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RATIOS OF UNIFORM RISK SPECTRUM AMPLITUDES FOR DIFFERENT PROBABILITIES OF EXCEEDANCE AND FOR SHALLOW, RANDOM SEISMICITY SURROUNDING THE SITE

by

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ABSTRACT

Ratios of Uniform Risk Spectra (URS) of Pseudo Relative Velocity (PSV) with different probabilities of exceedance have been studied in terms of their dependence on the site seismicity. It has been found that these ratios do not depend much on the period of vibration. Also, dependence of these spectra on viscous damping in the range of 0 to 20 percent of critical is small. The ratios are strong functions of the maximum earthquake magnitude, M, (Modified Mercalli Intensity, I) expected in a region, overall seismicity, A, and B, in equation $\log_{10} N = A - BM$ ($\log_{10} N = A - BI$) relating the number of earthquakes with their magnitudes (Intensities).

INTRODUCTION

In the design of safety related systems and components of nuclear power plants, for example, at present U.S. Nuclear Regulatory Commission regulations require analysis for two levels of strong earthquake shaking. In one (Safe Shutdown Earthquake - SSE), it is postulated that the site will be shaken by the "largest possible" strong earthquake motion. In this case the load combinations and the permissible stresses are chosen to reflect the fact that this shaking is an unlikely event. It is required that the safety related systems remain functional during this event. In another, also required design condition (Operating Basis Earthquake - OBE), it is supposed that the structures will be shaken by a less severe earthquake motion which is more likely to occur during the plant life. For this design case different load combination and different permissible stress conditions are prescribed and it is required that major systems and components remain operational during strong shaking.

Once the load combinations and permissible stress conditions are set, it is seen from the above example that the final dimensions of structures and equipment and their design details may depend primarily on one of these two chosen design bases which describe the "largest possible" or "more likely to occur" earthquake motion at a site. Consequently, the overall structure to structure uniformity of designed strength to resist earthquake vibrations will in a direct way depend on the choice of these two design levels. While a point might be made that these two design levels can be different for different structural systems, so that different selected functionals can be optimized on a case by case basis, it might also be considered that for ease in the analysis and a more direct engineering judgemental approach, the probabilities of exceeding these two levels might be fixed for all similar or related structures.

In design of the nuclear power plants in the United States, for example, it has been customary to study in detail the amplitudes of strong earthquake ground shaking for the "largest possible" earthquake motions at the site (Safe Shutdown Earthquake - SSE) and to take the amplitudes of the "more likely strong shaking" (Operating Basis Earthquake- OBE) equal to one half of those for the "largest possible" earthquake excitation. While this procedure certainly simplifies the detail and the extent of the studies required to prescribe the two design levels of shaking, it is clear that it must result in the probabilities of exceeding the two design levels (and in particular that of OBE) very different than those that might be sought. It is further seen that these probabilities may vary considerably from active, to intermediate, to quiet seismic zones.

In the considerations for selecting the "largest possible" (SSE) amplitudes of strong shaking for design purposes, safety considerations play a prominent role. On the other hand, in choosing the amplitudes of the "more likely levels of shaking" (OBE) the requirement that the structures and equipment remain operable during and after strong shaking may be transformed into an economical decision process where the selected design level of shaking may be directly linked to the chosen risk that this level may be exceeded and the economical implications of the resulting events. It thus seems useful to compute the ratios of the two associated spectral amplitudes (OBE/SSE) for use in design such that the probability that those will exceeded is known.

The aim of this report is to present such computations and to show the ratios of probabilistic pseudo relative response spectra for different probabilities of exceedance and in terms of the parameters which describe the local seismicity.

It appears that for certain sites the often used ratio of the two design levels equal to one half (amplitudes of OBE spectra/amplitudes of SSE spectra = 1/2) may not be appropriate if it is based on the detailed studies of the SSE amplitudes only. This is because (1) this approach implies that the physical bases employed to determine the largest amplitudes of strong shaking are the same as for the analysis of what may be the more likely amplitudes of shaking (OBE) and (2) that the differences of these two levels of shaking can be represented by a constant independent of local seismicity and of other site specific effects.

SEISMICITY MODELS AND SPECTRAL AMPLITUDES

It is beyond the scope of this work to model the most general seismicity distribution in space, since the number of different fault geometries and of their relative configurations is very large. For important construction sites one can develop specific estimates of the local seismicity and of its sources in time and space. From the computed Uniform Risk Spectra (URS)(Anderson and Trifunac 1977, 1978) one can then choose the amplitudes of the "largest possible", the "most likely" or any other desired spectral amplitudes and their ratios by defining what these levels are supposed to represent. For many applications however, it may suffice to find the ratios of computed URS for different probabilities of exceedance when the seismicity is described in terms of a large uniform shallow source zone surrounding the site. Following Westermo et al (1980), seismicity within such zone can be described by

$$N(M) = \begin{cases} 10^{A-BM} & M \le M_{max} \\ 0 & M > M_{max} \end{cases} \tag{1}$$

or by

$$N(I) = \begin{cases} 10^{A-BI} & I \le I_{max} \\ 0 & I > I_{max} \end{cases} \tag{2}$$

In these equations $N(\cdot)$ is the number of earthquakes per year per $10^3 km^2$ within the range $M - 0.25$ to $M + 0.25$ (for equation (1)) and within $I - 0.5$ and $I + 0.5$ (for equation 2)). M represents magnitude, I the intensity on the Modified Mercalli Intensity scale and A and B are constants which describe the surrounding seismic zone. M_{max} and I_{max} represent the largest magnitude and intensity respectively of earthquakes expected to occur within a zone.

Ground motion amplitudes will be described here in terms of the Pseudo Relative Velocity (PSV) Spectrum amplitudes of single-degree-of-freedom, viscously damped, oscillators with eleven natural periods between T = 0.04 sec and 12.5 sec, and with fractions of critical damping ζ = 0., 0.02, 0.05, 0.10 and 0.20. Uniform Risk Spectra of these PSV amplitudes have been computed for a range of A, B, M_{max} and I_{max} by Westermo et al (1980). Those can be employed directly to compute the amplitude ratios for different probabilities of exceedance. Their amplitudes correspond to a future interval of 50 years and are for shallow seismicity only. Scaling of ground motion amplitudes in terms of M is based on the recorded data in the Western United States and in California in particular. Calculations using intensity statistics incorporate amplitude attenuations east of Rocky Mountains (Westermo et al 1980).

In all calculations of Westermo et al (1980), it is assumed that the earthquakes with magnitudes $M < 3$ or intensities $I < 3$ contribute insignificant amplitudes for engineering considerations so that N(M) and N(I) in equations (1) and (2) are used to describe the seismicity between $M_{min} = 3$ ($I_{min} = 3$) and variable M_{max} (I_{max}) only. In this report the same assumption is also employed.

RATIOS OF SPECTRAL AMPLITUDES

Figures 1a and 1b present examples of computed spectral ratios of Uniform Risk PSV Spectrum amplitudes for $A = 0.7$, $B = 0.8$, $M_{min} = 3$ and $M_{max} = 5.5$ and $A = 4.23$, $B = 1.00$, $M_{min} = 3$ and $M_{max} = 6.5$ plotted versus natural period of the oscillators, T, in seconds and for five dampings $\zeta = 0, 0.02, 0.05, 0.1$ and 0.20 (+:$\zeta = 0$; x:$\zeta = 0.02$; *:$\zeta = 0.05$; #:$\zeta = 0.1$; +•:$\zeta = 0.20$). Three plots are shown in this figure for different probabilities or exceeding the URS amplitudes. The first (left) diagram shows the ratios of URS with probability of exceedance equal to 70 per cent and spectra with the probabilities of exceedance equal to 50, 30, 10 and 5 per cent. The second (center) shows the ratios of spectra with 90 per cent of chance of being exceeded and the spectra with 70, 50, 30, 10 and 5 per cent chance of being exceeded. The third (right) plot shows the ratios of amplitudes for spectra with 95 per cent and 90, 70, 50, 30, 10 and 5 per cent chance of being exceeded, respectively. Fig. 1a (1b)

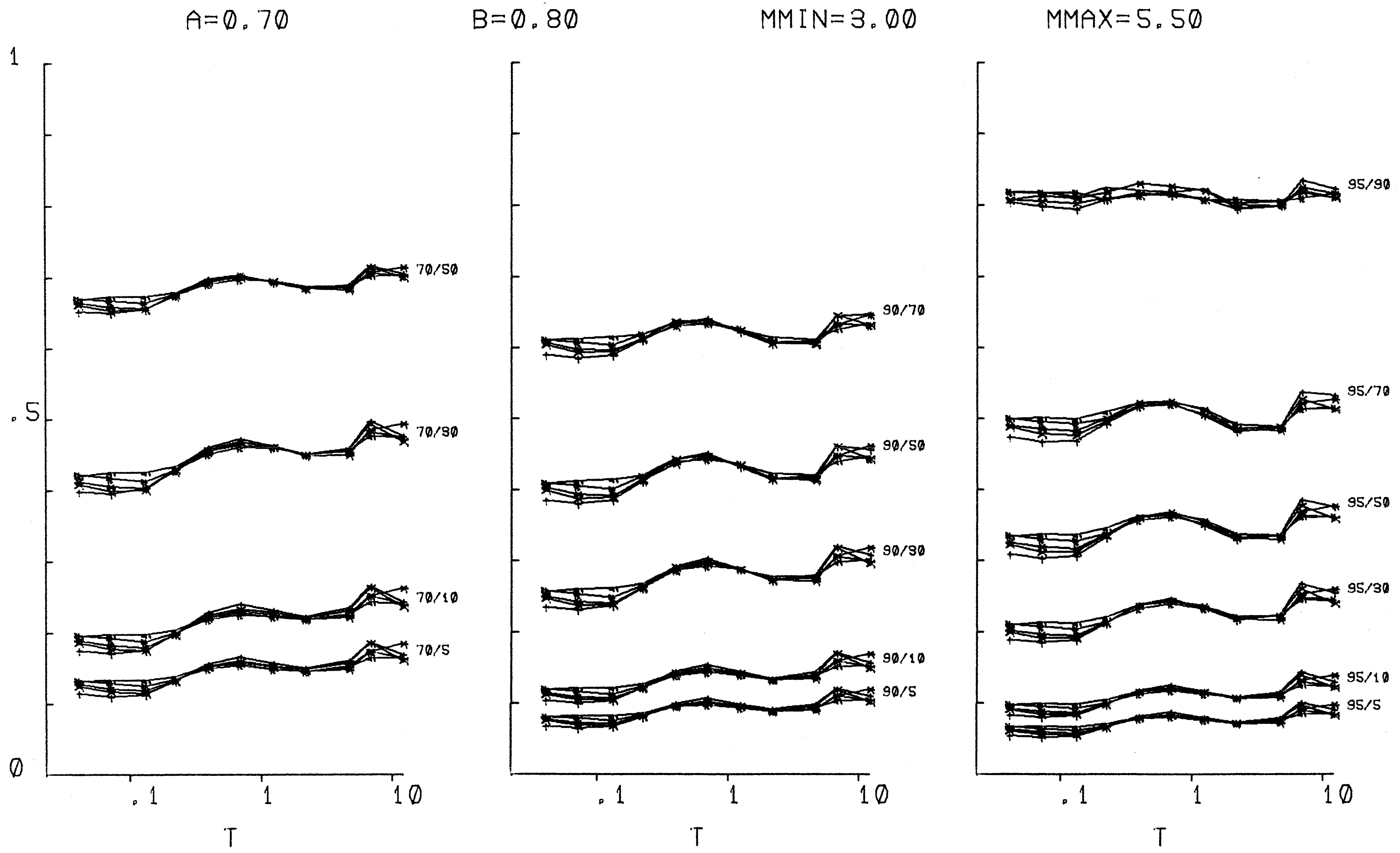

Fig. 1a

Ratios of computed URS amplitudes plotted versus period T. The label 70/50, for example, means that the ratio of amplitudes corresponds to URS spectra with 70 and 50 per cent chance of being exceeded. Ratios for five dampings are shown.

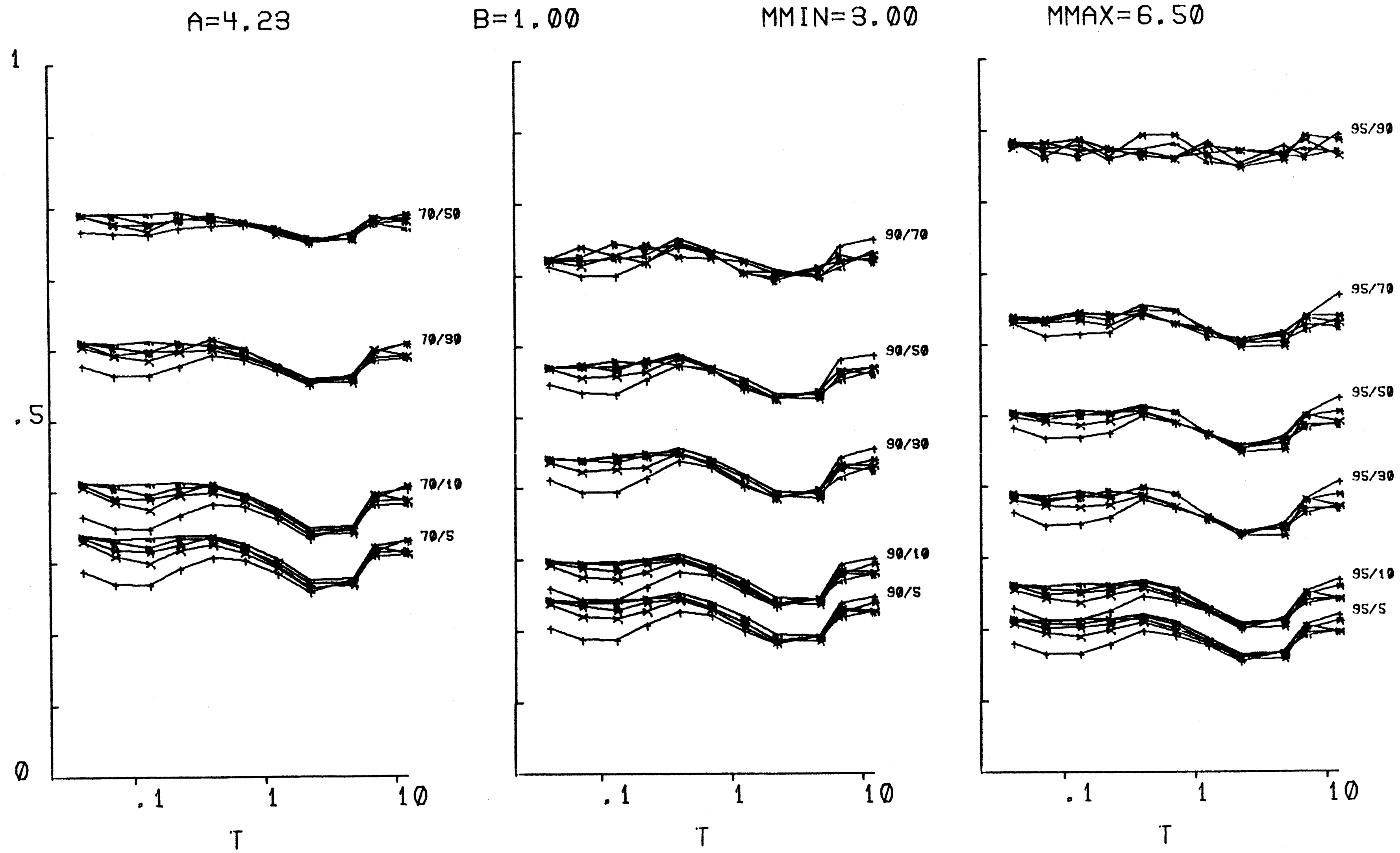

Fig. 1b
Ratios of computed URS amplitudes plotted versus period T. The label 70/50, for example, means that the ratio of amplitudes corresponds to URS spectra with 70 and 50 per cent chance of being exceeded. Ratios for five dampings are shown.

illustrates graphically a portion of one page of Tables in the report by Westermo et al (1980). For example, it could illustrate the ratios of URS of OBE with probabilities of being exceeded equal to 70, 90 and 95 per cent and SSE URS amplitudes with probabilities of exceedance going down to 5 per cent.

It is seen from Figure 1 that (1) essentially all ratios between 0 and 1 are possible, (2) that the ratios are relatively constant with period T and (3) are not too dependent on damping. Detailed study of such plots for different A, B and M_{max} (I_{max}) further shows, that the spectral ratios similar to those shown in Figure 1 are fairly constant for essentially all A, B, M_{max} and I_{max} considered by Westermo et al (1980). For small B (e.g.0.6) and small M_{max} (e.g.M_{max} = 5.5) these ratios are more dependent on damping. For large B (e.g.1.4) and large M_{max} (e.g.M_{max} = 7.5) this dependence becomes negligible.

Small variations of spectral ratios shown in Figure 1 with respect to T suggest that for many applications it may be sufficient to present only the ratios averaged over T. Dependence of these average ratios is shown in Figure 2 for scaling in terms of earthquake magnitude and epicentral distance and in Figure 3 for scaling in terms of the Modified Mercalli Intensity, plotted versus B. The effect of damping on average spectral ratios is seen to be small and could be neglected or averaged out.

For small A (low seismicity) ratios of URS of PSV change little with respect to B. As A increases the negative slope of these ratios with respect to B increases. This slope also increases for increasing difference

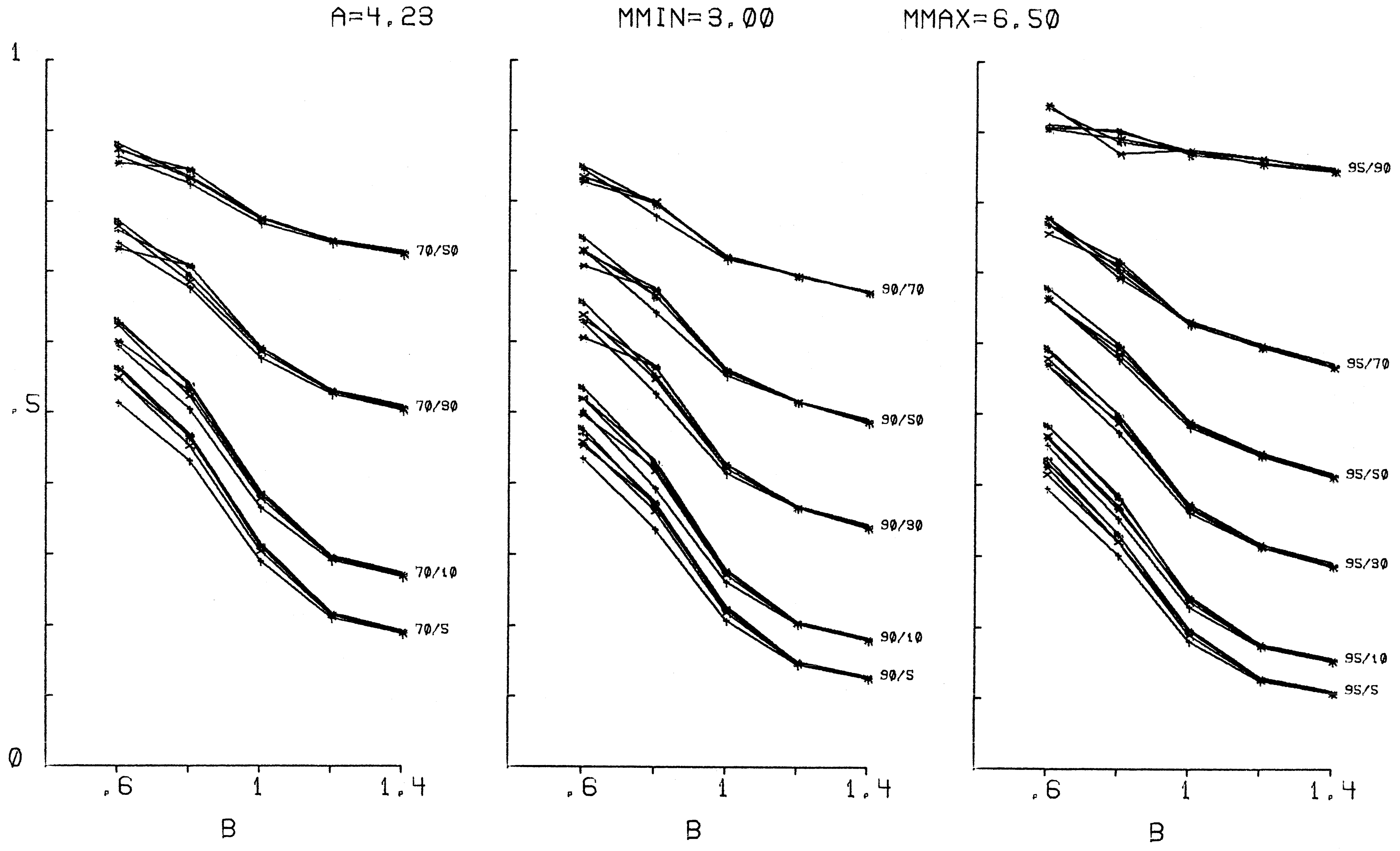

Fig. 2
Spectral Ratios Averaged Over Eleven Periods for Five Dampings

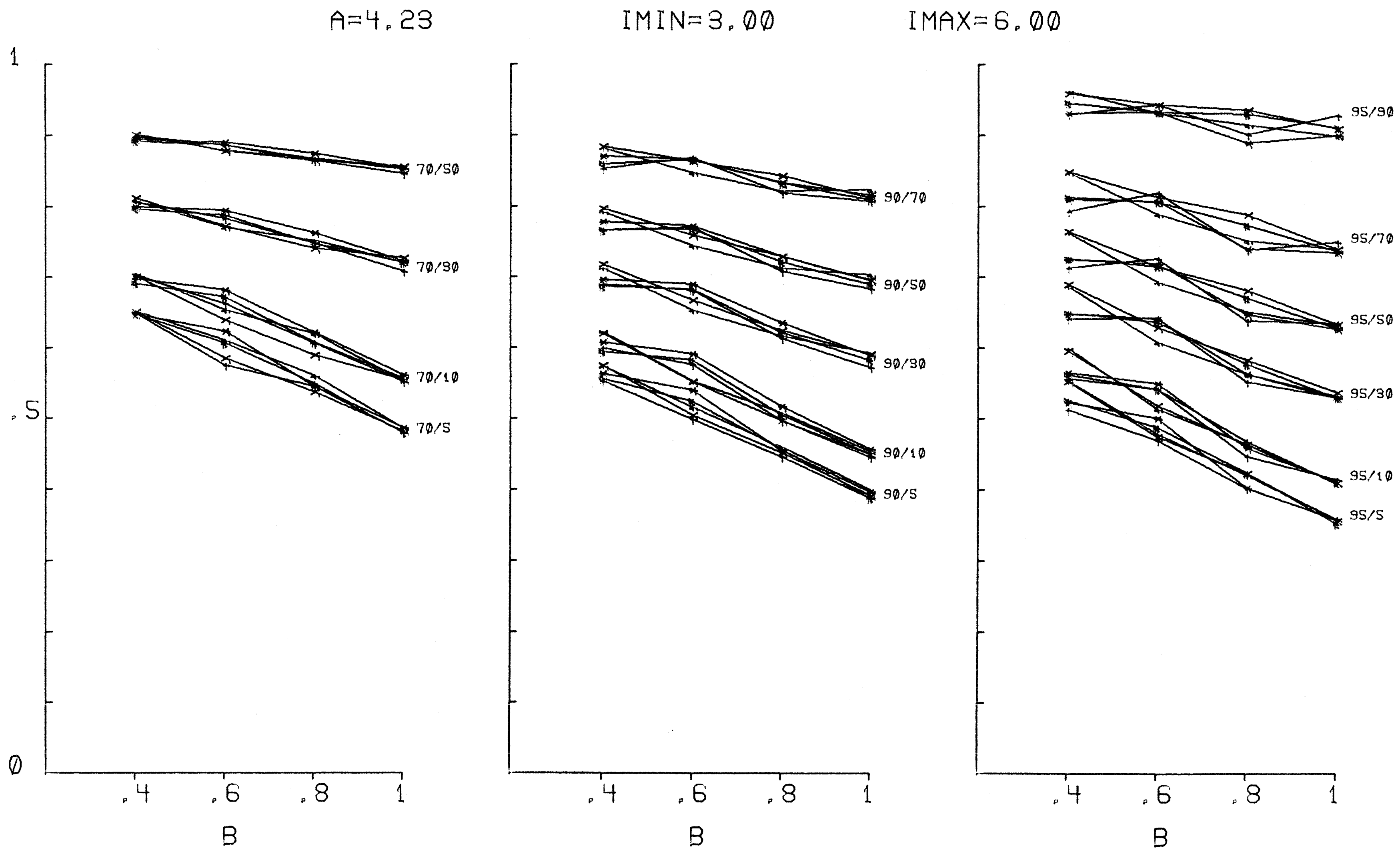

Fig. 3
Spectral Ratios Averaged Over Eleven Periods for Five Dampings

in the probabilities of exceeding URS whose ratio is taken, that is, in general, the ratio for 95/5 probabilities leads to steeper negative slope of the ratios with respect to B than the ratio with 95/90 probabilities for example. Similar trends for scaling in terms of Modified Mercalli Intensity are present in the corresponding spectral ratios.

