AFCRL-67-0549

THE NEW ENGLAND SEISMIC NETWORK

F. Thomas Turcotte

Trustees of Boston College
Chestnut Hill, Mass. 02167

Contract Number: F1962867C0021

Project Number: 8652

Task Number: 865205

Work Unit Number: 86520501

FINAL REPORT

Period Covered: 15 September 1966 - September 15, 1967

15 October 1967

Contract Monitor: Henry A. Ossing
Terrestrial Sciences Laboratory

Work Sponsored by Advanced Research Projects Agency, Project Vela-Uniform
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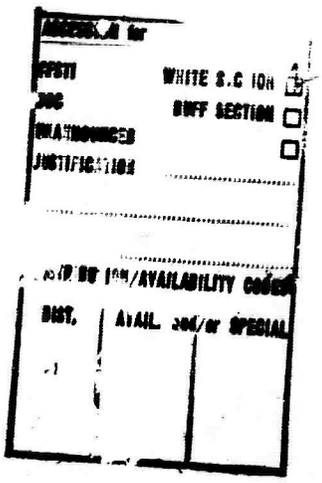
Prepared for
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS



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ABSTRACT

A description of the station sites and instrumentation forming the New England Seismic Network.

Local earthquake activity recorded from September 15, 1966 to September 15, 1967 is summarized.

Magnification curves for the recording system form an Appendix.

TABLE OF CONTENTS

1. INTRODUCTION

The New England Seismic Network is composed of four substations located in northern New England which telemeter seismic data to the main recording station at the Observatory in Weston, Massachusetts.

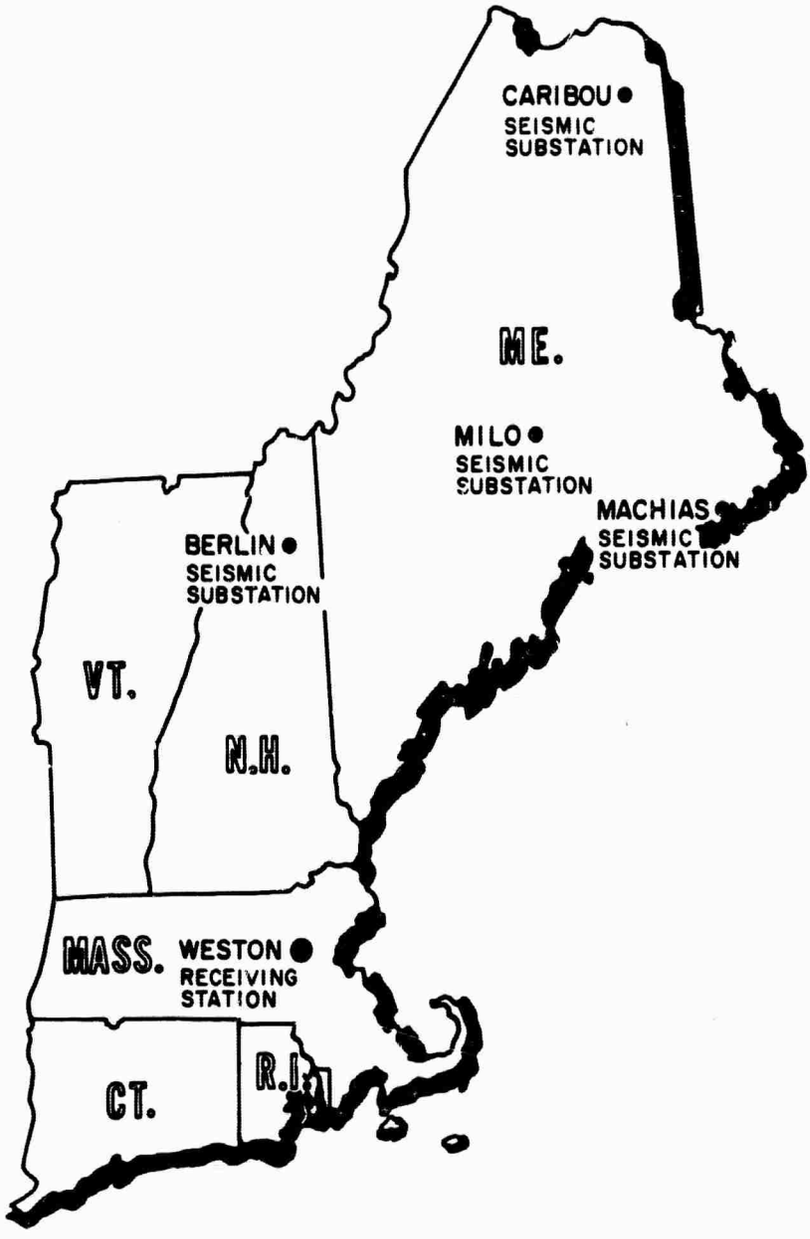
The station at Milo, Maine is near the center of a diamond shaped pattern formed by the remaining four stations at Berlin, New Hampshire; Caribou, Maine; Machias, Maine; and Weston, Massachusetts. This pattern insures that no potential epicenter in northern New England will be more than 150 miles from at least two seismic stations. Furthermore, the known active areas in New Hampshire and Maine are less than 100 miles from at least two of the recording sites.

The station sites are mapped in Figure 1. Station coordinates and inter-station distances are given in Table 1.

The original choice of site locations was governed by four factors: bedrock conditions, proximity of power lines, proximity of suitable telephone cables, and absence of nearby noise sources. Slight cover of bedrock was desired to provide minimum weathering with modest excavation. Avoided noise sources were railways, heavy machinery installations, highways and heavily traveled roads, lakes and coastal surf.

2. STATION ENVIRONMENT

Berlin: This station is located in northern New Hampshire, due north of Weston. The site is north of Berlin, four miles from the junction of state highway 26 and 110B, along 110B. The recording site is near the base



New England SEISMIC NETWORK

Figure 1

SITE LOCATION INFORMATION
TABLE 1

Site	Symbols	Longitude	Latitude	Elevation in Meters
Berlin, N. H.	BNH-B	71°15'23"W	44°35'26"N	472
Milo, Maine	MIM-M	69°14'25"W	45°14'37"N	140
Machias, Maine	EMM-E	67°29'22"W	44°44'21"N	20
Caribou, Maine	CBM-C	68°07'15"W	46°55'57"N	250
Weston, Mass.	WES-W	71°19'20"W	42°23'05"N	60

The distances from Milo to the network stations are tabulated below, together with the x, y coordinates in a grid system with Milo, Maine at the origin.

Site	Distance (km)	Distance (Deg)	Grid Coordinates (km) x(East)	Grid Coordinates (km) y(North)
CBM	200.74	1.803	71.11	187.73
MIM	0.00	0.000	0.00	0.00
EMM	134.53	1.209	122.30	- 56.06
BNH	189.39	1.701	-174.94	- 72.57
WES	366.88	3.296	-183.59	-317.65

steep hillside, 250 feet from the lightly traveled highway, and 120 feet from a residence. The distance to the nearest point on the Grand Trunk Railway is 8000 feet.

Caribou: The recording site is four miles northwest of the city of Caribou in northern Maine. The station is approximately 150 feet east of Route 162 and 25 feet off a little used roadway. There are trees averaging 20 feet in height in the immediate vicinity of the recording hut. The Aroostook Valley Railroad tracks are 5200 feet to the west. The bedrock outcropping in this area is a fissile limestone with vertical dip. The topography is flat.

Machias: This recording station is the easternmost point of the Network, and is located 2.5 miles northwest of Machias, Maine. The site is 30 feet south of Route 192 and is near an occupied house. Bedrock at this location is a fine grained, homogeneous granite. Rabley Lake is approximately 3.5 miles northeast of the site while the nearest point of the Maine Central Railroad is 7700 feet southeast. The topography is flat.

Milo: The station is midway between the towns of Milo and Dover-Foxcroft in central Maine. The recording hut is on exposed bedrock in a large flat open field, 150 feet north of Route 16. The Bangor and Aroostook Railway is 9150 feet to the south, and Dow Pond is 8200 feet northwest of the station.

