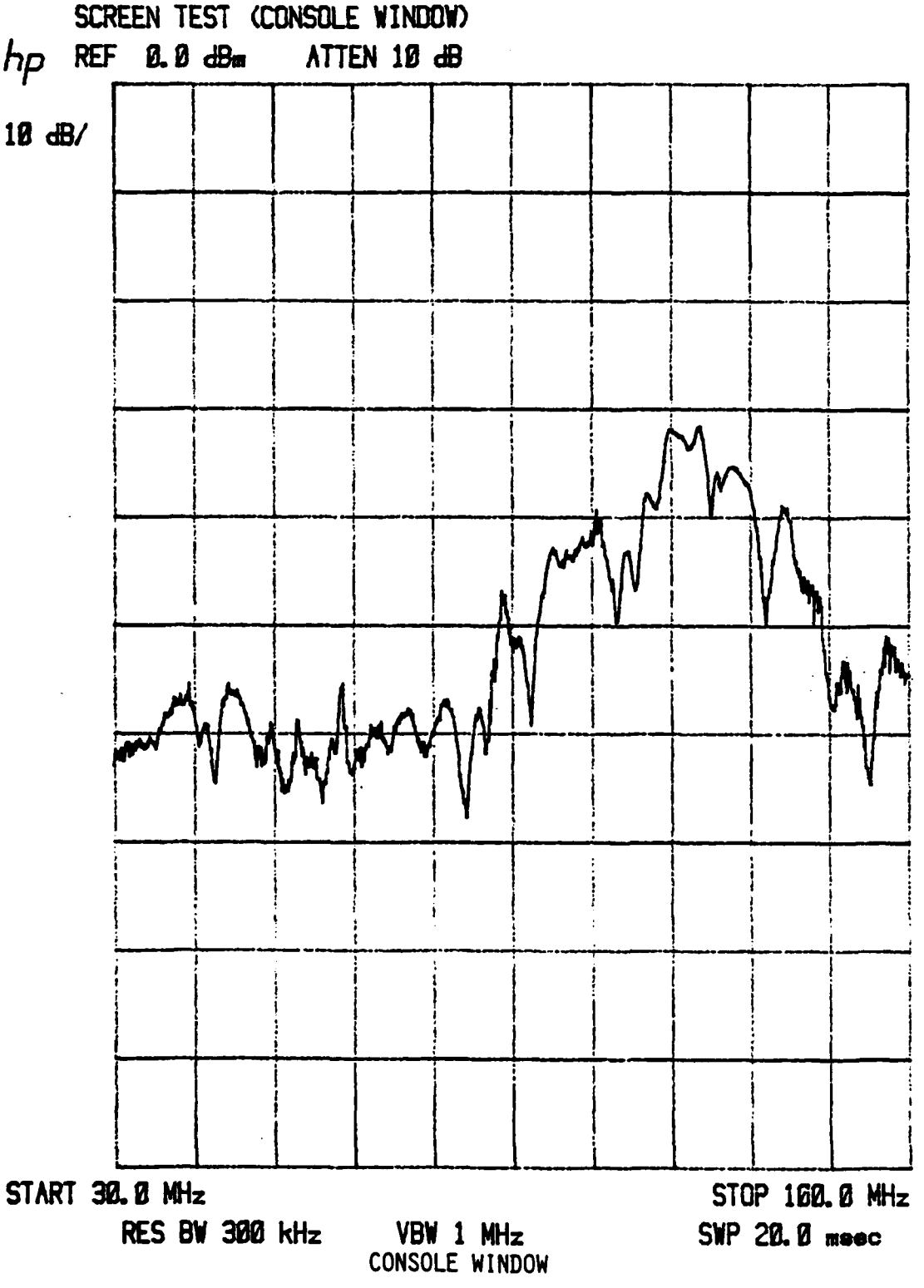

Figure A-21. Console window.