Spectral ratios presented in Figures 4 through 39 may reduce or eliminate a need for lengthy probabilistic computations whenever seismicity at a site is primarily influenced by random occurrence of shallow earthquakes. Since spectral ratios appear to change only little for different periods T and since the spectral amplitudes tend to absolute accelerations as $T \to 0$ the ratios in Figures 4 through 39 approximate the ratios of peak absolute ground accelerations for the corresponding probabilities of being exceeded. Therefore, for example, in selecting the SSE and OBE peak accelerations for scaling design spectra for nuclear power plants, the approximate ratio of amplitudes of OBE to those of SSE can be read of directly from the diagrams in these Figures. To do this, one must have or select the probabilities of exceeding the OBE and SSE amplitudes.

On one hand, these probabilities may be difficult to select at present since the current procedures for scaling SSE and OBE amplitudes are formally deterministic. On the other hand, the results presented here point out that the deterministic formalism inevitably results in the probabilities of exceeding OBE to SSE amplitude ratios which vary considerably from one site to another so that the gain in simplified design formalism is offset by the loss in the uniformity of the physical conditions associated with possible future earthquake shaking. The deterministic for-

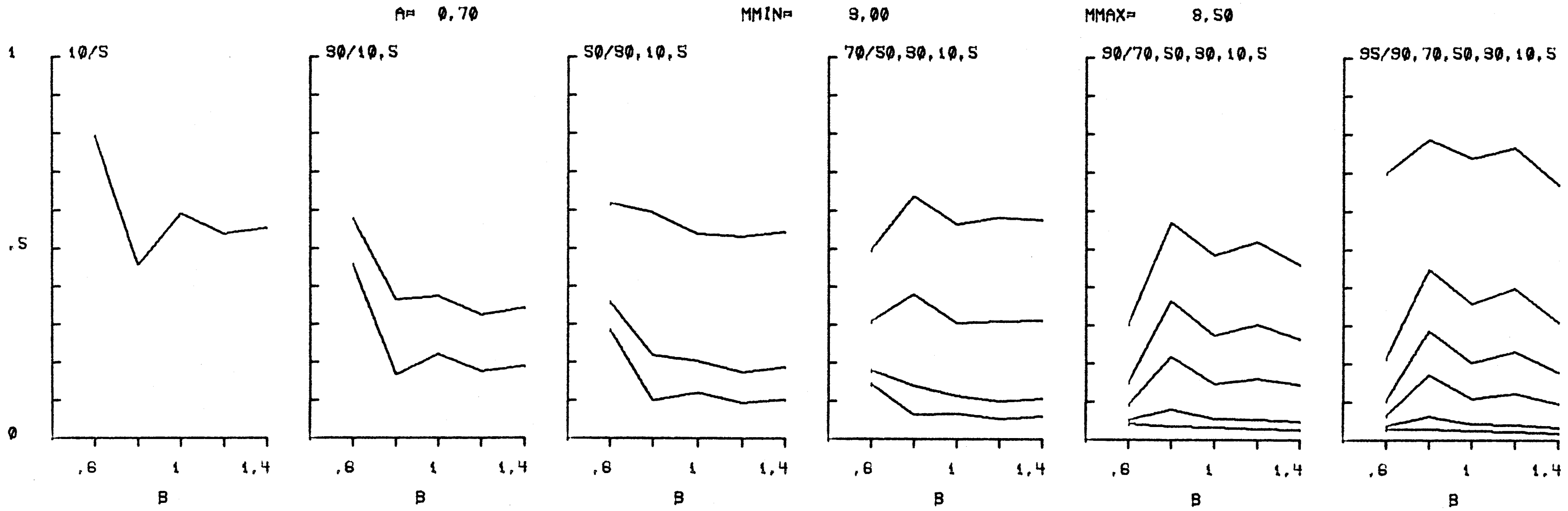

Fig. 4

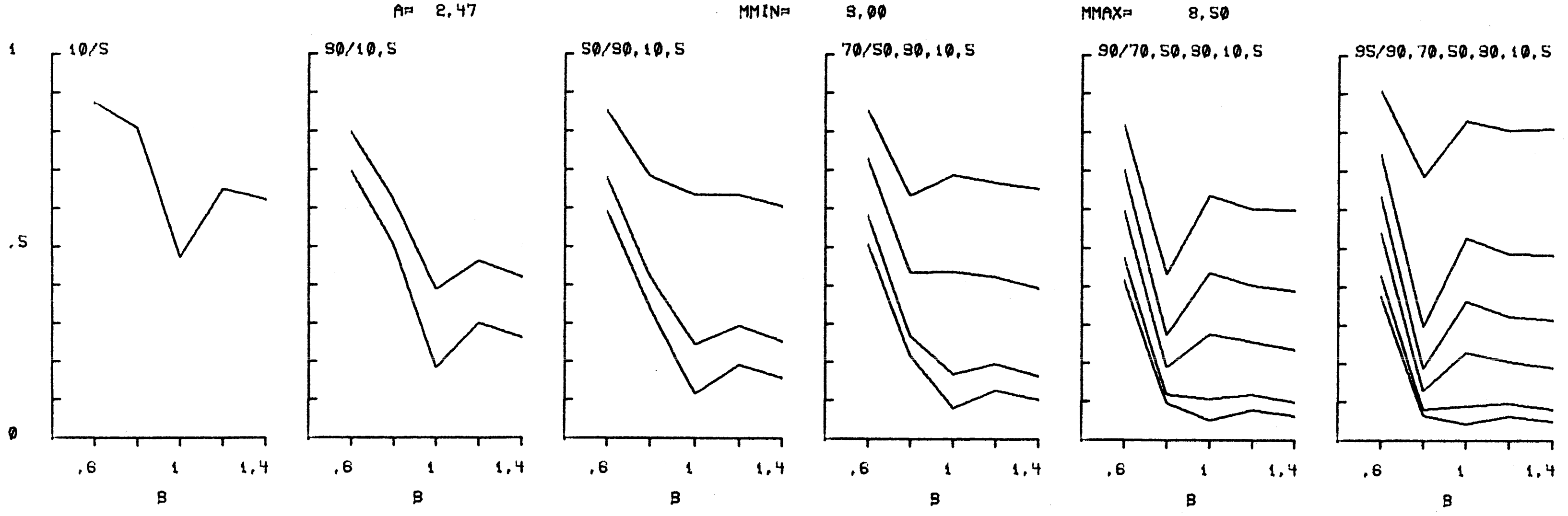

Fig. 5

Figs. 4 and 5. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

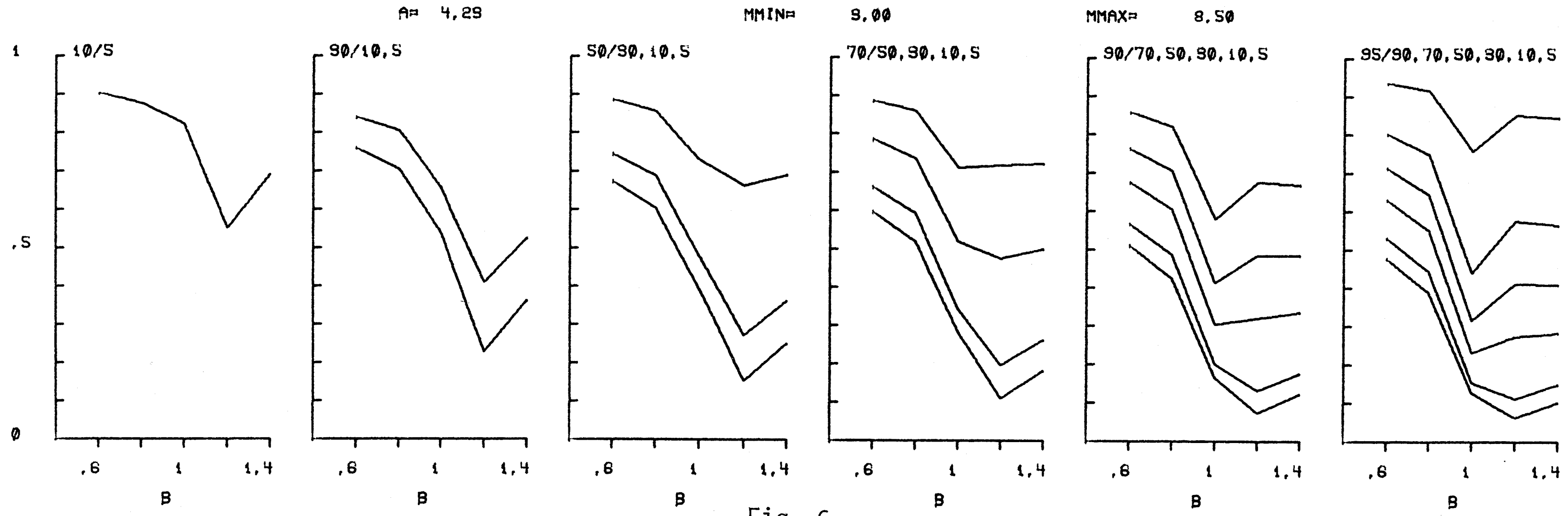

Fig. 6

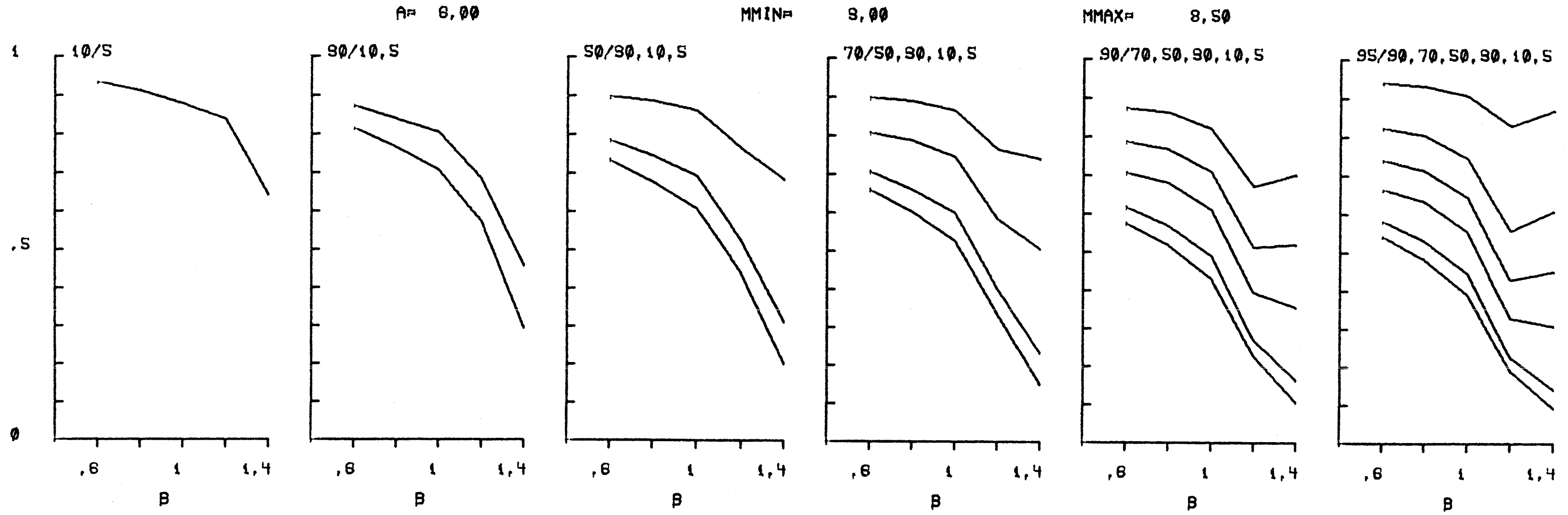

Fig. 7

Figs. 6 and 7. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

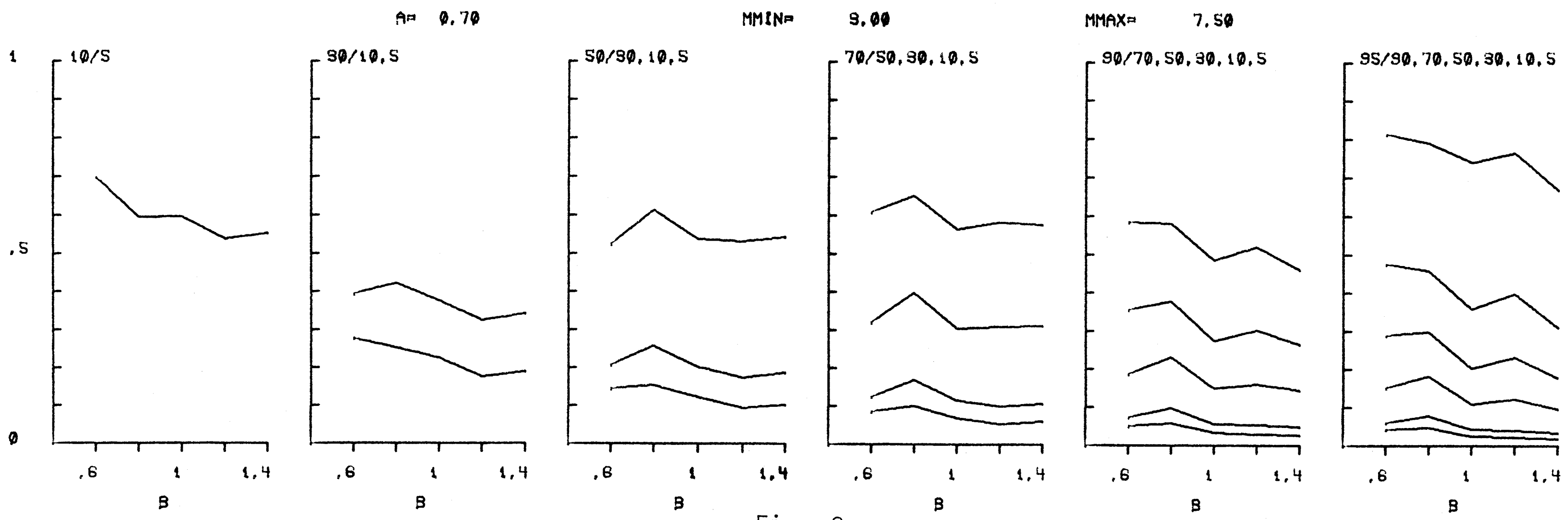

Fig. 8

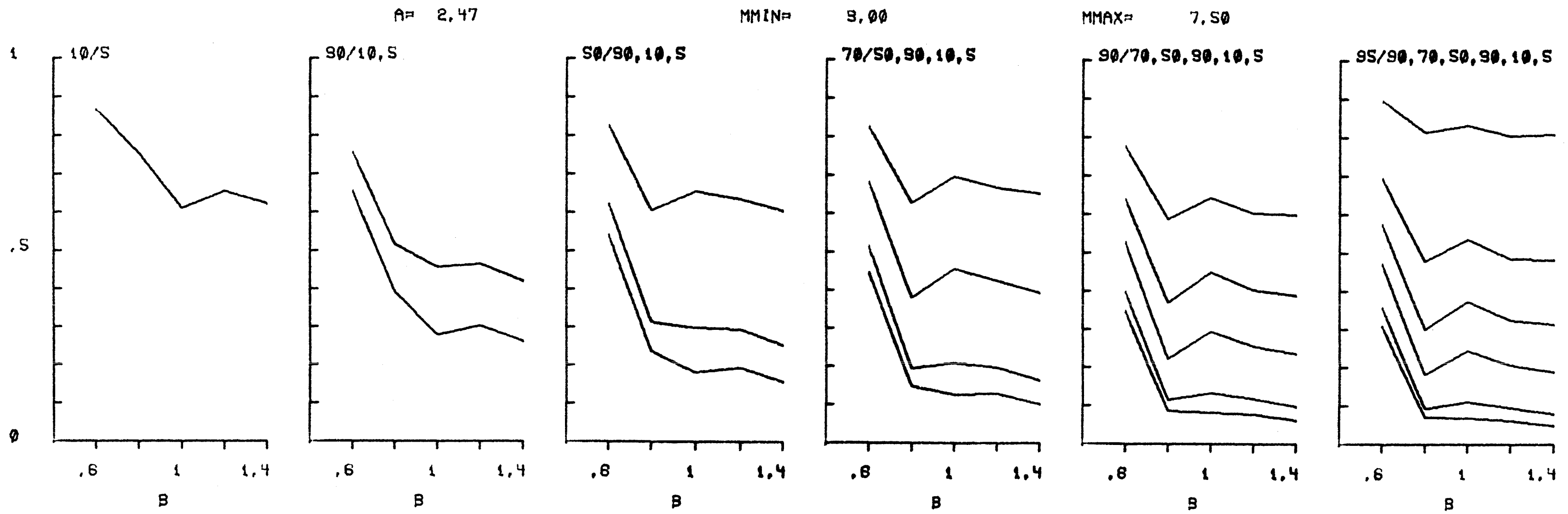

Fig. 9

Figs. 8 and 9. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

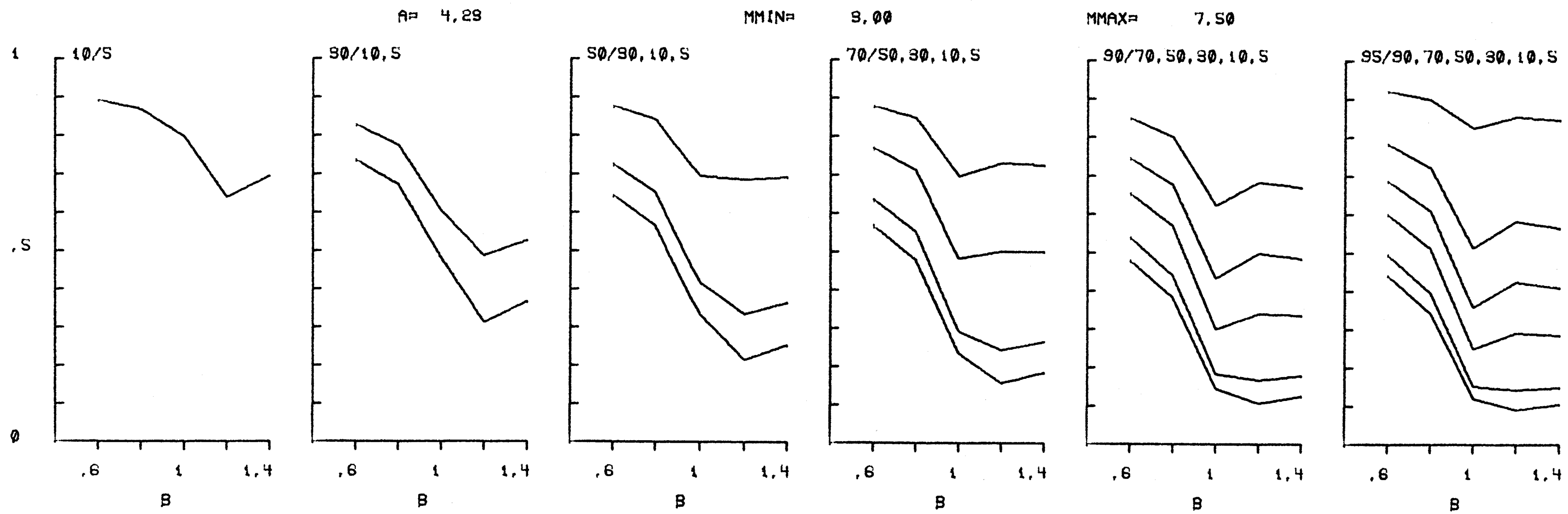

Fig. 10

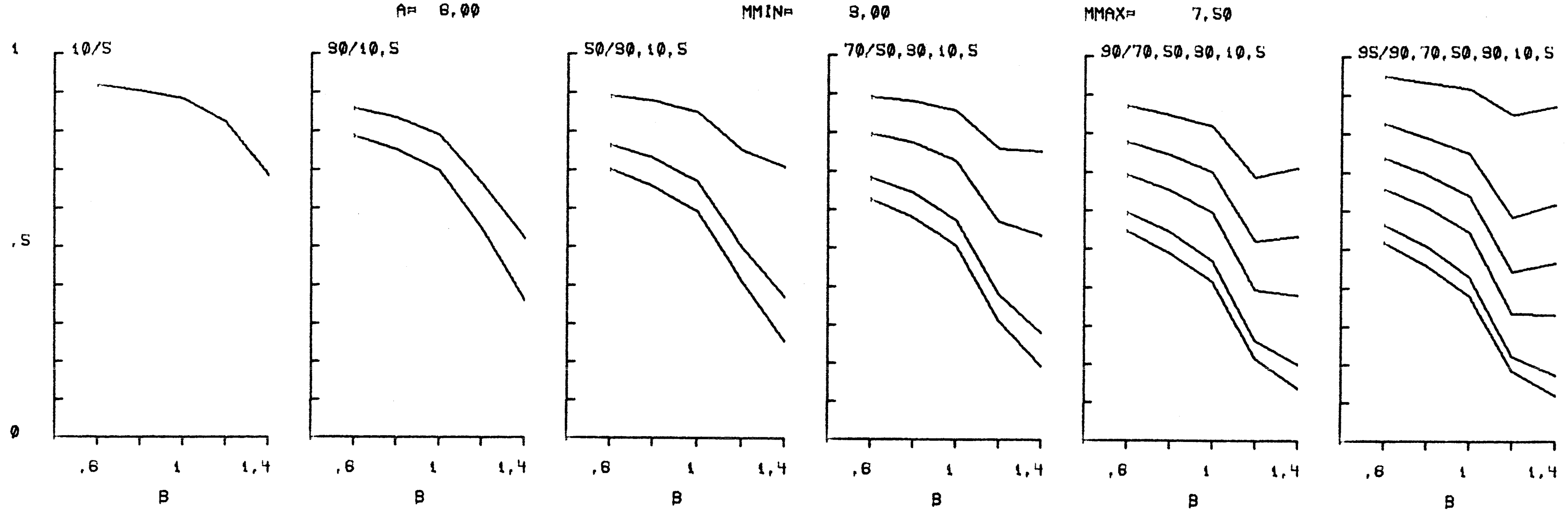

Fig. 11

Figs.10 and 11. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

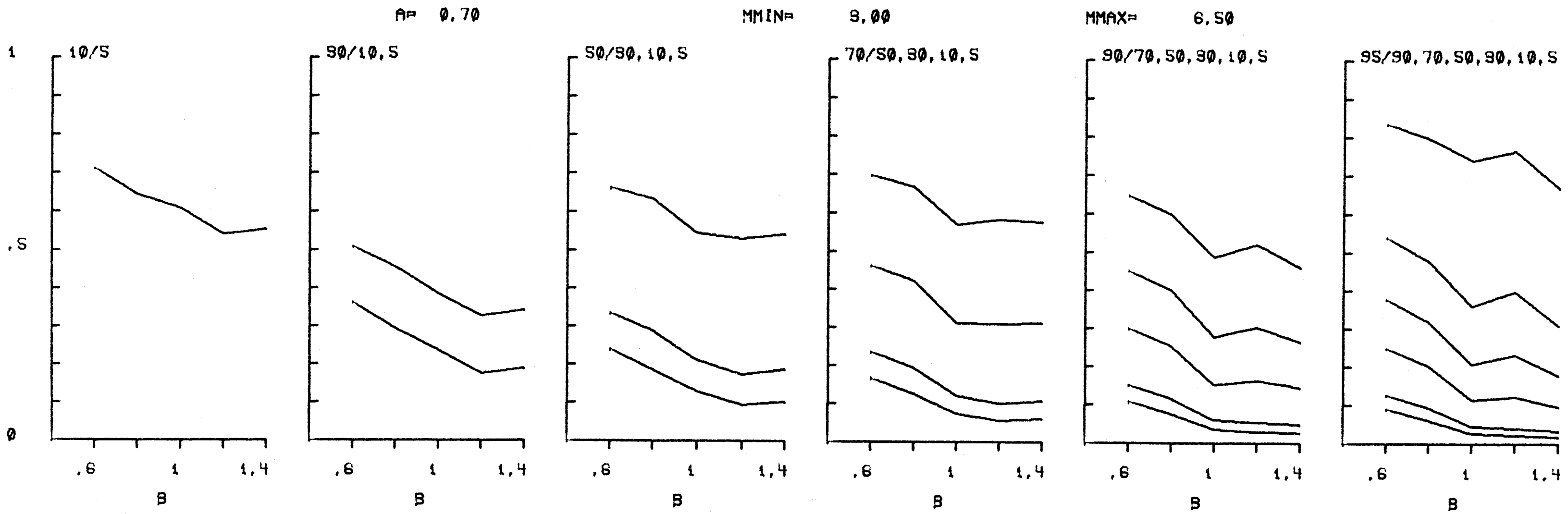

Fig. 12

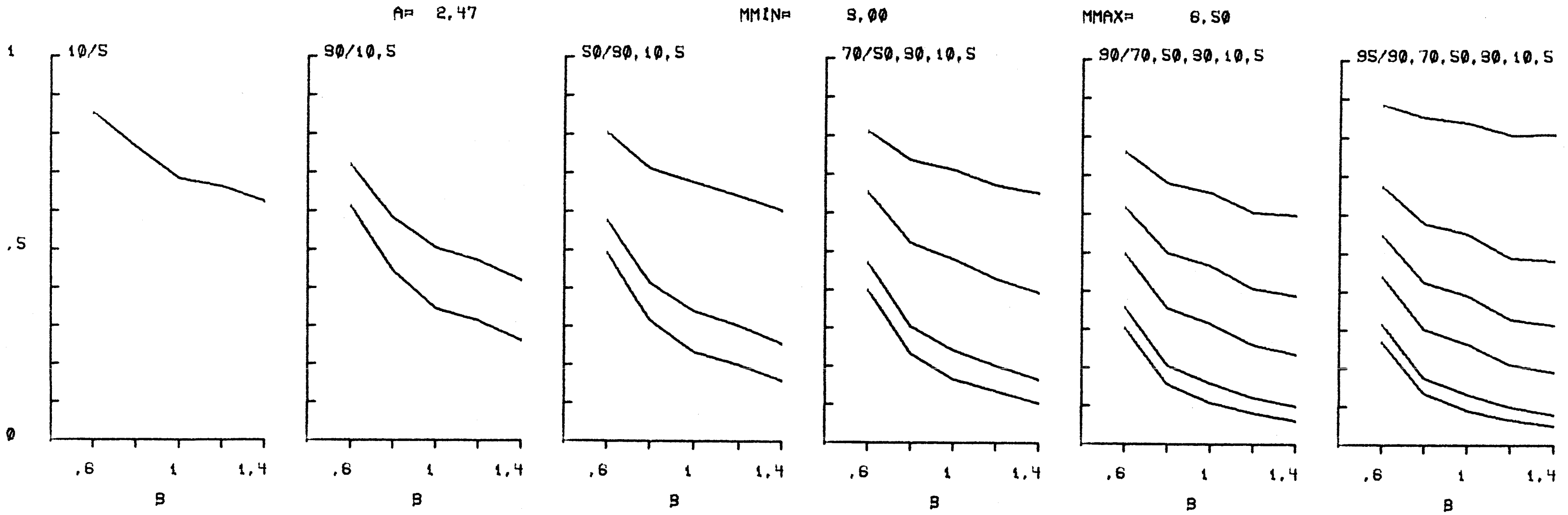

Fig. 13

Figs.12 and 13. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

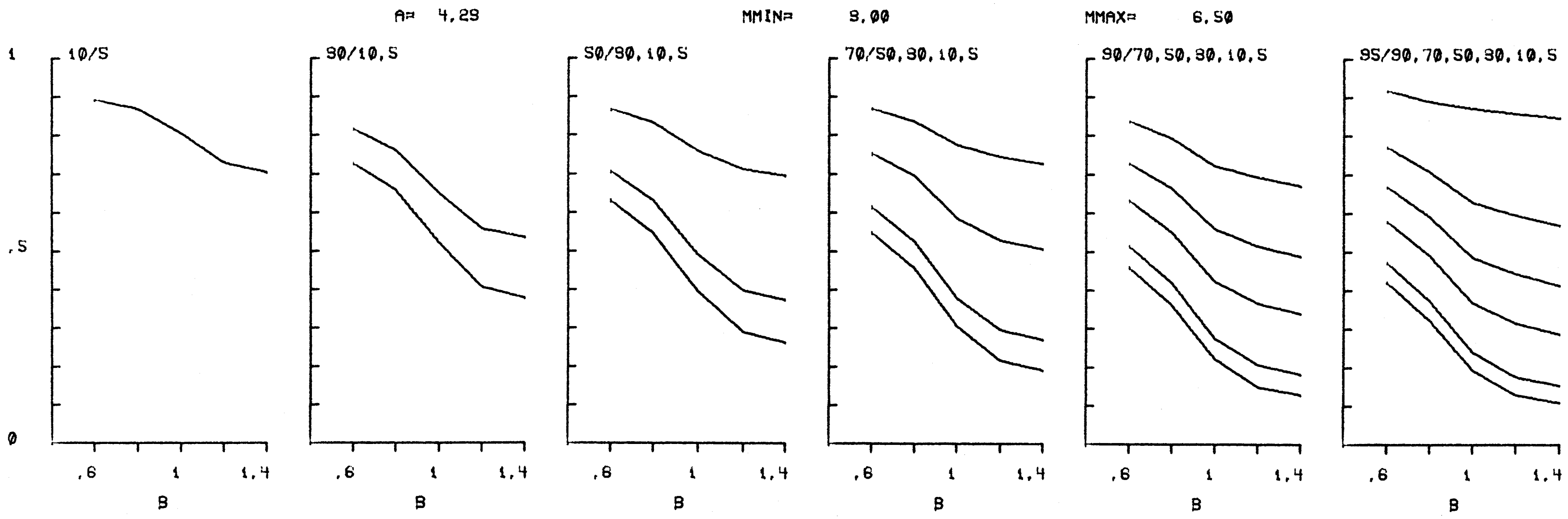

Fig. 14

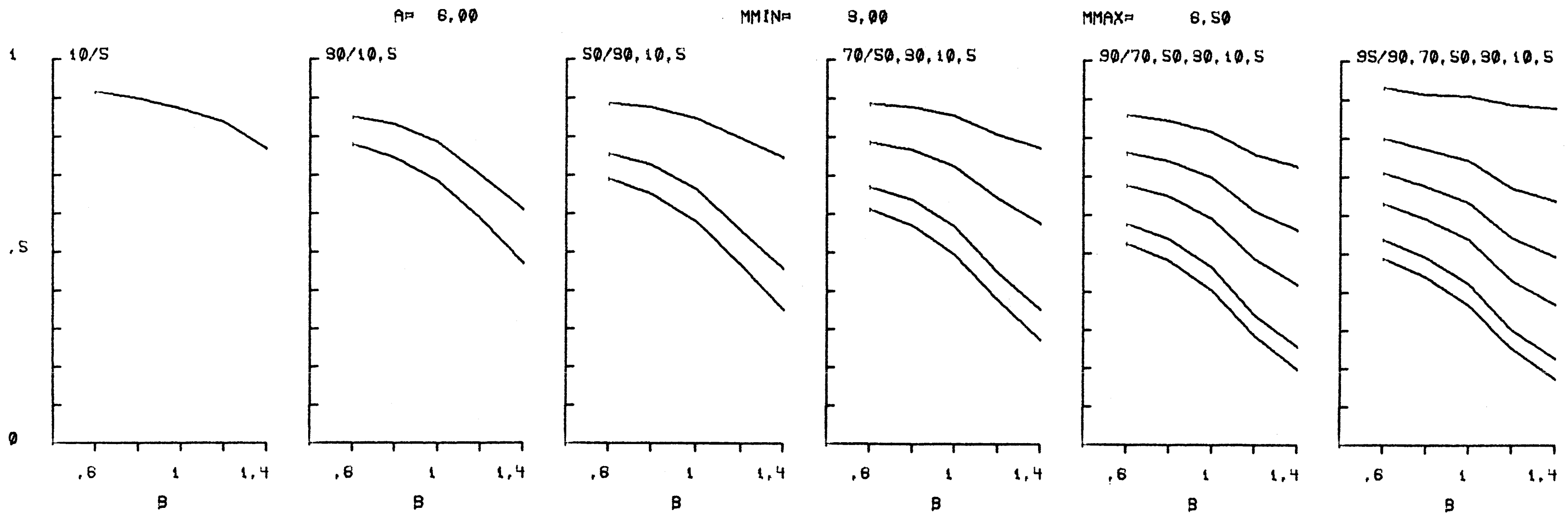

Fig. 15

Figs. 14 and 15. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

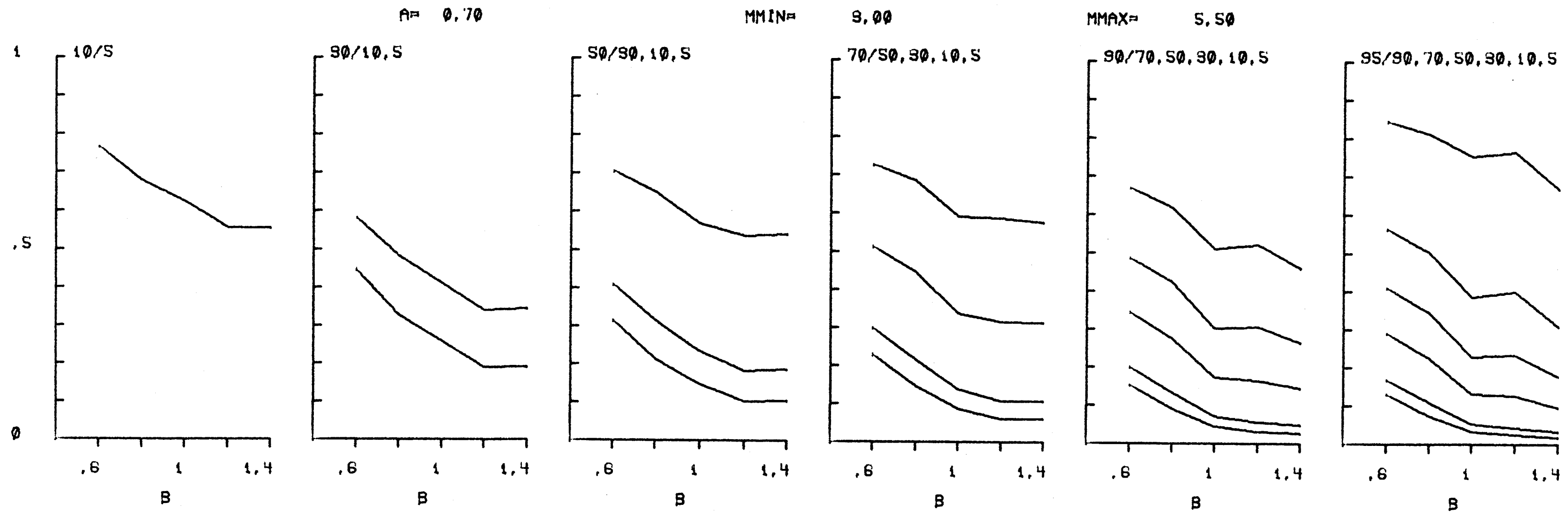

Fig. 16

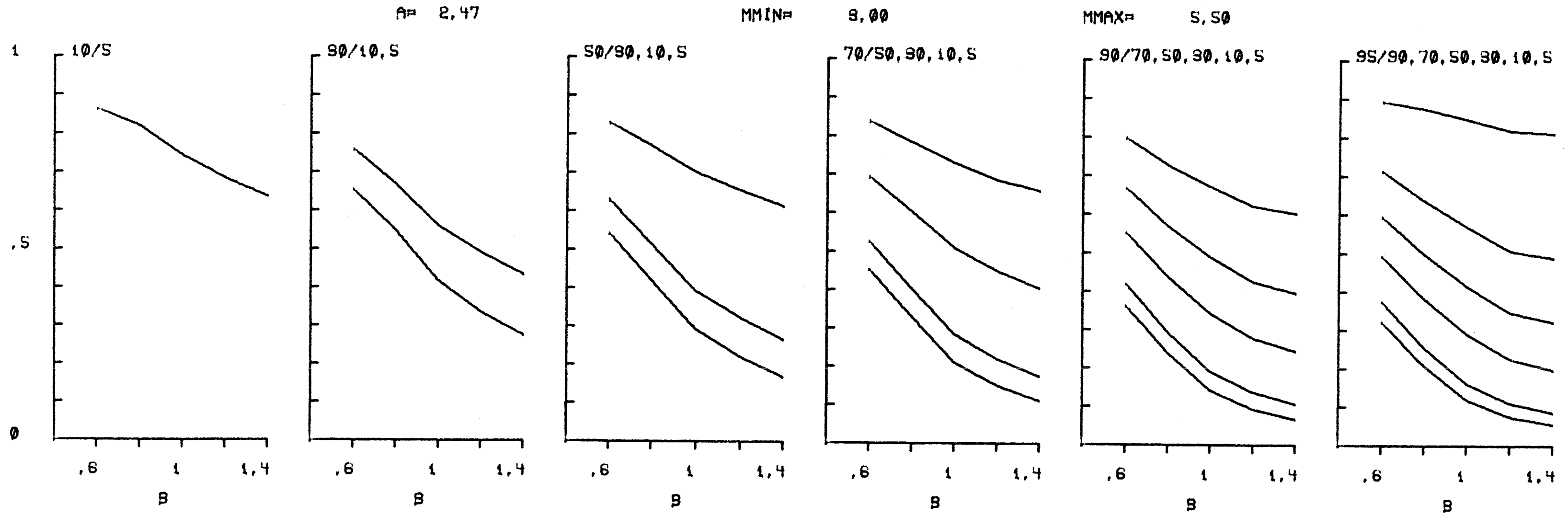

Fig. 17

Figs. 16 and 17. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

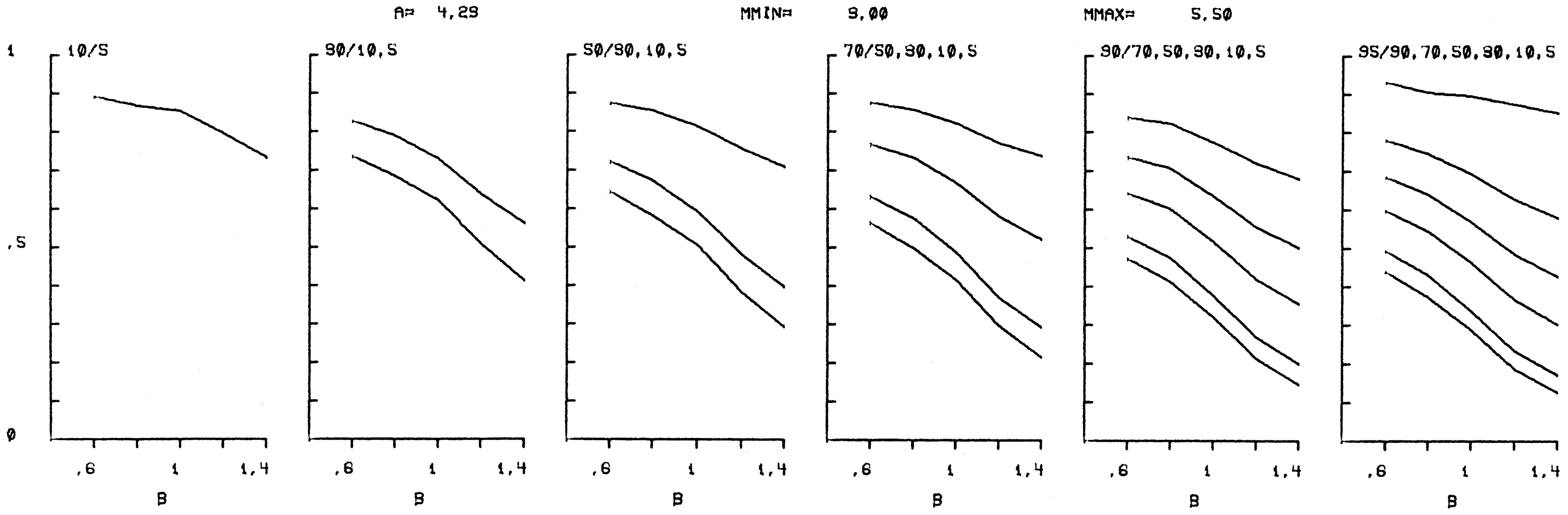

Fig. 18

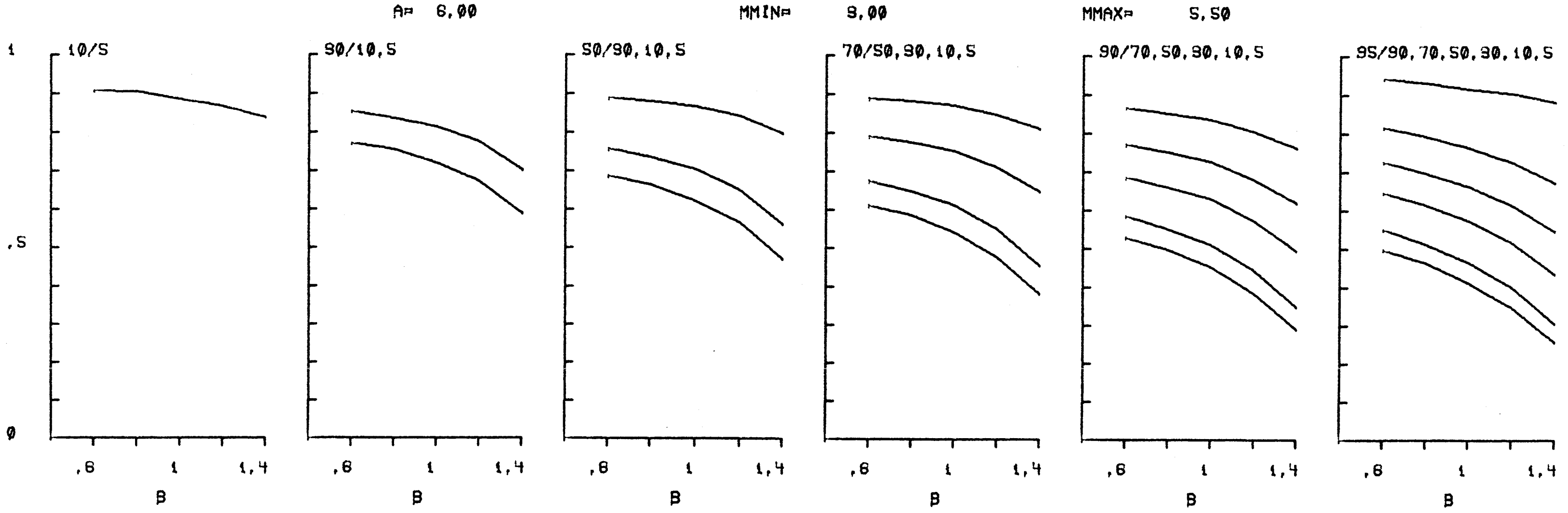

Fig. 19

Figs. 18 and 19. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

