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A STUDY OF THE FEASIBILITY OF AN EXTENSION OF SERIES 60 TO BLOCK COEFFICIENTS ABOVE .80

by
Finn C. Michelsen
James L. Moss

for
Maritime Administration
U.S. Department of Commerce
Contract No. MA-2564, Task 8
Washington, D.C.

Administered through: October 1969

OFFICE OF RESEARCH ADMINISTRATION · ANN ARBOR

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ABSTRACT

From the study of the hull forms of Series 60 as well as those of other well known series, it is concluded that the proportions of the super ships of full form being built today and in the future are such that these proportions cannot be covered by an extrapolation of the Series 60. The same thing is true for other series. Due to the economic importance of these large ships, it is recommended that a comprehensive study be undertaken with a number of unrelated hull forms to map out combinations of hull lines and design parameters which give promise of superior overall performance. Following this, it may be deemed appropriate to return to the development of a new systematic series suitable for the full form ships under consideration.

INTRODUCTION

Economic analysis of the transportation of bulk cargoes, such as oil and ore, has consistently been directing the shipping industry towards the construction of larger and larger ships. It is not surprising, therefore, that maximum ship size seems to have been dictated by evolution of shipyard facilities and technology, as well as harbors and terminals. This situation is not much different from what is occurring in the air transport industry. There appears to be one distinct difference between the two industries, however. Whereas the larger aircraft in use today and in the near future are stretched or scaled versions of their forerunners, we find that in the case of ships, the proportions are constantly being changed with size. Ships are now being built to such proportions and fullnesses that they lie outside the range of parameters covered by earlier systematic series model testing programs. The designers have, therefore, had to rely on results obtainable from model tests performed on each separate design. Undoubtedly, some of the larger ship operators are presently in possession of sufficient data to allow for a satisfactory optimization of ship designs from the hydro-dynamic point of view. But such data have been hard earned and are propriatory. It is clear that for the shipping industry as a whole, it would be preferable if the full forms required for the super ships of today and tomorrow be studied systematically under the sponsorship of an agency representing that industry and that all results be published. It was in this spirit that a proposal was submitted in October of 1964, to the Maritime Administration, by the University of Michigan, that a study be made of Series 60 to investigate the feasibility of extending that Series to block coefficients up to .90.

A somewhat more ambitious project than undertaken had been suggested by the H-2 panel of SNAME and was prepared and submitted to the National Science Foundation for approval and funding. The ruling of N.S.F. was that the proposed research fell outside its sphere of interest, whereupon the recommendation of the H-2 panel was to submit to the Maritime Administration, a proposal covering only the initial planning stages of the study.

Upon consultation with the H-2 panel, it was agreed that as a part of the study a careful screening of test results other than those offered by Series 60 should be included. It was opportune that a "Bibliography of Methodical Series Resistance Experiments with Ship Model" was being prepared at Stevens Institute of Technology. This bibliography is reproduced in the appendix. It is found that the Series which included full ships, invariably limited the block coefficient to less than .80. Except for general statements pertaining to the various series, nothing new could be learned that could be of assistance in extrapolating any one series into the range of block coefficients above .80. The data published on Series 60 can, in this respect, be considered typical.

RESULTS OF DATA SEARCH

The search and evaluation of the test data available in the literature is no small task, especially when no prevalent trend is found. One reason for the long time it has taken for this report to be prepared has been that there has always been the hope that new data would become available which would produce such trends. It has become increasingly evident that such data will not be forthcoming as pointed out earlier. The reason for this is that the super ships of full form are given proportions quite different from previous series hull designs because of the difference in size. At $C_B = .80$, the match of hull data from earlier series and more recent full forms of $C_B > .80$ is not too good. It should also be kept in mind that $C_B = .80$ was an end point of Series 60 which was useful for plotting data. But this hull of the Series 60 is probably far from being an optimum.