Aside from farming activity one or two days a year, man-made noise is not significant at any of the recording sites. The microseism level is only slightly higher at the Machias station in spite of the proximity of this station to the ocean (the city of Machias is at the Head of an inlet to the Bay of Maine).

3. INSTRUMENTATION

Each station has a concrete pier poured on bedrock and is housed in a small Butler building. The instrumentation at each site is a three-component set of short period portable Benioff seismometers. The seismometers have auxiliary calibration coils, and calibration pulses are controlled remotely from Weston.

Peak magnification is normally about 150,000 (on the x20 film viewer) at -18db. Variations in microseism levels are such that the gain may be doubled (-12db) during the quieter summer months while maintaining excellent signal to noise characteristics; or halved to 75,000 (-24db) during portions of the winter months with poor signal to noise characteristics.

The seismometers are set for critical damping. Gains at the recording sites are set so that a 0.1 gram weight lift equivalent calibration current will drive the voltage controlled oscillator to 85% of its bandwidth.

4. CALIBRATION

Calibration curves for each telemetered component are presented in the Appendix. The curves apply directly to data viewed on the x20 magnification film viewer and recorded at -18db.

The harmonic magnification $\mathcal{M}_{(f)}$ is obtained from

$$\mathcal{M}_{(f)} = \frac{A f^2}{K i_s} \qquad (1)$$

where f is the frequency of the sinusoidal current i_s driving the seismometer. A is the amplitude of recorded motion read on the film viewer, and K is defined by

$$K = \frac{G}{4\pi^2 M} \qquad (2)$$

with

$$G = \frac{x_t \; g \;\; \text{Wt.} \; x10^{-5}}{x_w \; i_t} \quad \frac{\text{newtons}}{\text{ampere}} \tag{3}$$

The moving mass M is 15 kilograms for the vertical seismometers and 14.75 kilograms for the horizontals. x_w is the amplitude of the pulse produced by the weight lift.

Since there are intermediate adjustments which affect the overall gain of the system, the magnification at any time may be obtained from the calibration pulse amplitudes (x') as follows:

$$\mathcal{M}'(f) = \frac{x' \; G_t \; i_t}{x_t \;\; G' \;\; i'} \quad \mathcal{M}_t(f) \tag{4}$$

where G is the dynamic constant of the auxiliary calibration coil, and i is the calibration current. The subscript t refers to values measured at the time the frequency response curves were obtained (i.e. the magnification results plotted in the Appendix). The primed values are those in effect on the date of interest. Normally

$$G' \; i' = G_t \;\; i_t$$

and Equation (1) reduces to

$$\mathcal{M}'(f) = \frac{x'}{x_t} \quad \mathcal{M}_t(f) \tag{5}$$

The values of x_t , G_t, K_t, and i_t are given in Table 2 for the individual components.

TABLE 2

Station	Component	G_t	K_t	i_t (ma)	Cal. Pulse x_t (-18db) (mm)
BNH	Z	1.225	2.069×10^{-3}	0.80	86
	EW	1.200	2.061×10^{-3}		88
	NS	1.186	2.037×10^{-3}		89
CBM	Z	1.289	2.178×10^{-3}	0.76	90
	EW	1.266	2.175×10^{-3}		87
	NS	1.240	2.129×10^{-3}		90
EMM	Z	1.189	2.008×10^{-3}	0.82	88
	EW	1.369	2.352×10^{-3}		91
	NS	1.494	2.566×10^{-3}		89
MIM	Z	1.374	2.321×10^{-3}	0.72	94
	EW	1.399	2.403×10^{-3}		91
	NS	1.367	2.348×10^{-3}		85

5. TERMINATION OF RECORDING PROGRAM

Recording of the telemeter data was stopped on September 15, 1967 with the termination of funding by ARPA.

Summary of Recorded Data
September 15, 1966 to September 15, 1967

During this period data were compiled and key punched for 573 distant earthquakes. Detailed arrival-time records were kept only for the larger quarry blasts in the New England and adjacent Canadian region. A listing of time and date of the smaller quarry activity was kept for each month. There were an average of 157 such explosions per month during the year.

Twenty-two local earthquakes were recorded and located in New England during this period. Thirteen occurred in a small sequence located northwest of Augusta, Maine on July 01, 1967.

Local Earthquakes
1966 - 1967

Date	Origin Time GMT h m s	Latitude (north) ° '	Longitude (west) ° '	Remarks
1966				
23 Oct	23 05 34	43.0	71.8	FELT: Goffstown, Hillsboro, Hooksett, Manchester, New Boston; N.H.
07 Nov	07 31 14	45.1	69.1	10 miles southwest of Milo, Maine.
07 Dec	02 48 25	44.2	60.6	Off coast of Nova Scotia.
1967				
02 Feb	13 40 09	41.4	71.4	FELT: Adamsville, Jamestown, Middletown, Newport, Wakefield, Wickford; Rhode Island.

Date	Origin Time GMT	Latitude (north)	Longitude (west)	Remarks
1967	h m s	° '	° '	
05 Feb	08 26 32	44.7	69.1	West of Bangor, Maine.
11 Mar	23 39 13.6	45 06	67 16	South of Milltown, Maine -Possible Blast.
28 Apr	12 23 32	46.3	67.9	FELT: Monticello, Maine.
12 May	20 55 14	45.1	70.6	North of Rangely, Maine.
15 May	22 47 11.6	42 14	69 50	22 miles northeast of Provincetown, Massachusetts.
01 Jul	14 09 07	44.4	69.9	Mag. 3.2
	15 33 32	44.4	69.9	Mag. 3.2
	41 47	44.4	69.9	Mag. 2.0
	46 28	44.4	69.9	Mag. 1.9
	48 10	44.4	69.9	
	55 58.2	44 23	69 52	Mag. 3.3
	59 50	44.4	69.9	Mag. 2.0
	16 00 42	44.4	69.9	Mag. 2.9
	02 51	44.4	69.9	Mag. 2.5
	05 40.2	44 23	69 52	Mag. 3.8 FELT: Auburn, Belgrade Lakes, Hallowell, Lewiston, Livermore Falls, Mercer, New Sharon, Norridgewock, North Monmouth, Turner, Vienna, Waterville, Wilton; Maine.
	11 18.9	44 23	69 52	Mag. 3.5
	16 18	44.4	69.9	Mag. 1.9
	19 32.6	44 23	69 52	Mag. 2.9

