

MOST Project - 4

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FREQUENCY COMPENSATED DUMILOAD

MARCH 1970

GENERAL ELECTRIC COMPANY
HEAVY MILITARY ELECTRONIC SYSTEMS
Syracuse, New York

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FREQUENCY COMPENSATED DUMILOAD

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11
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⑫ 44 p.

General Electric Company
Heavy Military Electronic Systems
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1. Introduction -

It is
 We believe that the technique of frequency compensation of the DUMILOAD electrical termination is not only desirable but necessary if an element's true operating conditions are to be simulated. This document, although it presents the results of a paper study only with no experimental verification, shows that the proposed technique does indeed appear to be feasible.

2. Sample Case Number 1 -

It
 It was assumed for this study that the test element as well as the DUMILOAD would consist of an AN/SQS-26 (CX) transducer element exclusive of mount. *While* better DUMISTACKS undoubtedly exist, since no experimental verification was planned at this time, it was felt that virtually any model (as long as it bore any resemblance at all to reality) would serve.

The desired head impedance of the test element versus frequency is shown on the following page. At any given frequency, the value

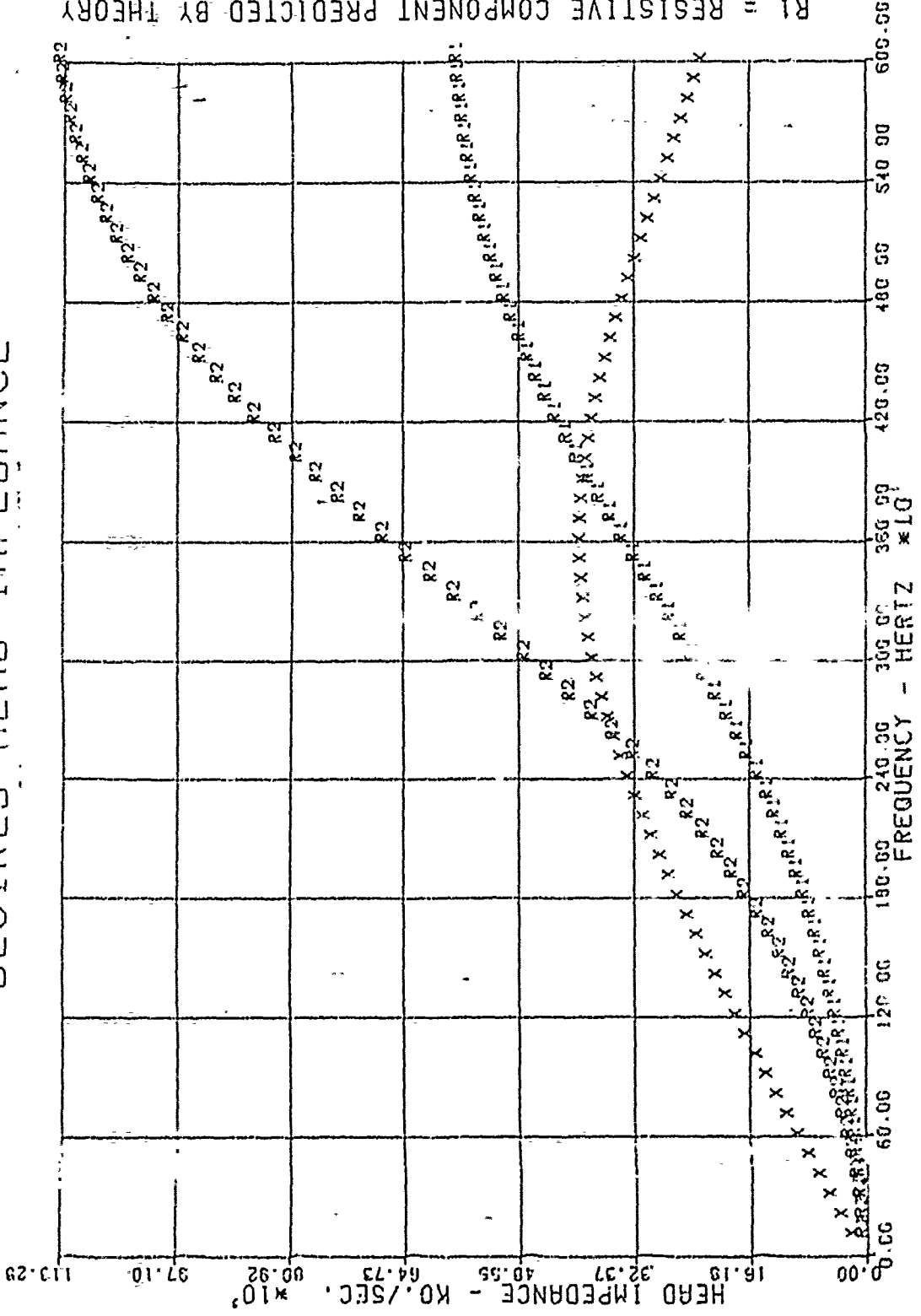
$$Z_H = R_1 + jX$$

corresponds to the theoretical radiation loading upon a circular piston of equivalent area at the end of an infinite pipe while the value

$$Z_H = R_2 + jX$$

corresponds more nearly to the value actually seen by an element (or to the value the element acts as though it sees) in free-field conditions. The experimental value was chosen for the first case.

DESIRED HEAD IMPEDANCE



R1 = RESISTIVE COMPONENT PREDICTED BY THEORY
R2 = OBSERVED RESISTIVE COMPONENT
X = REACTIVE COMPONENT PREDICTED BY THEORY

Knowing the desired head impedance and possessing a model for the DUMISTACK, the necessary electrical terminating impedance may be determined. Then, employing General Electric's OPTIM program, a curve fit to this impedance is obtained. For this particular case, a function of the form:

$$Z(s) = 1.8 \times 10^5 \left[\frac{s^2 + As + B}{s(s^2 + Cs + D)} \right]$$

provides an accurate fit to the data. The two following figures show the desired magnitude and phase curve compared with the results of the curve fit. Then, possessing numerical values for A, B, C and D, we may turn to the more difficult task of synthesizing a network which will yield the desired driving-point impedance.

The driving-point impedance $Z(s)$ can be classed as a general R-L-C network. A realization of this impedance can be obtained by partial fraction expansion if certain conditions are met, otherwise, other techniques must be utilized.

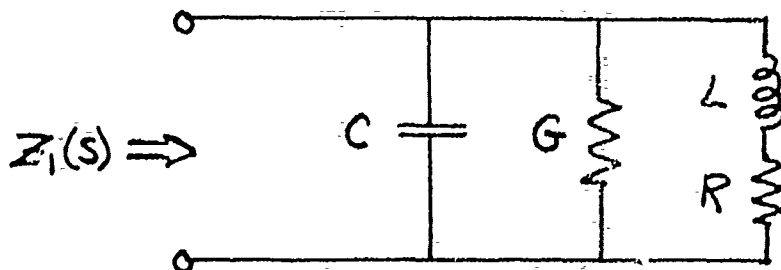
For a function $Z_1(s)$ to be realizable by partial fraction expansion, that is for the function

$$Z_1(s) = \frac{a_1 s + a_0}{s^2 + b_1 s + b_0}$$

the following condition must be met

$$a_1 b_1 \geq a_0 \geq 0$$

with the above condition met, the following network is the realization of $Z_1(s)$



in which

$$C = \frac{1}{a_1} \text{ farads}, \quad L = \frac{a_1^3}{a_1^2 b_0 - a_0(a_1 b_1 - a_0)} \text{ henrys}$$

and

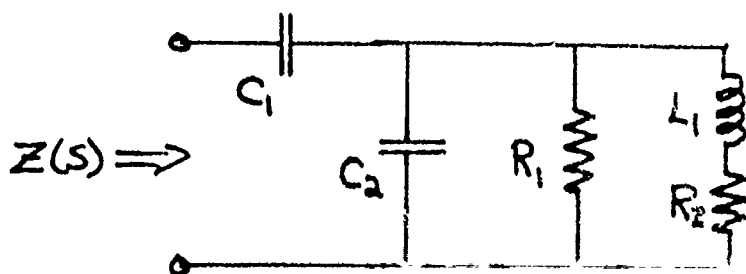
$$\frac{R}{L} = \frac{a_0}{a_1}, \quad \frac{G}{C} = \frac{a_1 b_1 - a_0}{a_1}$$

The driving-point impedance $Z(s)$ is not of the form described above, but by simple manipulation this form can be obtained, that is

$$Z(s) = \frac{B}{D} \frac{1}{s} + \frac{\left(\frac{D-B}{D}\right)s + \left(\frac{AD-BC}{D}\right)}{s^2 + Cs + D}$$

Now $Z(s)$ is of the form described above.

For both the examples given, A, B, C, and D were such that all conditions were satisfied, so that the driving-point impedance $Z(s)$ could be realized by the network