It has become evident that there is no purpose in extending Series 60 to higher block coefficients. It can, in fact, be concluded that model studies of full hull forms should be pursued completely independent of most of the series hull data available. In support of this opinion Figures 1-10 are presented. The models included in these figures are listed in Table 1. Many more data points could have been included, but this would serve no purpose since nothing new would be added.

Neither would plots of other parameters have altered the picture.

Although Figure 1 shows a great deal of scatter, it is clear that full ships generally have high values of B/H. A value of $B/H \geq 3.0$ is not unreasonable for a full form super tanker and may indeed become commonplace. Figure 2 shows a clear trend. It only needs to be extended to lower L/B values. A half angle of entrance may have no meaning for full ships. There is, for instance, every reason to believe that elliptic waterlines may become conventional. It proves to be difficult to extend Series 60 to $C_B > .80$ because $1/2\alpha_E$ would be abnormally large for high C_B's. This is tied into the relationship between L/B, L_E/L_{PP} and $1/2\alpha_E$. (See Figures 4 and 8.) From Figure 8 it seems as though Series 60 could be extended to $L_E/L_{PP} \simeq 0.2$ @ $C_B = .85$, but from Figure 4 it is evident that this could be done only for very high L/B's. Therefore, for low L/B and high C_B, L_E/L_{PP} must be greater than 0.2, or the apparent Series 60 trend from Figure 8 will not hold for stubby oil tankers. Perhaps a way to have high C_B and low L/B is to design with different styles of hull lines such as spoon bow and/or barge stern. On the other hand, it may be found that the block coefficient is indeed not the best parameter to use as a variant in a study of a systematic series. Figure 5 needs no further comments. Figure 6 does show a trend. The low points belong to Great Lakes Freighters which are out of place when it comes to displacement-length ratio. It can be expected that the value of the displacement-length ratio will go considerably higher than the data shown for full ships of low L/B values. Figure 7 needs no comments. In Figure 9, the Series 60 extension may prove to be representing better practice than indicated by the data point. The same may be said for Figure 10, although L/B and C_B should probably not be related in this way for the full form hulls.

SUMMARY

From the study of the literature, it is concluded that the proportions of well known existing series, as represented by Series 60, the BSRA Series and T.S.S., are such that a systematic extrapolation of non-dimensional lines to hull form with $C_B > 0.8$ to cover the range of fullness of interest in the design of super bulk and oil carriers is inadvisable.

Three reports on tests of hull forms which were restricted to cover the region of $C_B > .80$, have come to the attention of the authors. One was conducted in Japan and comprised a total of 35 models. These covered the range $.80 \le C_B \le .84$ (except for three models of $C_B = .78$) $6.17 \le L/B \le 7.84$ and $2.16 \le B/H \le 3.06$. The parent hull form is of conventional design and does not have any bow bulb. The report on this series has been translated at The University of Michigan and is included in the appendix of this report.

The testing of 35 models represents a considerable effort. It is regretable, therefore, that the results presented are only valid for hull forms closely related to those of the series. Even trends in behavior of the resistance coefficient, with respect to hull parameter variations, may not be strictly valid for a different hull shape.

A second study is a "Methodical Series of Experiments on Cylindrical Bows" conducted at NSMB. A paper on this study is to be read before RINA in November 1969. This series consists

of 12 models and covers the range $.80 \leq C_B \leq .85$. It represents an investigation of the performance of a new hull form as compared to the conventional hull form as presented by the Japanese Series mentioned earlier. In some respect, the two series are, therefore, complimentary, but they can hardly be thought of as comprising one combined series.

A third report, "Experimental Study on Buttock Flow Stern" by Watanabe, Sakao, Komaru and Konishi, published in the March issue of Japan Shipbuilding and Marine Engineering, deals with the design of a new stern which is much like a barge stern. For the full form ships of $C_B = .84$, it was found that a significant reduction in power could be achieved. The need for maneuvering tests was pointed out, however, since the developed hull form is directionally unstable.