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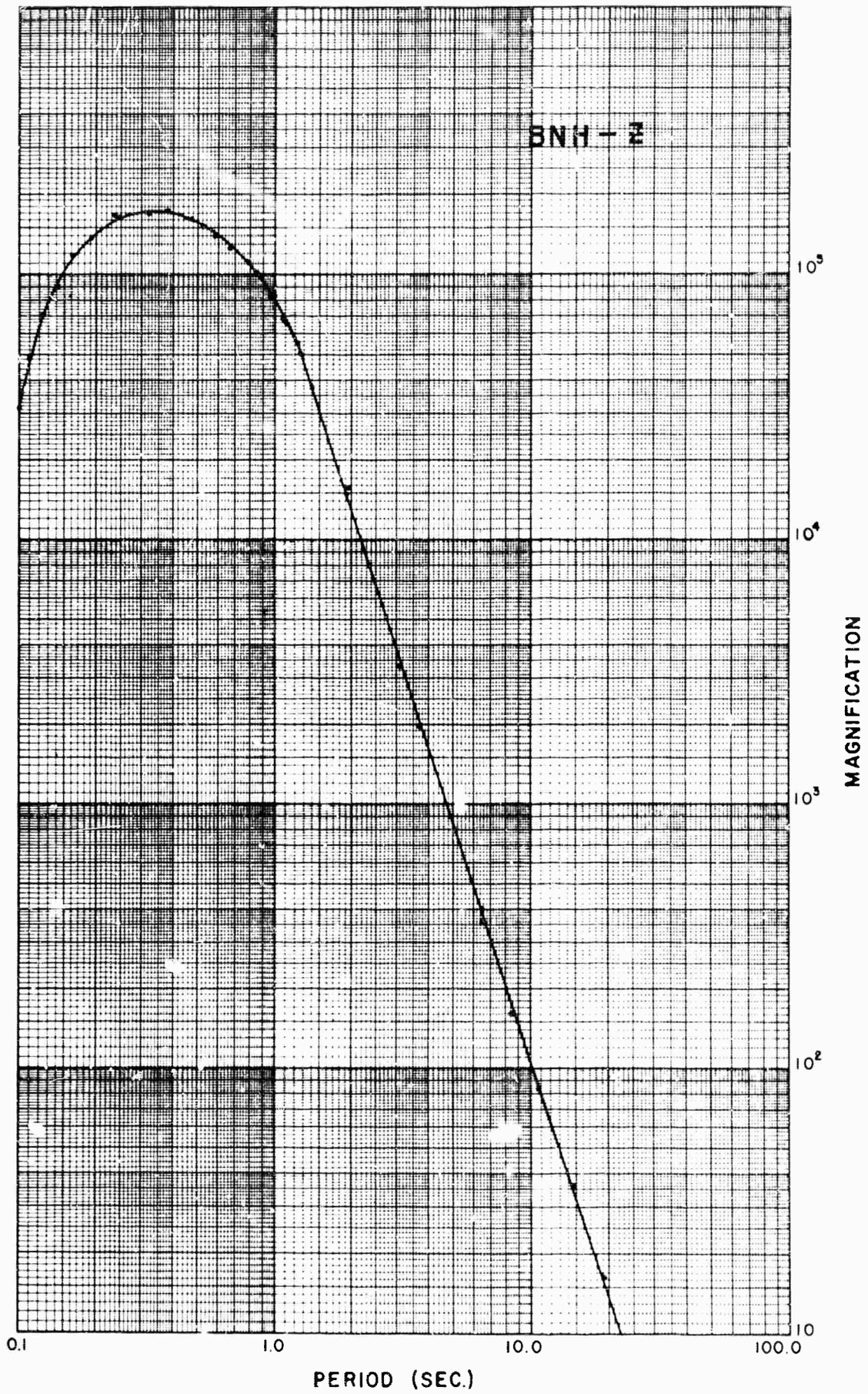
4. Operation and Maintenance Manual, Benioff Portable Seismometers, Geotechnical Corporation, Garland, Texas.