where

$$C_1 = \frac{D}{B} \text{ farads}$$

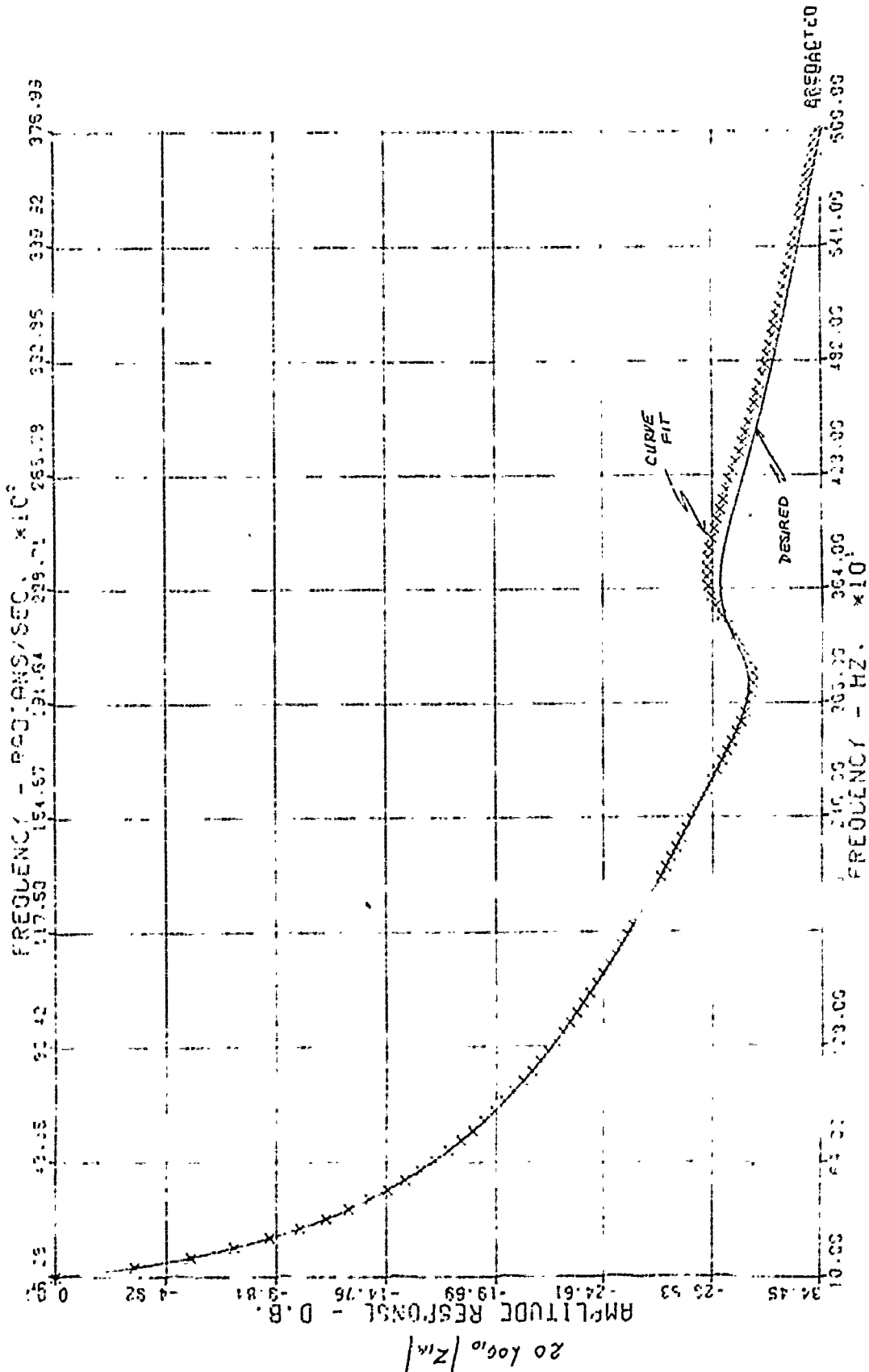
$$C_2 = C$$

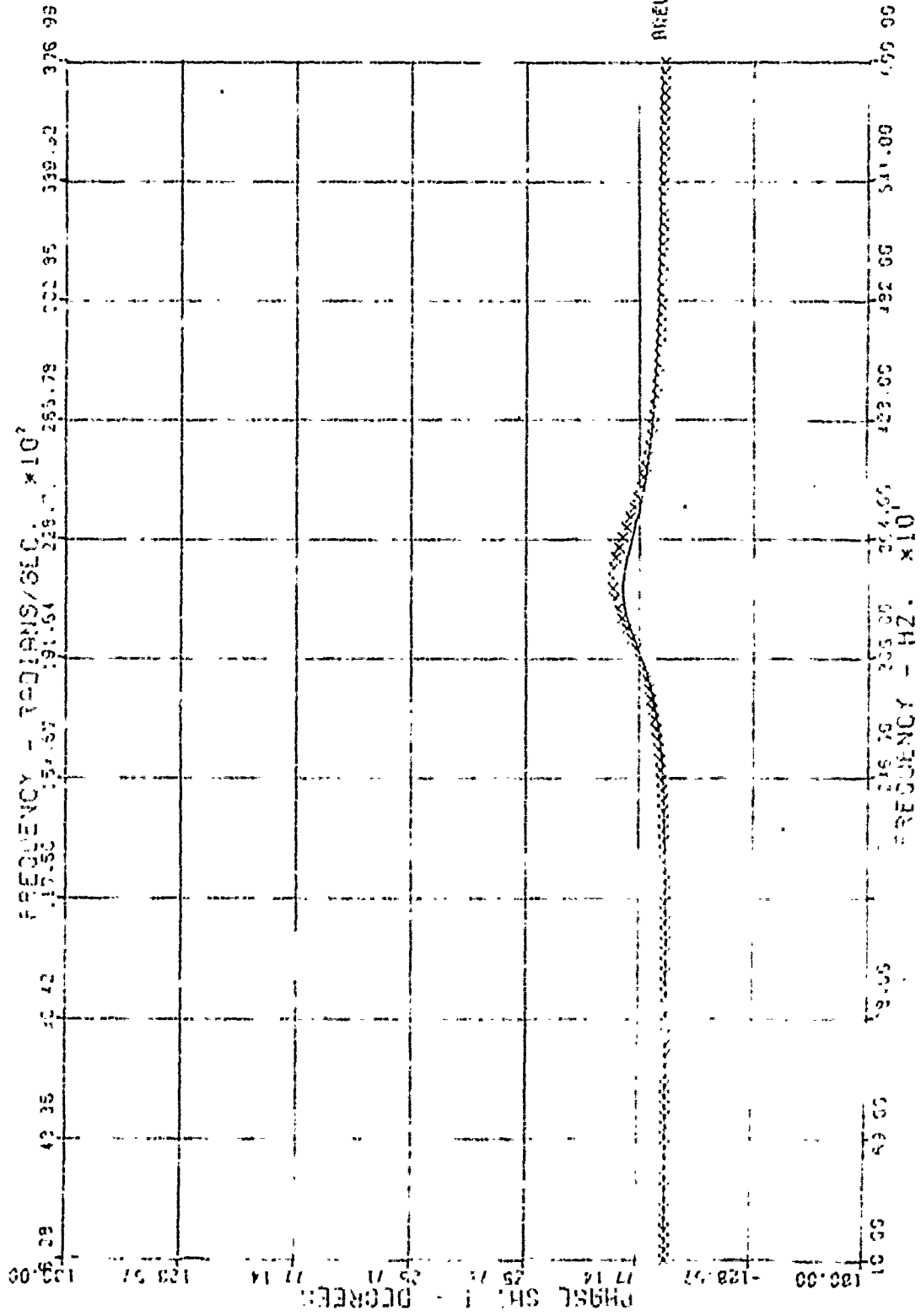
$$R_1 = \frac{R}{G}$$

$$R_2 = R$$

$$L_1 = L$$

0 db = $1.8 \times 10^5 \Omega$

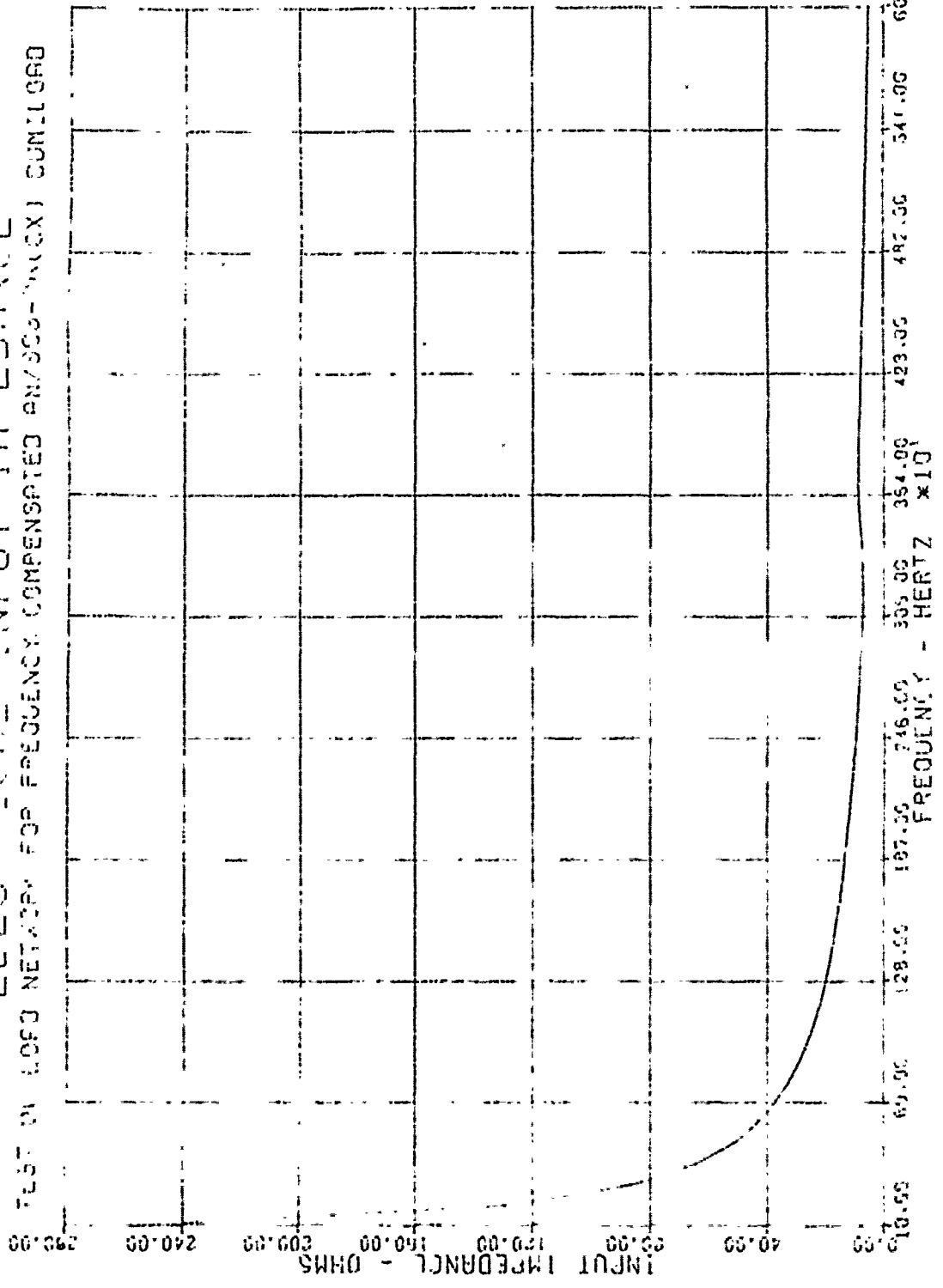




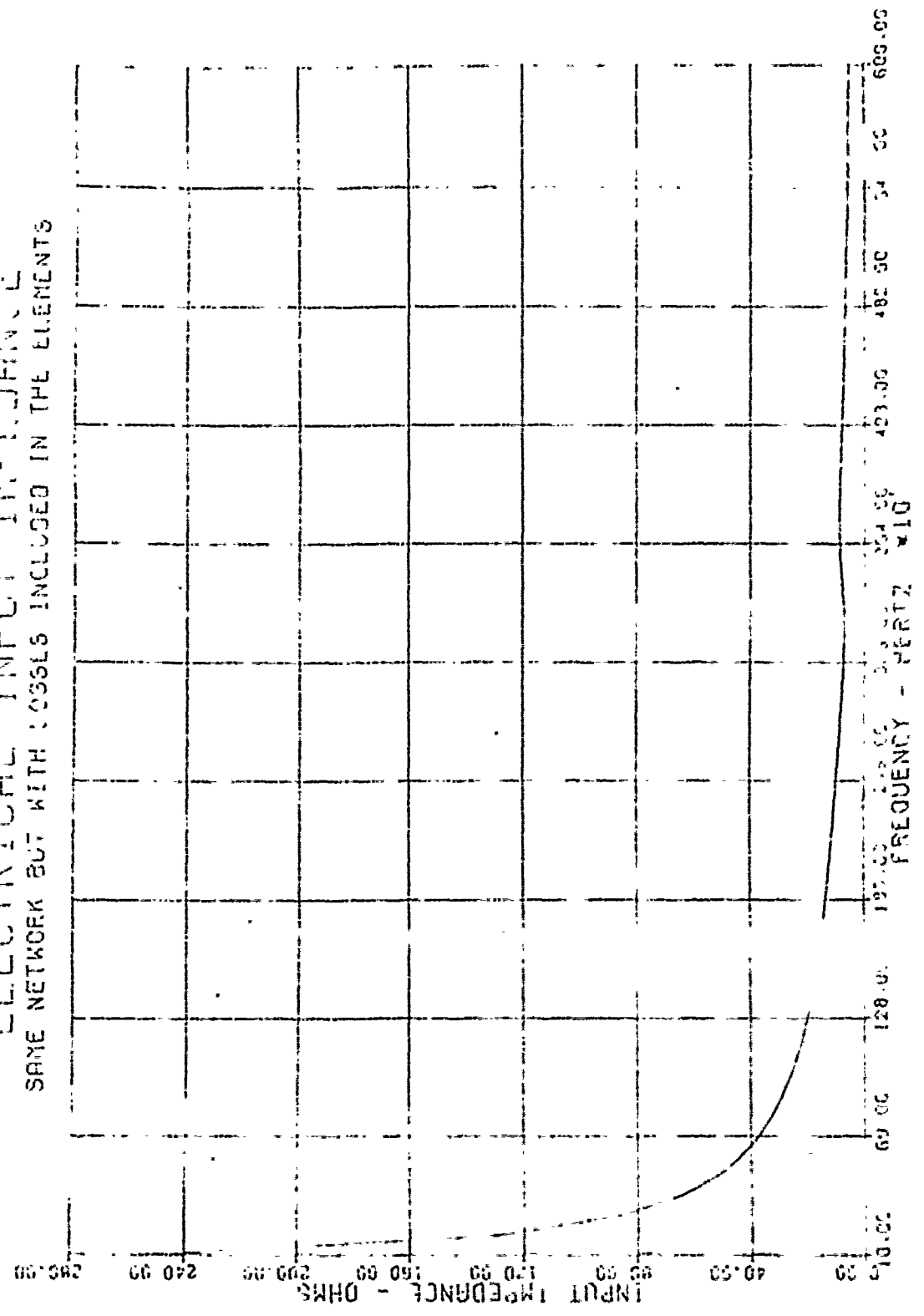
Once the network (although possibly not the optimal one) has been synthesized, it must be analyzed to determine the necessary component rating values. The network was analyzed for two driving conditions, constant power input and constant volt-ampere input with both ideal components and lossy (inductors with Q's of 400 and capacitors with loss tangents of 0.001) components used. The graphs on the following pages present the voltages, currents and power losses versus frequency for these four cases.

Based upon experience, the constant volt-ampere drive probably corresponds more nearly to what would be seen in practice than does the constant power drive.

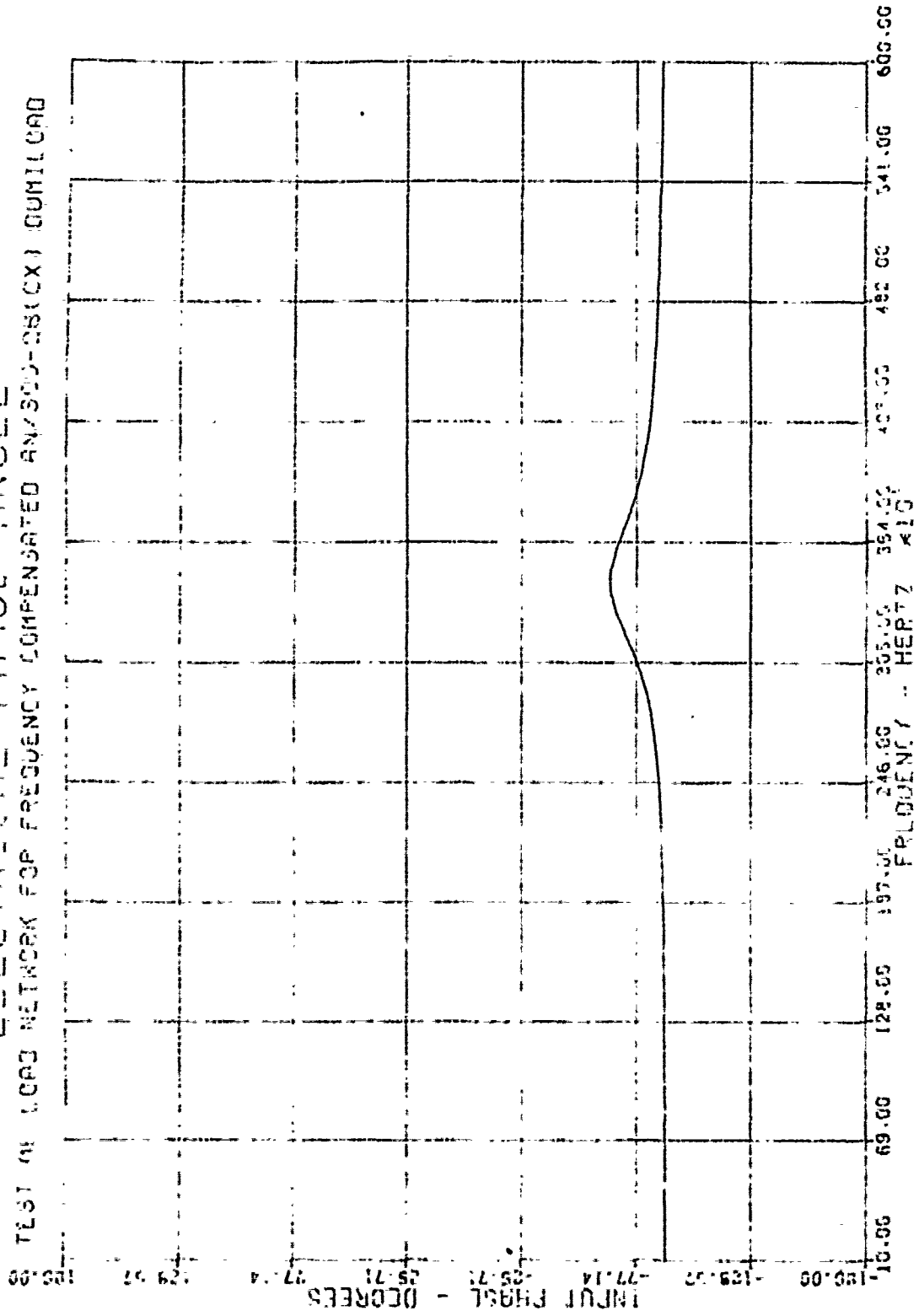
ELECTRICAL INPUT IMPEDANCE
 TEST ON LOGO NETWORK FOR FREQUENCY COMPENSATED AM/SCS-10(CX) CUMILGRD



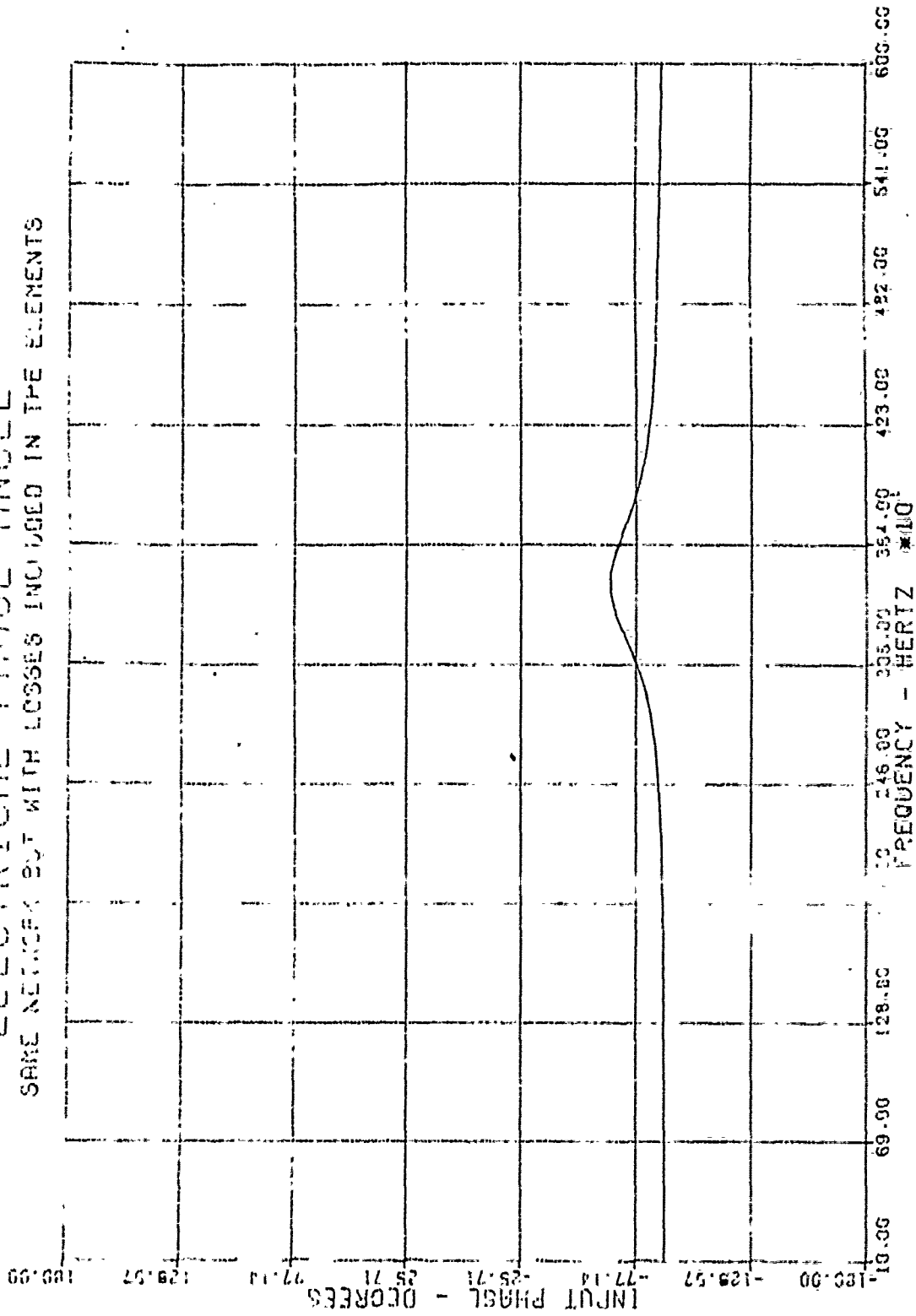
ELECTRICAL INPUT IMPEDANCE
SAME NETWORK BUT WITH LOSSLS INCLUDED IN THE ELEMENTS