The conclusion reached is that before embarking on any one systematic series of hull forms, it will be advisable to investigate a number of radically different and unrelated hull forms, such as forms exhibiting parabolic or elliptic waterlines, spoon bows, barge sterns and other variations for the purpose of evaluating their relative performance. This evaluation must include aspects of performance related to propulsion, stability of flow around stern, maneuvering, steering characteristics and performance in waves and shallow water.

The number of parameters are thus too great to allow for a systematic variation of all of these. Furthermore, such a procedure would be costly, time consuming and probably wasteful, on account of bad combinations of hull parameters resulting from following prescribed variations of these. The recommendation is, therefore, to develop a limited number of full hull forms based on experience and partially on an intelligent extrapolation of existing knowledge, and to test these forms to establish a complete set of performances. A searching program of this kind should be expected to include extreme values of hull parameters.

TABLE I

Ship	Δ	L/B	B/H	C_B	LCB% From	L_e/LBP	$1/2\alpha$	$\Delta/(.01L)^3$
1	34,080	9.49	2.83	.864	1.87	.200		94.00
2	28,421	9.45	2.75	.863	1.40	.212	47.5	98.30
3	28,764	9.59	2.74	.864	1.40	.207	47.5	95.50
4	11,600	8.55	2.67	.783	1.30	.245	42.0	111.75
5	38,312	9.00		.872	1.00		38.5	119.98
6	47,644	6.72	2.60	.791				197.00
7	40,500	7.10	2.68	.794				169.19
8	60,000	6.85	2.73	.803				180.05
9	60,084	7.04	2.88	.829				167.87
10	62,720	8.42	2.21	.815				144.02
11	58,800	7.07	2.83	.777	4.80	.310	32.5	156.70
12	60,200	6.94	2.64	.768				171.85
13	32,550	7.37	2.34	.758				184.80
14	80,659	6.58	2.90	.800			31.5	181.57
15		7.34	2.46	.800				210.00
16		7.14	2.42	.774	1.80			219.95
17		7.34	2.34	.776	2.91			214.90
18		7.27	2.50	.796	1.61			212.45
19		7.20	2.46	.800	1.51			219.45
20		7.09	2.49	.802	1.01			224.00
21		6.72	2.64	.805	1.60			233.80
22		7.75	2.40	.811	1.96			197.05

TABLE I (cont.)

Ship	Δ	L/B	B/H	C_B	LCB% From	L_e/LBP	1/2α	$\Delta/(.01L)^3$
23		7.55	2.41	.819	1.50			221.90
24		7.00	2.46	.822	1.52			238.35
25		9.68	2.74	.857	2.00	.207	47.3	95.50
26		9.47	2.74	.866	1.40	.209	47.3	100.90
27		8.54	2.67	.783	3.20	.245	42.0	111.75
28		9.22	2.94	.855	1.80	.209	47.5	95.24
29		9.45	2.75	.863	1.40	.212	47.5	98.30
30		6.68	2.72	.860			50.0	
31		6.68	2.72	.840			45.0	
32		6.68	2.72	.820			38.0	
33		6.68	2.72	.800			33.0	
34	13,045	7.27	2.12	.798	2.01	.250	35.8	189.28
35	13,090	7.27	2.12	.801	1.98	.250	33.0	189.93
36	13,072	7.27	2.12	.800	2.00	.287	37.4	186.92
37	13,068	7.27	2.12	.800	2.02	.237	33.9	189.61
38	13,070	7.27	2.12	.800	2.00	.287	37.4	189.64
39	13,055	7.27	2.12	.799	1.97		36.8	190.81
40	13,058	7.27	2.12	.799	1.96		36.8	190.86
41	13,052	7.27	2.12	.799	1.95		34.6	190.77
42	13,056	7.27	2.12	.799	1.96		29.5	190.83