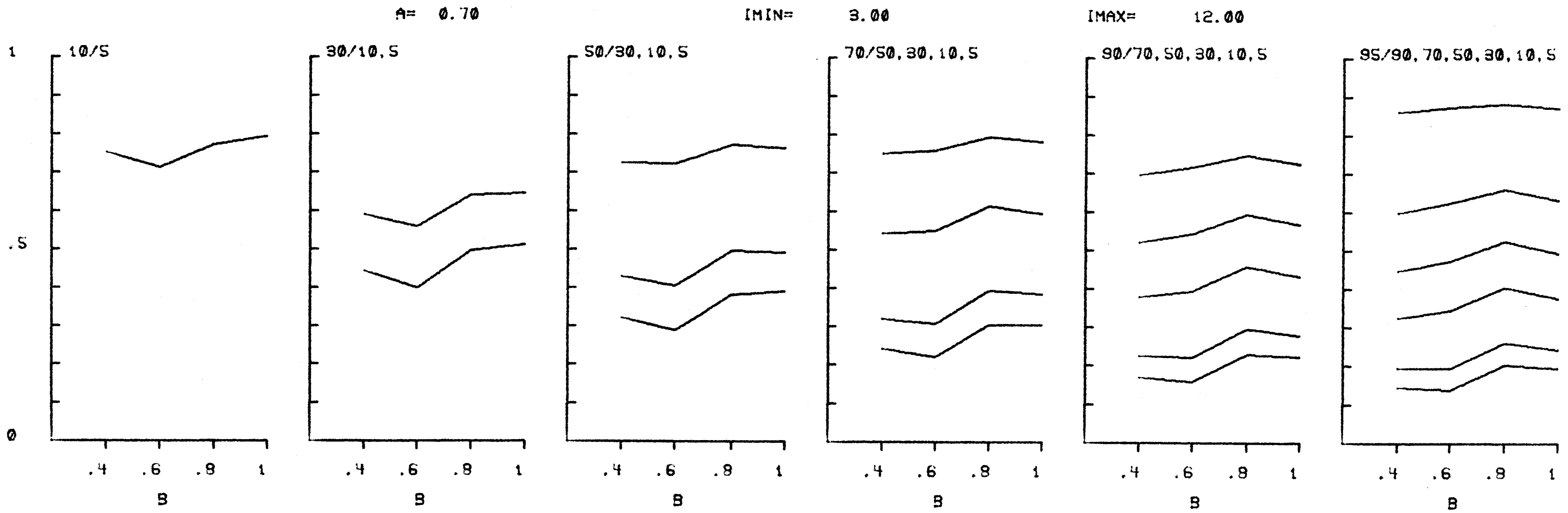

Fig. 20

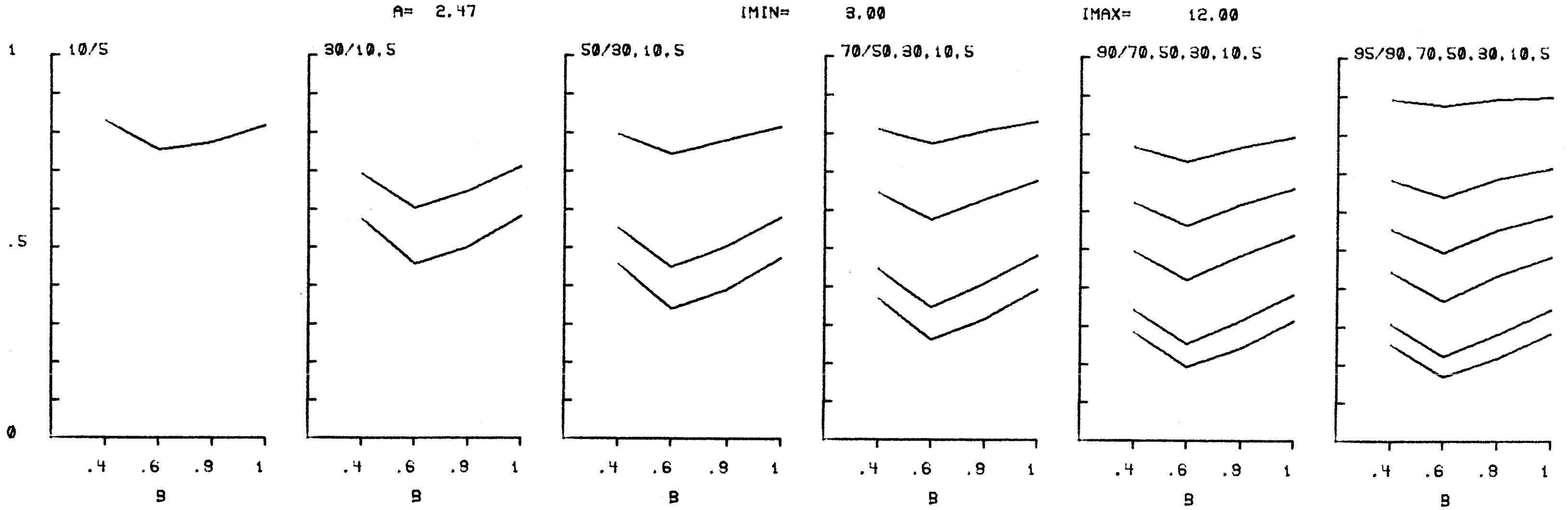

Fig. 21

Figs. 20 and 21. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

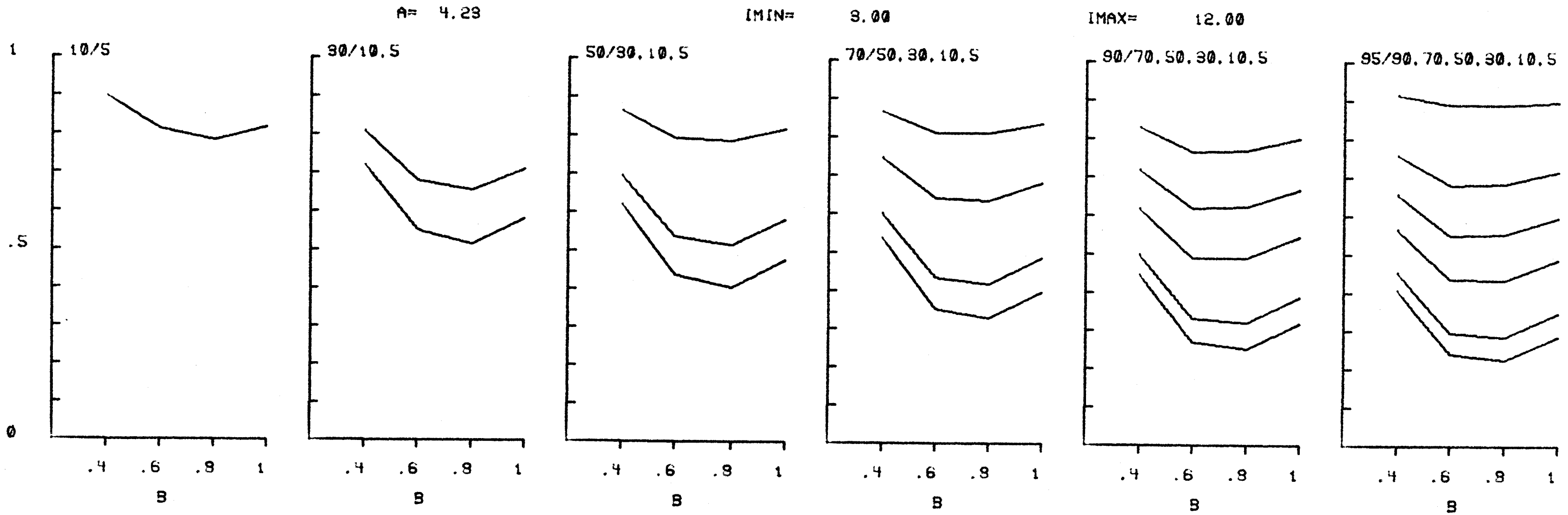

Fig. 22

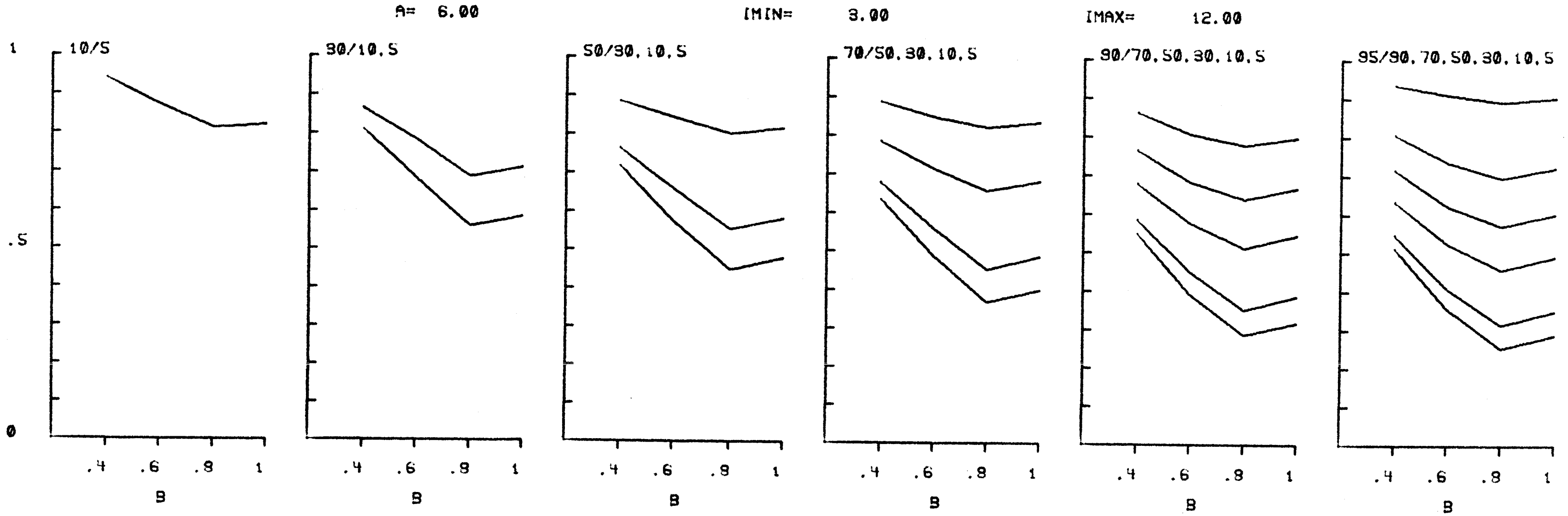

Fig. 23

Figs. 22 and 23. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

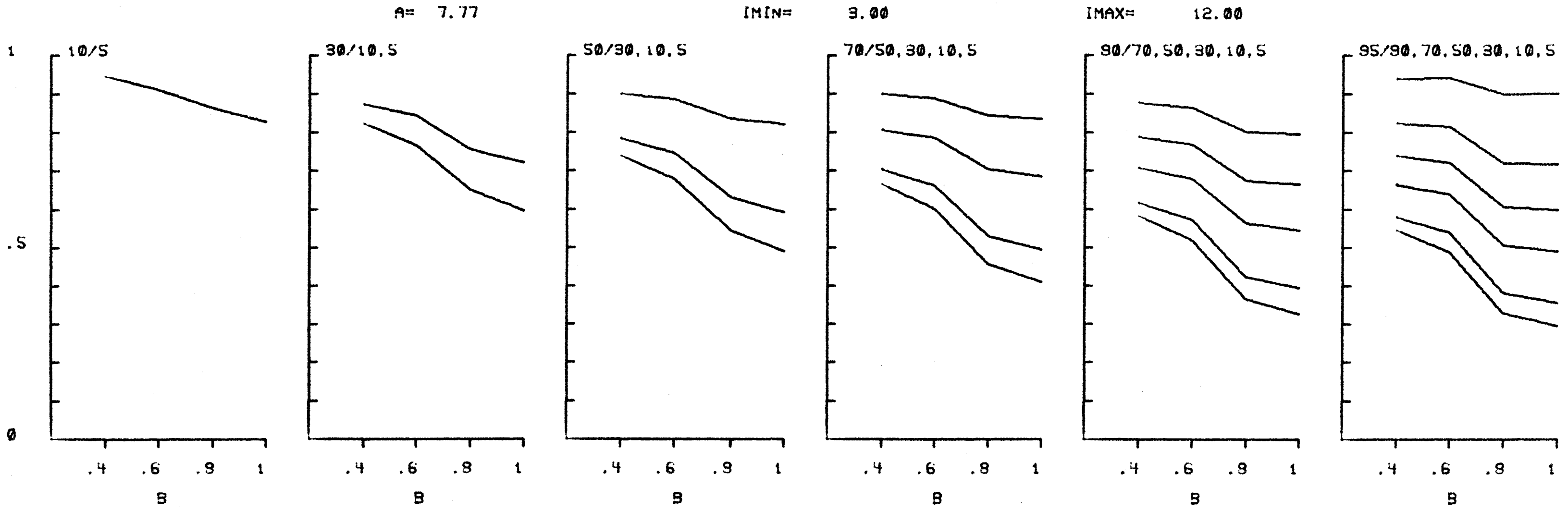

Fig. 24

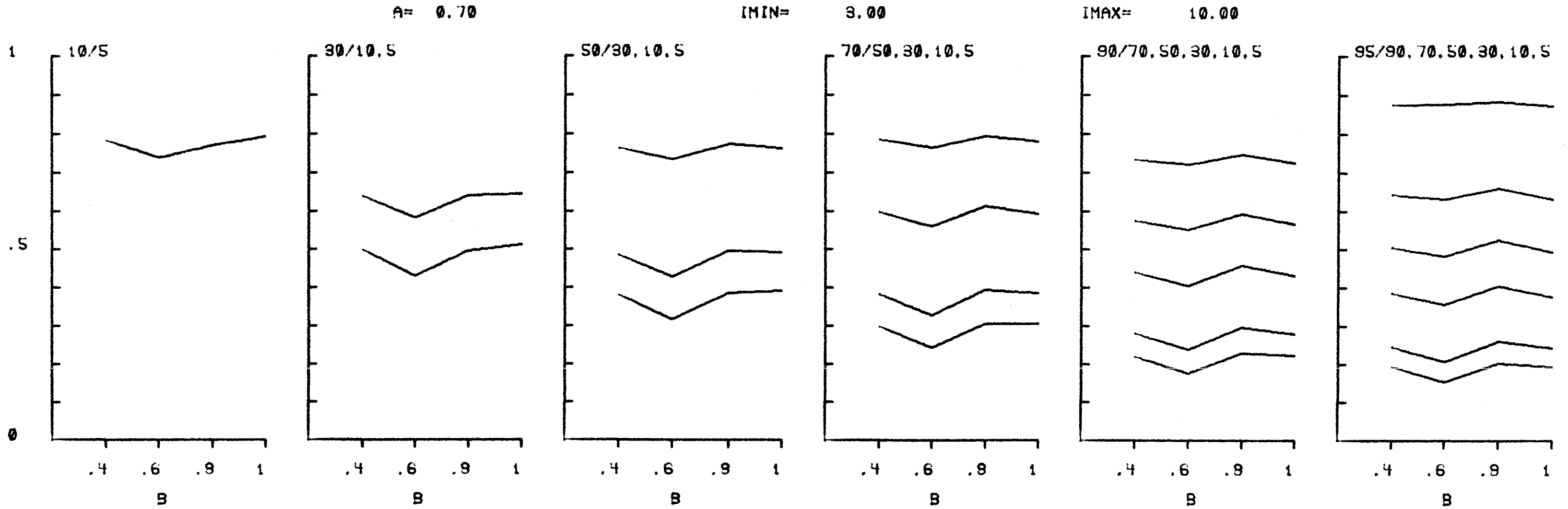

Fig. 25

Figs. 24 and 25. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

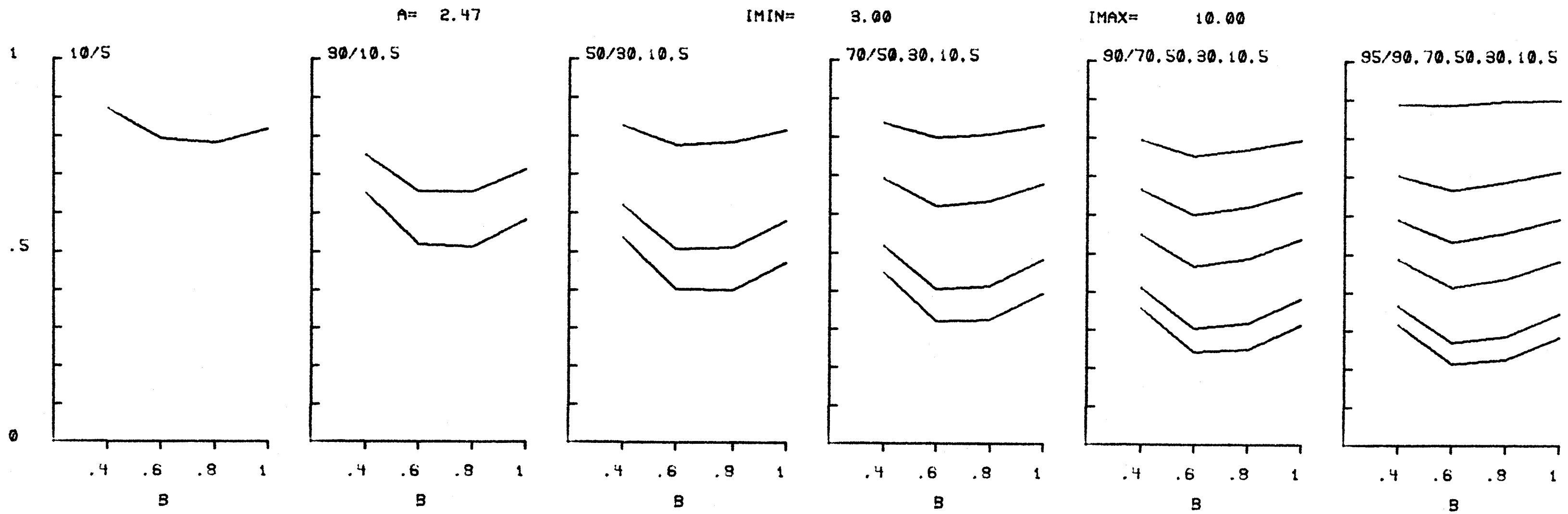

Fig. 26

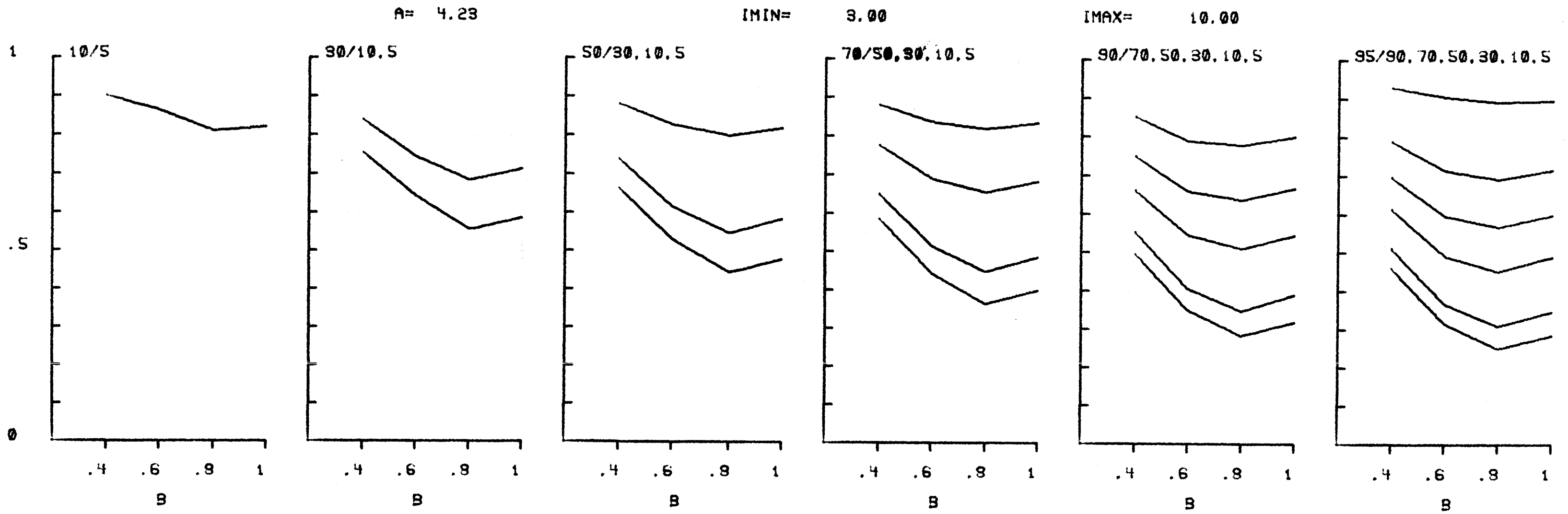

Fig. 27

Figs. 26 and 27. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

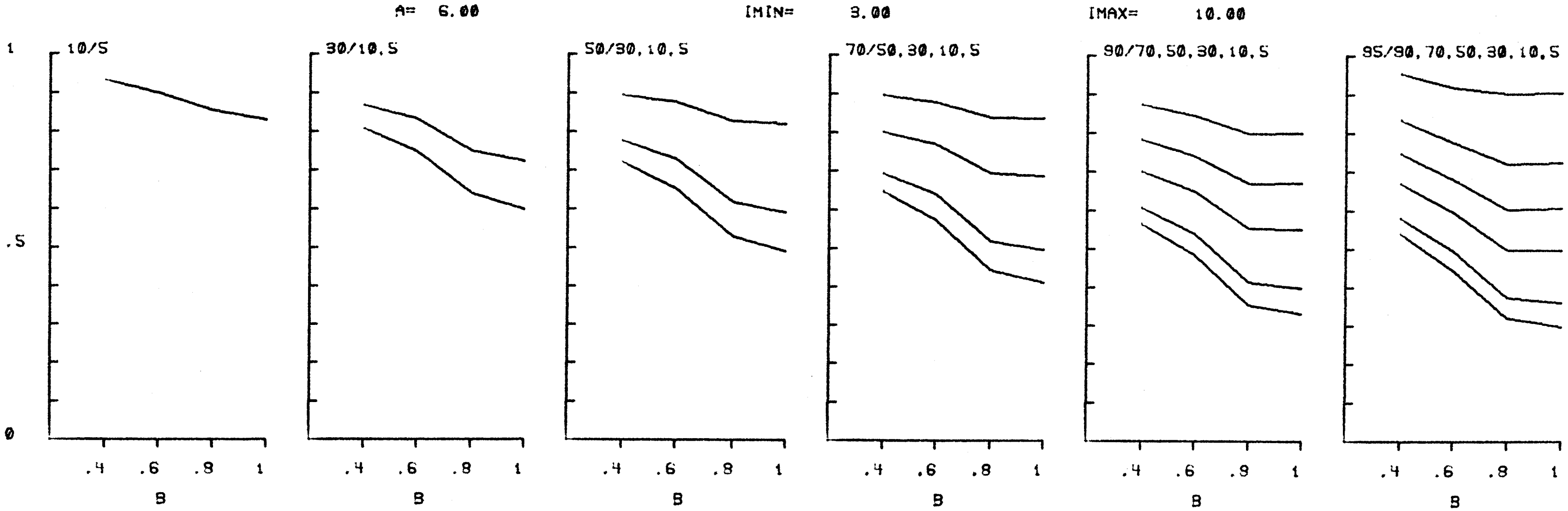

Fig. 28

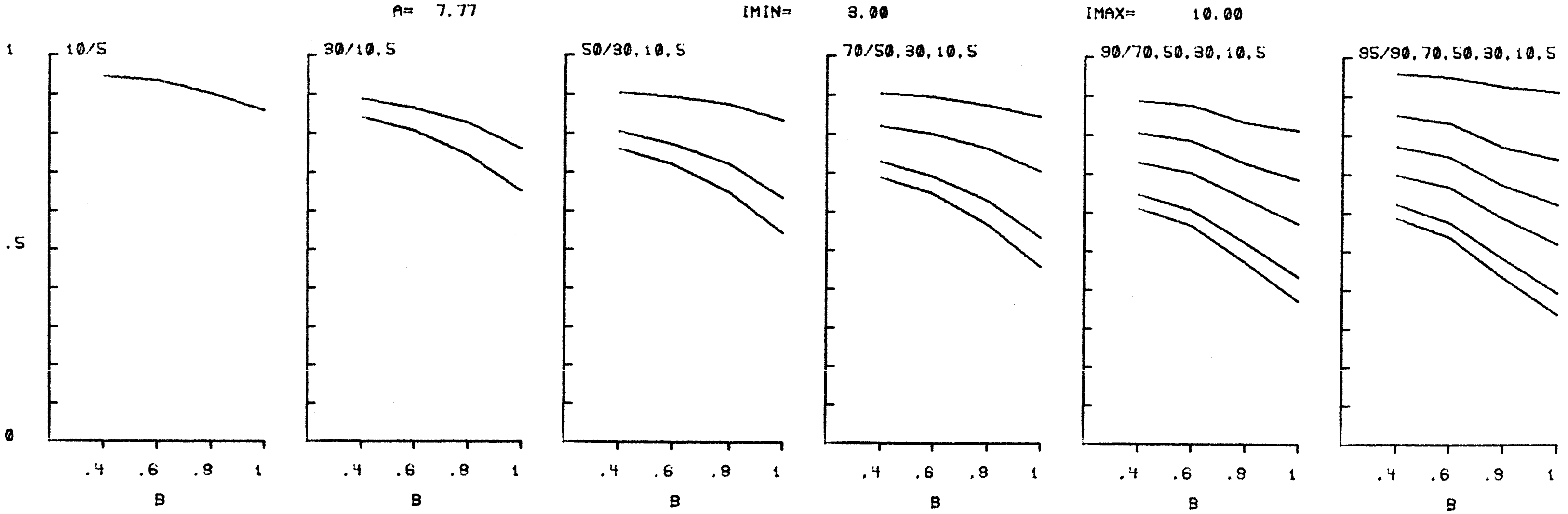

Fig. 29

Figs. 28 and 29. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

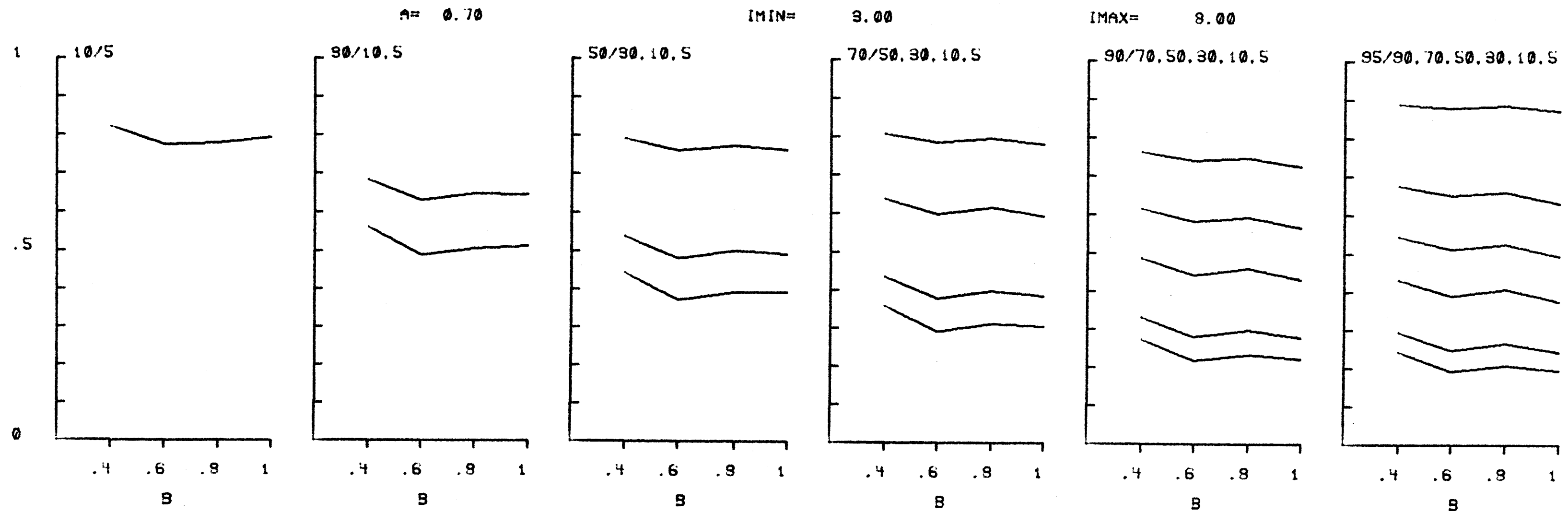

Fig. 30

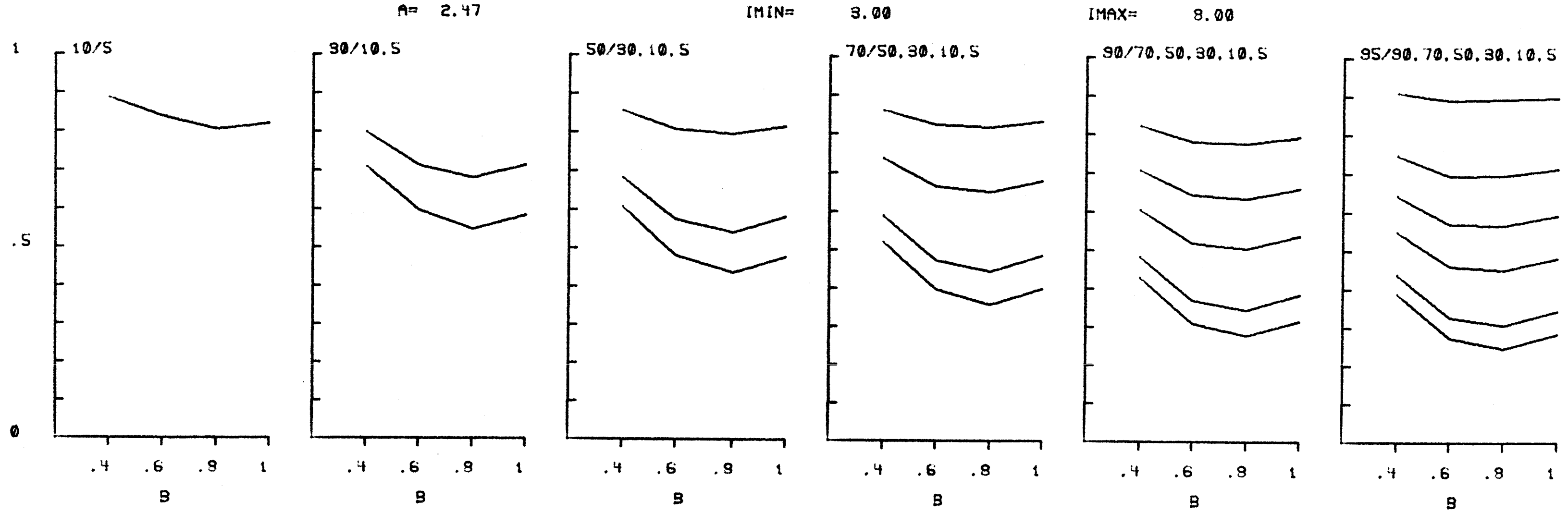

Fig. 31

Figs. 30 and 31. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

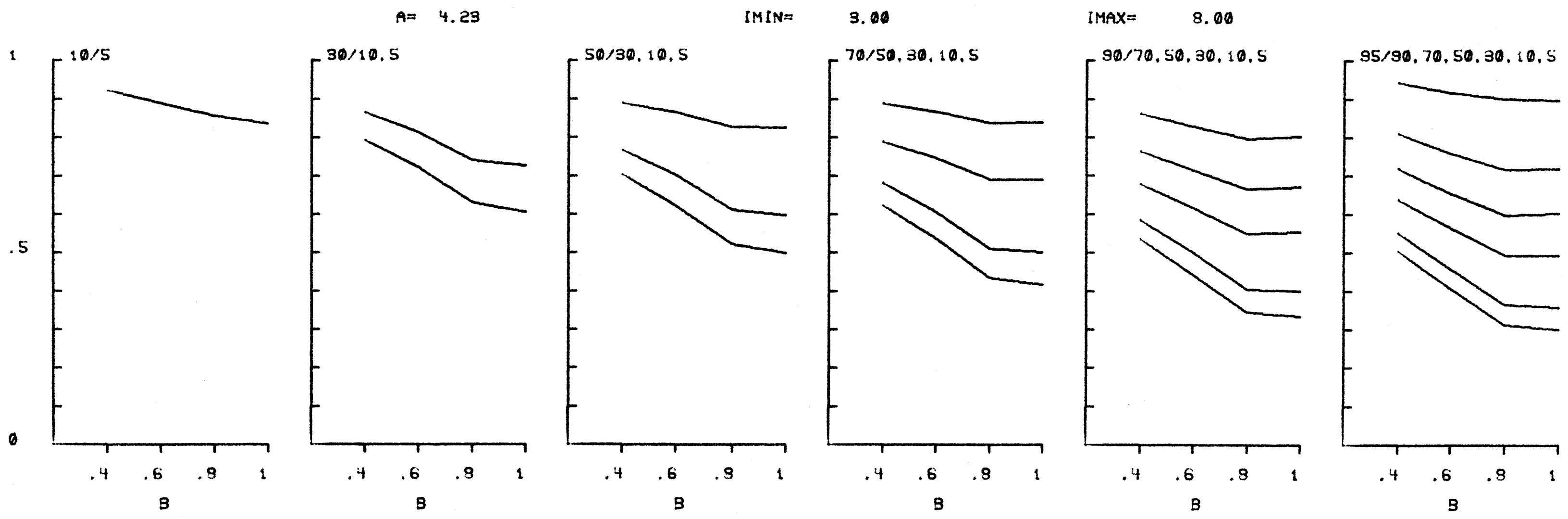

Fig. 32

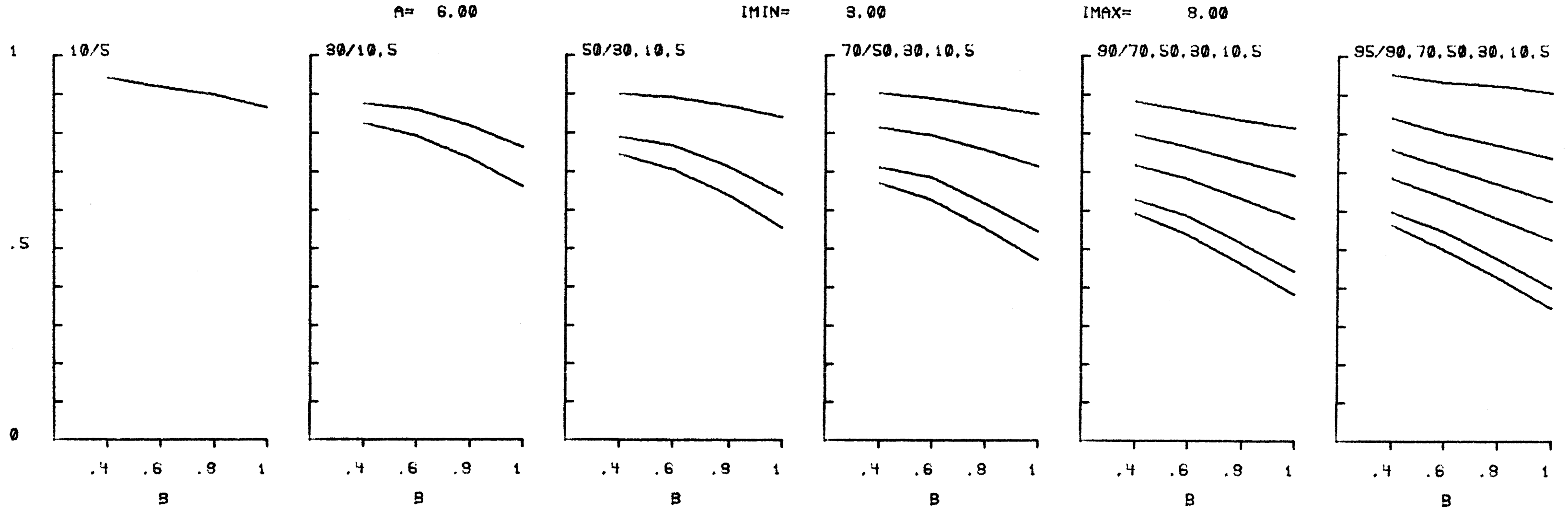

Fig. 33

Figs. 32 and 33. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

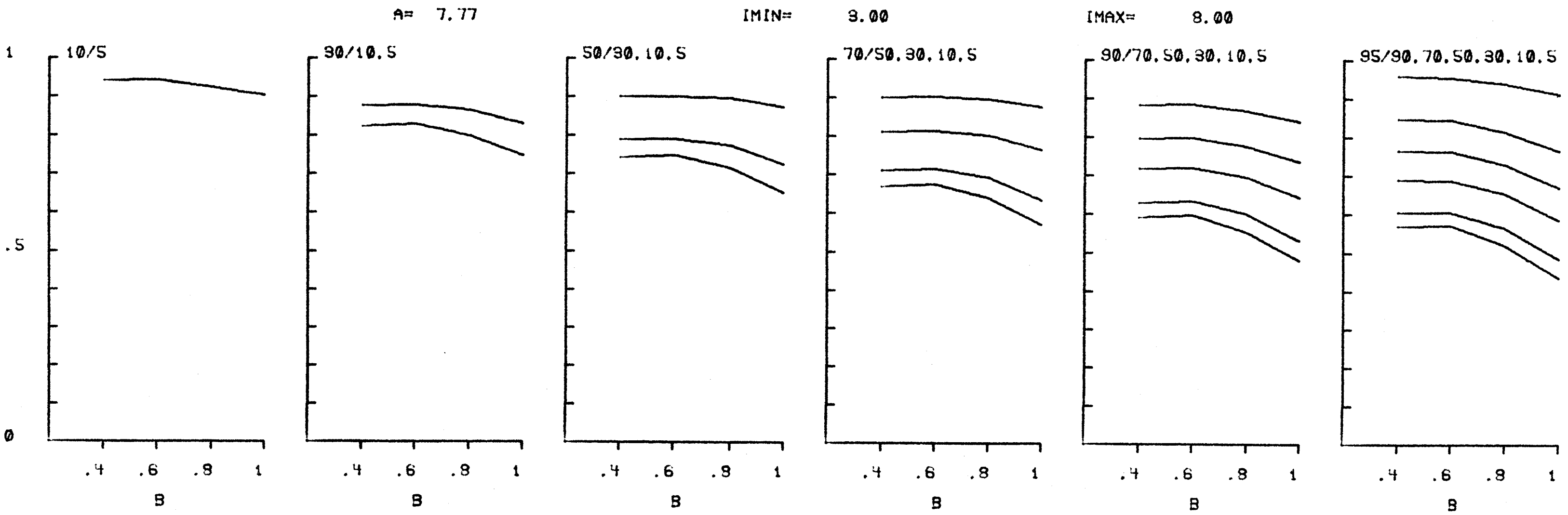

Fig. 34

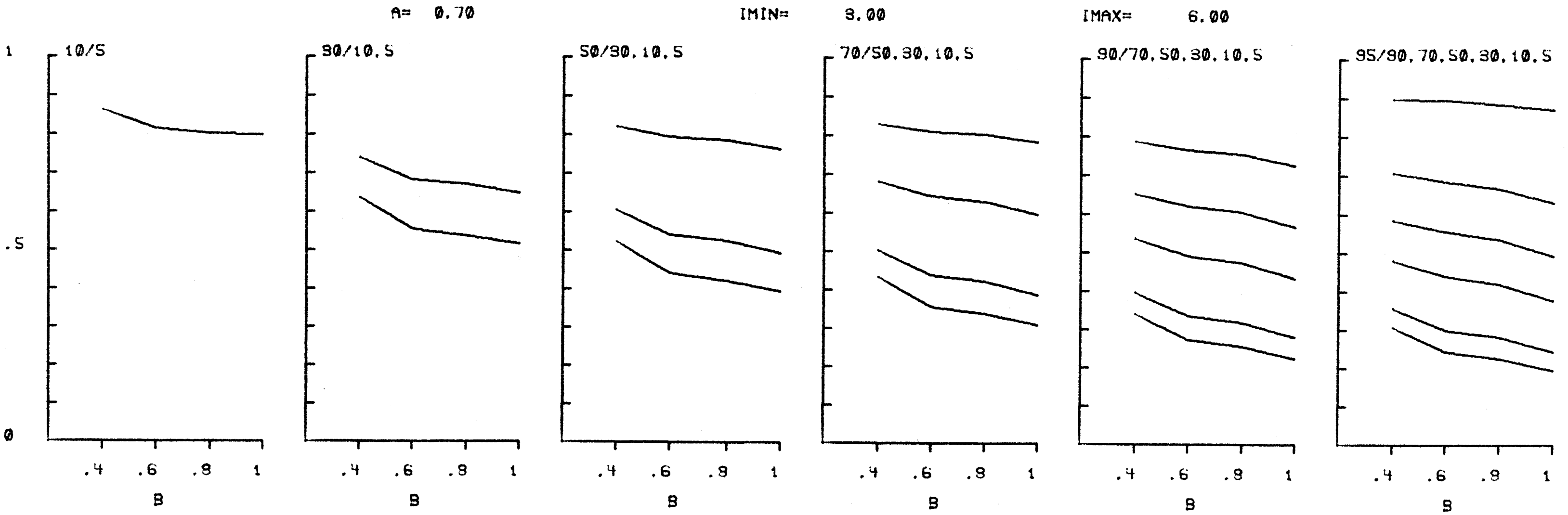

Fig. 35

Figs. 34 and 35. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