ELECTRICAL PHASE ANGLE
 TEST OF LOAD NETWORK FOR FREQUENCY COMPENSATED ANALOG-OSC(X) LOAD

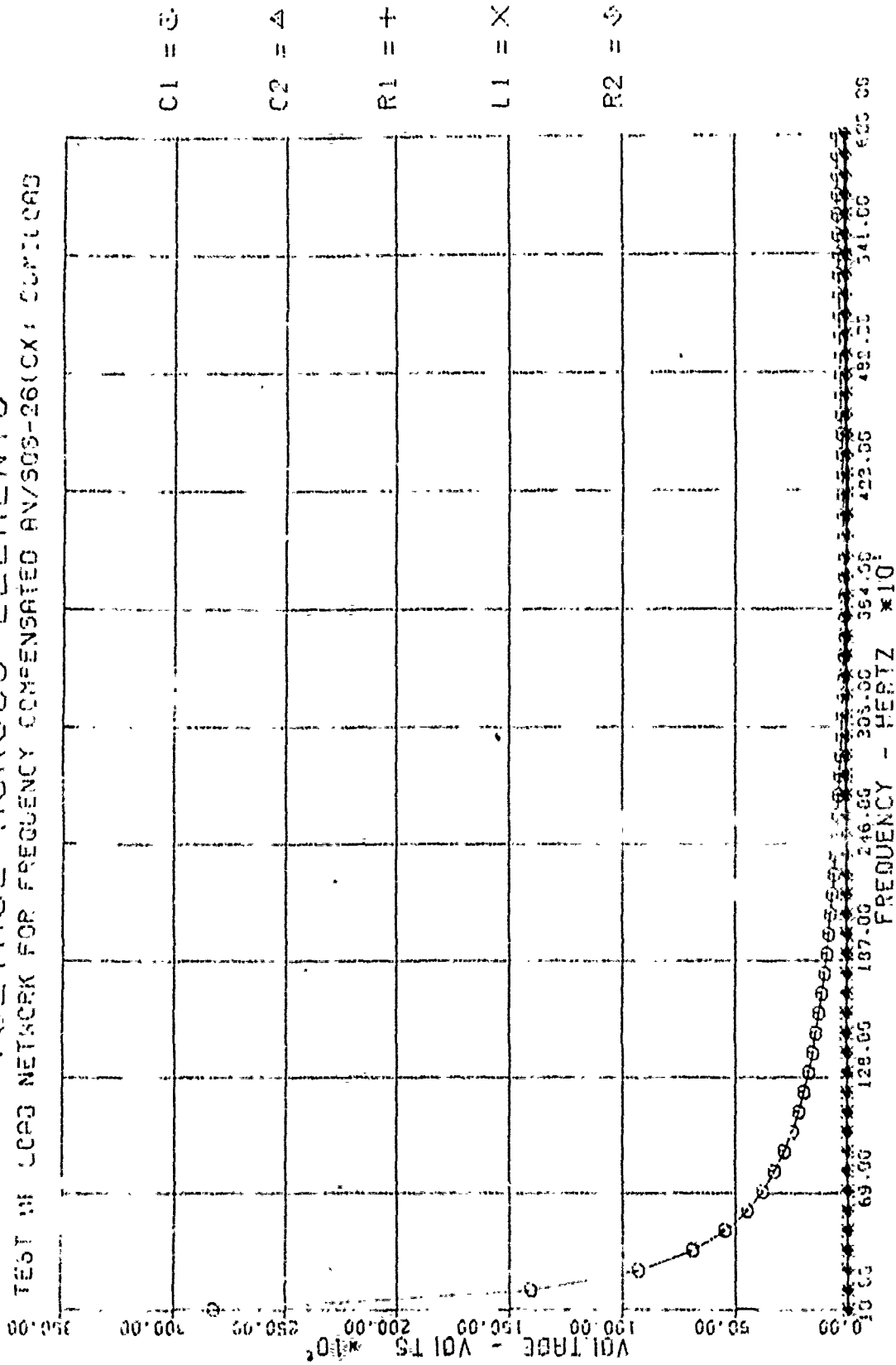


ELECTRICAL PHASE ANGLE
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



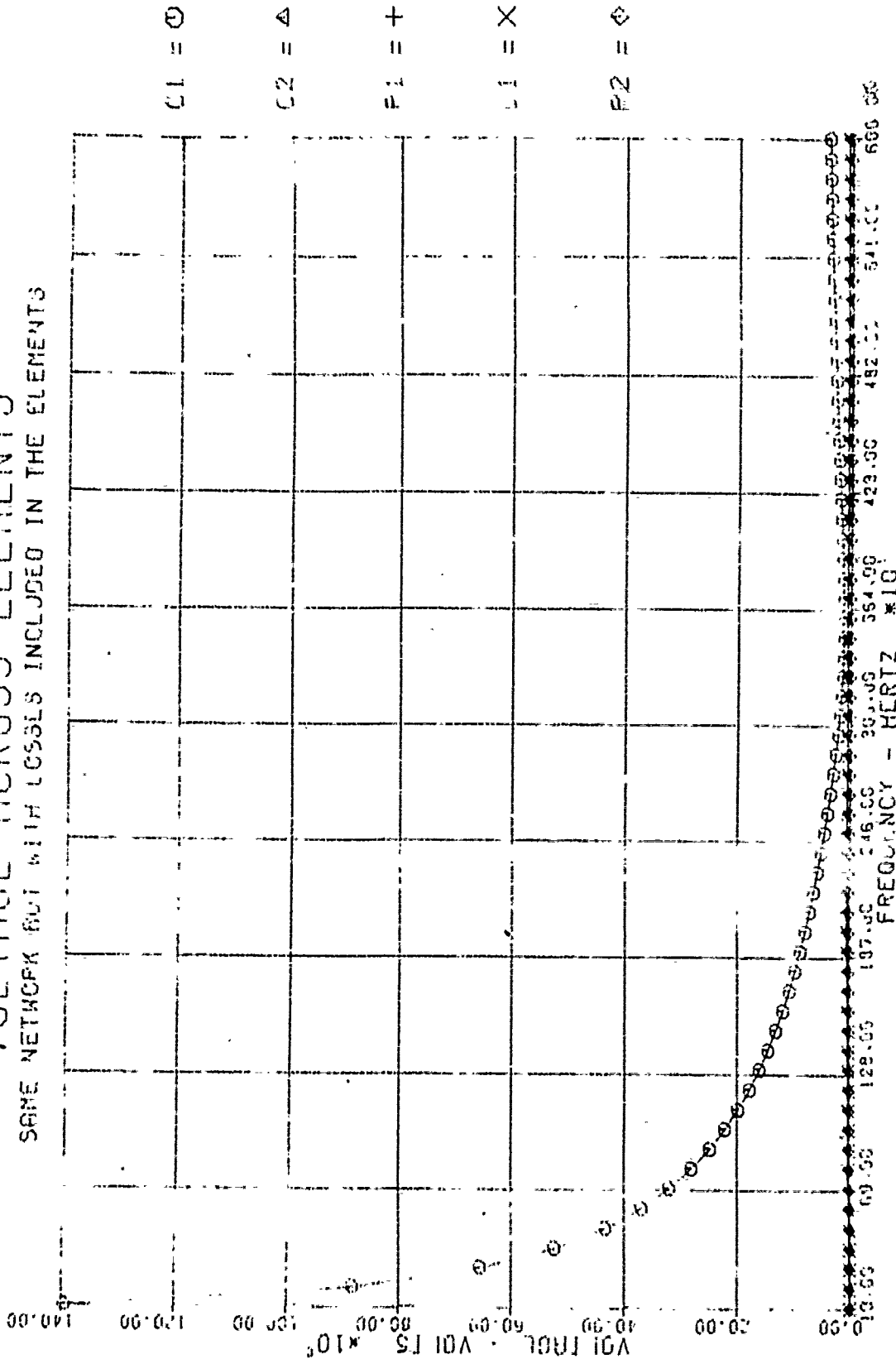
VOLTAGE ACROSS ELEMENTS

TEST IN LCAP NETWORK FOR FREQUENCY COMPENSATED AN/SOS-26(CX) CUMULCAD



POWER INPUT = 1000.00

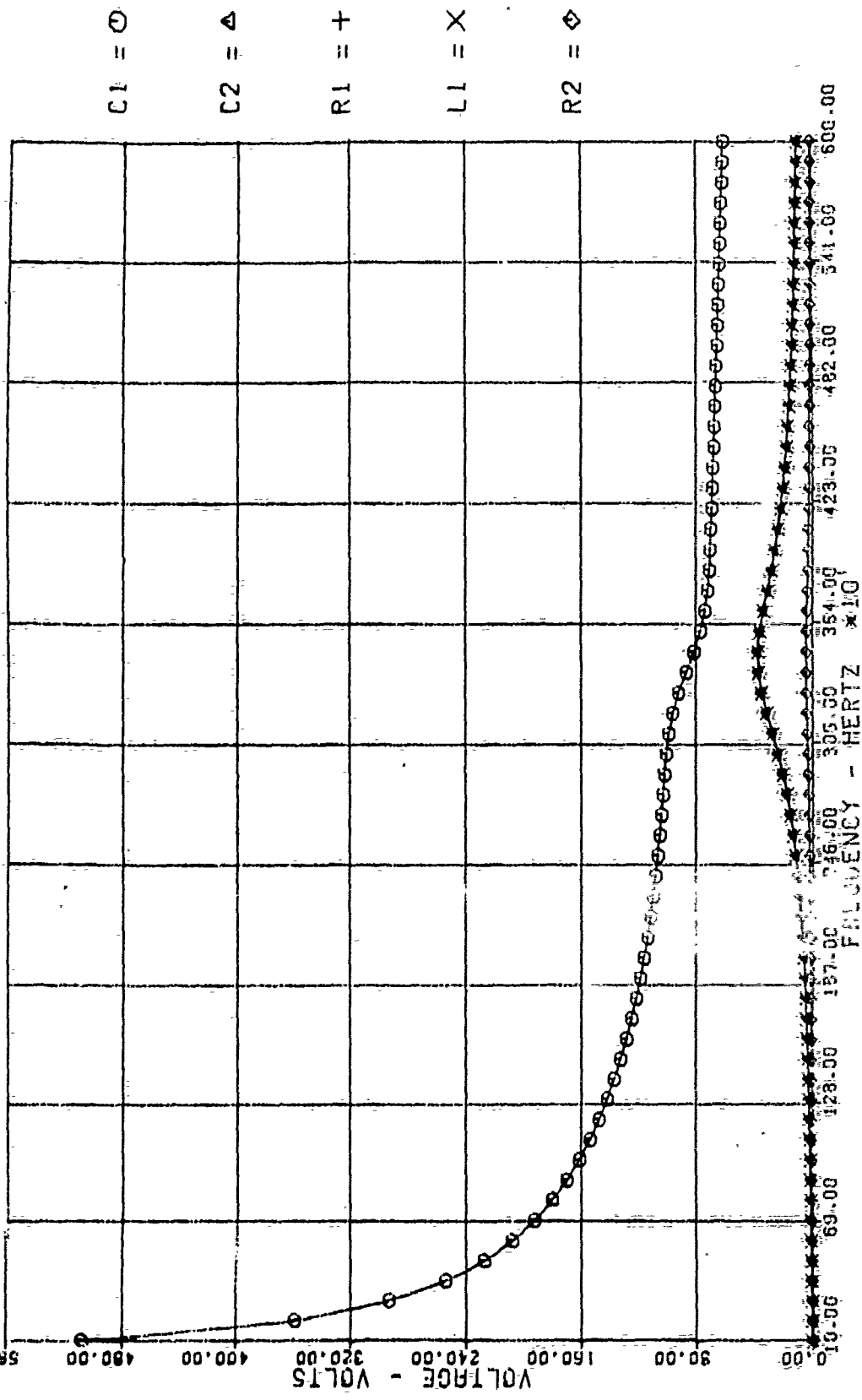
VOLTAGE ACROSS ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



POWER INPUT = 1000.00

VOLTAGE ACROSS ELEMENTS

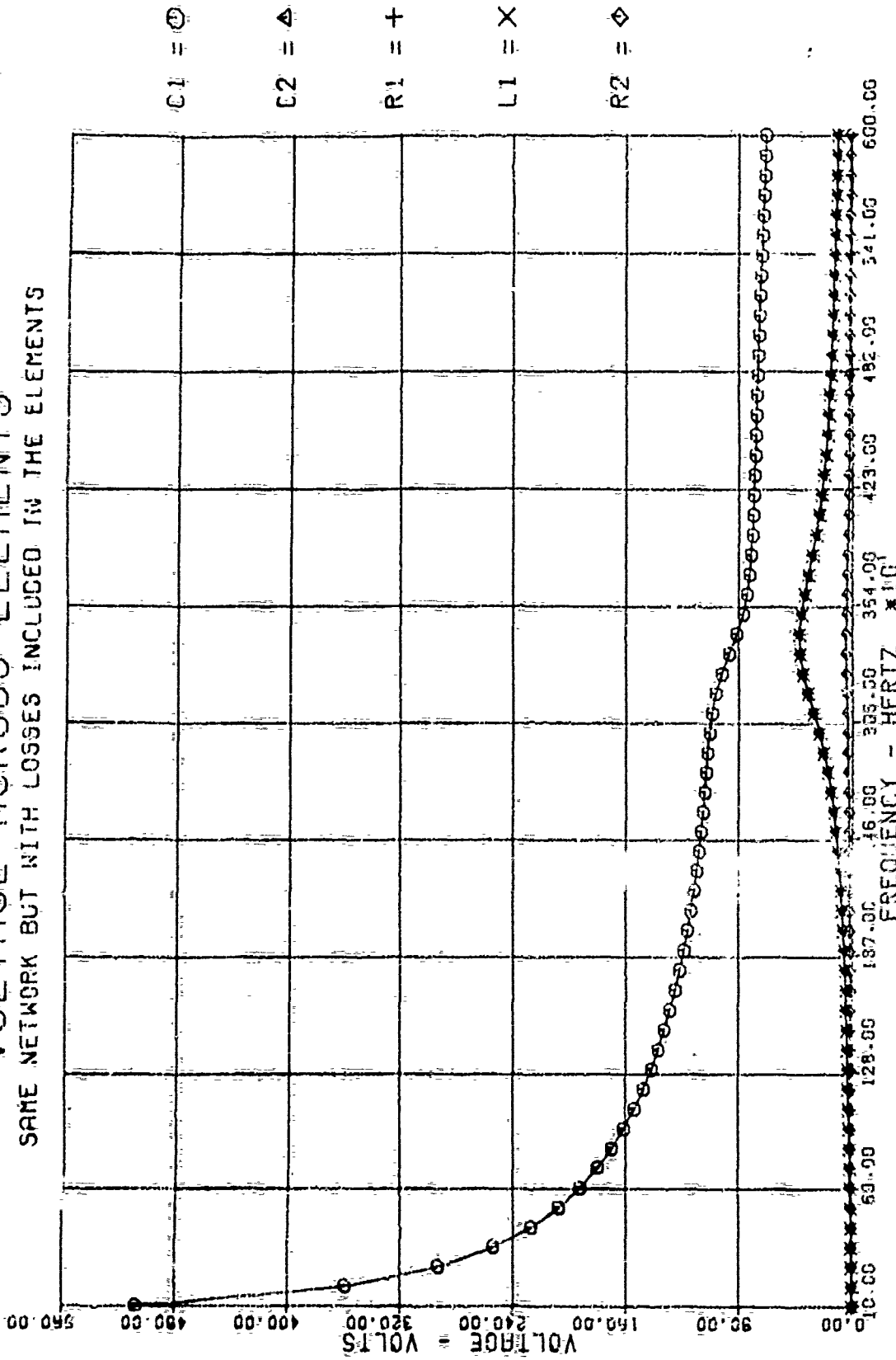
TEST OF LOAD NETWORK FOR FREQUENCY COMPENSATED AN/SQS-26(CX) 50MIL LOAD



VOLT-AMPERE INPUT = 1000.00

VOLTAGE ACROSS ELEMENTS

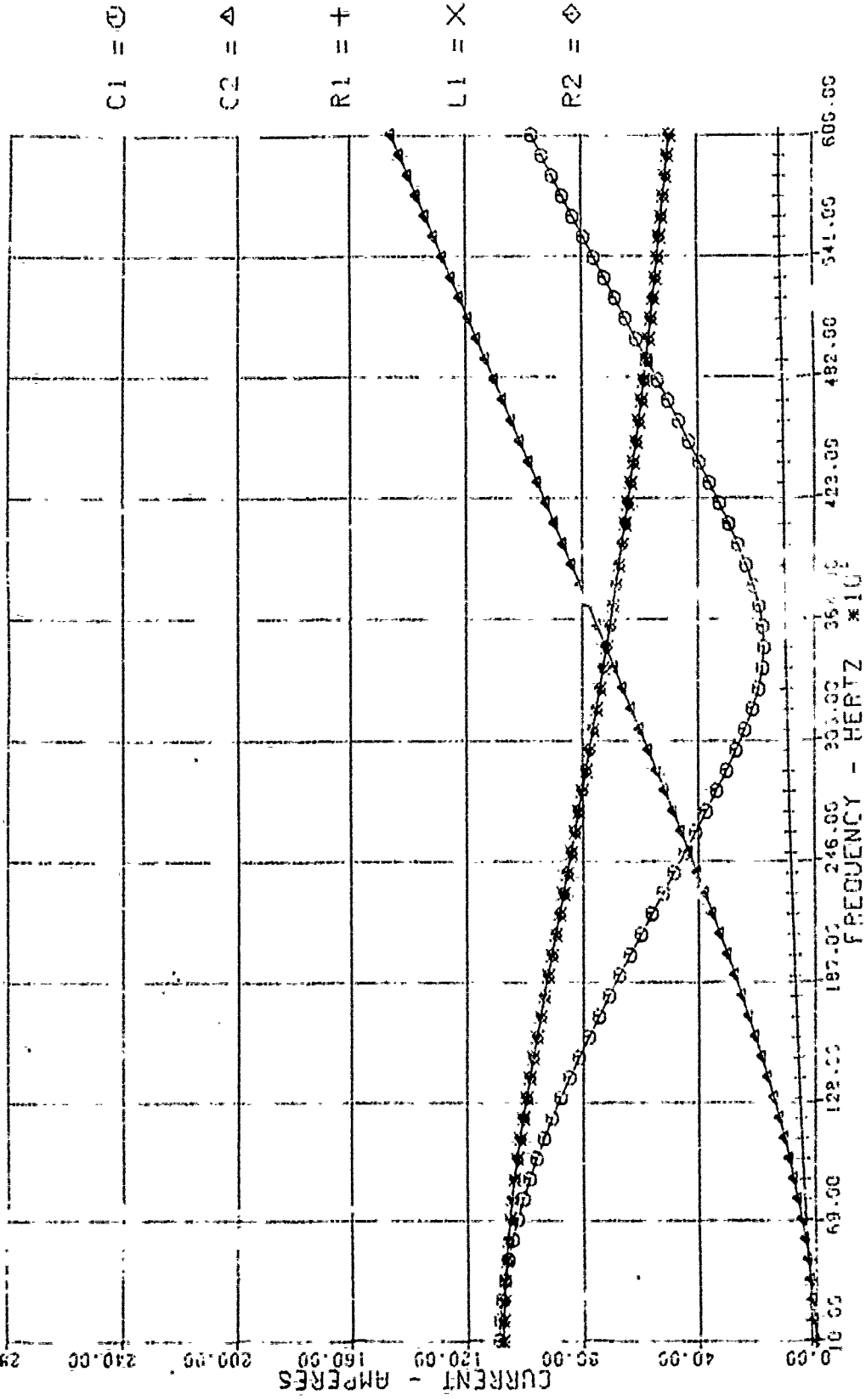
SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