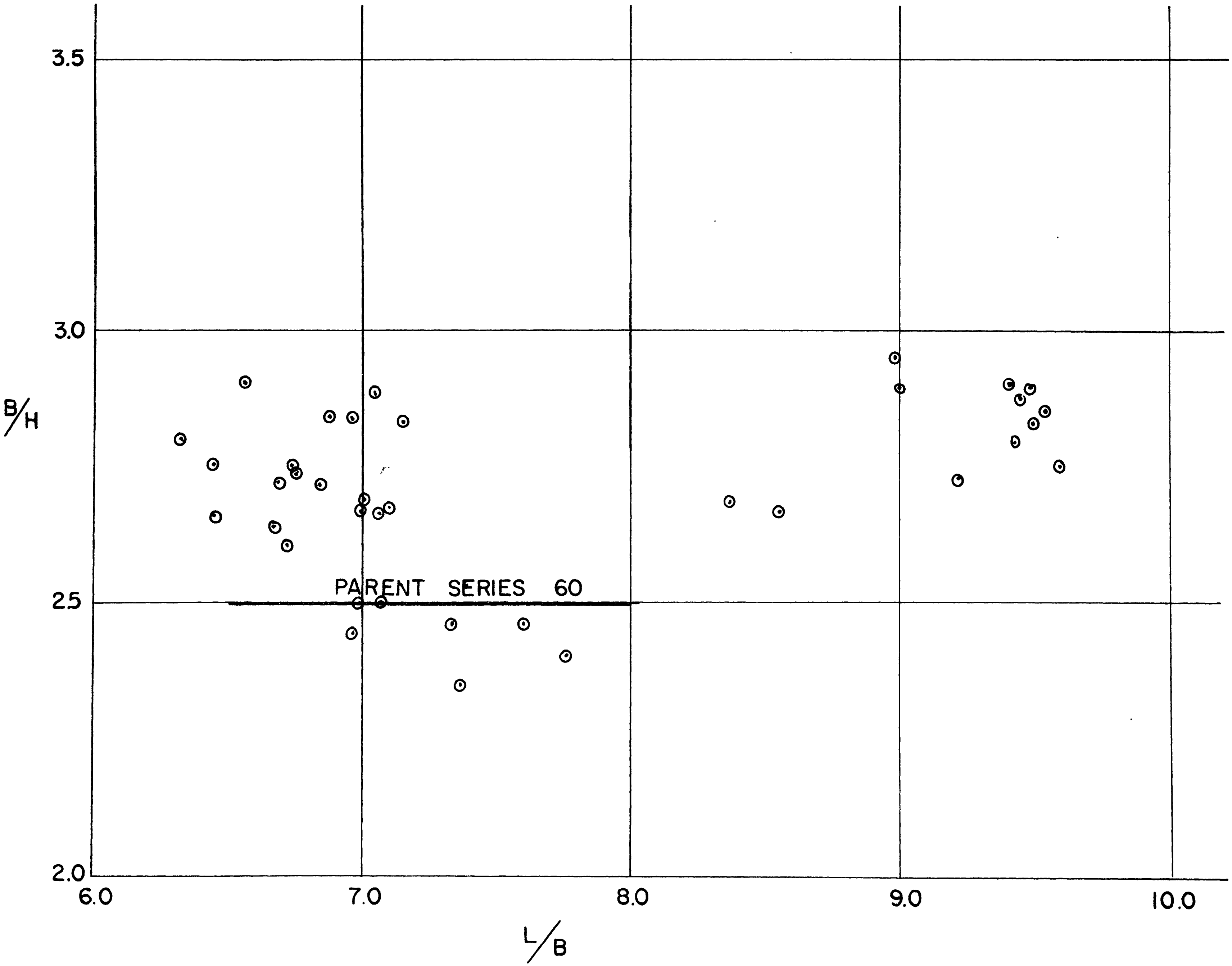