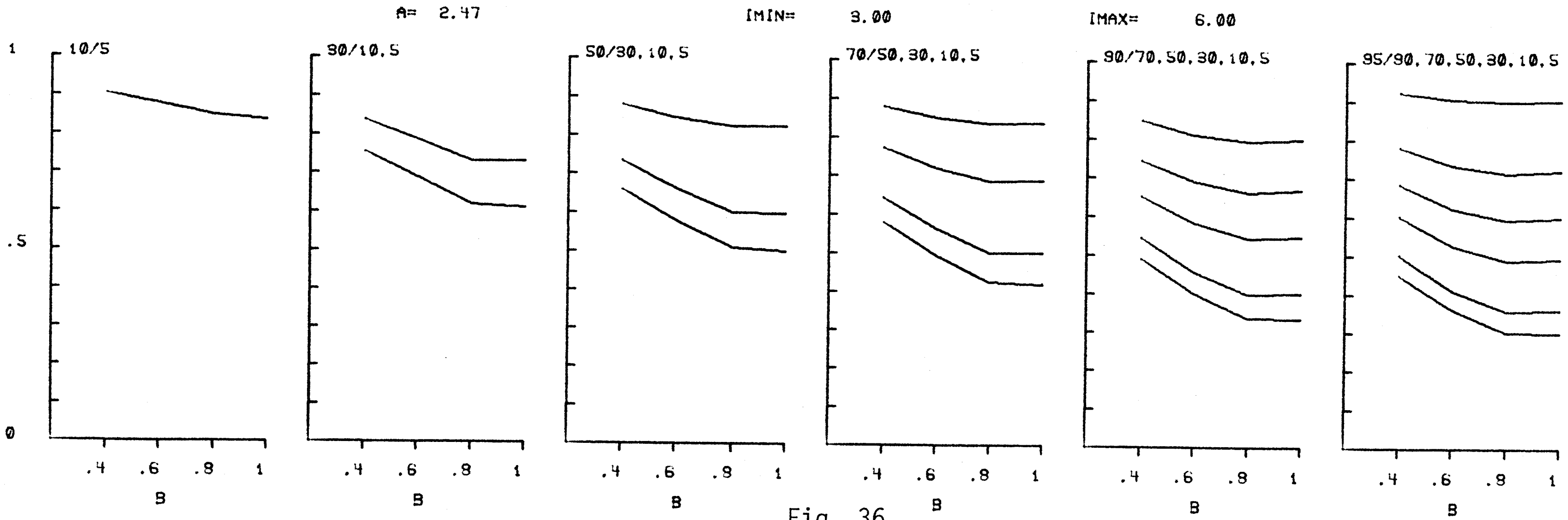

Fig. 36

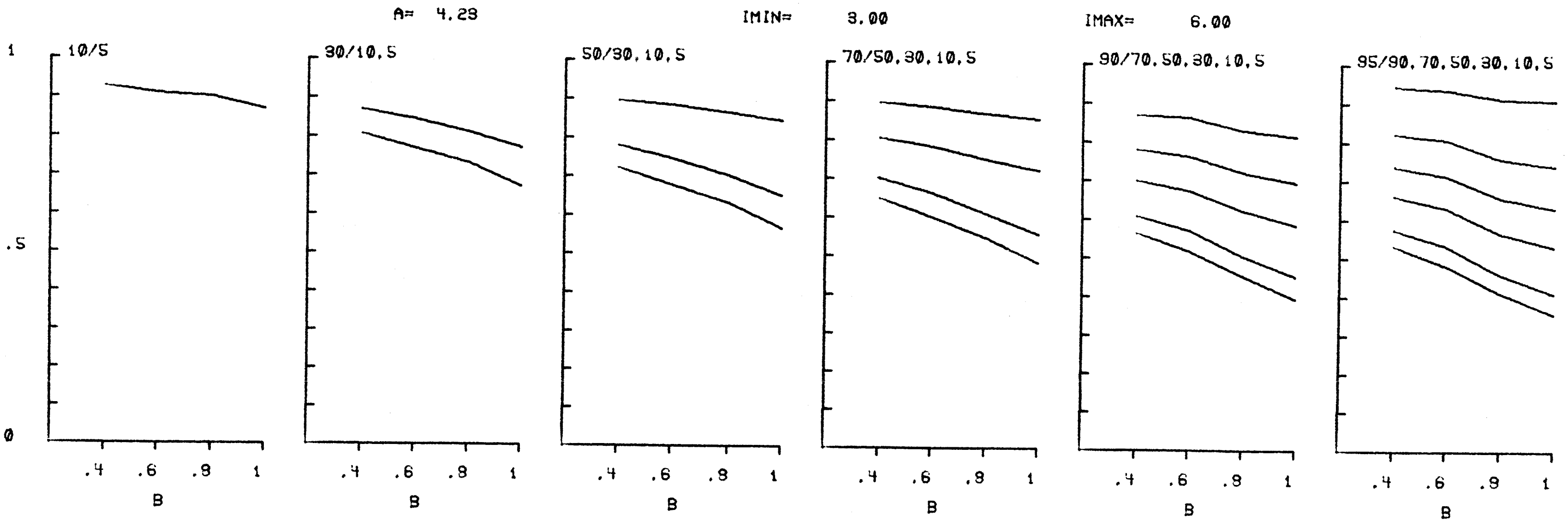

Fig. 37

Figs. 36 and 37. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

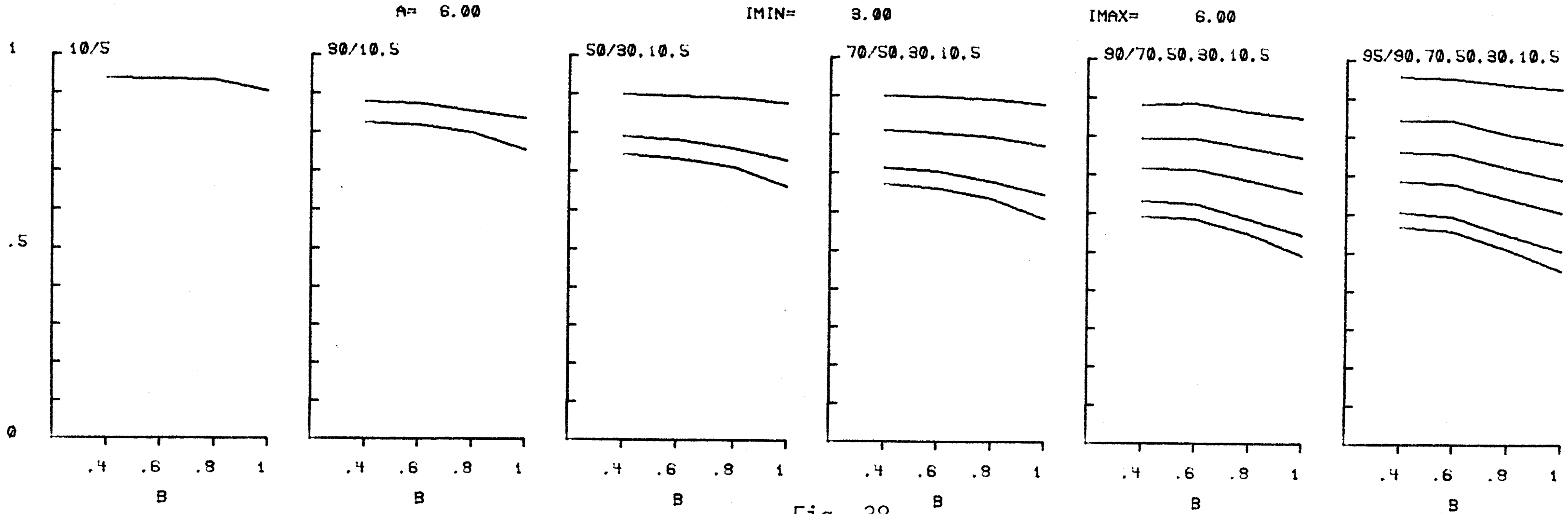

Fig. 38

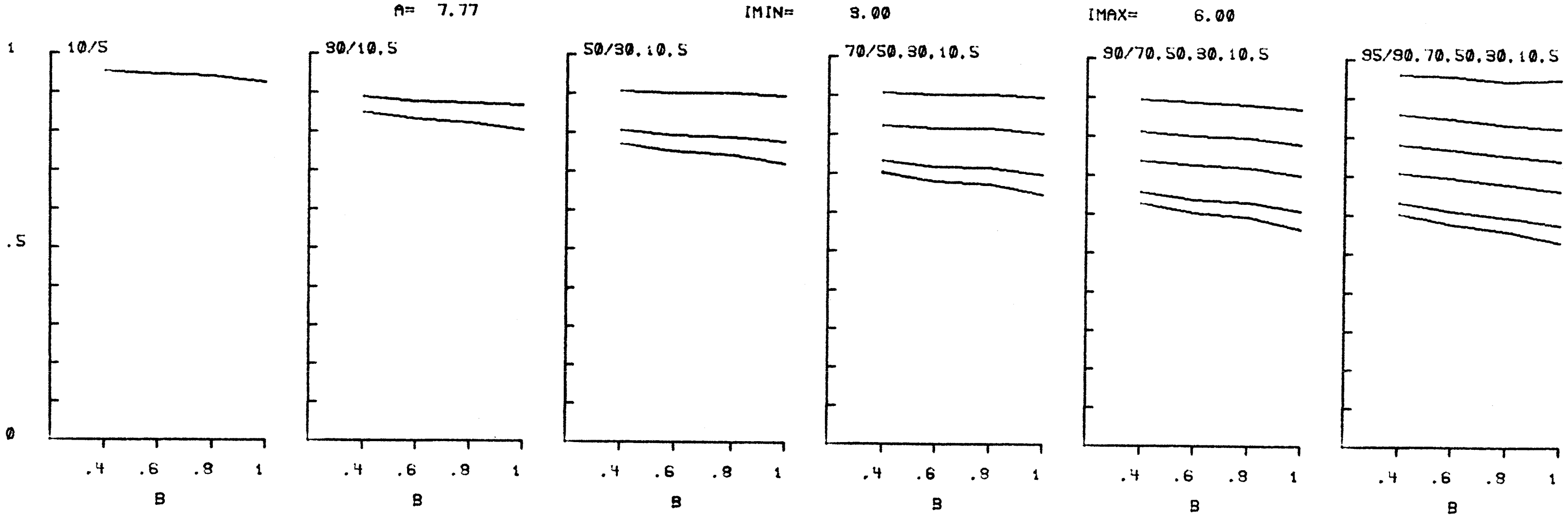

Fig. 39

Figs. 38 and 39. Spectral Ratios Averaged Over Eleven Periods and Five Dampings.

malism in choosing the largest possible amplitudes of strong shaking (SSE) by its qualitative nature and often limited data base simply avoids quantitative considerations of what may be the probability of exceeding the chosen amplitudes of ground motion. Assigning exceedance probabilities to OBE and SSE accurately may be difficult, but choosing probabilities in the range from, say, 5 per cent to 95 per cent and avoiding the tail amplitudes of the poorly known distribution functions there, may be much closer to the true result; if for no other reason by directly and explicitly modeling the realistic uncertainties in the problem.

Analysis of the trends of the spectral ratios in figures 4 through 39 shows generally systematic decrease for large B and for greater probabilities of exceeding the smaller of the two design spectra (e.g. OBE). In some cases this trend is accompanied by sudden variations of the ratios for two different yet adjacent B values (e.g. Figures 5, 7, 9). In most other cases studied here, however, this trend gradually decreases with increasing B.