VOLT-AMPERE INPUT = 1000.00

CURRENT THROUGH ELEMENTS

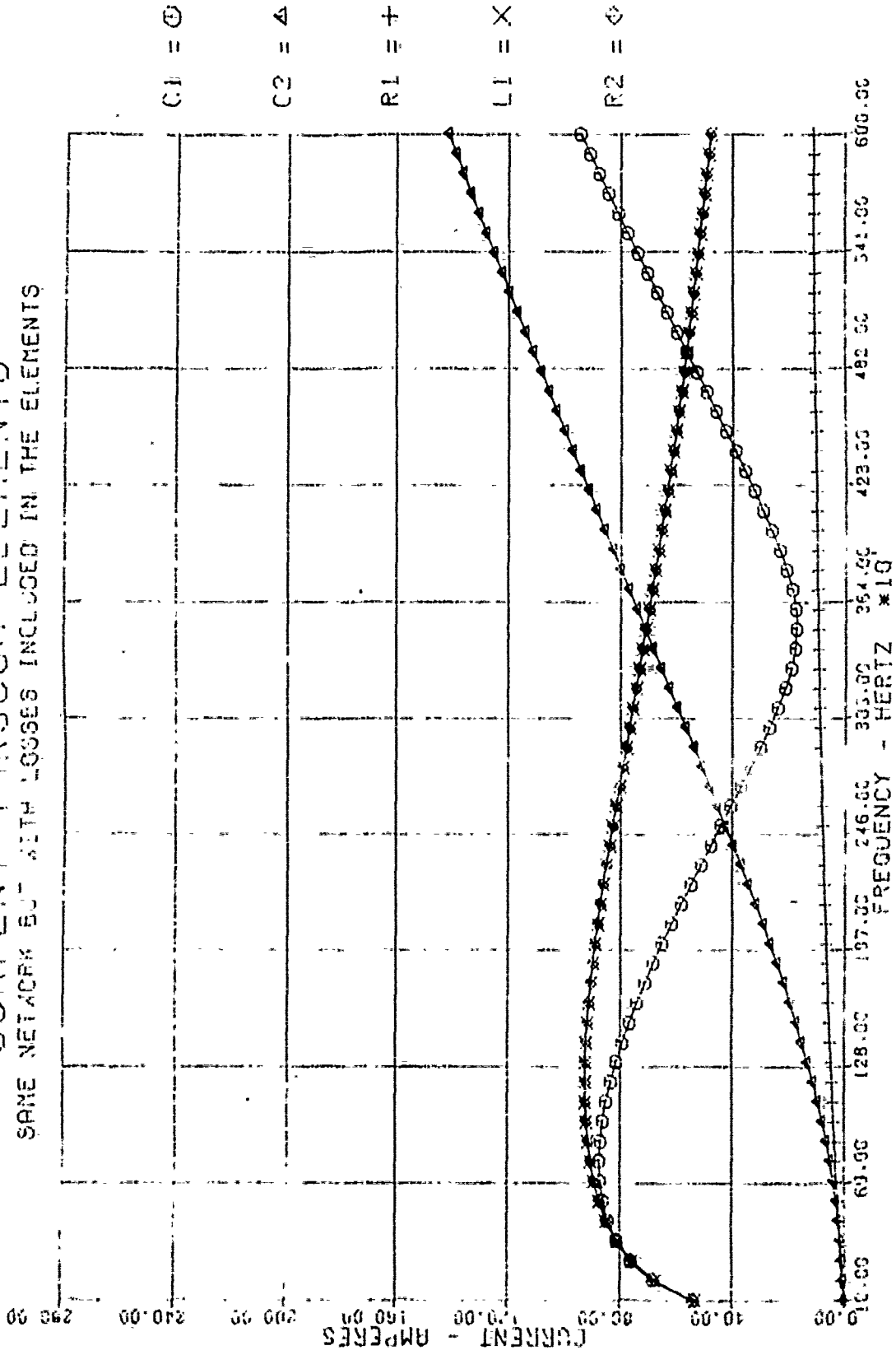
TEST IN LOAD NETWORK FOR FREQUENCY COMPENSATED AN/305-26(CX) CUMUL: QND



POWER INPUT = 1000.00

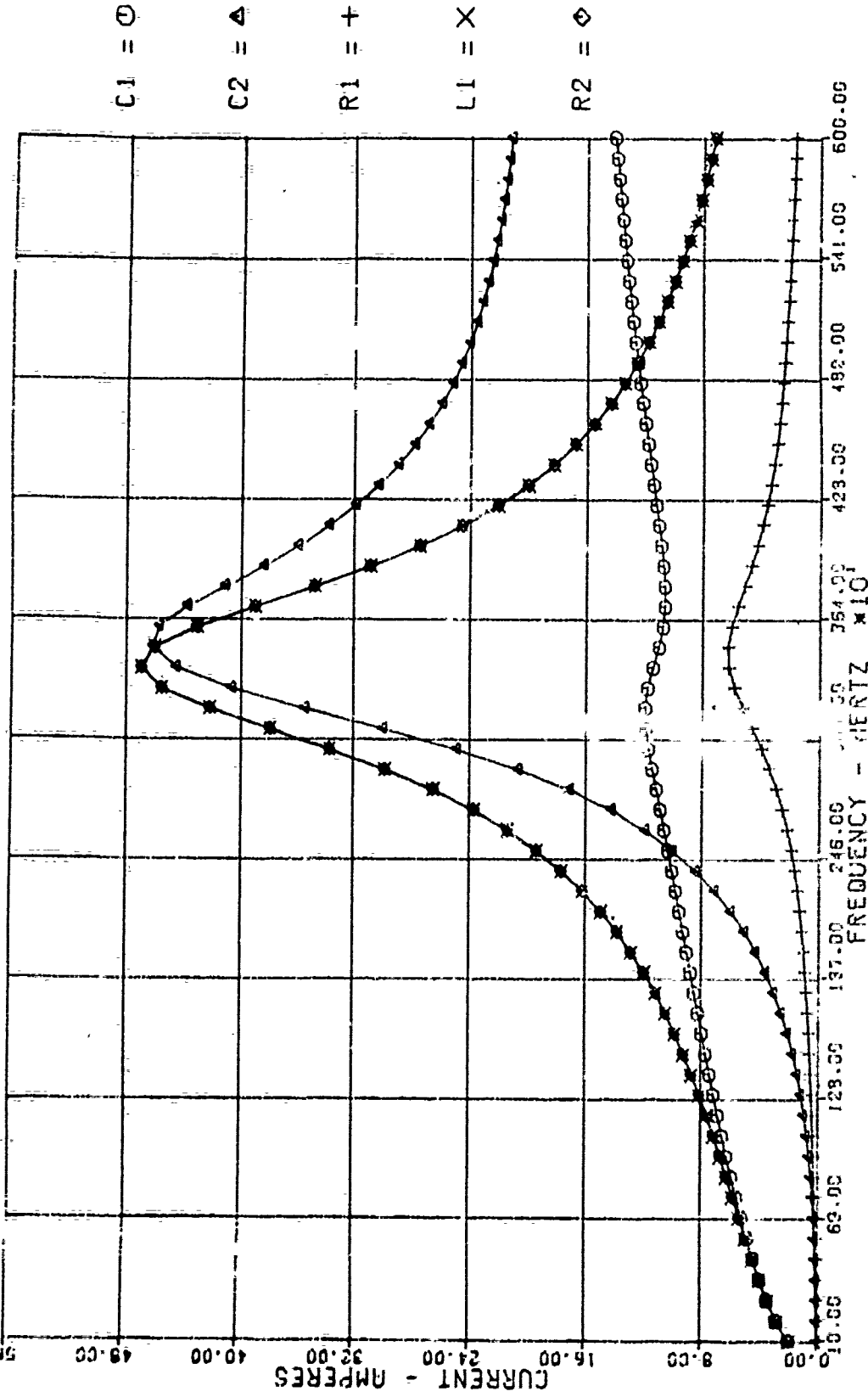
CURRENT THROUGH ELEMENTS

SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



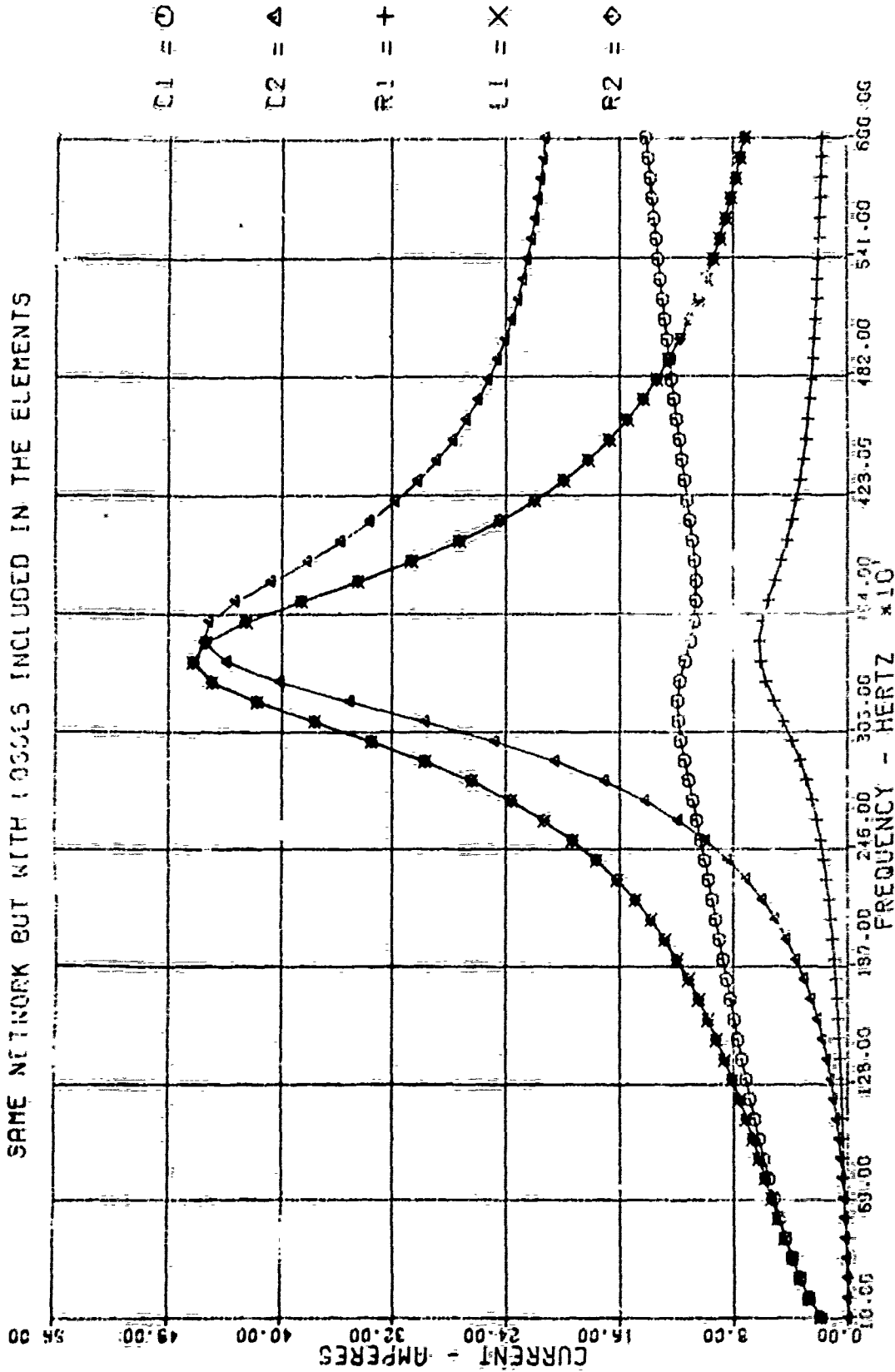
POWER INPUT = 1000.00

CURRENT THROUGH ELEMENTS
 TEST OF LOAD NETWORK FOR FREQUENCY COMPENSATED AN/30S-26(CX) GUN LOAD



VOLT-AMPERE INPUT = 1000.00

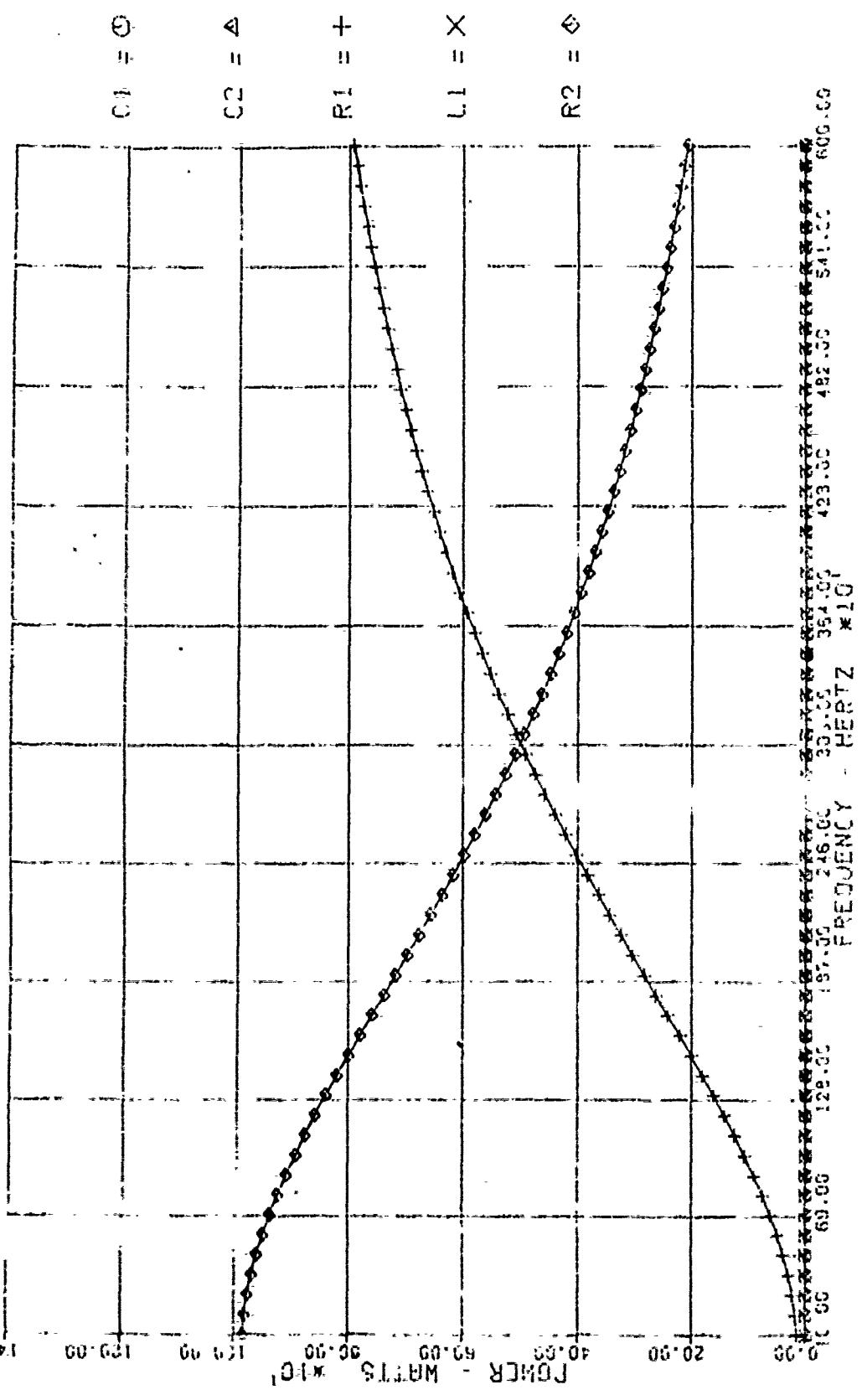
CURRENT THROUGH ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