APPENDIX

Magnification curves for the recording system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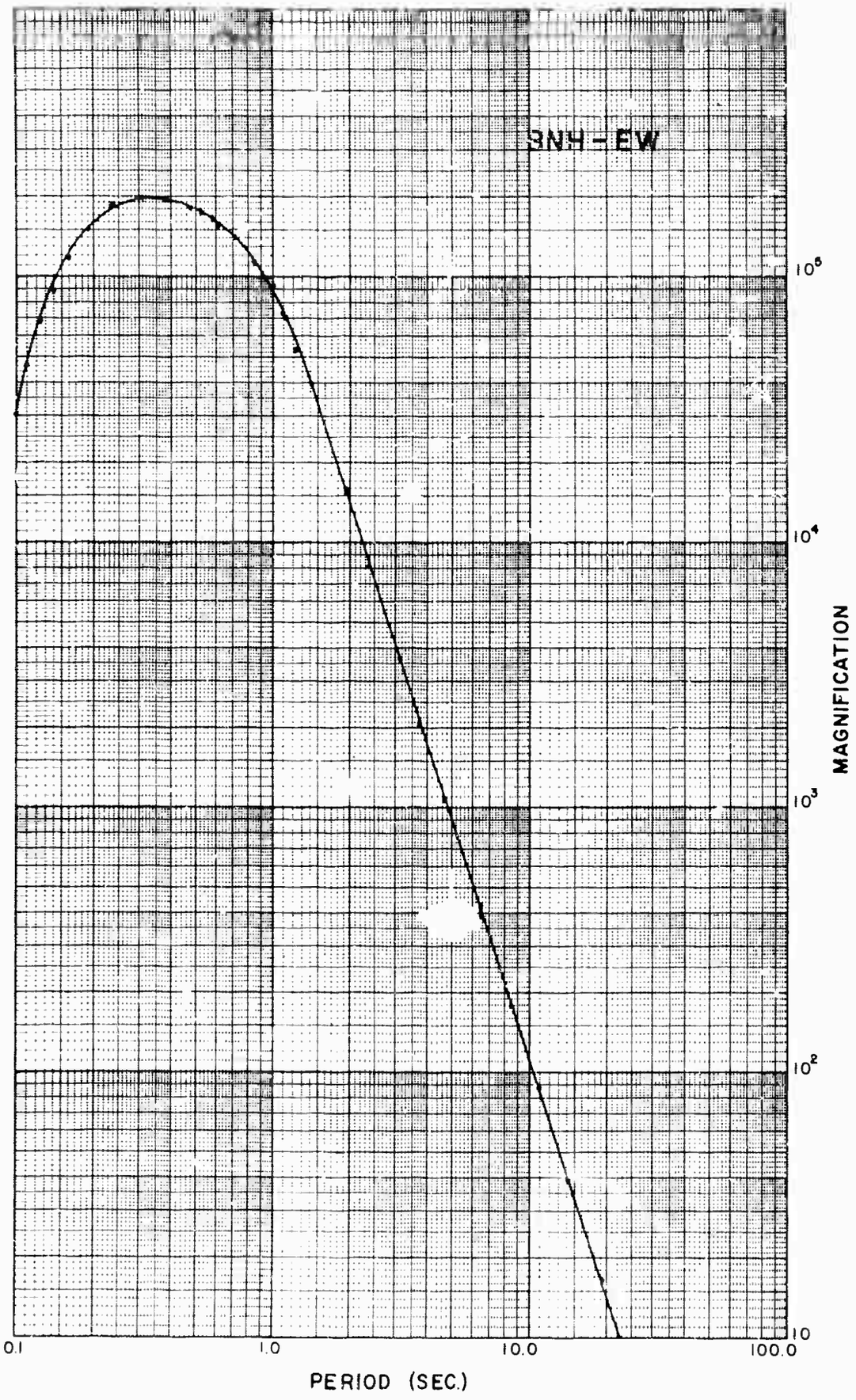
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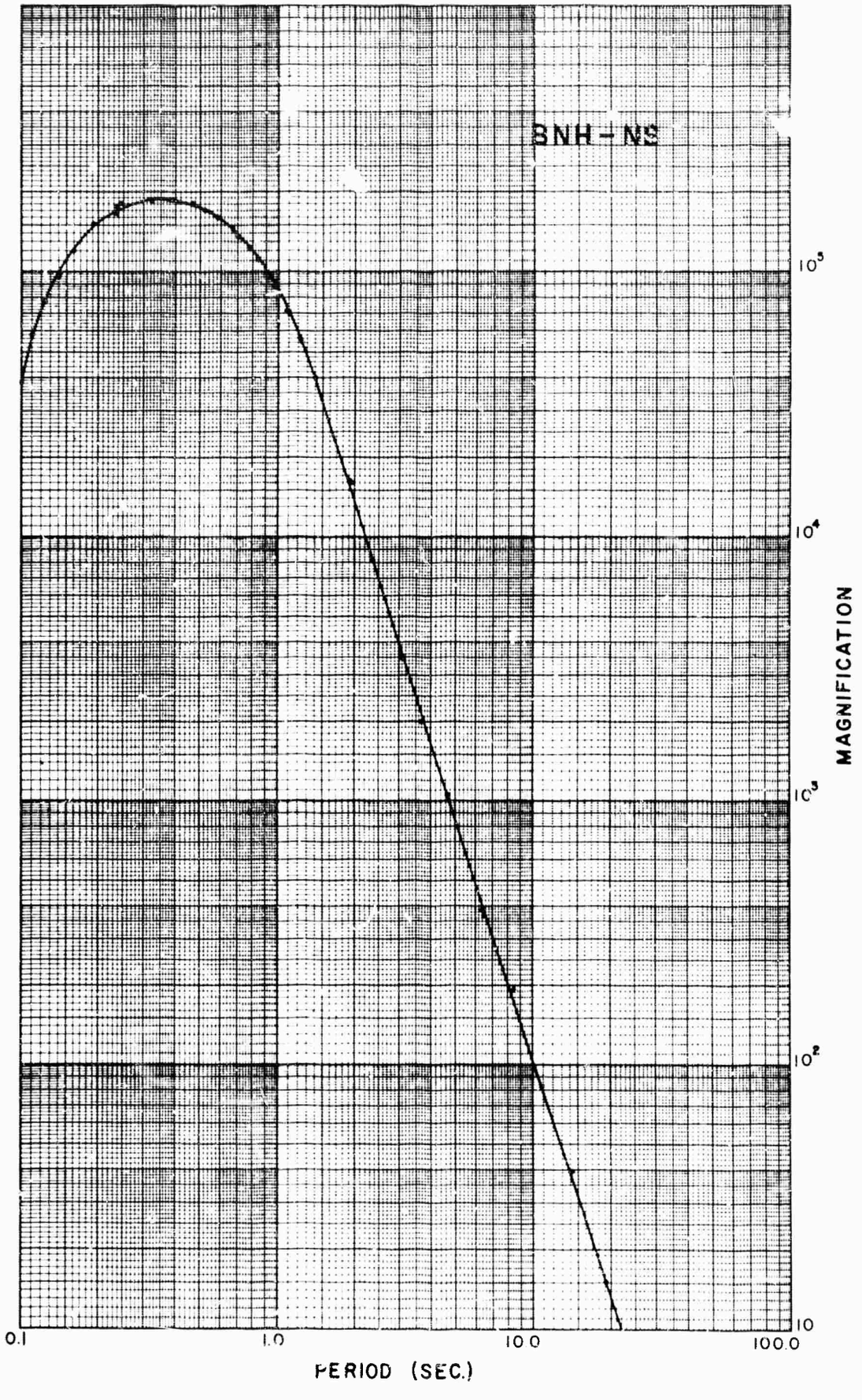