To study more systematically how these trends decrease with B and to find how the ratios depend on M_{max} and A, straight lines of the form $C_0 + C_1 B$ were least squares fitted to all data in Figures 4 through 39. Figures 40 through 43 and Table I present C_0 and C_1 for different cut-off magnitudes M_{max} = 5.5, 6.5, 7.5 amd 8.5, for different probabilities of URS and for A from 0.7 to 6.0. It is seen that with increasing A C_0 approaches 1. The coefficient C_1 is less sensitive to A for M_{max} = 5.5 and 6.5. For greater M_{max} (7.5 and 8.5), however, $|C_1|$ increases with A. Figures 44 through 47 and Table II present the corresponding

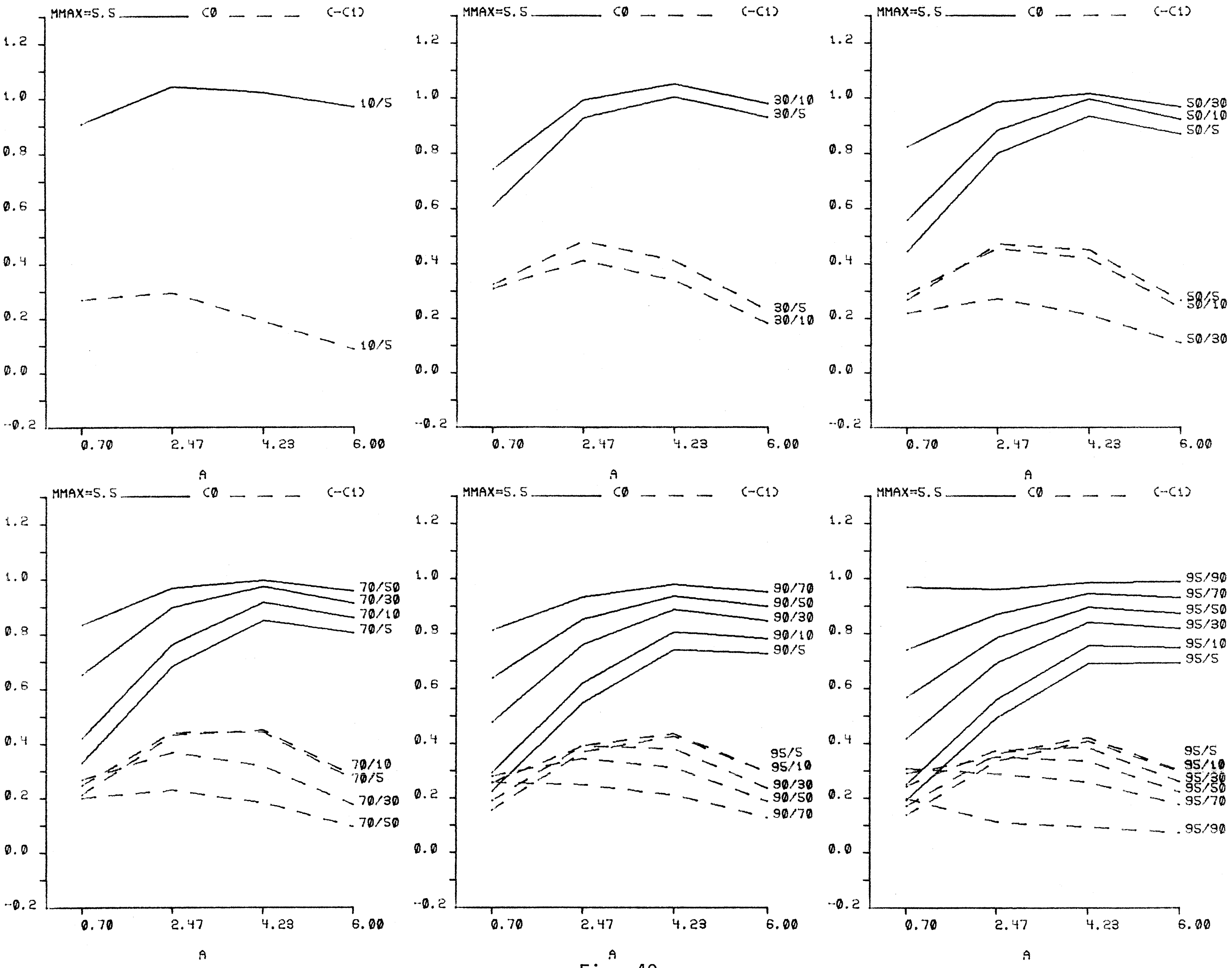

Fig. 40

Fig. 40. Least Square Fit-Coefficients C_0 and C_1 as a Function of M_{max} and A for Different Spectal Ratios.

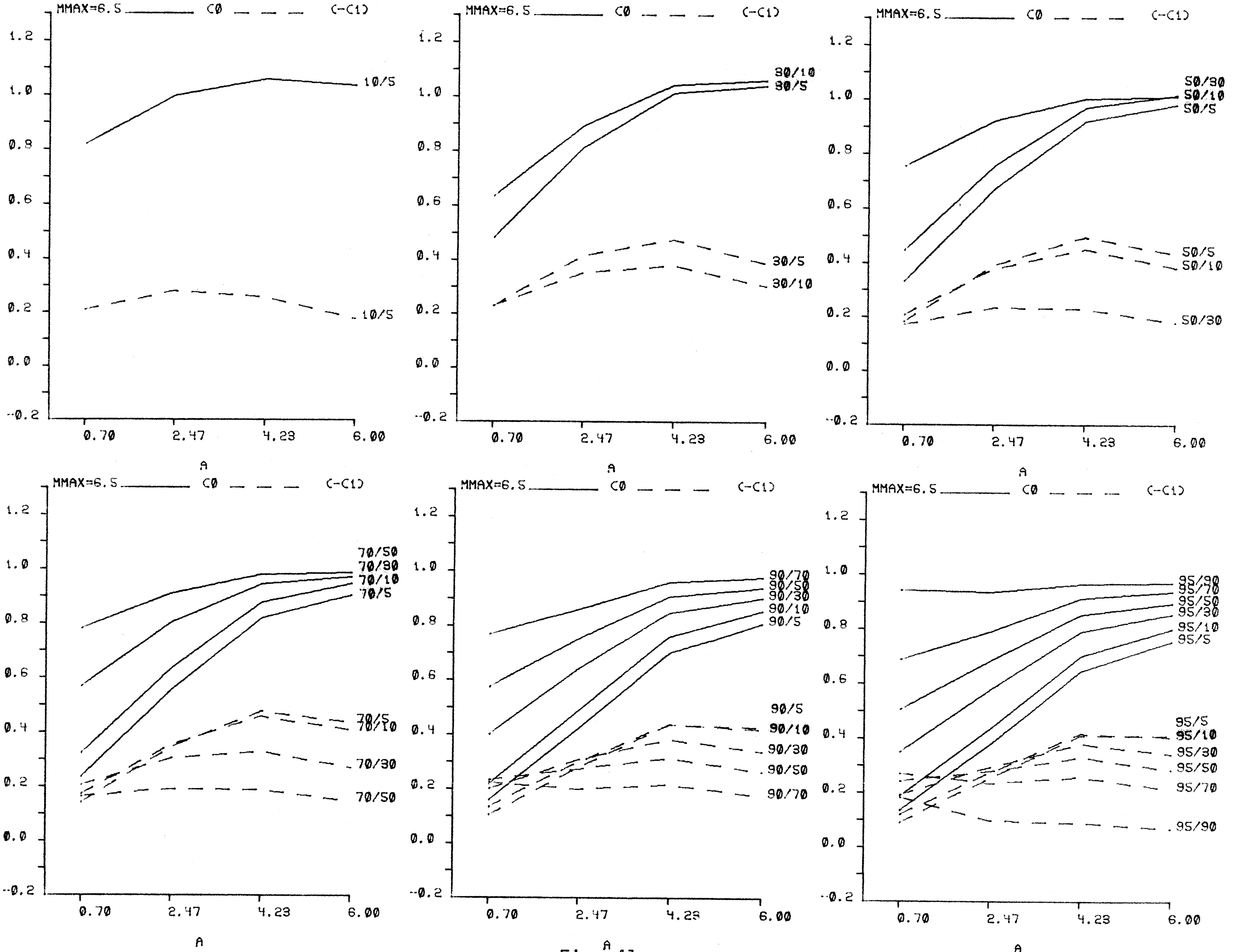

Fig. 41

Fig. 41. Least Square Fit-Coefficients C_0 and C_1 as a Function of M_{max} and A for Different Spectral Ratios.

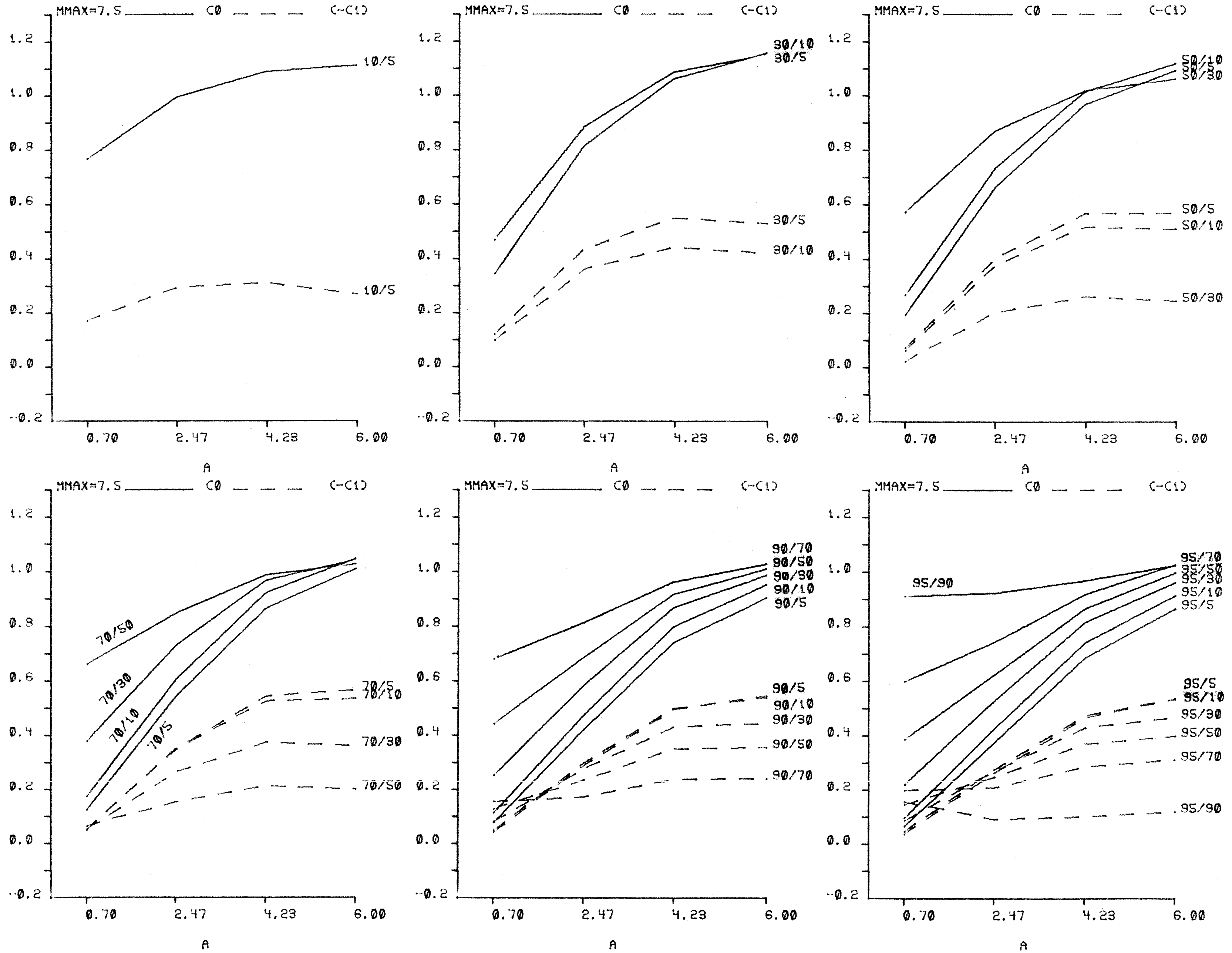

Fig. 42

Fig. 42. Least Square Fit-Coefficients C_0 and C_1 as a Function of M_{max} and A for Different Spectral Ratios.

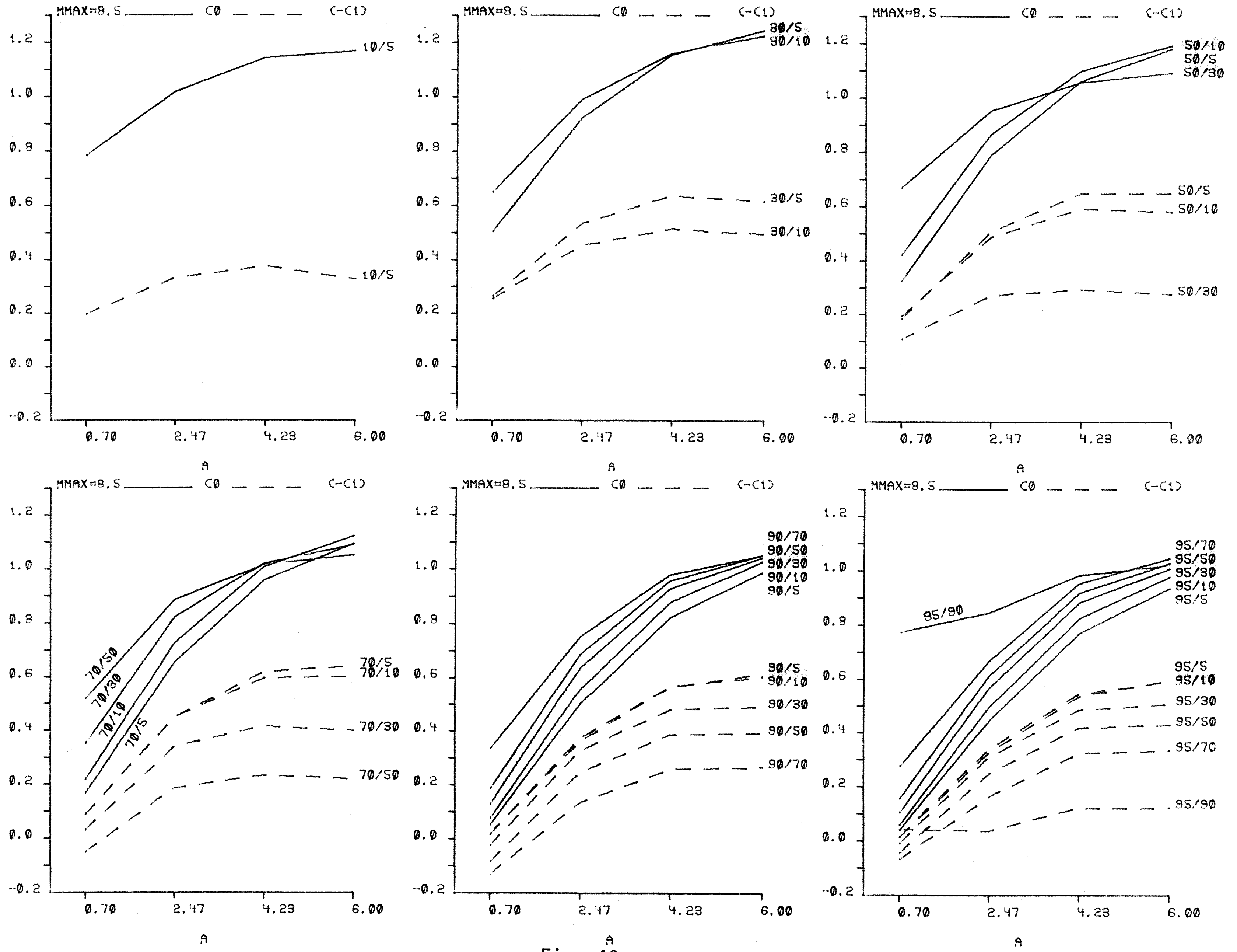

Fig. 43

Fig. 43. Least Square Fit-Coefficients C_0 and C_1 as a Function of M_{max} and A for Different Spectral Ratios.