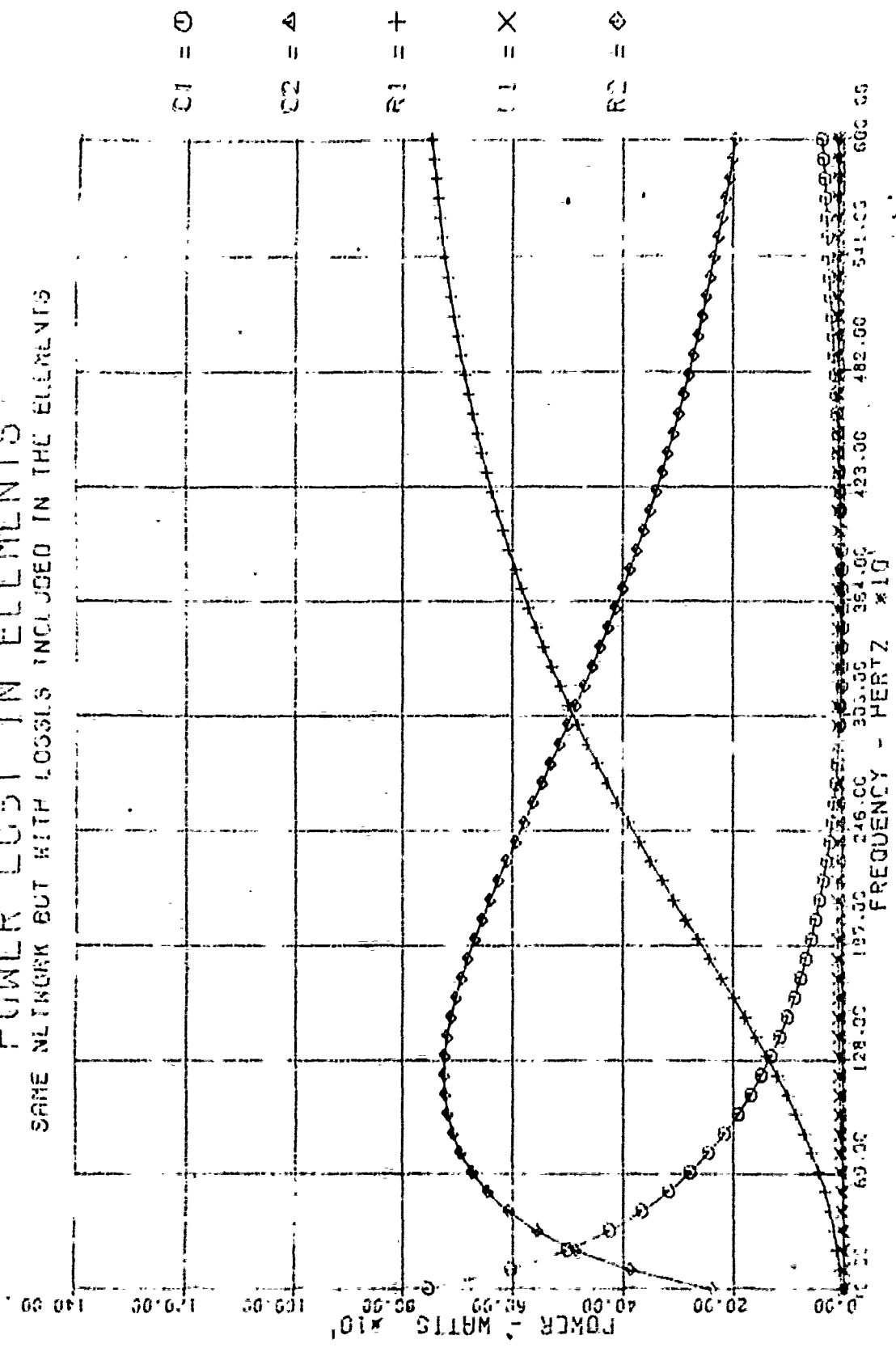
VOLT-AMPERE INPUT = 1000.00

POWER LOST IN ELEMENTS

TEST #1: LCAG NETWORK FOR FREQUENCY COMPENSATED AN/593-26(CX) CONTROL

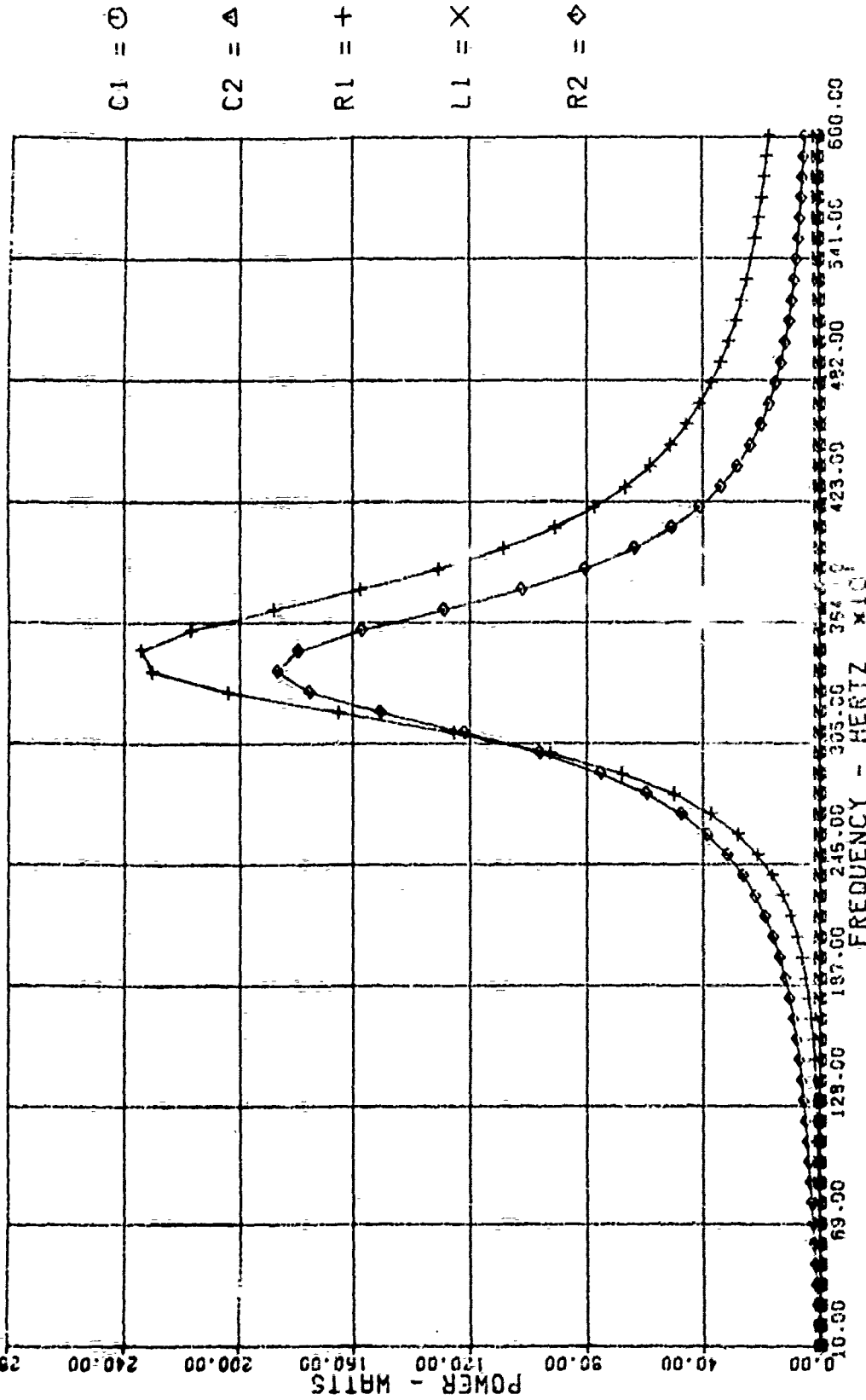


POWER LOST IN ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS

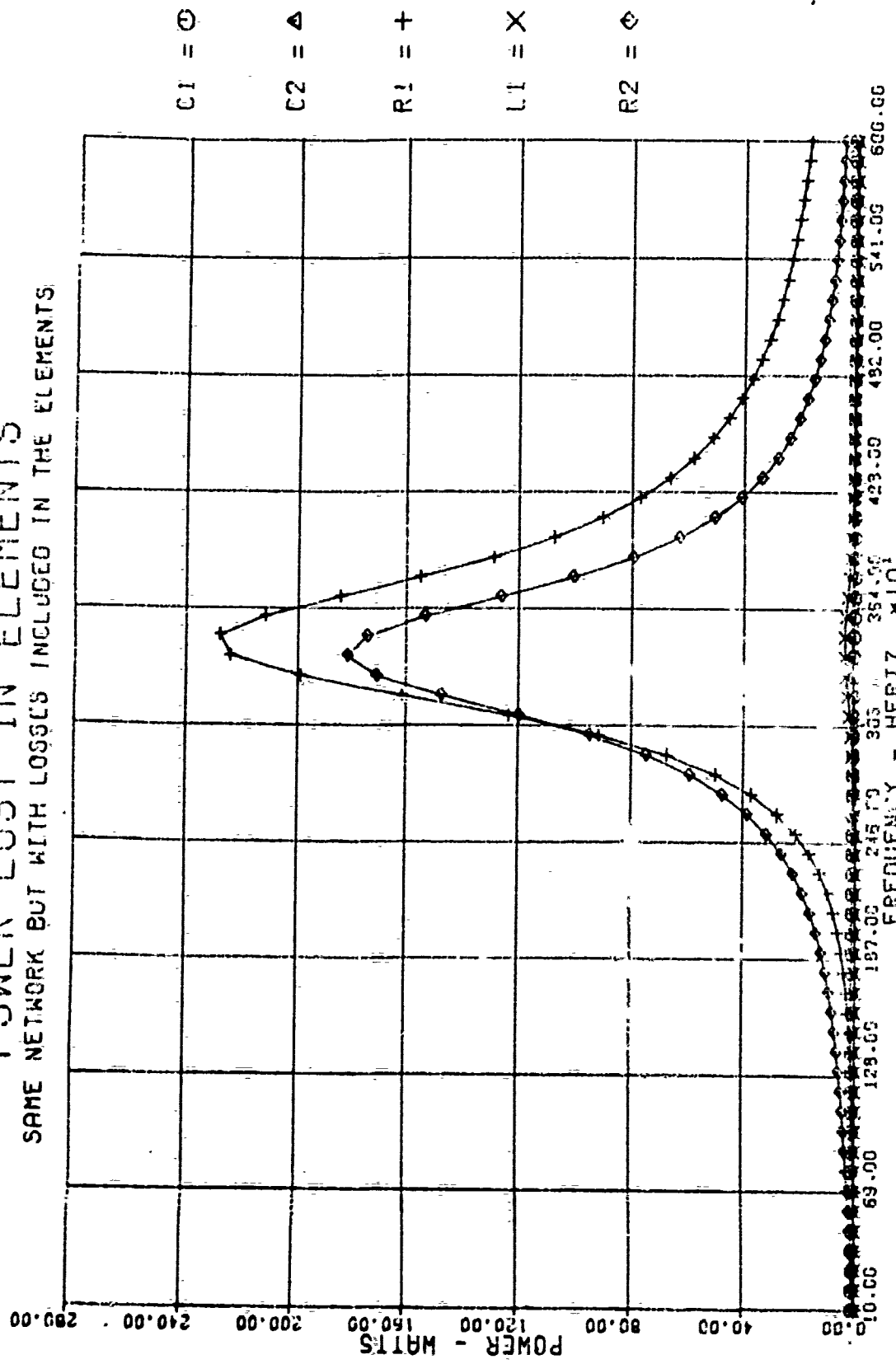


POWER INPUT = 1000.00

POWER LOST IN ELEMENTS
 TEST OF LOAD NETWORK FOR FREQUENCY COMPENSATED AN/SOS-26(CX) 0.01MILLOAD



POWER LOST IN ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS

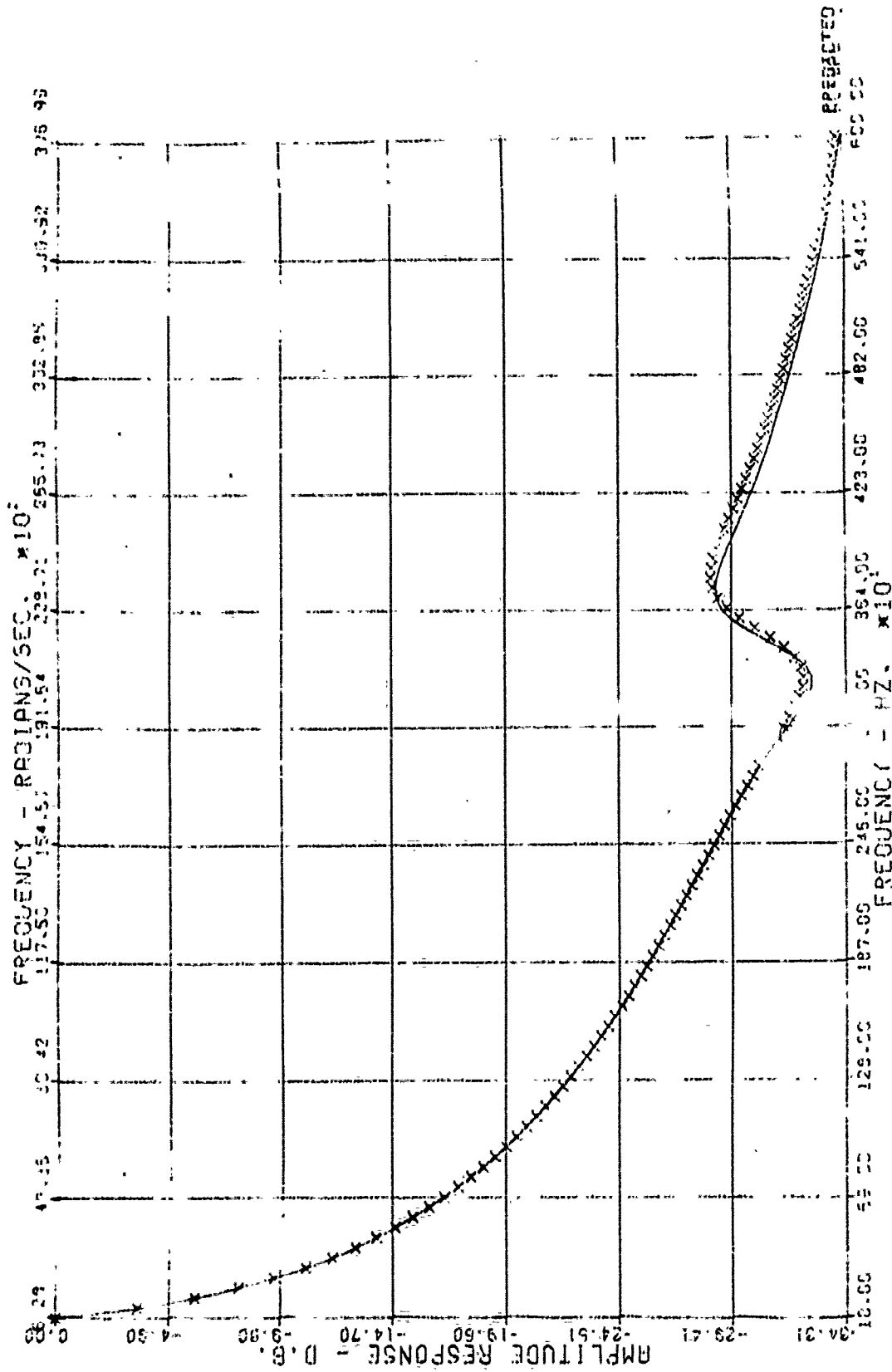


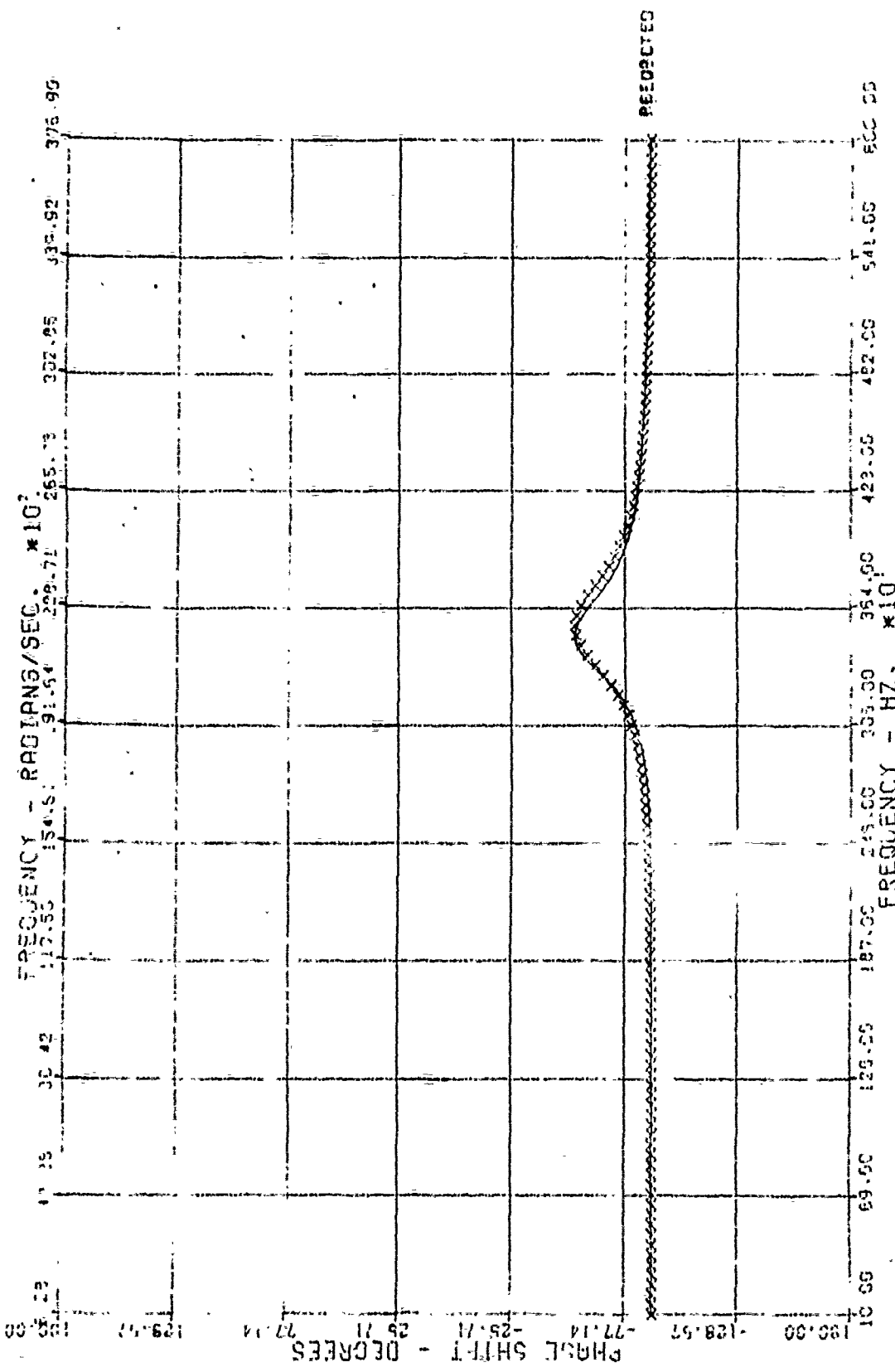
VOLT-AMPERE INPUT = 1000.00

3. Sample Case Number 2 -

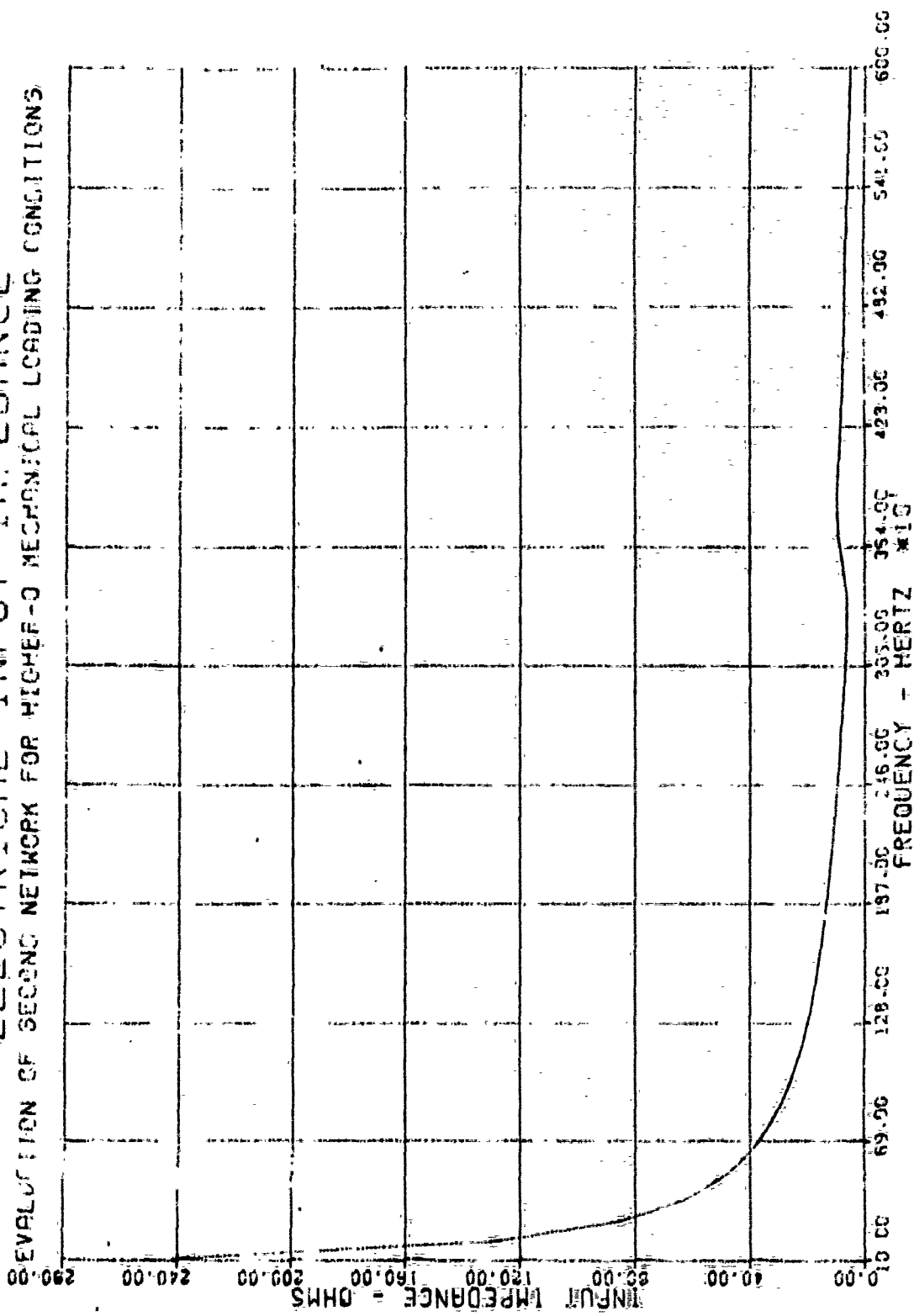
For this case, the first of the two radiation loads, the theoretical one was chosen. Since the impedance curve retains basically the same shape, the same form for the driving-point impedance function may be used and the same type of network (with slightly different component values) will yield the desired value.

The analysis conditions remain as before with the results being presented on the following pages.