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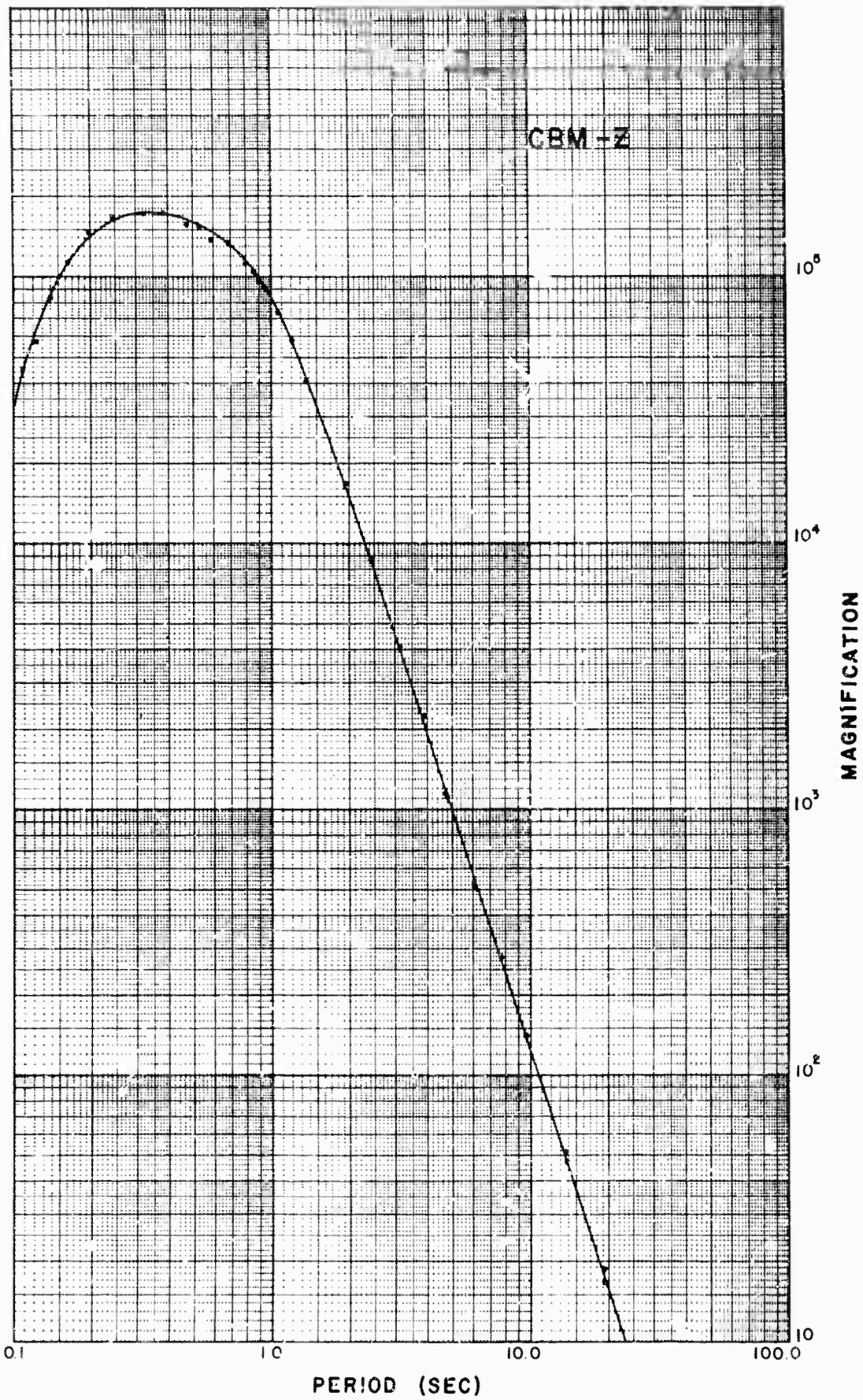
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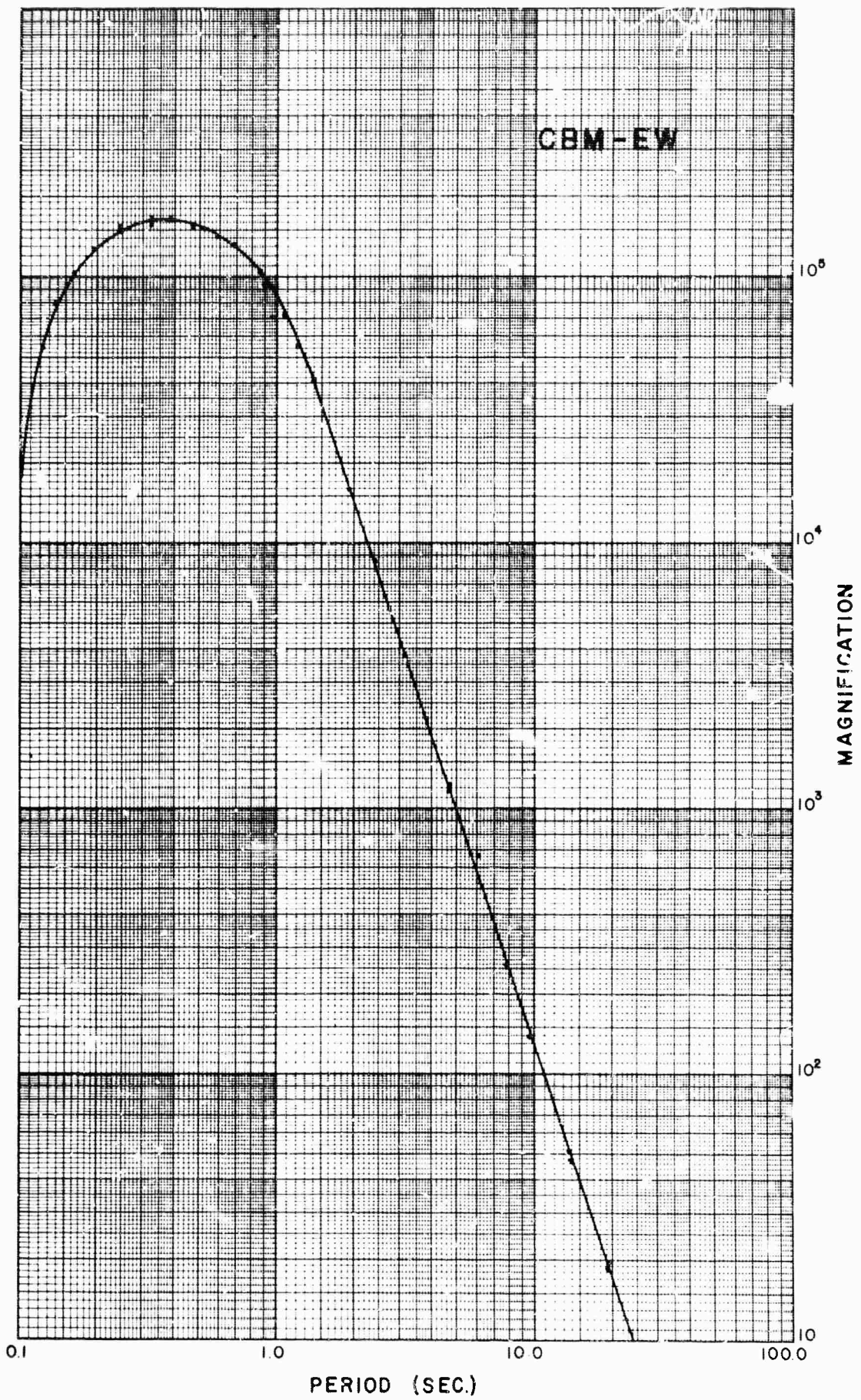
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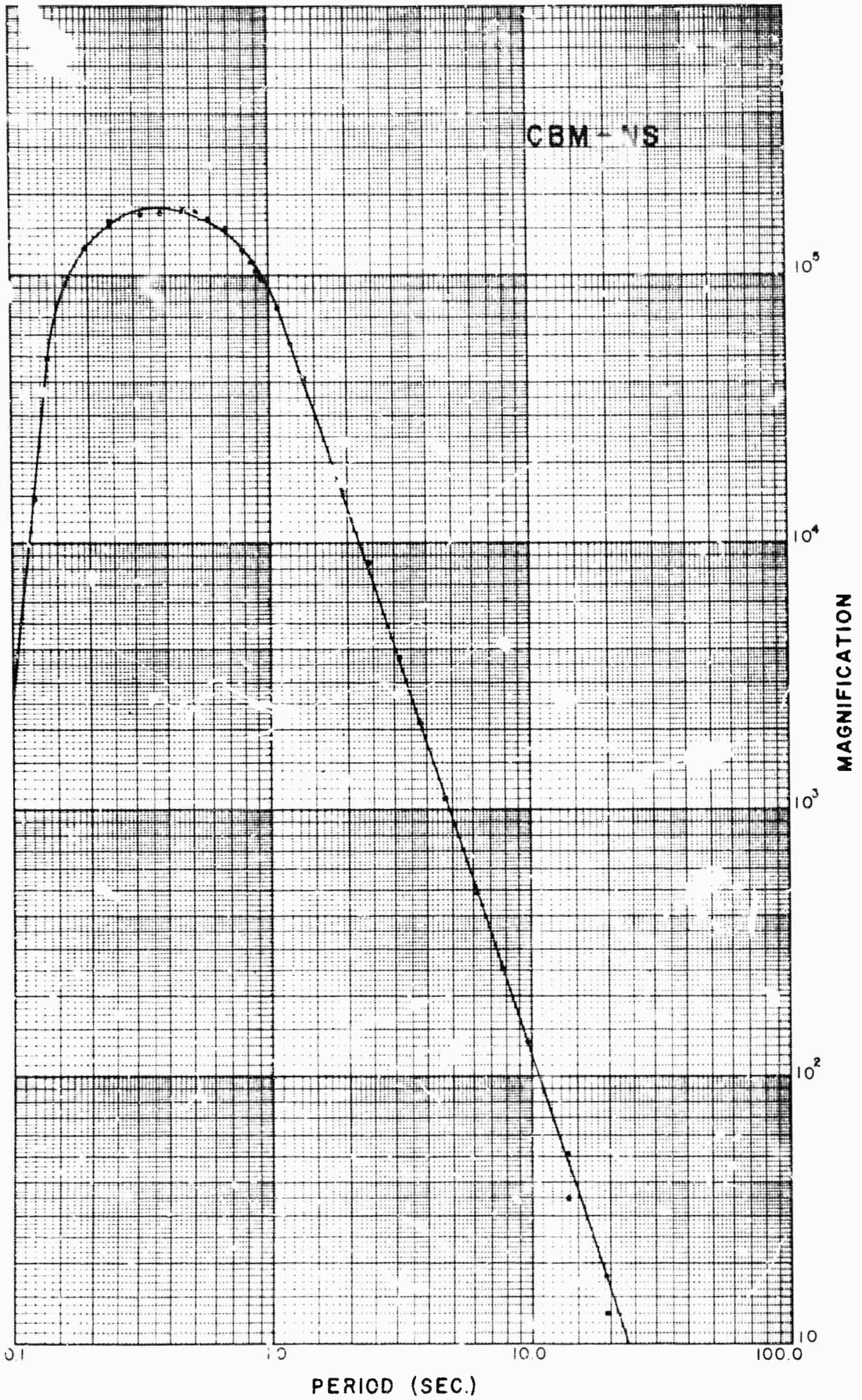