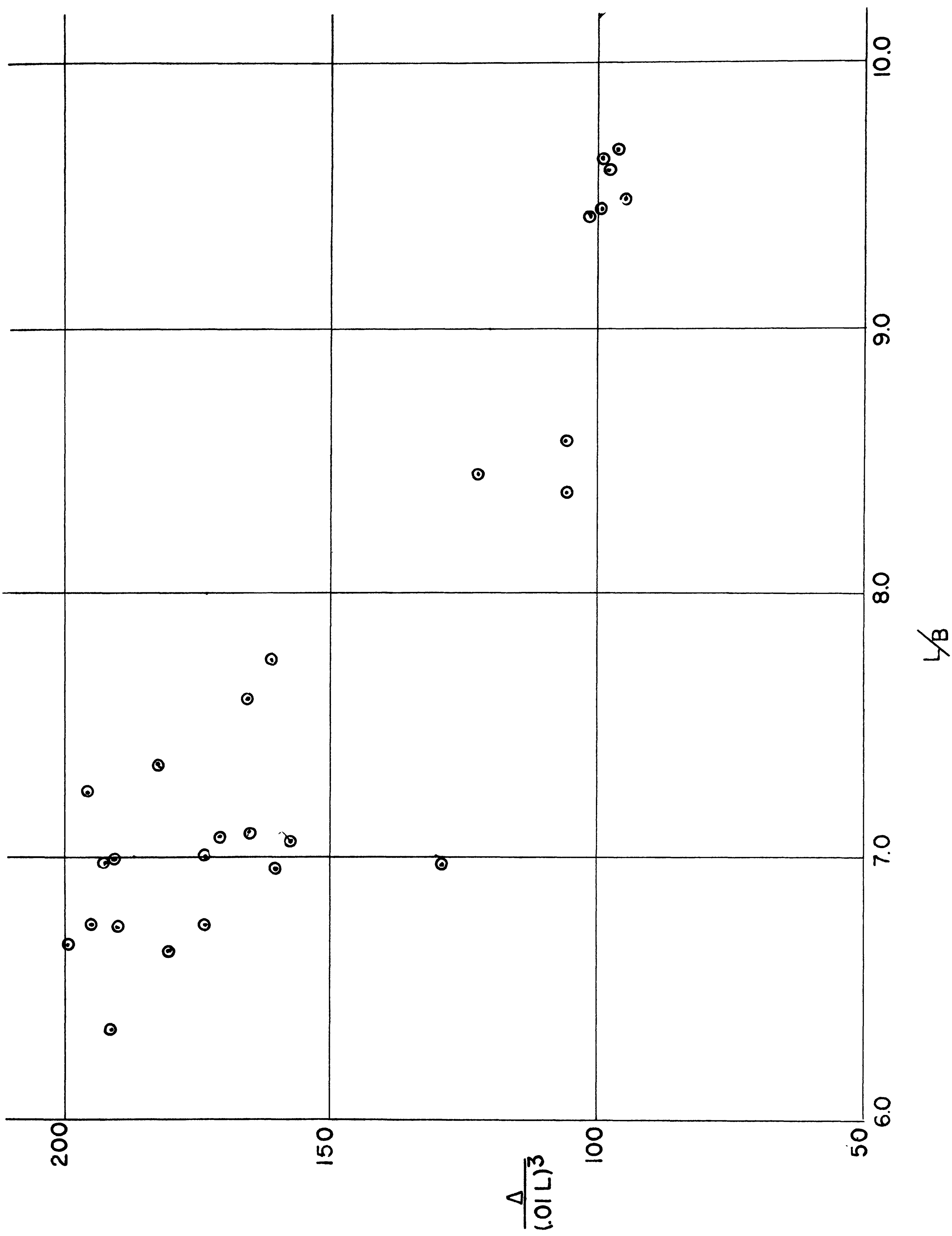