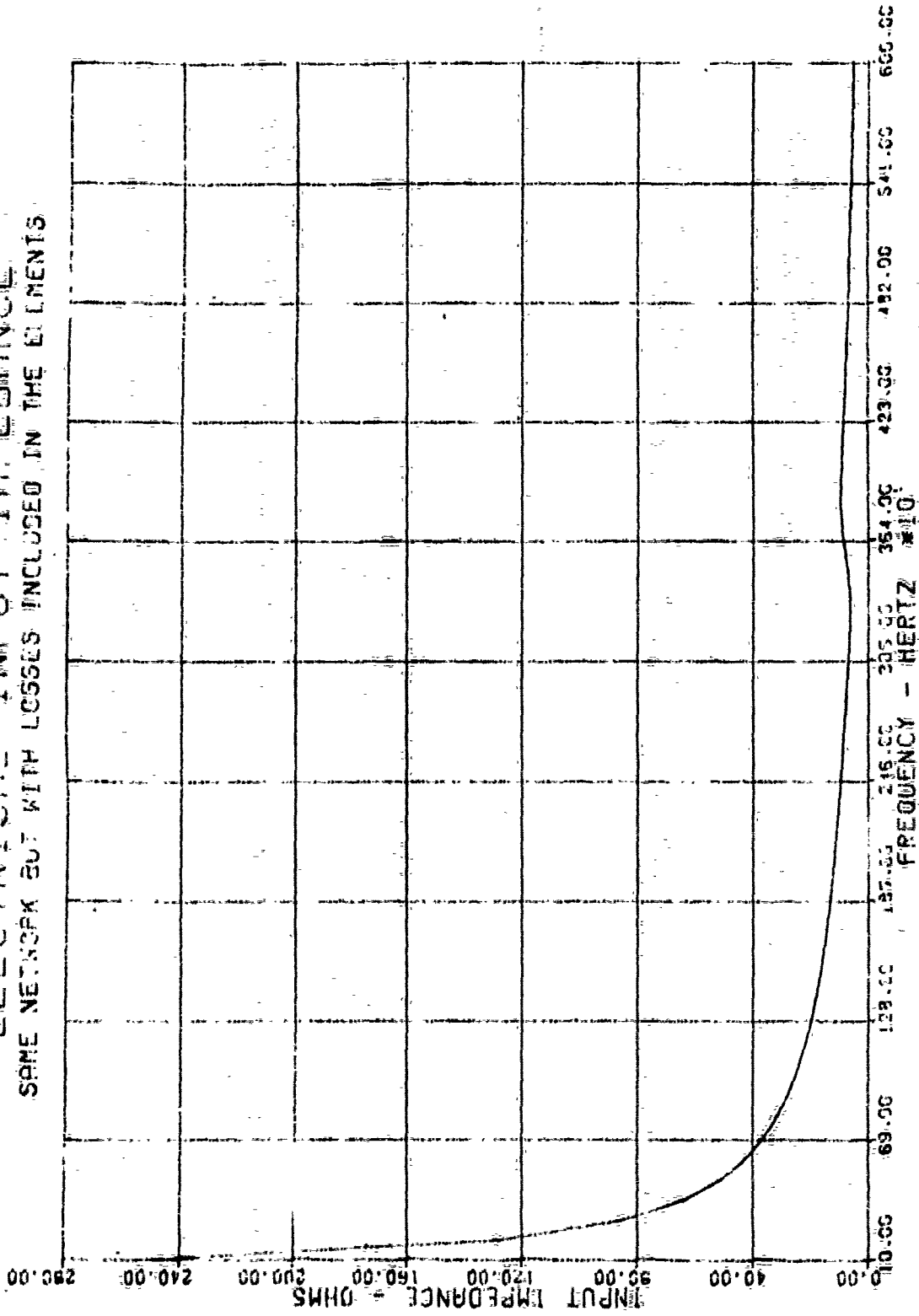




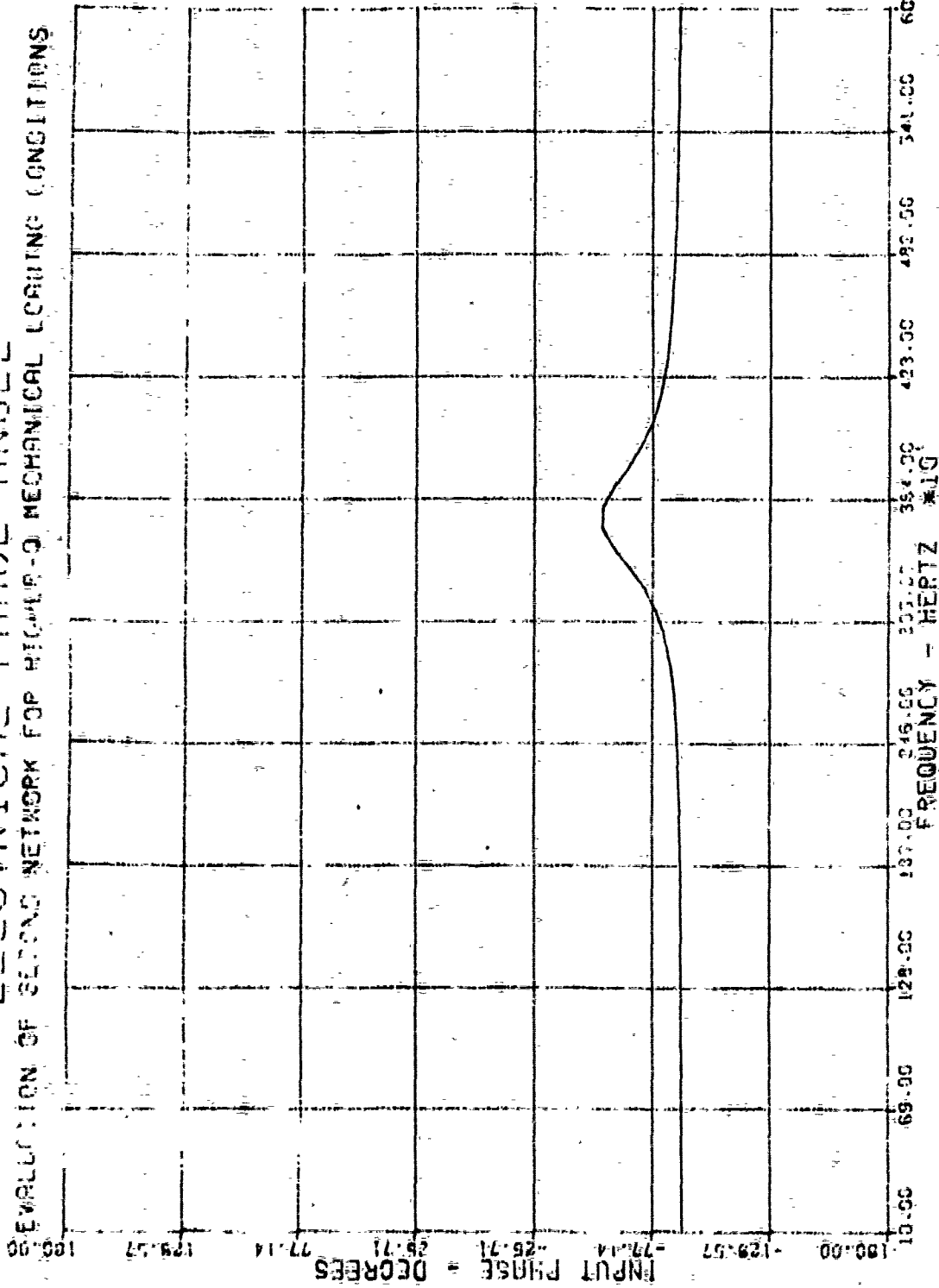
ELECTRICAL INPUT IMPEDANCE
 EVALUATION OF SECOND NETWORK FOR HIGHER-O MECHANICAL LOADING CONDITIONS



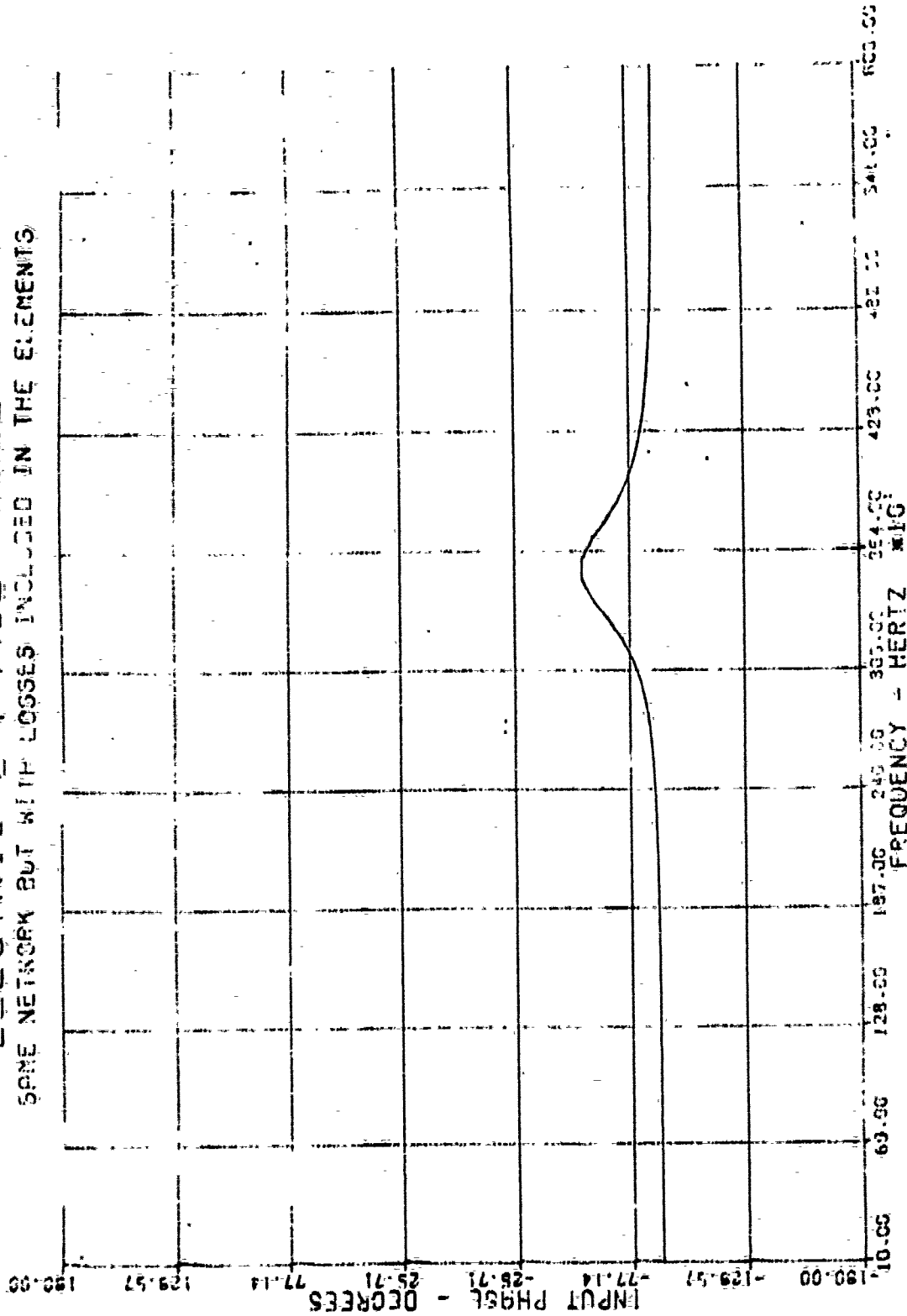
ELECTRICAL INPUT IMPEDANCE
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