Table I

Coefficients C_0 and C_1 in $R_{x\%:y\%} = C_0+C_1B$ where $R_{x\%:y\%}$ represents a ratio of URS amplitudes with x% chance of being exceeded to URS amplitudes with y% chance of being exceeded. x is shown from 10% to 95% and y from 5% to 90%.

```
                       MMIN=  3.00   MMAX=  5.50   A=  6.000
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
  C0=       .99       .93       .87       .82       .75       .69
  C1=     -.07      -.18      -.22      -.26      -.30      -.30

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
  C0=                 .95       .90       .84       .78       .72
  C1=               -.13      -.19      -.24      -.29      -.29

                             70%:50%   70%:30%   70%:10%   70%: 5%
  C0=                           .96       .91       .86       .80
  C1=                         -.10      -.17      -.27      -.28

                                       50%:30%   50%:10%   50%: 5%
  C0=                                     .96       .92       .87
  C1=                                   -.11      -.24      -.27

                                                 30%:10%   30%: 5%
  C0=                                               .98       .93
  C1=                                             -.18      -.23

                                                           10%: 5%
  C0=                                                         .97
  C1=                                                       -.09
```

```
                       MMIN=  3.00   MMAX=  5.50   A=  4.234
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
  C0=       .99       .94       .90       .84       .75       .69
  C1=     -.09      -.26      -.33      -.38      -.42      -.41

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
  C0=                 .98       .94       .89       .81       .74
  C1=               -.21      -.31      -.38      -.43      -.43

                             70%:50%   70%:30%   70%:10%   70%: 5%
  C0=                          1.00       .97       .92       .85
  C1=                         -.18      -.32      -.44      -.45

                                       50%:30%   50%:10%   50%: 5%
  C0=                                    1.02       .99       .93
  C1=                                   -.21      -.42      -.45

                                                 30%:10%   30%: 5%
  C0=                                              1.05      1.00
  C1=                                             -.34      -.41

                                                           10%: 5%
  C0=                                                        1.02
  C1=                                                       -.19
```

```
                MMIN=  3.00   MMAX=  5.50   A=  2.467
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=       .96       .87       .79       .69       .56       .49
C1=      -.11      -.29      -.35      -.37      -.36      -.33

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                 .93       .85       .76       .62       .55
C1=                -.25      -.34      -.39      -.39      -.37

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                           .97       .90       .76       .68
C1=                          -.23      -.37      -.44      -.43

                                    50%:30%   50%:10%   50%: 5%
C0=                                     .99       .88       .80
C1=                                    -.27      -.46      -.47

                                              30%:10%   30%: 5%
C0=                                               .99       .93
C1=                                              -.41      -.48

                                                        10%: 5%
C0=                                                        1.04
C1=                                                        -.30
```

```
                MMIN=  3.00   MMAX=  5.50   A=   .701
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=       .97       .74       .57       .42       .25       .19
C1=      -.20      -.31      -.29      -.24      -.17      -.14

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                 .81       .64       .48       .29       .23
C1=                -.26      -.28      -.26      -.19      -.16

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                           .83       .65       .42       .33
C1=                          -.20      -.27      -.25      -.21

                                    50%:30%   50%:10%   50%: 5%
C0=                                     .82       .56       .44
C1=                                    -.22      -.29      -.27

                                              30%:10%   30%: 5%
C0=                                               .74       .61
C1=                                              -.31      -.32

                                                        10%: 5%
C0=                                                         .91
C1=                                                        -.27
```

```
                    MMIN=  3.00   MMAX=  6.50   A=  6.000
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .97       .94       .90       .85       .80       .75
C1=        -.07      -.21      -.29      -.34      -.41      -.41

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .98       .94       .90       .85       .81
C1=                  -.18      -.27      -.34      -.42      -.43

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .99       .97       .95       .90
C1=                            -.15      -.27      -.41      -.44

                                        50%:30%   50%:10%   50%: 5%
C0=                                       1.01      1.02       .98
C1=                                      -.18      -.38      -.43

                                                  30%:10%   30%: 5%
C0=                                                 1.06      1.04
C1=                                                -.30      -.39

                                                            10%: 5%
C0=                                                           1.03
C1=                                                          -.18



                    MMIN=  3.00   MMAX=  6.50   A=  4.234
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .97       .91       .85       .79       .70       .65
C1=        -.09      -.26      -.33      -.38      -.42      -.41

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .96       .91       .85       .76       .70
C1=                  -.22      -.32      -.38      -.44      -.44

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .98       .94       .88       .82
C1=                            -.19      -.33      -.46      -.48

                                        50%:30%   50%:10%   50%: 5%
C0=                                       1.00       .97       .92
C1=                                      -.23      -.45      -.50

                                                  30%:10%   30%: 5%
C0=                                                 1.04      1.01
C1=                                                -.38      -.48

                                                            10%: 5%
C0=                                                           1.06
C1=                                                          -.26
```

```
                    MMIN=   3.00    MMAX=   6.50    A=   2.467
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .94       .79       .68       .58       .44       .38
C1=        -.10      -.23      -.28      -.30      -.27      -.25

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .86       .75       .64       .49       .42
C1=                  -.20      -.28      -.31      -.30      -.28

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .91       .80       .63       .55
C1=                            -.19      -.31      -.35      -.35

                                        50%:30%   50%:10%   50%: 5%
C0=                                        .92       .76       .67
C1=                                      -.24      -.38      -.39

                                                  30%:10%   30%: 5%
C0=                                                  .89       .81
C1=                                                -.35      -.42

                                                            10%: 5%
C0=                                                           1.00
C1=                                                          -.28
```

```
                    MMIN=   3.00    MMAX=   6.50    A=    .701
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .94       .69       .51       .35       .19       .13
C1=        -.18      -.27      -.24      -.19      -.12      -.09

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .77       .57       .40       .22       .16
C1=                  -.23      -.23      -.20      -.13      -.10

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .78       .57       .33       .24
C1=                            -.16      -.21      -.17      -.14

                                        50%:30%   50%:10%   50%: 5%
C0=                                        .75       .45       .33
C1=                                      -.17      -.21      -.18

                                                  30%:10%   30%: 5%
C0=                                                  .63       .48
C1=                                                -.23      -.23

                                                            10%: 5%
C0=                                                            .82
C1=                                                          -.21
```

```
                    MMIN=  3.00   MMAX=  7.50   A=  6.000
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=       1.02      1.02       .99       .96       .91       .87
C1=       -.12      -.31      -.40      -.47      -.53      -.53

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                 1.03      1.01       .99       .95       .91
C1=                 -.24      -.36      -.44      -.54      -.55

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                           1.03      1.04      1.05      1.01
C1=                           -.20      -.36      -.53      -.57

                                       50%:30%   50%:10%   50%: 5%
C0=                                     1.06      1.12      1.09
C1=                                     -.24      -.51      -.57

                                                 30%:10%   30%: 5%
C0=                                               1.15      1.16
C1=                                               -.42      -.53

                                                           10%: 5%
C0=                                                         1.11
C1=                                                         -.27
```

```
                    MMIN=  3.00   MMAX=  7.50   A=  4.234
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=        .97       .92       .87       .81       .74       .68
C1=       -.10      -.28      -.37      -.43      -.47      -.46

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                  .96       .92       .87       .80       .74
C1=                 -.24      -.35      -.43      -.50      -.49

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                            .99       .97       .92       .87
C1=                           -.21      -.37      -.53      -.54

                                       50%:30%   50%:10%   50%: 5%
C0=                                     1.02      1.02       .97
C1=                                     -.26      -.52      -.57

                                                 30%:10%   30%: 5%
C0=                                               1.09      1.06
C1=                                               -.44      -.55

                                                           10%: 5%
C0=                                                         1.09
C1=                                                         -.31
```

```
                    MMIN=   3.00    MMAX=   7.50    A=   2.467
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .92       .74       .62       .53       .42       .38
C1=        -.09      -.21      -.25      -.27      -.28      -.26

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .81       .68       .58       .47       .42
C1=                  -.17      -.24      -.28      -.30      -.29

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .85       .73       .60       .54
C1=                            -.15      -.26      -.35      -.35

                                        50%:30%   50%:10%   50%: 5%
C0=                                        .87       .73       .66
C1=                                      -.20      -.38      -.40

                                                  30%:10%   30%: 5%
C0=                                                  .88       .81
C1=                                                -.36      -.44

                                                            10%: 5%
C0=                                                           1.00
C1=                                                          -.29




                    MMIN=   3.00    MMAX=   7.50    A=    .701
          95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .91       .60       .39       .22       .10       .07
C1=        -.16      -.20      -.15      -.09      -.05      -.04

                    90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .68       .44       .25       .11       .08
C1=                  -.16      -.13      -.08      -.05      -.04

                              70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .66       .38       .18       .12
C1=                            -.07      -.05      -.05      -.05

                                        50%:30%   50%:10%   50%: 5%
C0=                                        .57       .27       .19
C1=                                      -.02      -.06      -.07

                                                  30%:10%   30%: 5%
C0=                                                  .47       .35
C1=                                                -.10      -.12

                                                            10%: 5%
C0=                                                            .77
C1=                                                          -.17
```

```
                MMIN=  3. 00  MMAX=  8. 50  A=  6. 000
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=     1. 02     1. 04     1. 03     1. 01      . 98      . 94
C1=     -. 12     -. 34     -. 43     -. 51     -. 59     -. 60

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=               1. 05     1. 05     1. 04     1. 03      . 99
C1=               -. 27     -. 39     -. 49     -. 60     -. 62

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                         1. 05     1. 09     1. 12     1. 10
C1=                         -. 22     -. 40     -. 60     -. 64

                                    50%:30%   50%:10%   50%: 5%
C0=                                   1. 09     1. 19     1. 18
C1=                                   -. 27     -. 58     -. 65

                                              30%:10%   30%: 5%
C0=                                             1. 23     1. 25
C1=                                             -. 49     -. 62

                                                        10%: 5%
C0=                                                       1. 17
C1=                                                       -. 33
```

```
                MMIN=  3. 00  MMAX=  8. 50  A=  4. 234
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=      . 98      . 95      . 92      . 88      . 83      . 77
C1=     -. 12     -. 33     -. 42     -. 49     -. 55     -. 54

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                . 98      . 96      . 93      . 88      . 82
C1=               -. 26     -. 39     -. 48     -. 57     -. 57

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                         1. 02     1. 02     1. 01      . 96
C1=                         -. 24     -. 42     -. 60     -. 62

                                    50%:30%   50%:10%   50%: 5%
C0=                                   1. 06     1. 10     1. 06
C1=                                   -. 29     -. 59     -. 65

                                              30%:10%   30%: 5%
C0=                                             1. 16     1. 15
C1=                                             -. 51     -. 64

                                                        10%: 5%
C0=                                                       1. 14
C1=                                                       -. 38
```

```
                MMIN=  3.00   MMAX=  8.50   A=  2.467
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=       .85       .67       .62       .57       .50       .45
C1=      -.04      -.16      -.25      -.31      -.34      -.33

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                 .75       .69       .64       .56       .50
C1=                -.14      -.25      -.33      -.37      -.36

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                           .89       .82       .73       .66
C1=                          -.19      -.34      -.45      -.45

                                    50%:30%   50%:10%   50%: 5%
C0=                                     .95       .87       .79
C1=                                    -.27      -.49      -.51

                                              30%:10%   30%: 5%
C0=                                               .99       .92
C1=                                              -.45      -.53

                                                        10%: 5%
C0=                                                        1.02
C1=                                                        -.33




                MMIN=  3.00   MMAX=  8.50   A=   .701
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=       .77       .28       .16       .11       .06       .04
C1=      -.04       .07       .04       .01      -.02      -.02

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                 .34       .19       .13       .08       .05
C1=                 .13       .08       .02      -.02      -.02

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                           .52       .36       .22       .17
C1=                           .05      -.03      -.09      -.09

                                    50%:30%   50%:10%   50%: 5%
C0=                                     .67       .42       .32
C1=                                    -.11      -.19      -.18

                                              30%:10%   30%: 5%
C0=                                               .65       .51
C1=                                              -.25      -.26

                                                        10%: 5%
C0=                                                         .78
C1=                                                        -.20
```

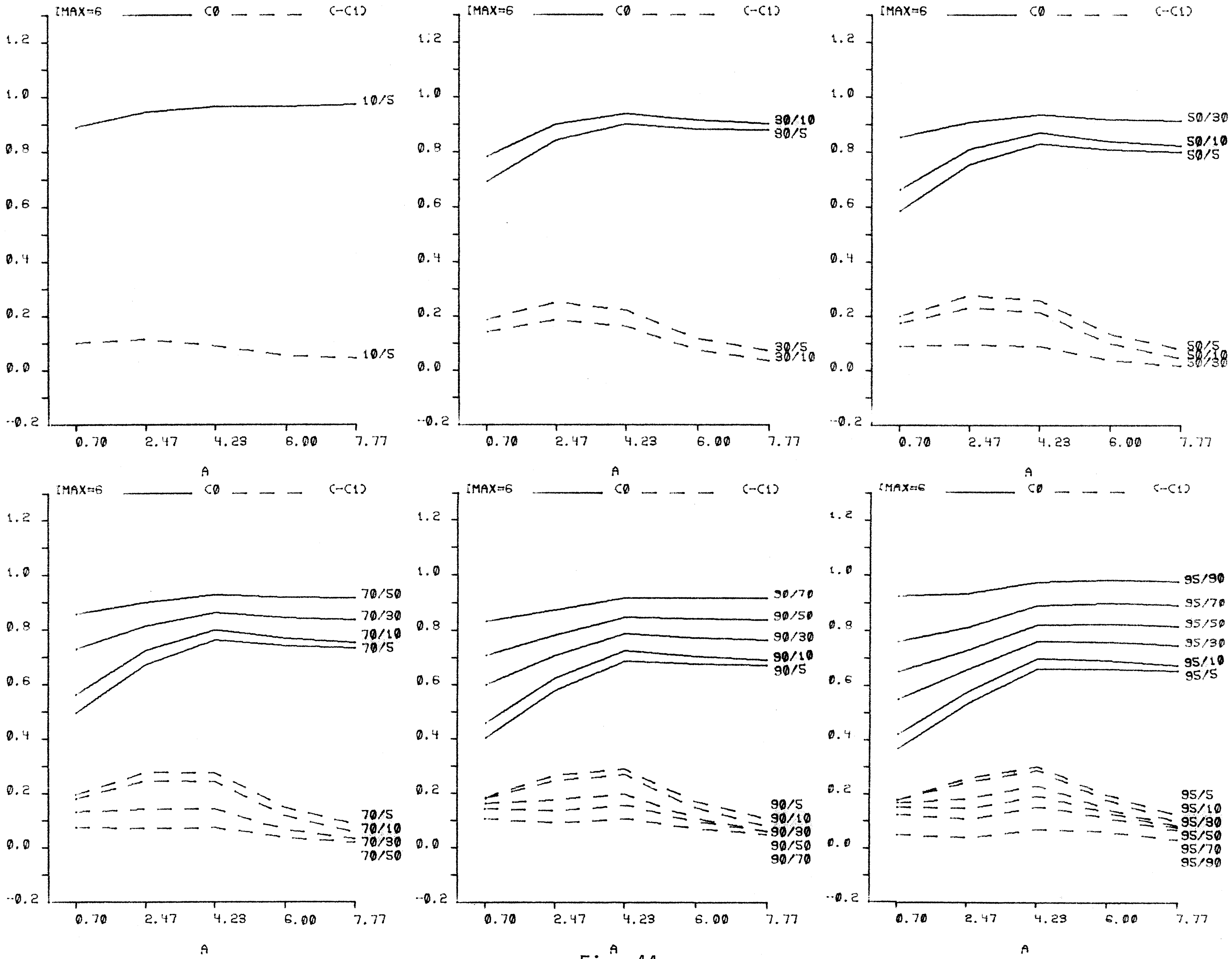

Fig. 44

Fig. 44. Least Square Coefficients C_0 and C_1 as a Function of I_{max} and A for Different Spectral Ratios.

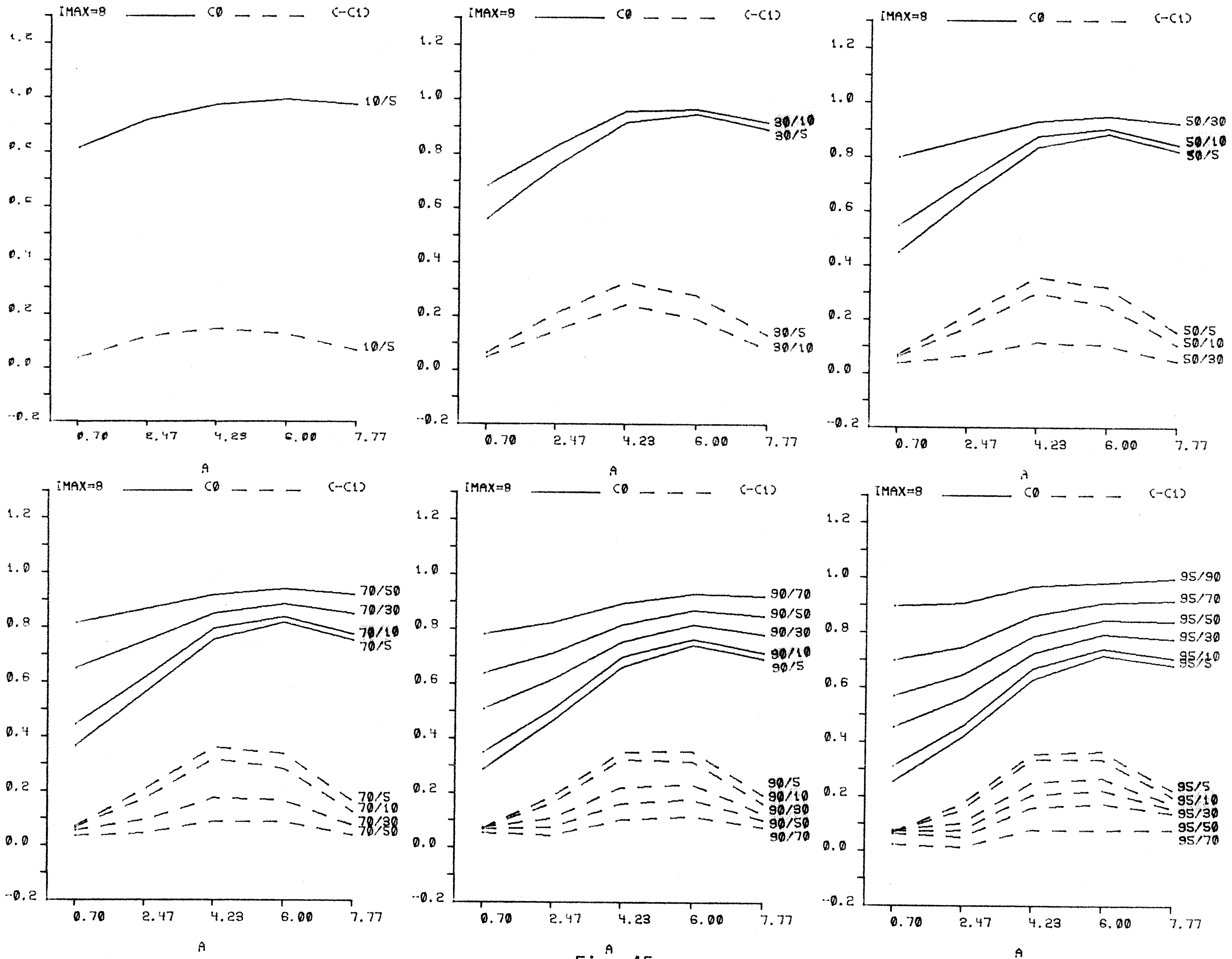

Fig. 45

Fig. 45. Least Square Cofficients C_0 and C_1 as a Function of I_{max} and A for Different Spectral Ratios.

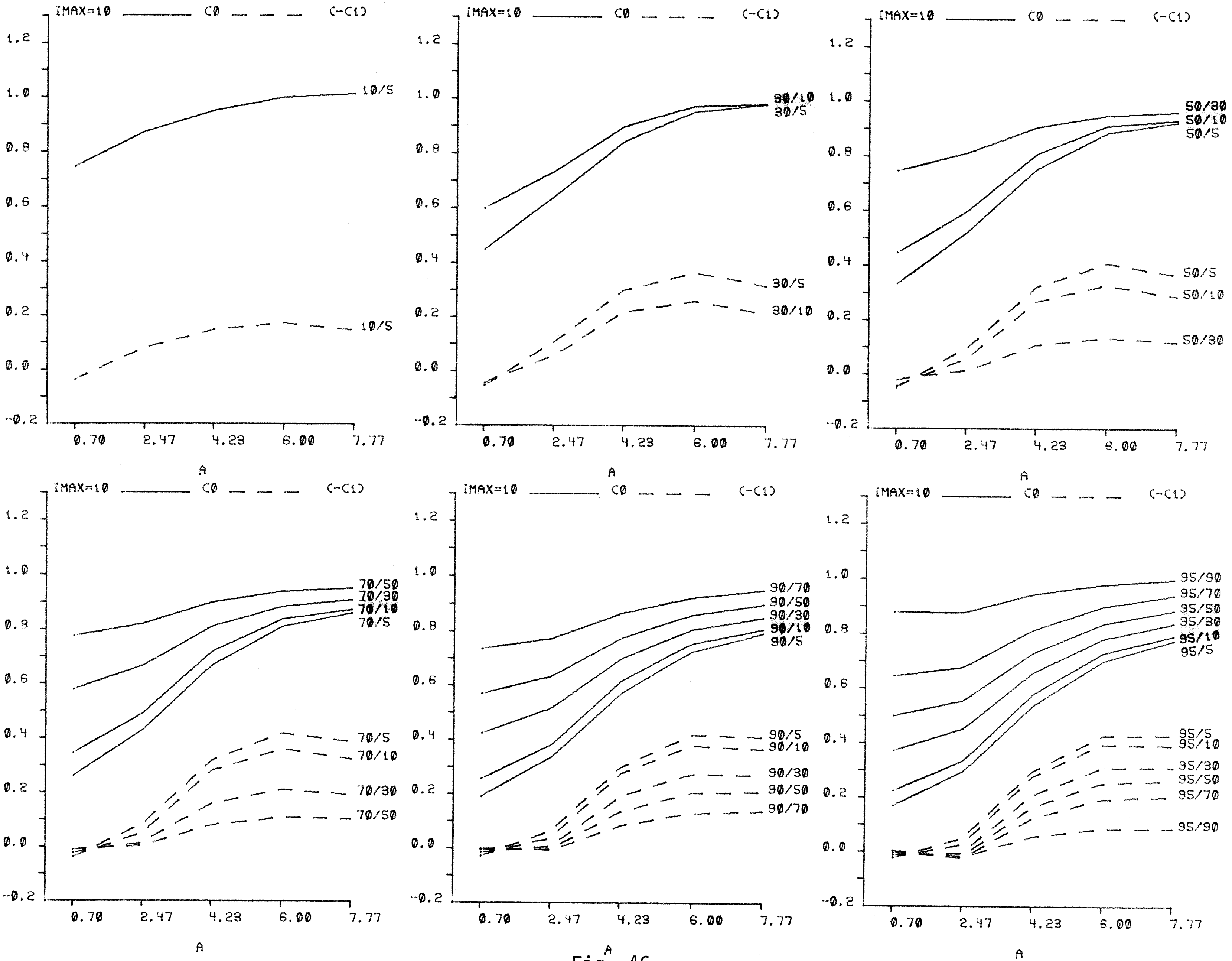

Fig. 46

Fig. 46. Least Square Coefficients C_0 and C_1 as a Function of I_{max} and A for Different Spectral Ratios.