FIGURE 1

FIGURE 2



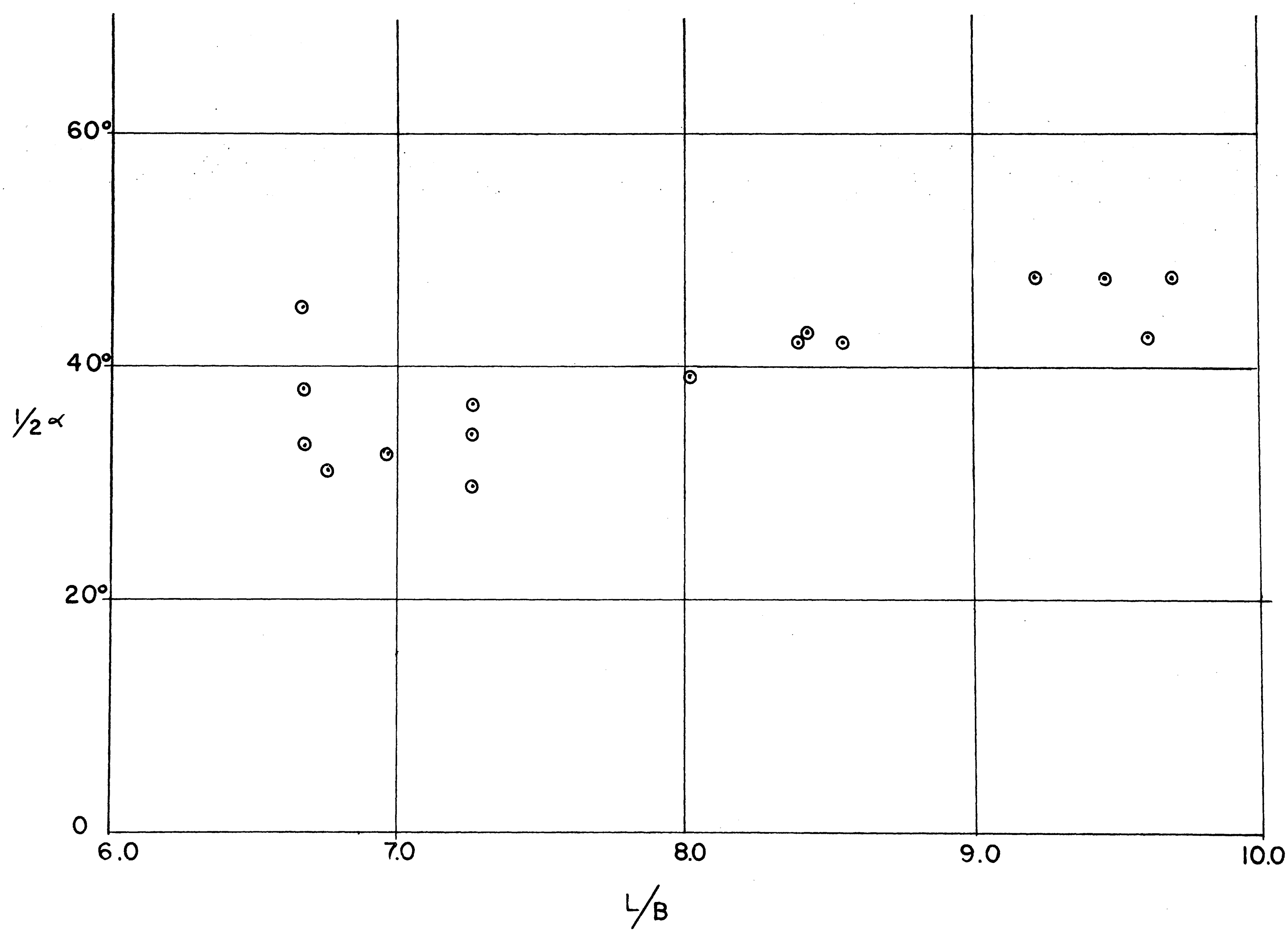