ELECTRICAL PHASE ANGLE
 EVALUATION OF SECOND NETWORK FOR HIGH-P-Q MECHANICAL LOADING CONDITIONS

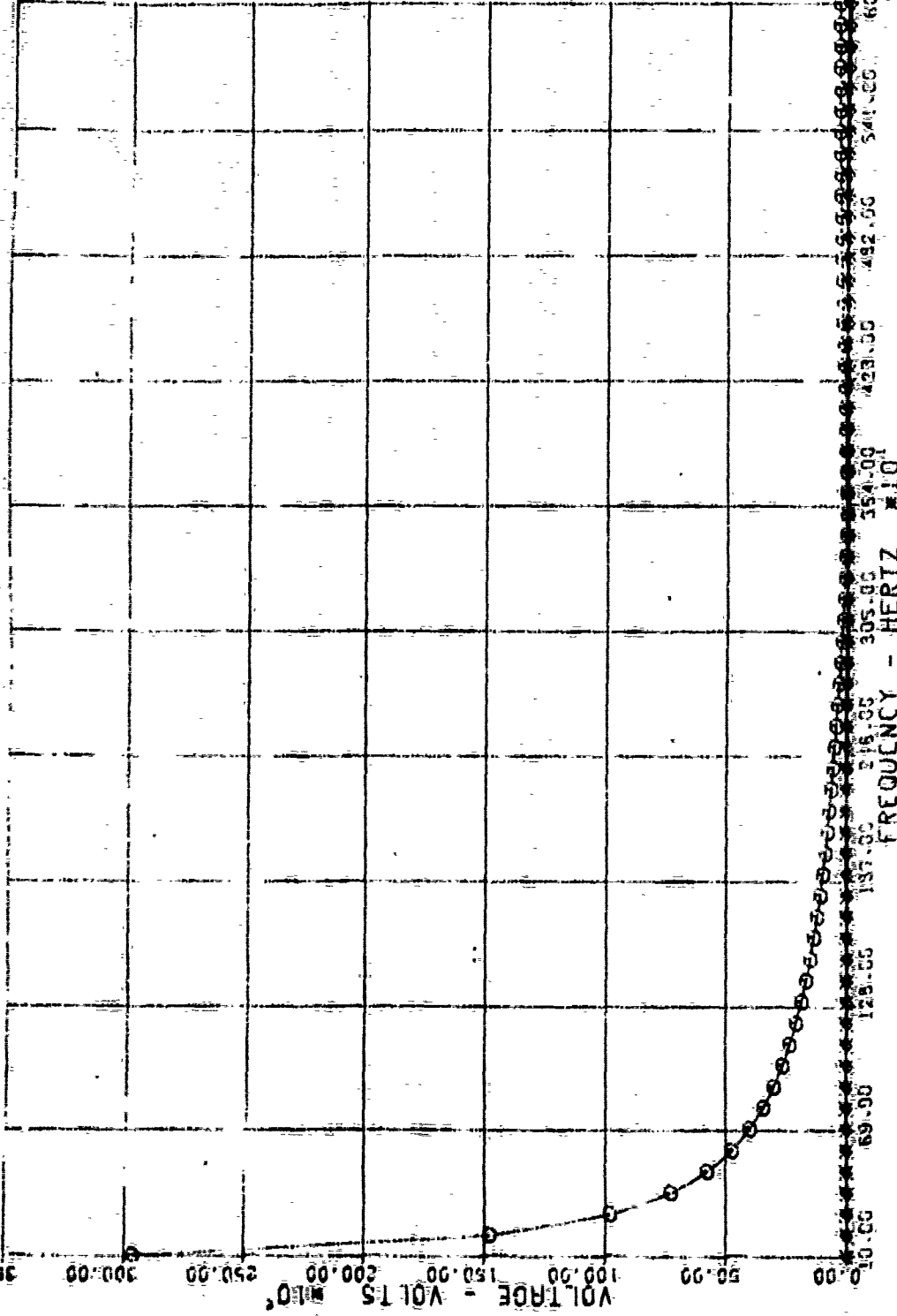


ELECTRICAL PHASE ANGLE
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



VOLTAGE SURGESS ELEMENTS

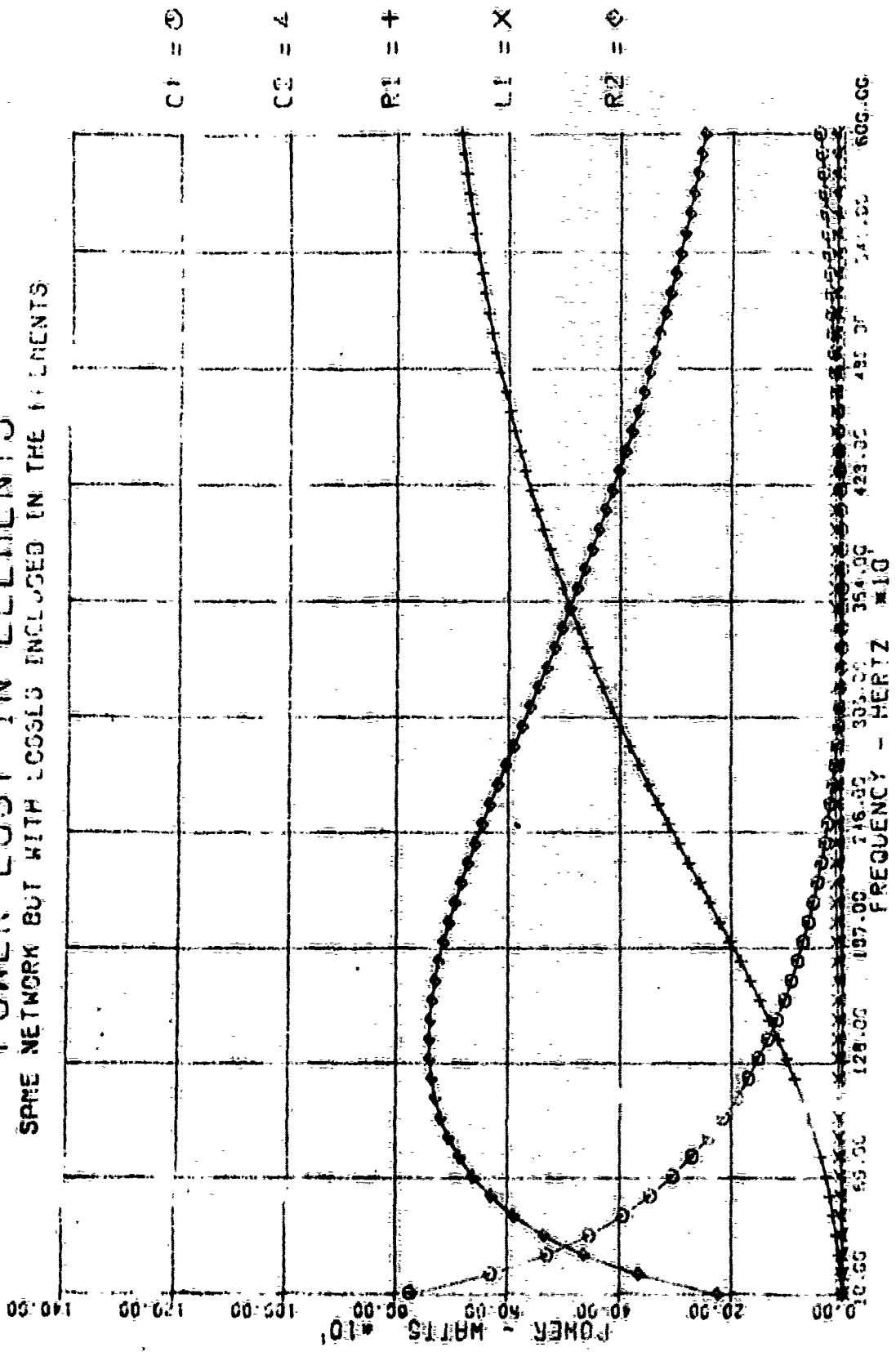
EVALUATION OF SECOND NETWORK FOR HIGHER-Q MECHANICAL COUPLING CONDITIONS



POWER INPUT = 1000.00

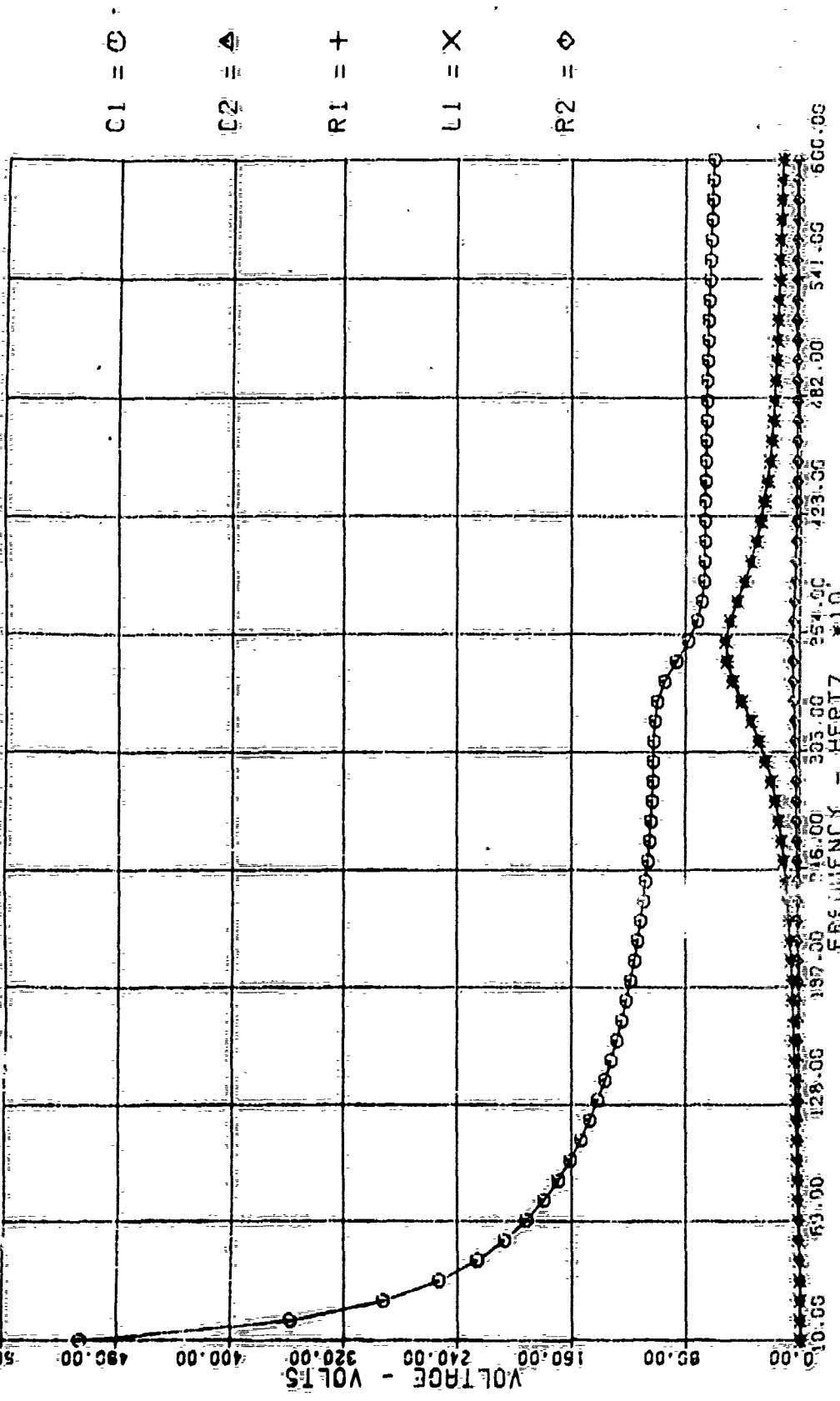
C1 = 0
 C2 = 2
 R1 = +
 L1 = X
 R2 = 0

POWER LOST IN ELEMENTS
 SAME NETWORK BUT WITH LOGS INCLUDED IN THE ELEMENTS



POWER INPUT = 1000.00

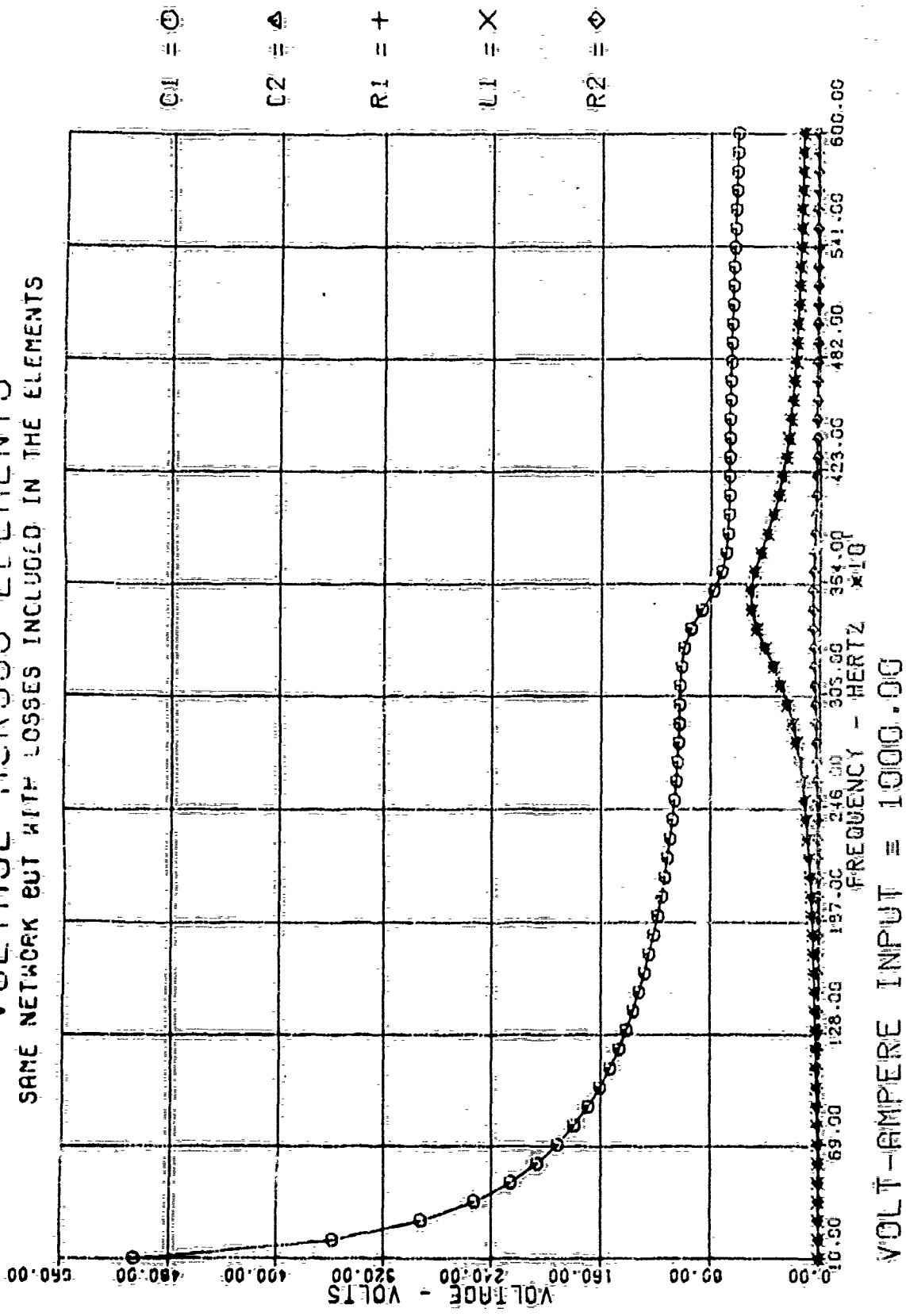
VOLTAGE ACROSS ELEMENTS
 EVALUATION OF SECOND NETWORK FOR HIGHER-MECHANICAL LOADING CONDITIONS



VOLT-AMPERE INPUT = 1000.00

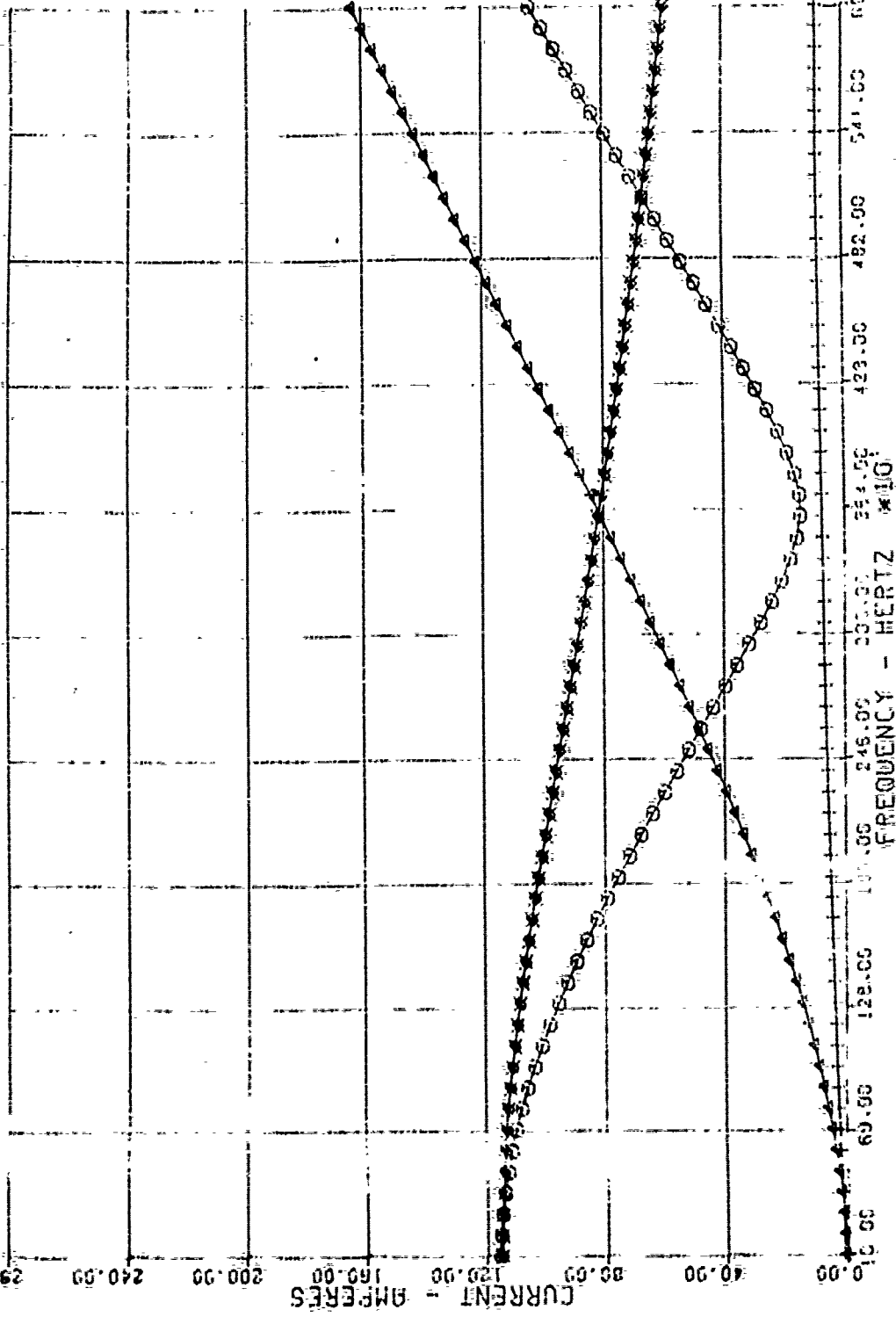
- C1 = ○
- C2 = △
- R1 = +
- L1 = X
- R2 = ◇

VOLTAGE ACROSS ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



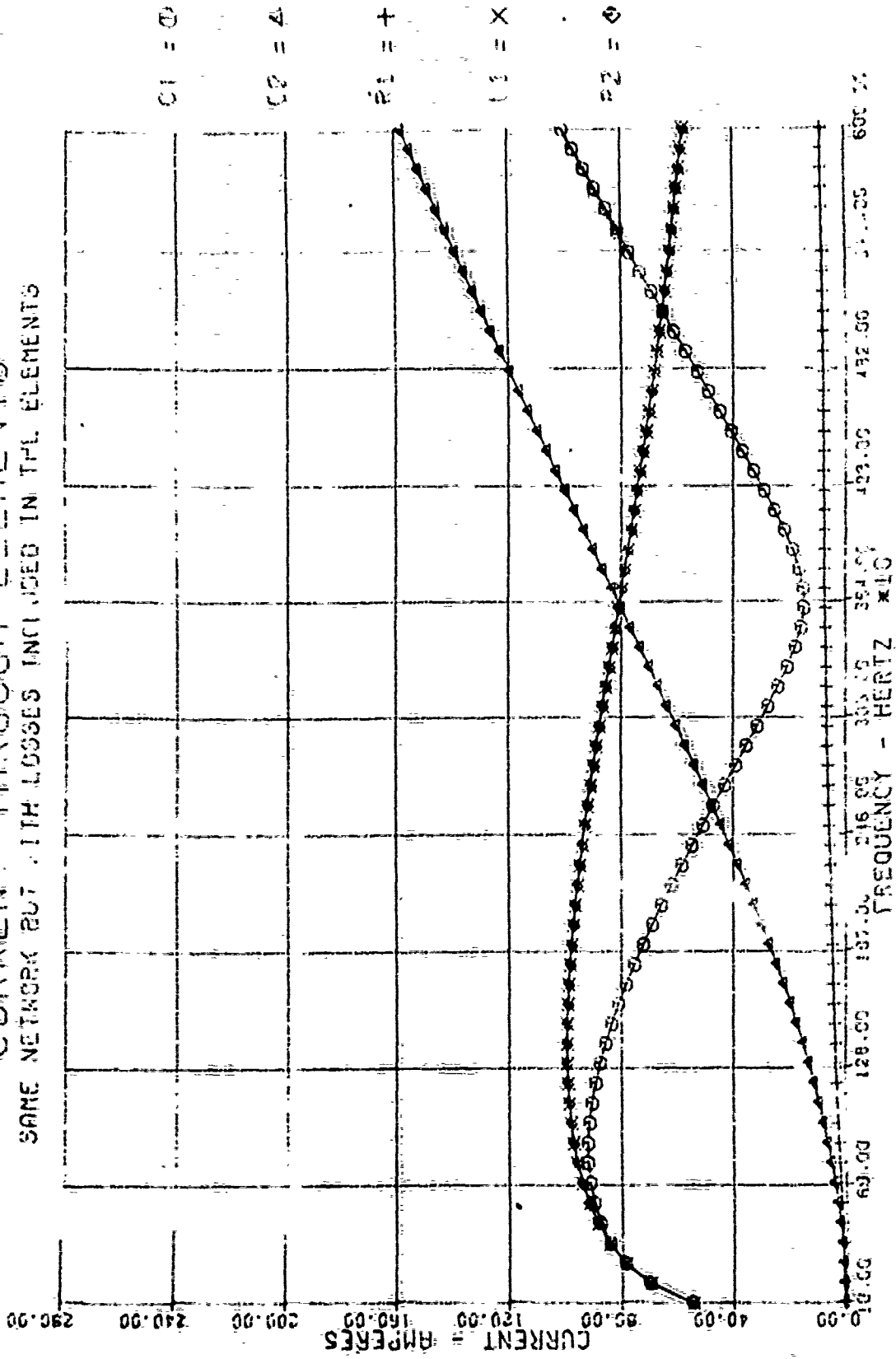
CURRENT THROUGH ELEMENTS

EVALUATION OF SECOND NETWORK FOR HIGHER-Q MECHANICAL LOADING CONDITIONS



POWER INPUT = 1000.00

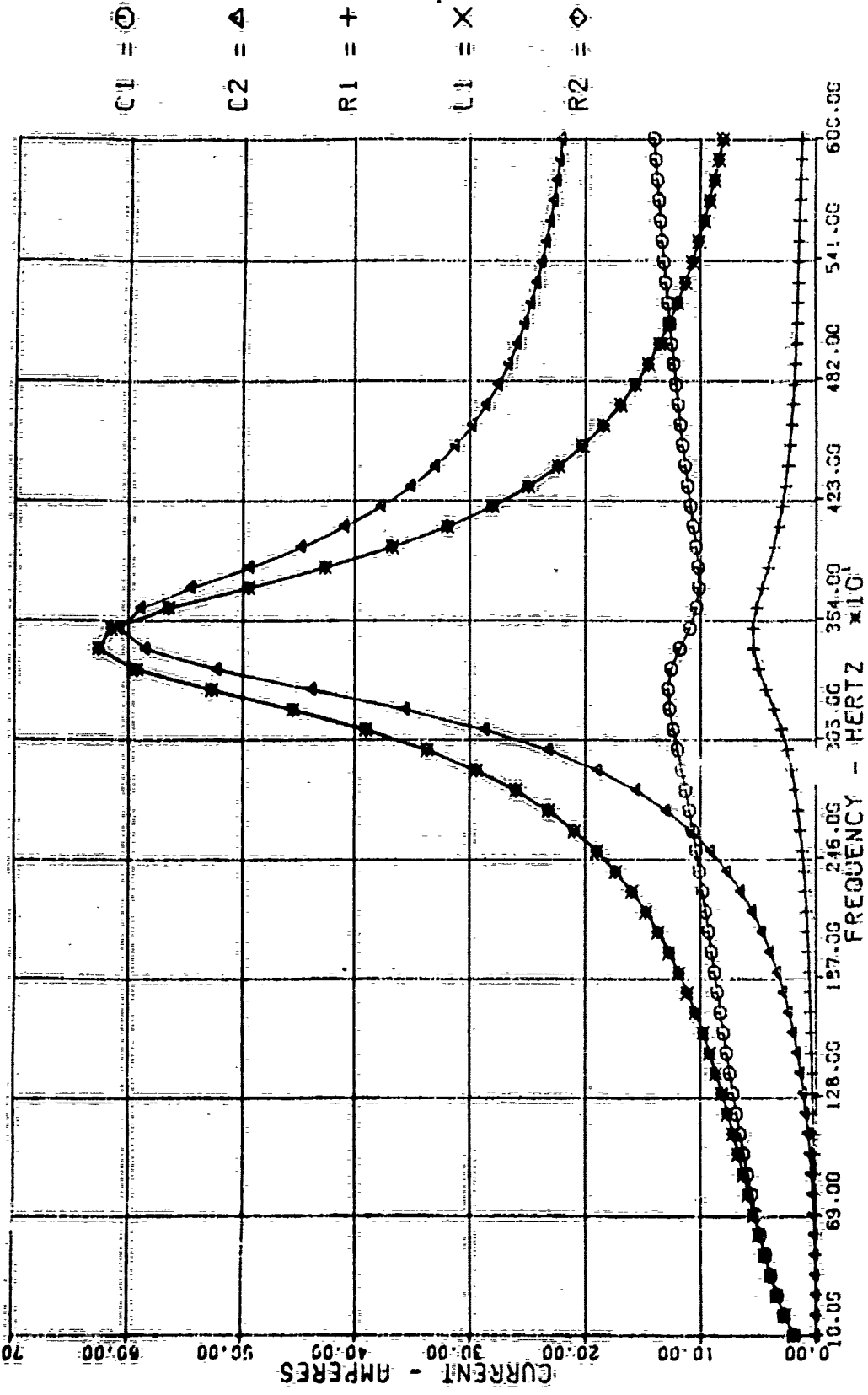
CURRENT THROUGH ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