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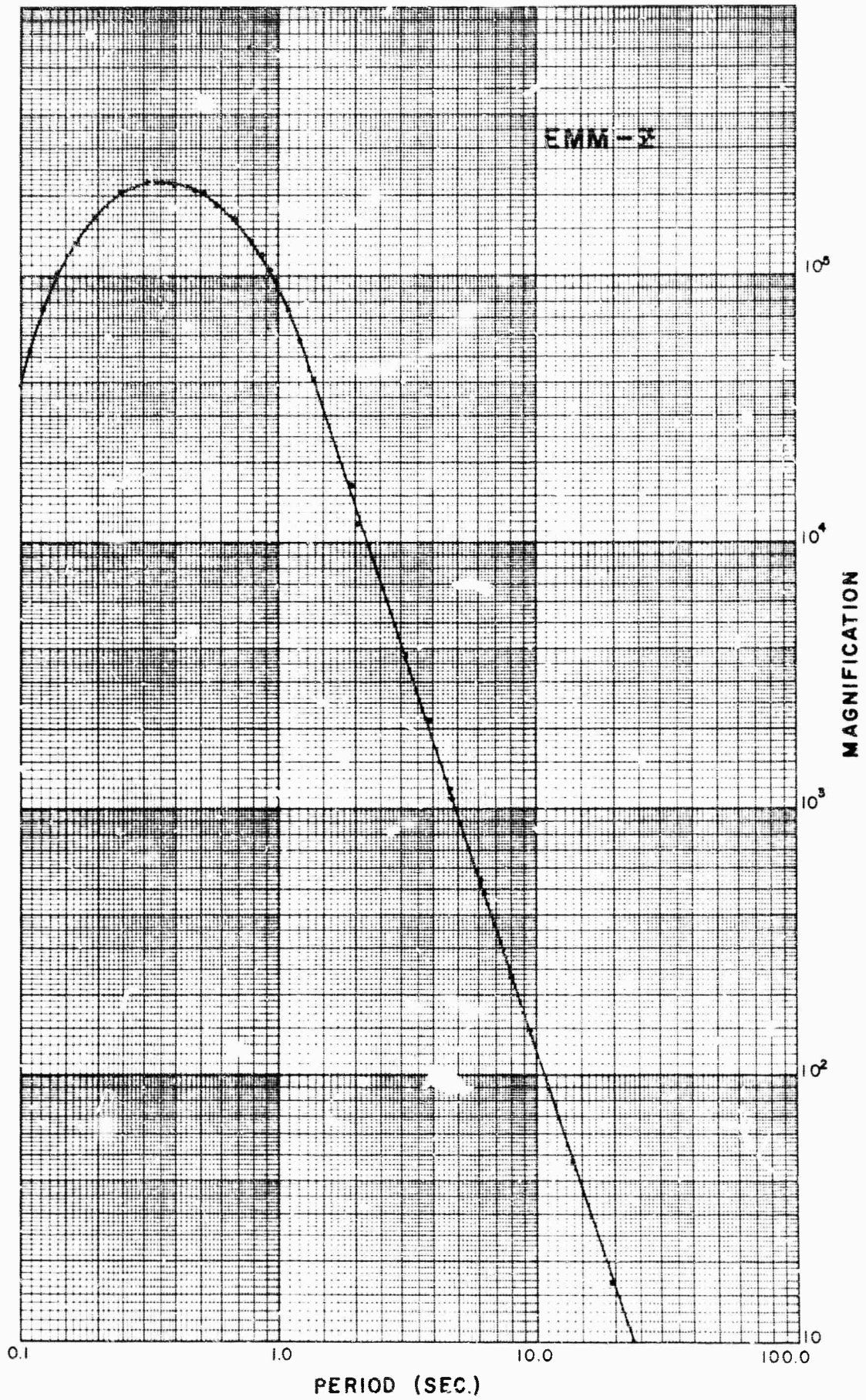
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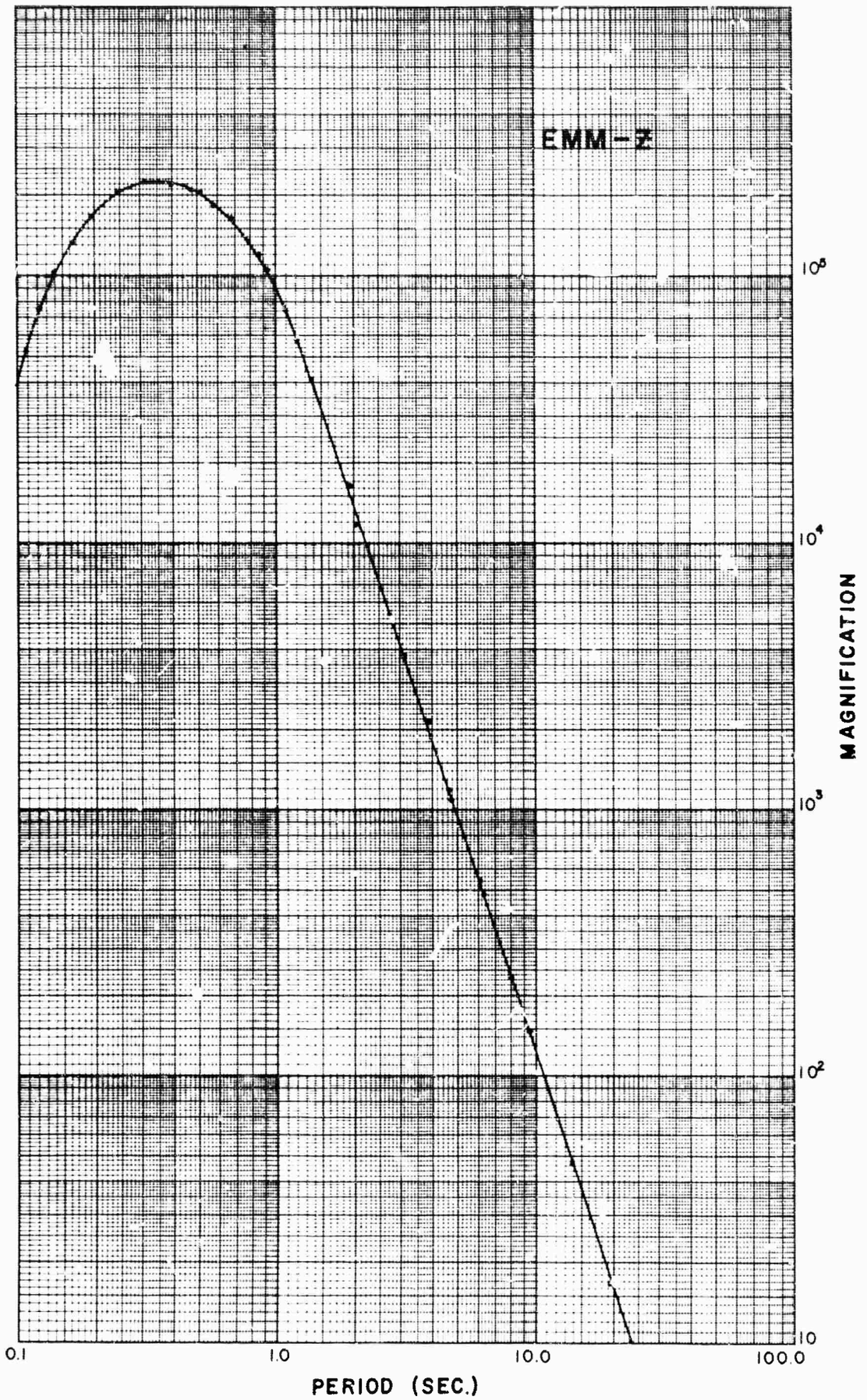
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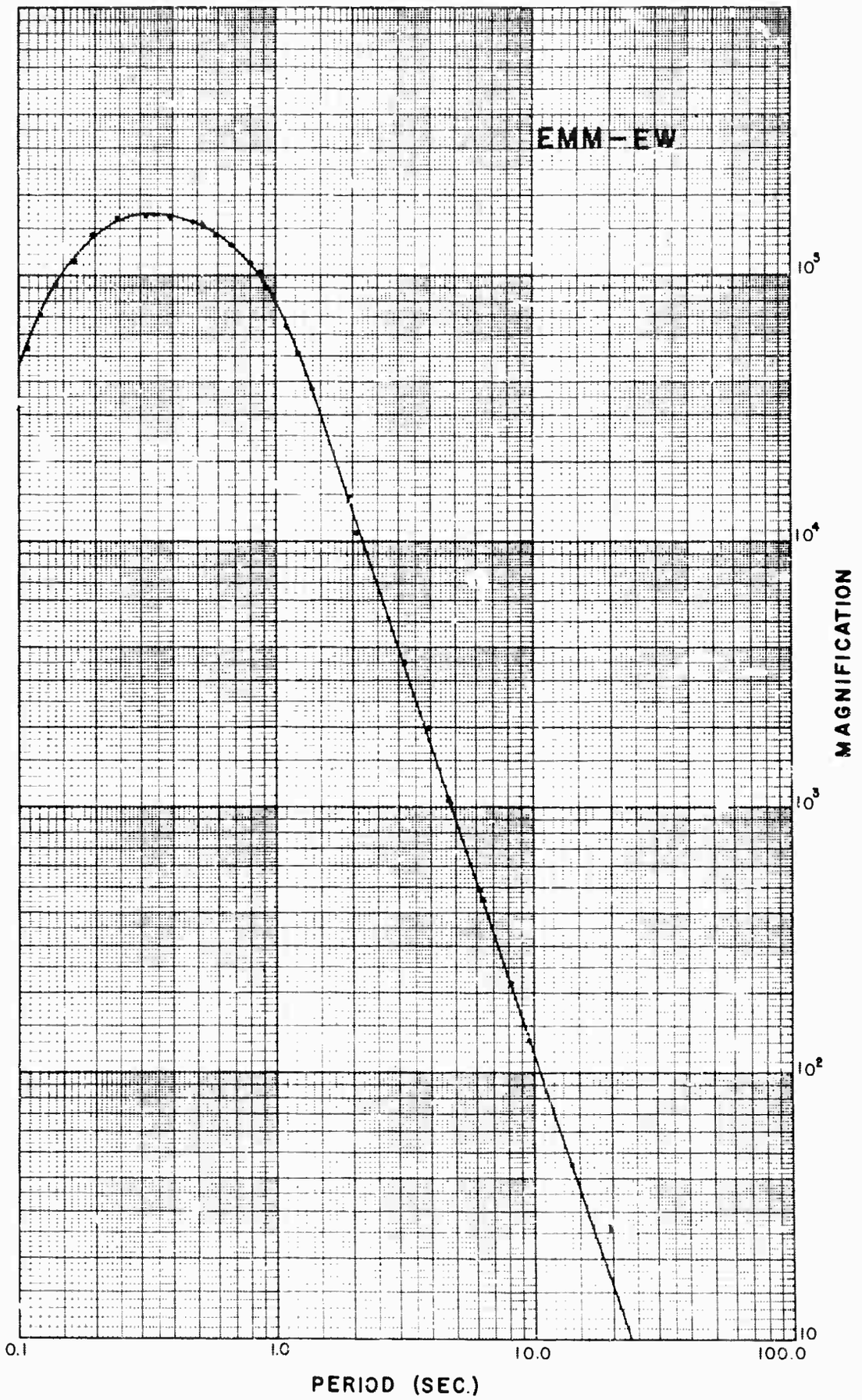