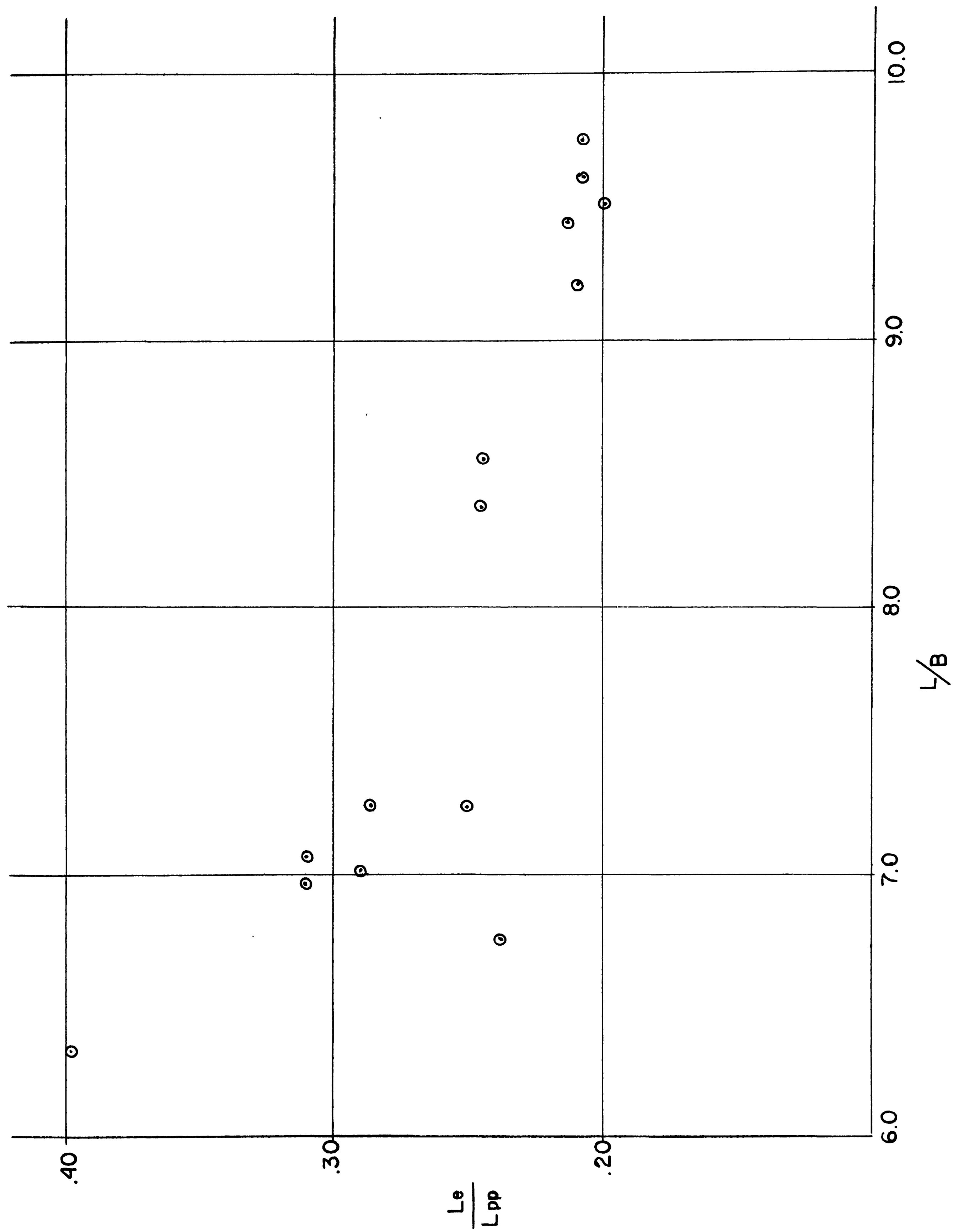