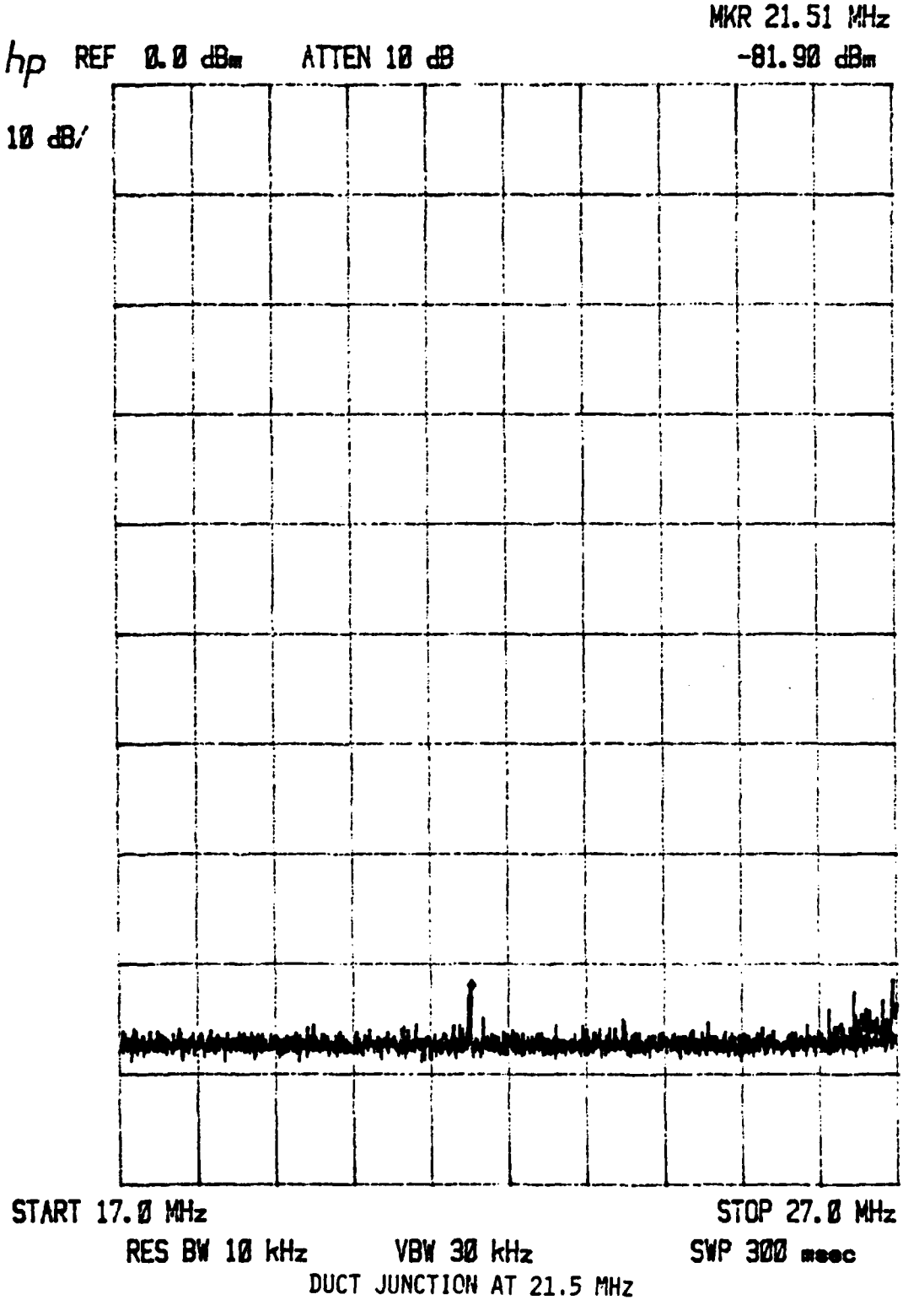

Figure A-22. Duct junction at 21.5 MHz.

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