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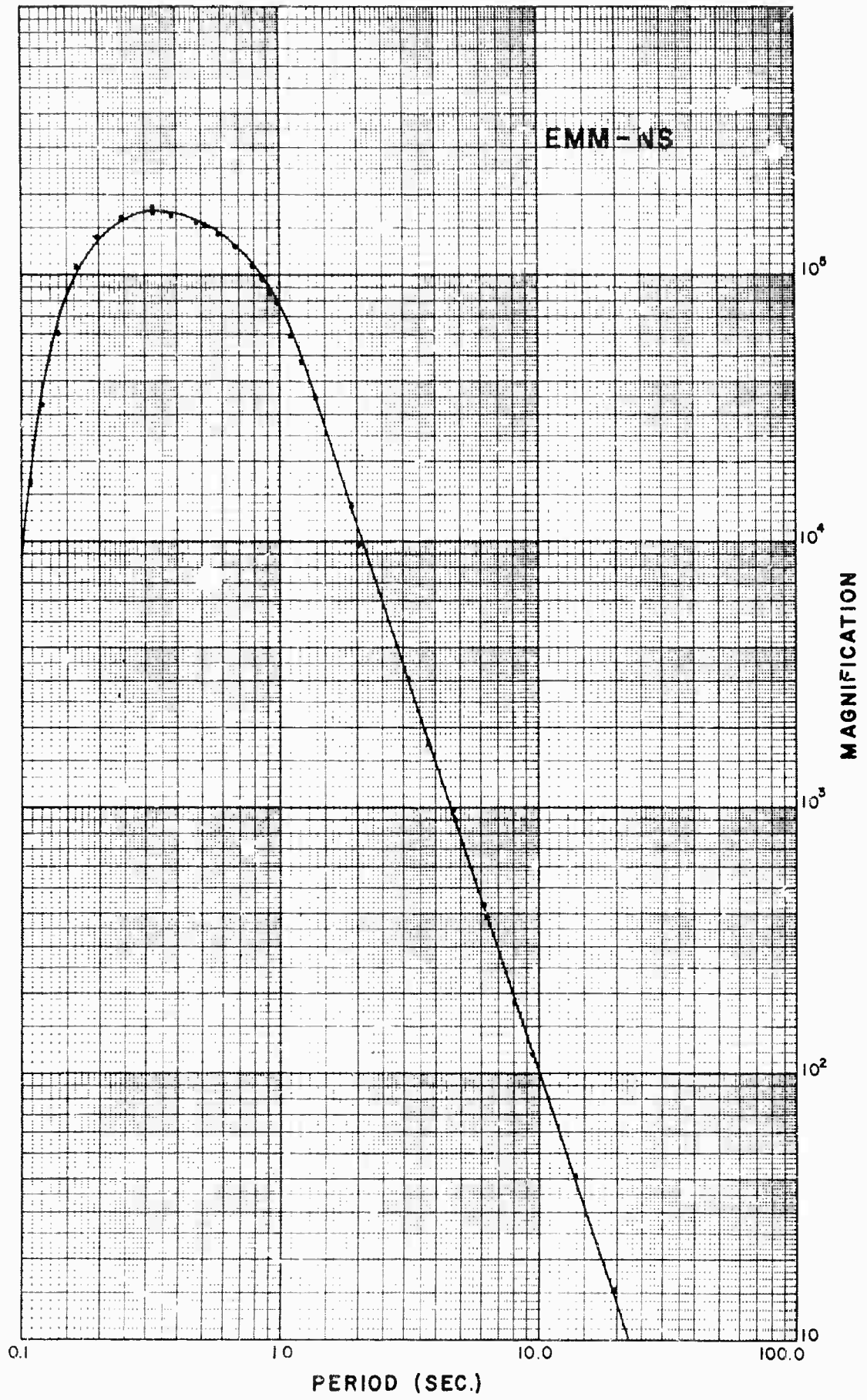
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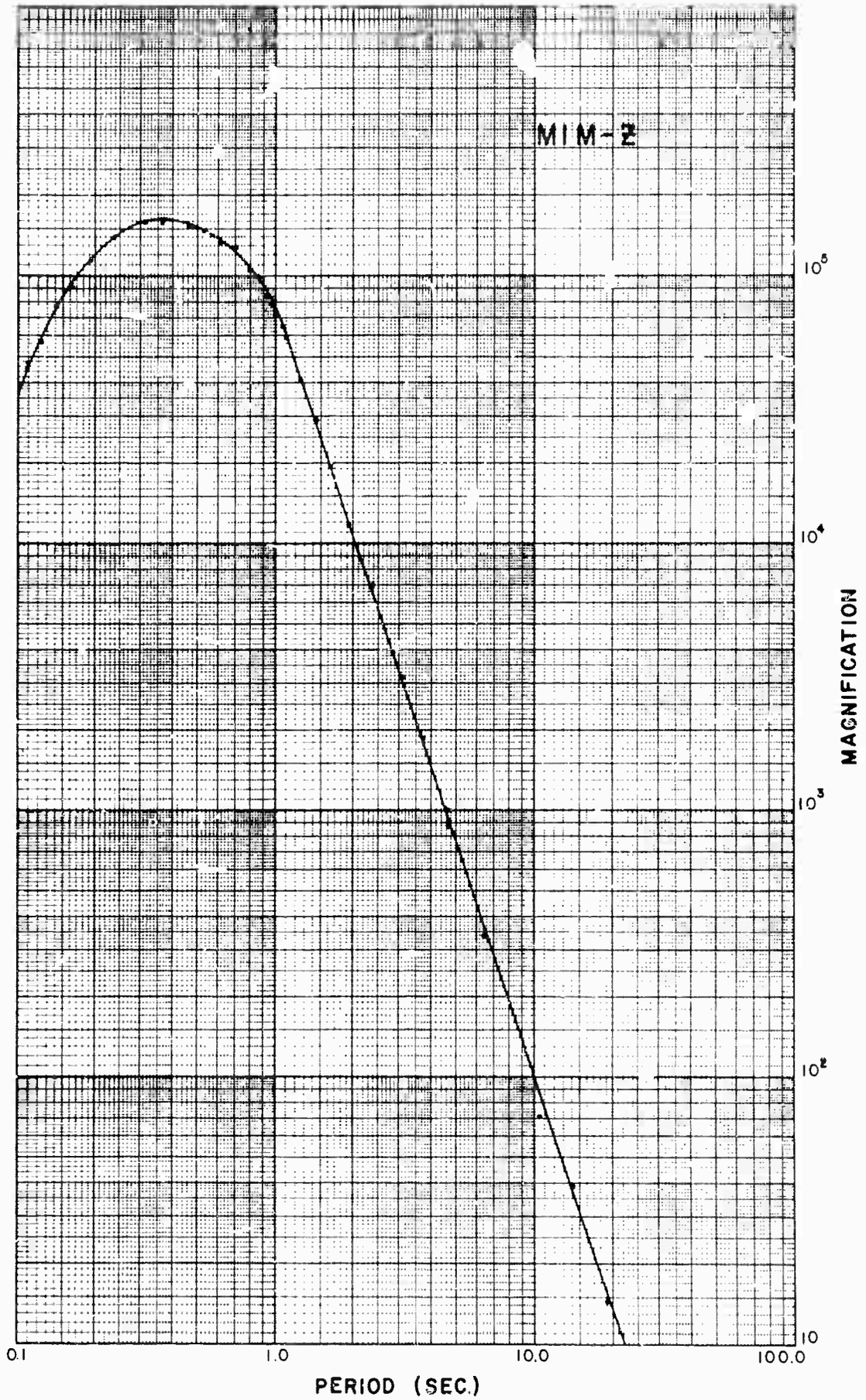
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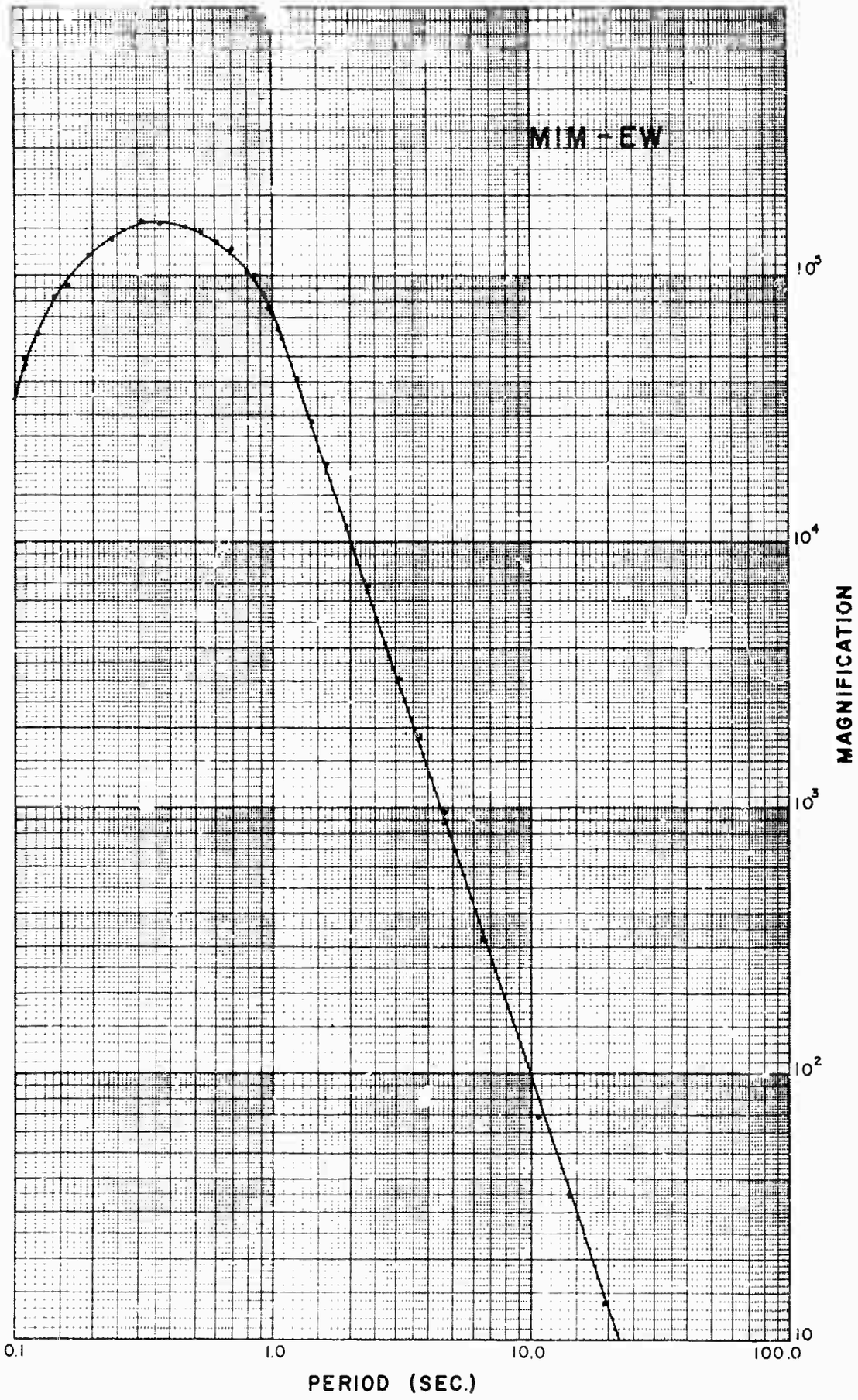