POWER INPUT = 1000.00

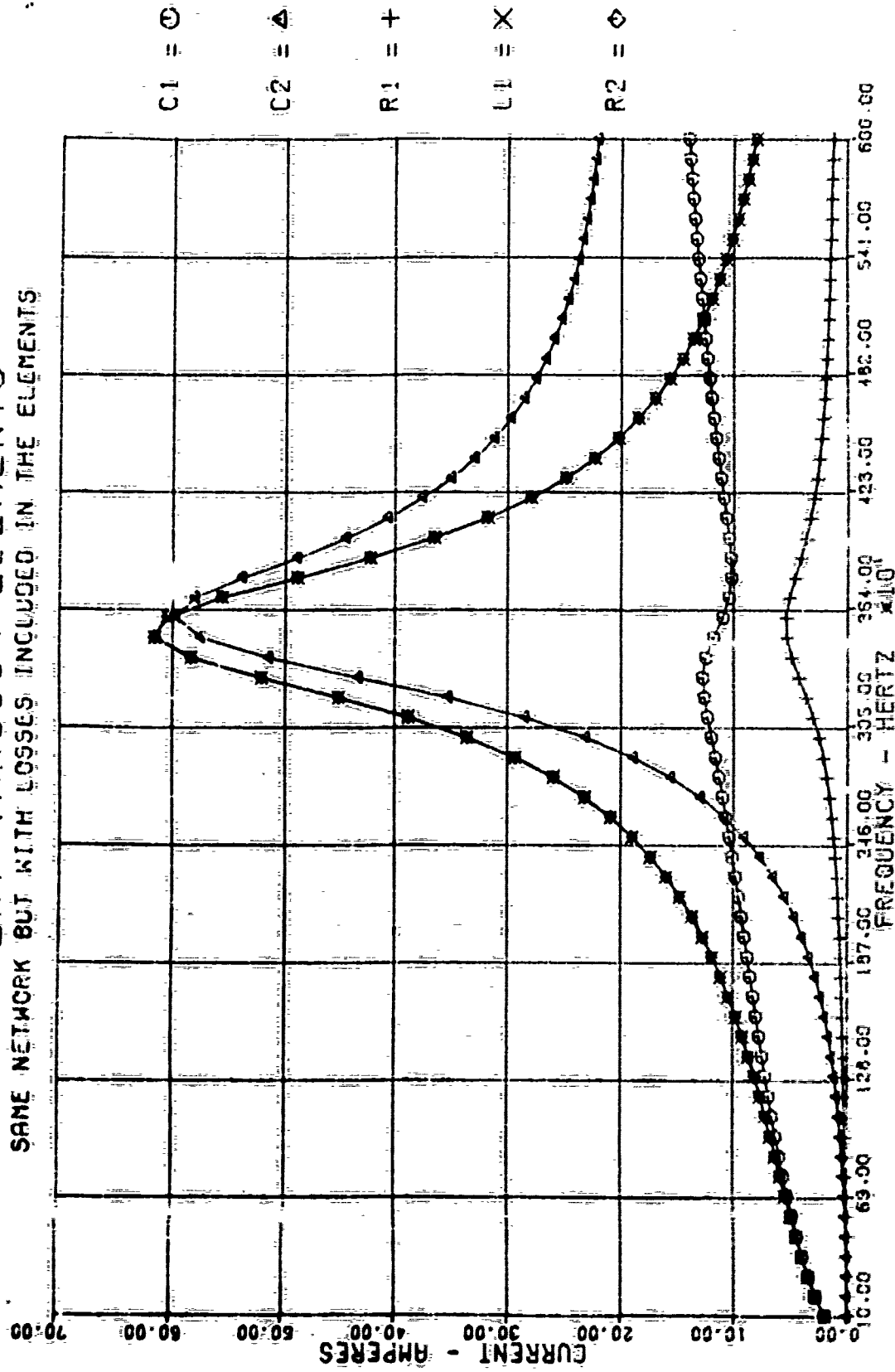
CURRENT THROUGH ELEMENTS

EVALUATION OF SECOND NETWORK FOR HIGHER-Q MECHANICAL LOADING CONDITIONS



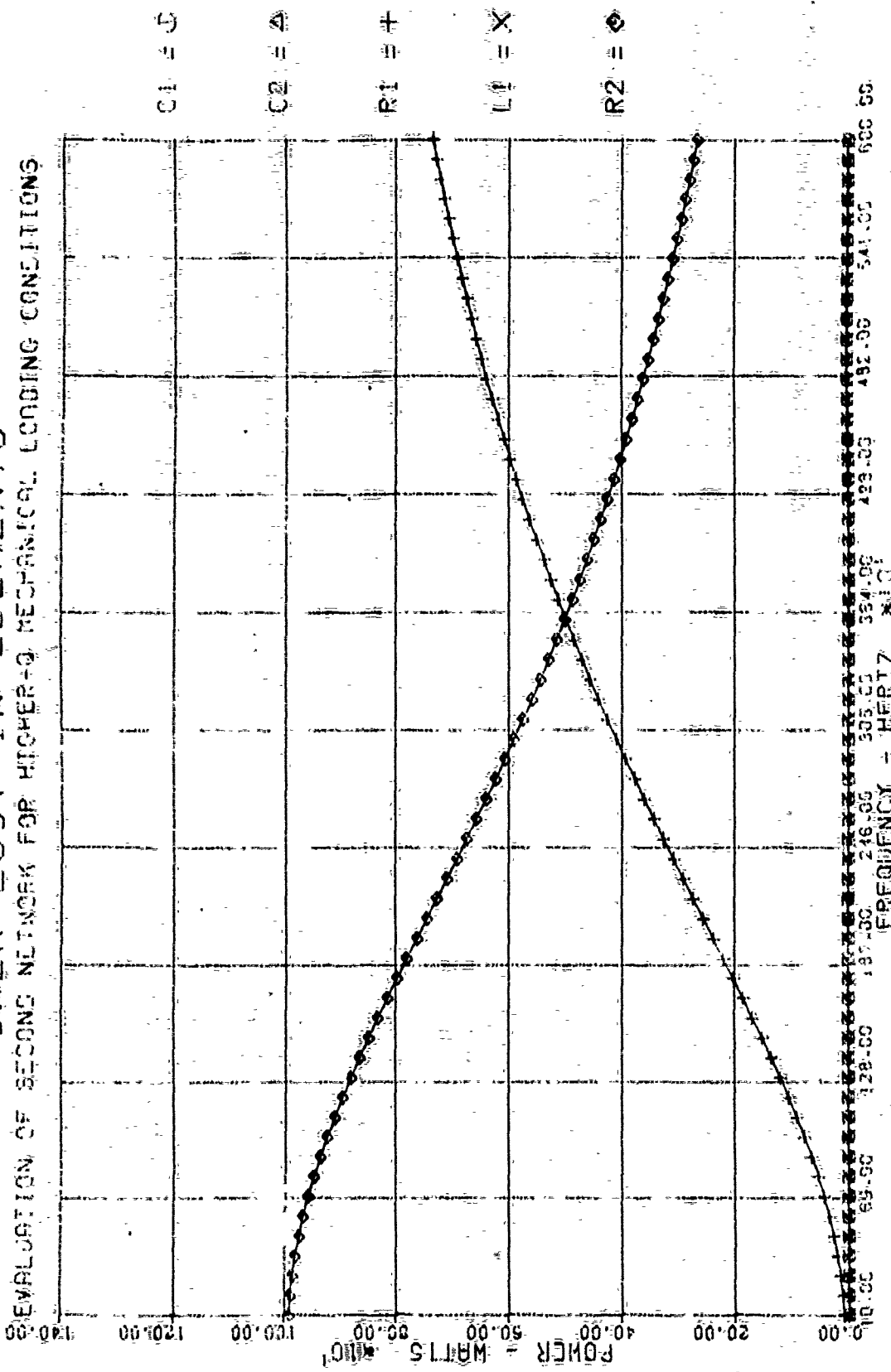
VOLT-AMPERE INPUT = 1000.00

CURRENT THROUGH ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



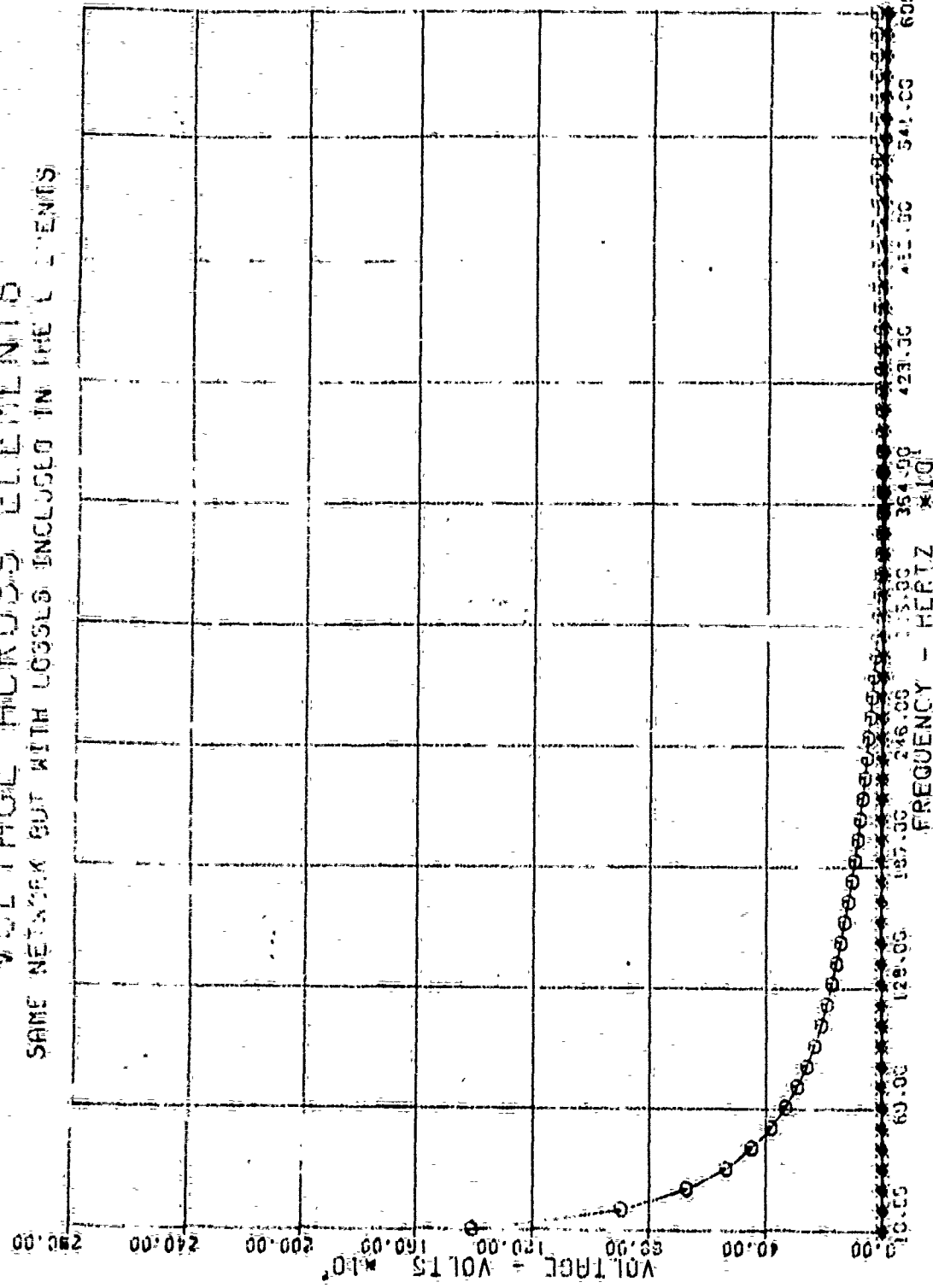
VOLT-AMPERE INPUT = 1000.00

POWER LOST IN ELEMENTS
 EVALUATION OF SECOND NETWORK FOR HIGHER-Q MECHANICAL LOADING CONDITIONS



POWER INPUT = 1000.00

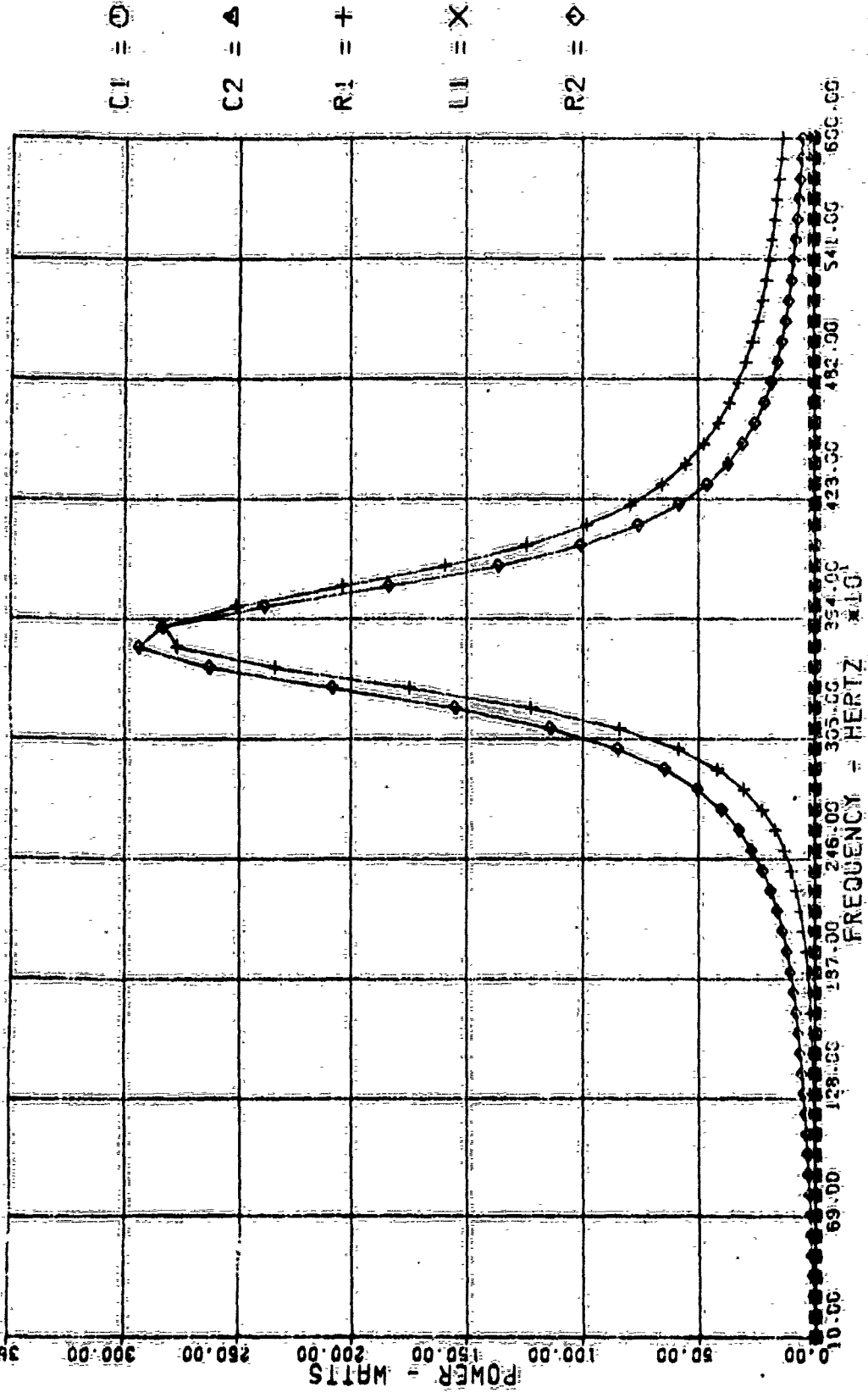
VOLTAGE ACROSS ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



C1 = ⊙
 C2 = △
 R1 = +
 L1 = X
 R2 = ⊙

POWER INPUT = 1000.00

POWER LOST IN ELEMENTS
 EVALUATION OF SECOND NETWORK FOR HIGHER-Q MECHANICAL LOADING CONDITIONS

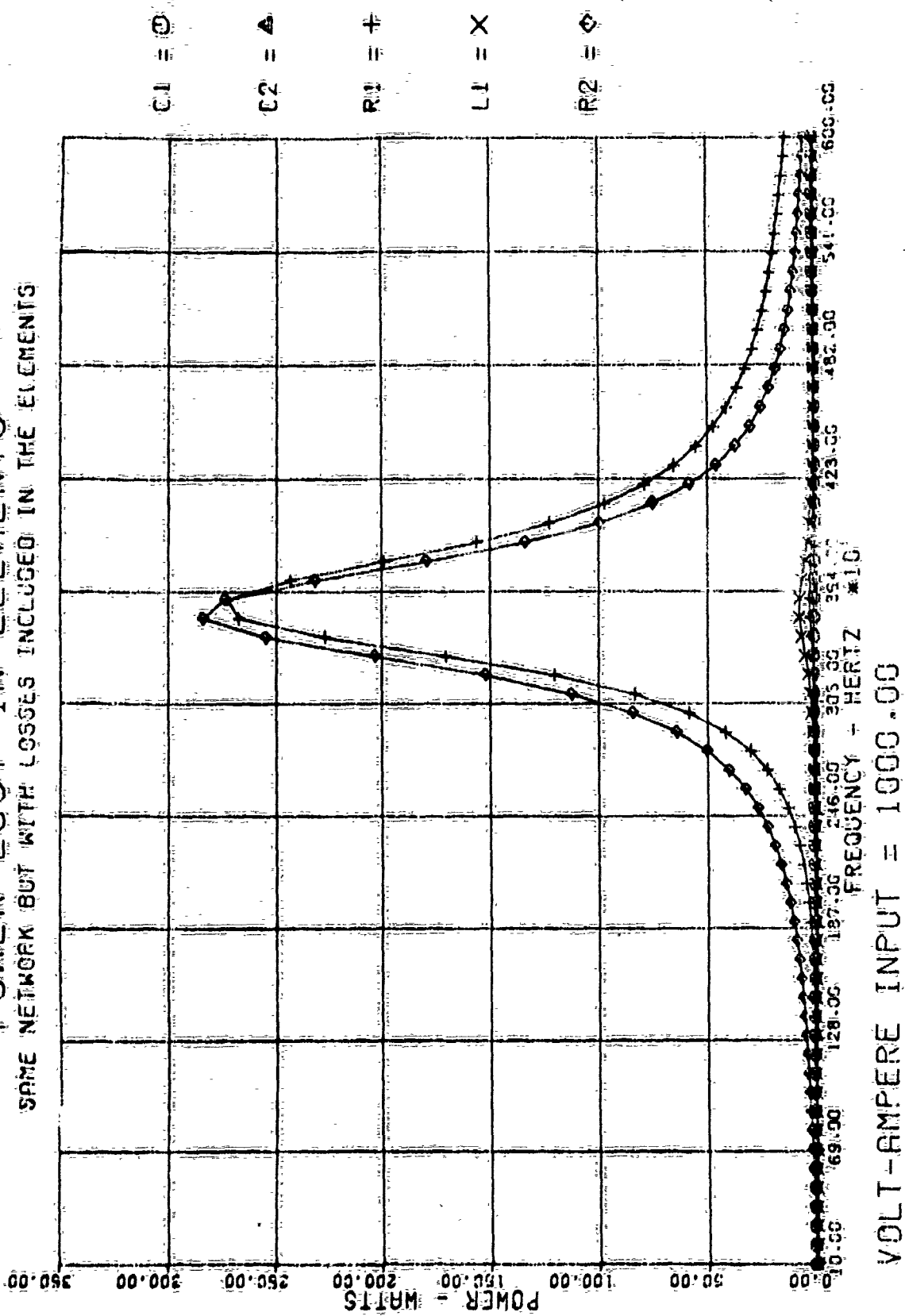


VOLT-AMPERE INPUT = 1000.00

FREQUENCY = HERTZ

▲10

POWER LOST IN ELEMENTS
 SAME NETWORK BUT WITH LOSSES INCLUDED IN THE ELEMENTS



VOLT-AMPERE INPUT = 1000.00

4. Summary -

This study shows the technique to be feasible although a slightly different type of network might yield more desirable component values. In fact, if the A, B, C and D terms in $Z(s)$ change by more than a minimal amount, a different type of network will probably have to be used to realize the driving-point impedance function.