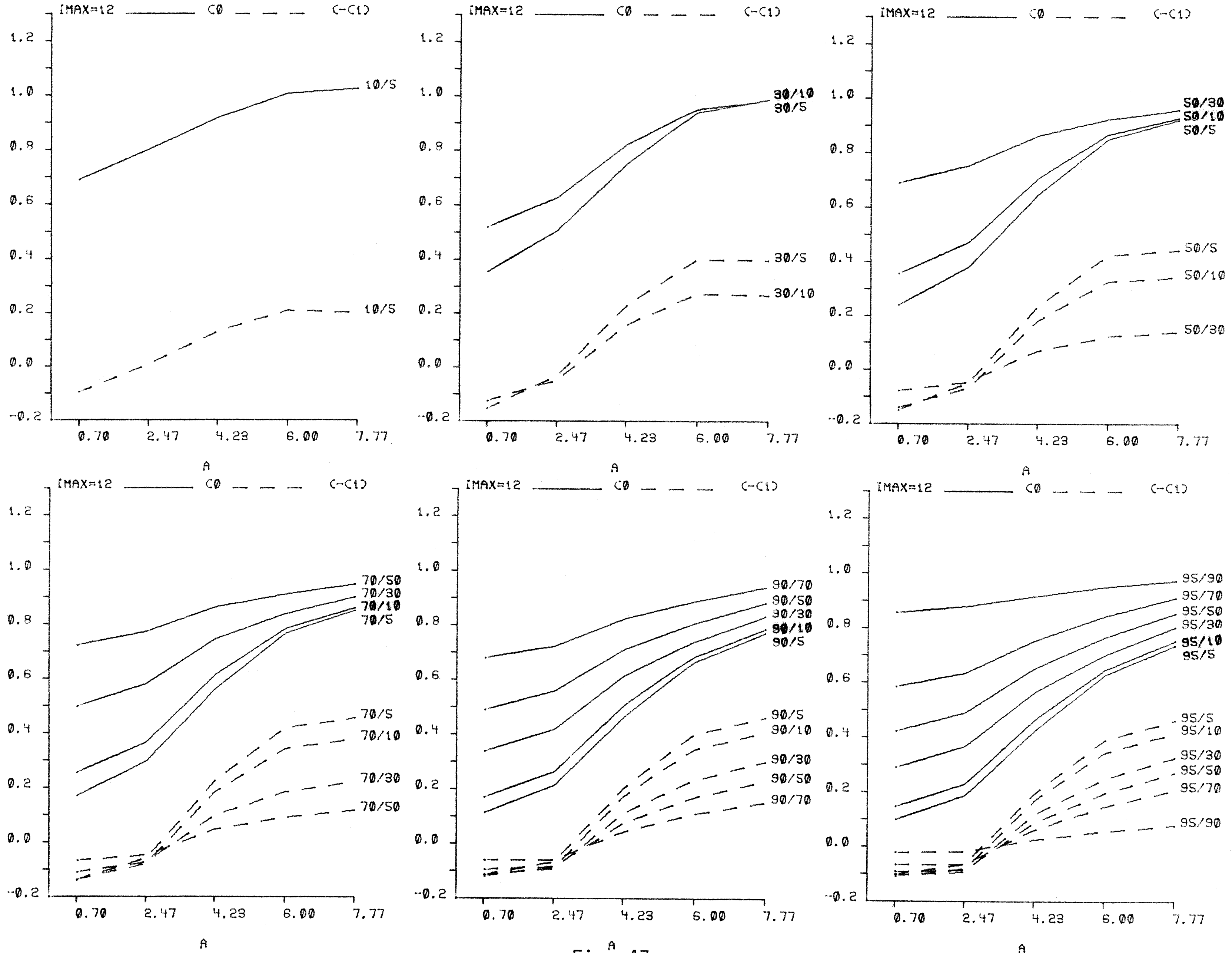

Fig. 47

Fig. 47. Least Square Coefficients C_0 and C_1 as a Function of I_{max} and A for Different Spectral Ratios.

Table II

Coefficients C_0 and C_1 in $R_{x\%:y\%} = C_0+C_1B$ where $R_{x\%:y\%}$ represents a ratio of URS amplitudes with x% chance of being exceeded to URS amplitudes with y% chance of being exceeded. x is shown from 10% to 95% and y from 5% to 90%.

```
                  IMIN=  3. 00   IMAX=  6. 00   A=  7. 766
        95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=        . 97      . 88      . 81      . 74      . 67      . 65
C1=       -. 03     -. 06     -. 07     -. 08     -. 09     -. 12

                  90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                  . 91      . 83      . 76      . 69      . 67
C1=                 -. 04     -. 05     -. 06     -. 08     -. 10

                            70%:50%   70%:30%   70%:10%   70%: 5%
C0=                            . 92      . 84      . 75      . 73
C1=                           -. 02     -. 03     -. 06     -. 09

                                      50%:30%   50%:10%   50%: 5%
C0=                                      . 91      . 82      . 80
C1=                                     -. 02     -. 05     -. 08

                                                30%:10%   30%: 5%
C0=                                                . 90      . 88
C1=                                               -. 03     -. 07

                                                          10%: 5%
C0=                                                          . 97
C1=                                                         -. 05




                  IMIN=  3. 00   IMAX=  6. 00   A=  6. 000
        95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=        . 98      . 89      . 82      . 75      . 68      . 66
C1=       -. 06     -. 11     -. 13     -. 14     -. 17     -. 19

                  90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                  . 91      . 84      . 77      . 70      . 67
C1=                 -. 06     -. 09     -. 11     -. 15     -. 17

                            70%:50%   70%:30%   70%:10%   70%: 5%
C0=                            . 92      . 84      . 77      . 74
C1=                           -. 04     -. 07     -. 12     -. 15

                                      50%:30%   50%:10%   50%: 5%
C0=                                      . 92      . 84      . 81
C1=                                     -. 04     -. 10     -. 13

                                                30%:10%   30%: 5%
C0=                                                . 91      . 88
C1=                                               -. 08     -. 12

                                                          10%: 5%
C0=                                                          . 97
C1=                                                         -. 05
```

```
                IMIN=  3. 00   IMAX=  6. 00  A=  4. 234
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=      . 97      . 89      . 82      . 76      . 69      . 66
C1=     -. 07     -. 15     -. 19     -. 23     -. 29     -. 30

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                . 91      . 84      . 78      . 72      . 68
C1=               -. 10     -. 15     -. 20     -. 27     -. 29

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                          . 93      . 86      . 80      . 76
C1=                         -. 07     -. 14     -. 24     -. 28

                                    50%:30%   50%:10%   50%: 5%
C0=                                    . 93      . 87      . 83
C1=                                   -. 09     -. 21     -. 26

                                              30%:10%   30%: 5%
C0=                                              . 94      . 90
C1=                                             -. 16     -. 22

                                                        10%: 5%
C0=                                                        . 97
C1=                                                       -. 09



                IMIN=  3. 00   IMAX=  6. 00  A=  2. 467
      95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=      . 93      . 81      . 72      . 65      . 58      . 53
C1=     -. 03     -. 10     -. 14     -. 18     -. 24     -. 26

                90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                . 87      . 78      . 70      . 62      . 58
C1=               -. 08     -. 13     -. 18     -. 25     -. 27

                          70%:50%   70%:30%   70%:10%   70%: 5%
C0=                          . 90      . 81      . 72      . 67
C1=                         -. 07     -. 14     -. 25     -. 28

                                    50%:30%   50%:10%   50%: 5%
C0=                                    . 91      . 81      . 76
C1=                                   -. 10     -. 23     -. 28

                                              30%:10%   30%: 5%
C0=                                              . 90      . 84
C1=                                             -. 19     -. 25

                                                        10%: 5%
C0=                                                        . 95
C1=                                                       -. 11
```

```
                  IMIN=  3.00   IMAX=  6.00   A=   .701
        95%:90%  95%:70%  95%:50%  95%:30%  95%:10%  95%: 5%
C0=        .92      .76      .64      .54      .42      .36
C1=      -.05     -.12     -.15     -.16     -.17     -.17

                 90%:70%  90%:50%  90%:30%  90%:10%  90%: 5%
C0=                 .83      .71      .60      .46      .40
C1=               -.10     -.14     -.16     -.18     -.18

                          70%:50%  70%:30%  70%:10%  70%: 5%
C0=                          .86      .73      .56      .50
C1=                        -.08     -.13     -.18     -.20

                                   50%:30%  50%:10%  50%: 5%
C0=                                   .85      .66      .58
C1=                                 -.09     -.17     -.20

                                            30%:10%  30%: 5%
C0=                                            .78      .69
C1=                                          -.14     -.19

                                                     10%: 5%
C0=                                                     .89
C1=                                                   -.10



                  IMIN=  3.00   IMAX=  8.00   A=  7.766
        95%:90%  95%:70%  95%:50%  95%:30%  95%:10%  95%: 5%
C0=      1.00       .92      .84      .77      .70      .68
C1=      -.08     -.14     -.16     -.17     -.20     -.22

                 90%:70%  90%:50%  90%:30%  90%:10%  90%: 5%
C0=                 .92      .85      .78      .71      .69
C1=               -.08     -.10     -.13     -.16     -.19

                          70%:50%  70%:30%  70%:10%  70%: 5%
C0=                          .92      .85      .78      .75
C1=                        -.04     -.07     -.13     -.16

                                   50%:30%  50%:10%  50%: 5%
C0=                                   .92      .84      .82
C1=                                 -.04     -.11     -.15

                                            30%:10%  30%: 5%
C0=                                            .91      .89
C1=                                          -.08     -.13

                                                     10%: 5%
C0=                                                     .97
C1=                                                   -.07
```

```
                 IMIN=   3.00    IMAX=   8.00    A=   6.000
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .98       .91       .85       .79       .74       .71
C1=         -.08      -.17      -.22      -.27      -.33      -.37

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .93       .87       .81       .76       .74
C1=                   -.12      -.18      -.23      -.31      -.35

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .94       .89       .84       .82
C1=                             -.09      -.17      -.28      -.34

                                       50%:30%   50%:10%   50%: 5%
C0=                                        .95       .90       .88
C1=                                       -.10      -.25      -.32

                                                 30%:10%   30%: 5%
C0=                                                  .96       .95
C1=                                                 -.19      -.28

                                                           10%: 5%
C0=                                                            .99
C1=                                                           -.13
```

```
                 IMIN=   3.00    IMAX=   8.00    A=   4.234
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .97       .86       .79       .72       .67       .63
C1=         -.08      -.16      -.20      -.25      -.33      -.35

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .89       .82       .75       .70       .66
C1=                   -.10      -.16      -.22      -.32      -.35

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .92       .85       .79       .75
C1=                             -.09      -.17      -.32      -.36

                                       50%:30%   50%:10%   50%: 5%
C0=                                        .93       .88       .84
C1=                                       -.11      -.30      -.36

                                                 30%:10%   30%: 5%
C0=                                                  .95       .91
C1=                                                 -.24      -.33

                                                           10%: 5%
C0=                                                            .97
C1=                                                           -.15
```

```
                    IMIN=   3.00    IMAX=   8.00    A=   2.467
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .91       .75       .64       .56       .46       .42
C1=         -.01      -.05      -.07      -.10      -.15      -.17

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .82       .71       .61       .51       .46
C1=                   -.04      -.07      -.11      -.16      -.18

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .86       .75       .62       .56
C1=                             -.05      -.09      -.17      -.21

                                       50%:30%   50%:10%   50%: 5%
C0=                                        .86       .71       .65
C1=                                       -.07      -.17      -.22

                                                 30%:10%   30%: 5%
C0=                                                  .83       .76
C1=                                                 -.14      -.21

                                                           10%: 5%
C0=                                                            .92
C1=                                                           -.12



                    IMIN=   3.00    IMAX=   8.00    A=    .701
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=          .89       .70       .57       .45       .31       .25
C1=         -.02      -.06      -.07      -.07      -.07      -.07

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                    .78       .64       .51       .35       .28
C1=                   -.05      -.07      -.07      -.07      -.07

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                              .82       .65       .44       .36
C1=                             -.03      -.06      -.07      -.07

                                       50%:30%   50%:10%   50%: 5%
C0=                                        .80       .54       .45
C1=                                       -.04      -.06      -.07

                                                 30%:10%   30%: 5%
C0=                                                  .68       .56
C1=                                                 -.05      -.06

                                                           10%: 5%
C0=                                                            .82
C1=                                                           -.04
```

```
                    IMIN=  3.00    IMAX= 10.00    A=  7.766
        95%:90%  95%:70%  95%:50%  95%:30%  95%:10%  95%: 5%
C0=         .99      .94      .88      .83      .79      .77
C1=        -.08     -.20     -.26     -.31     -.39     -.43

                 90%:70%  90%:50%  90%:30%  90%:10%  90%: 5%
C0=                  .95      .89      .85      .81      .79
C1=                 -.14     -.21     -.27     -.36     -.41

                          70%:50%  70%:30%  70%:10%  70%: 5%
C0=                           .95      .91      .87      .86
C1=                          -.10     -.19     -.32     -.39

                                   50%:30%  50%:10%  50%: 5%
C0=                                    .96      .93      .92
C1=                                   -.12     -.28     -.36

                                            30%:10%  30%: 5%
C0=                                             .98      .98
C1=                                            -.21     -.32

                                                     10%: 5%
C0=                                                     1.01
C1=                                                     -.15



                    IMIN=  3.00    IMAX= 10.00    A=  6.000
        95%:90%  95%:70%  95%:50%  95%:30%  95%:10%  95%: 5%
C0=         .98      .90      .83      .78      .73      .70
C1=        -.08     -.19     -.25     -.31     -.39     -.43

                 90%:70%  90%:50%  90%:30%  90%:10%  90%: 5%
C0=                  .92      .86      .80      .75      .73
C1=                 -.13     -.20     -.27     -.38     -.42

                          70%:50%  70%:30%  70%:10%  70%: 5%
C0=                           .94      .88      .84      .81
C1=                          -.11     -.21     -.36     -.42

                                   50%:30%  50%:10%  50%: 5%
C0=                                    .95      .91      .88
C1=                                   -.13     -.33     -.41

                                            30%:10%  30%: 5%
C0=                                             .97      .95
C1=                                            -.26     -.37

                                                     10%: 5%
C0=                                                     1.00
C1=                                                     -.17
```

```
                IMIN=  3.00   IMAX= 10.00    A=  4.234
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=         .94       .81       .73       .66       .58       .53
C1=       -.06      -.12      -.16      -.21      -.28      -.29

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                   .86       .77       .70       .62       .57
C1=                 -.08      -.13      -.19      -.27      -.30

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                             .90       .81       .72       .67
C1=                           -.08      -.16      -.28      -.32

                                       50%:30%   50%:10%   50%: 5%
C0=                                       .91       .81       .75
C1=                                     -.11      -.27      -.32

                                                 30%:10%   30%: 5%
C0=                                                 .90       .84
C1=                                               -.22      -.30

                                                           10%: 5%
C0=                                                           .95
C1=                                                         -.15
```

```
                IMIN=  3.00   IMAX= 10.00    A=  2.467
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=         .88       .67       .55       .45       .33       .29
C1=         .02       .03       .02       .01     -.02      -.05

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                   .77       .63       .51       .38       .33
C1=                   .01       .00     -.01      -.04      -.06

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                             .82       .67       .49       .43
C1=                           -.00      -.01      -.05      -.08

                                       50%:30%   50%:10%   50%: 5%
C0=                                       .81       .59       .52
C1=                                     -.01      -.06      -.10

                                                 30%:10%   30%: 5%
C0=                                                 .73       .64
C1=                                               -.06      -.11

                                                           10%: 5%
C0=                                                           .87
C1=                                                         -.08
```

```
                  IMIN=  3.00   IMAX= 10.00   A=   .701
        95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=        .88       .64       .50       .37       .22       .17
C1=      -.00      -.00       .00       .01       .02       .03

                  90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                  .73       .57       .42       .25       .19
C1=                -.00       .01       .02       .03       .03

                            70%:50%   70%:30%   70%:10%   70%: 5%
C0=                            .77       .58       .35       .26
C1=                            .01       .02       .04       .04

                                      50%:30%   50%:10%   50%: 5%
C0=                                      .74       .44       .33
C1=                                      .02       .04       .05

                                                30%:10%   30%: 5%
C0=                                                .60       .45
C1=                                                .04       .05

                                                          10%: 5%
C0=                                                          .75
C1=                                                          .04




                  IMIN=  3.00   IMAX= 12.00   A=  7.766
        95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=        .97       .91       .85       .80       .75       .73
C1=      -.08      -.21      -.27      -.33      -.41      -.46

                  90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                  .94       .88       .83       .79       .77
C1=                -.15      -.23      -.30      -.41      -.46

                            70%:50%   70%:30%   70%:10%   70%: 5%
C0=                            .95       .90       .86       .85
C1=                          -.12      -.22      -.38      -.45

                                      50%:30%   50%:10%   50%: 5%
C0=                                      .96       .93       .92
C1=                                    -.14      -.34      -.44

                                                30%:10%   30%: 5%
C0=                                                .98       .99
C1=                                              -.27      -.40

                                                          10%: 5%
C0=                                                         1.03
C1=                                                         -.20
```

```
                       IMIN=   3.00   IMAX= 12.00    A=   6.000
          95%:90%    95%:70%    95%:50%    95%:30%    95%:10%    95%: 5%
C0=          .95        .84        .76        .70        .65        .63
C1=        -.06       -.15       -.19       -.25       -.34       -.39

                     90%:70%    90%:50%    90%:30%    90%:10%    90%: 5%
C0=                     .89        .81        .74        .69        .67
C1=                   -.11       -.17       -.23       -.35       -.40

                                70%:50%    70%:30%    70%:10%    70%: 5%
C0=                                .91        .84        .78        .76
C1=                              -.09       -.18       -.34       -.42

                                           50%:30%    50%:10%    50%: 5%
C0=                                           .92        .87        .85
C1=                                         -.12       -.33       -.42

                                                      30%:10%    30%: 5%
C0=                                                      .95        .94
C1=                                                    -.27       -.40

                                                                 10%: 5%
C0=                                                                1.01
C1=                                                               -.21



                       IMIN=   3.00   IMAX= 12.00    A=   4.234
          95%:90%    95%:70%    95%:50%    95%:30%    95%:10%    95%: 5%
C0=          .91        .75        .65        .56        .46        .42
C1=        -.02       -.06       -.09       -.12       -.17       -.19

                     90%:70%    90%:50%    90%:30%    90%:10%    90%: 5%
C0=                     .82        .71        .61        .51        .46
C1=                   -.04       -.08       -.11       -.17       -.20

                                70%:50%    70%:30%    70%:10%    70%: 5%
C0=                                .86        .74        .61        .56
C1=                              -.05       -.10       -.18       -.22

                                           50%:30%    50%:10%    50%: 5%
C0=                                           .86        .71        .65
C1=                                         -.07       -.18       -.24

                                                      30%:10%    30%: 5%
C0=                                                      .82        .75
C1=                                                    -.16       -.23

                                                                 10%: 5%
C0=                                                                 .92
C1=                                                               -.13
```

```
                   IMIN=  3.00   IMAX= 12.00   A=  2.467
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=         .88       .63       .49       .37       .23       .18
C1=         .02       .07       .09       .09       .08       .07

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                   .72       .56       .42       .26       .21
C1=                   .06       .08       .09       .09       .07

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                             .77       .58       .36       .29
C1=                             .05       .07       .08       .06

                                       50%:30%   50%:10%   50%: 5%
C0=                                       .75       .47       .38
C1=                                       .05       .07       .05

                                                 30%:10%   30%: 5%
C0=                                                 .63       .50
C1=                                                 .05       .03

                                                           10%: 5%
C0=                                                           .80
C1=                                                          -.01



                   IMIN=  3.00   IMAX= 12.00   A=   .701
         95%:90%   95%:70%   95%:50%   95%:30%   95%:10%   95%: 5%
C0=         .86       .58       .42       .29       .15       .10
C1=         .02       .07       .09       .11       .11       .10

                   90%:70%   90%:50%   90%:30%   90%:10%   90%: 5%
C0=                   .68       .49       .34       .17       .11
C1=                   .06       .09       .11       .12       .11

                             70%:50%   70%:30%   70%:10%   70%: 5%
C0=                             .72       .50       .25       .17
C1=                             .07       .11       .14       .14

                                       50%:30%   50%:10%   50%: 5%
C0=                                       .69       .36       .24
C1=                                       .08       .14       .15

                                                 30%:10%   30%: 5%
C0=                                                 .52       .35
C1=                                                 .12       .15

                                                           10%: 5%
C0=                                                           .69
C1=                                                           .10
```

coefficients for the scaling of spectra in terms of the Modified Mercalli Intensity at the site.

Fitting of straight lines $C_0 + C_1B$ for the data in Figures 4 through 39 should be considered as a smoothing operation aimed at eliminating the fluctuations in the spectral ratios, rathern than as an approximation to the compouted changes of these ratios with A, B and M_{max}. Thus, if an estimate of spectral ratios for design purposes is to be made on the basis of this work, it is recommended that one employs Figures 40 through 47 and Tables I and II for given M_{max} (I_{max}), A, B, and the desired probabilities of exceeding the design spectra.

CONCLUSIONS

In this report the dependence of the ratios of Uniform Risk Spectra (URS) of Pseudo Relative Velocity (PSV) amplitudes for different exceedance probabilities have been analyzed as functions of local seismicity for uniform shallow source zone surrounding the site. These ratios may be useful for many two level seismic design considerations, but may be of particular interest for the examination of the ratios of spectrum amplitudes for the "Safe Shut Down" (SSE) and "Operating Basis (OBE) earthquake shaking postulated for many nuclear power plants in the United States.

It has been found that the ratios of OBE to SSE spectral amplitudes can vary from very small values to almost one. This shows that the ratio of one half, often used in nuclear industry probably does not lead to the desired probabilities of exceeding the OBE spectrum amplitudes.

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