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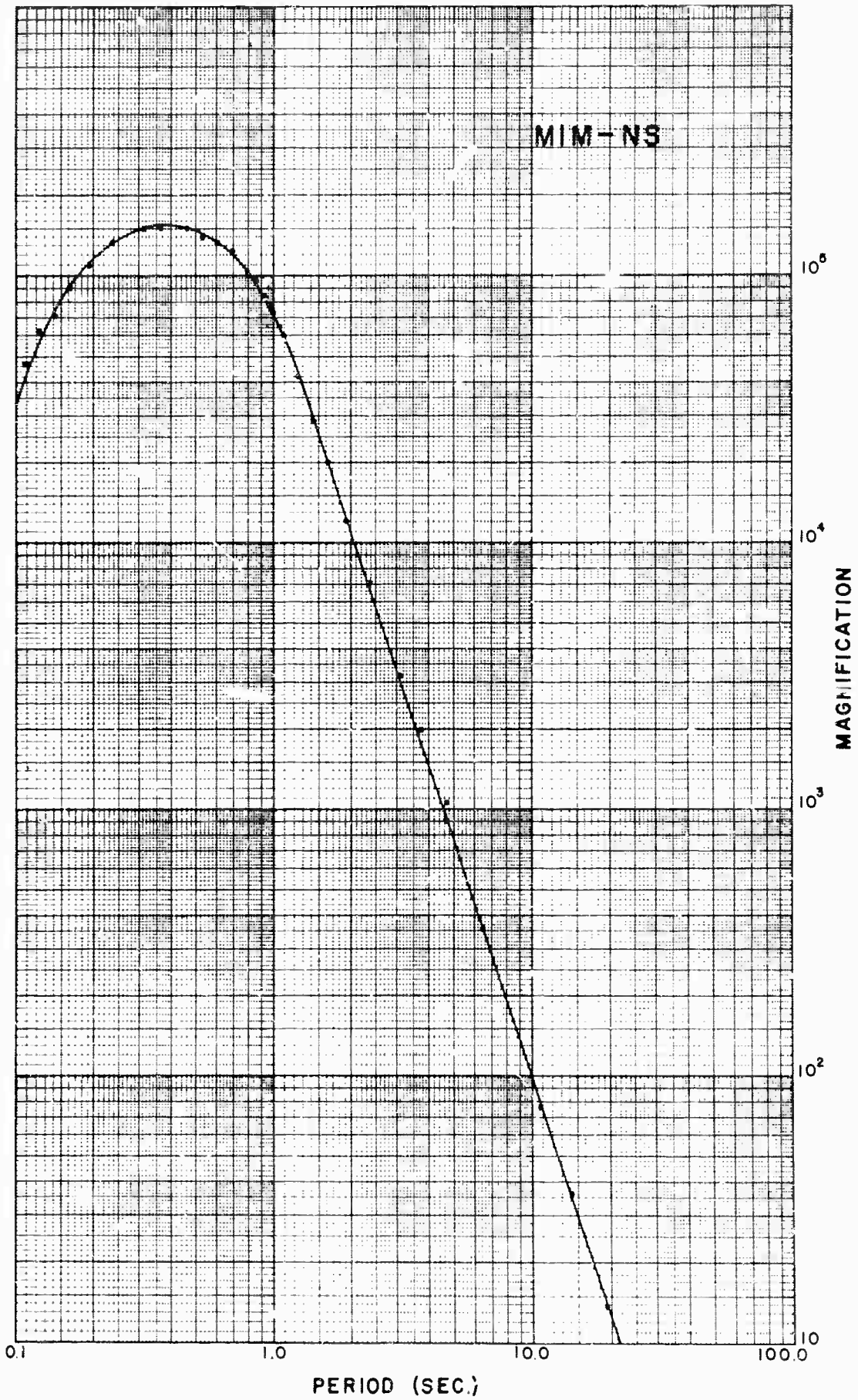
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	ROLE	WT	ROLE	WT	ROLE	WT
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