FIGURE 3

FIGURE 4



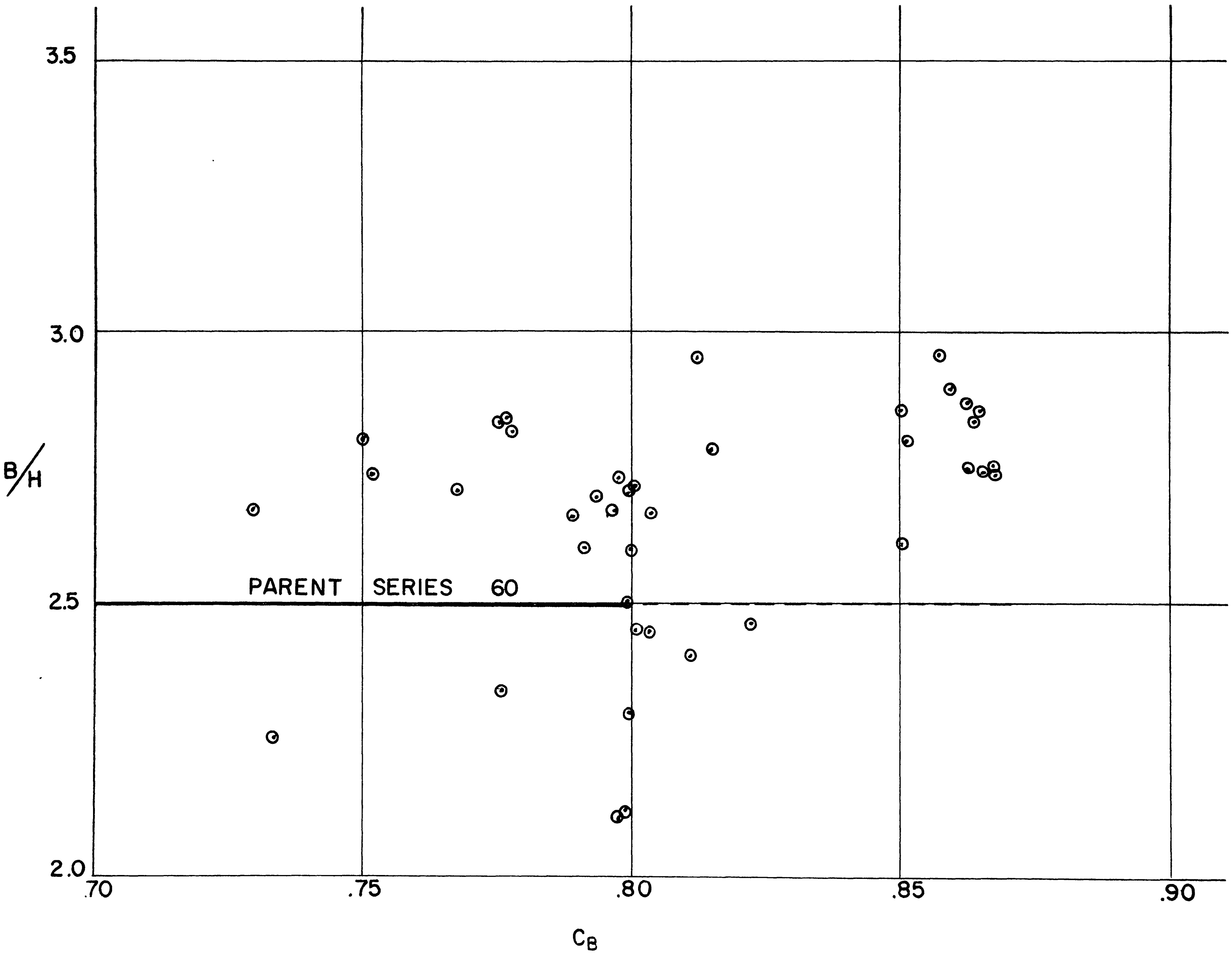
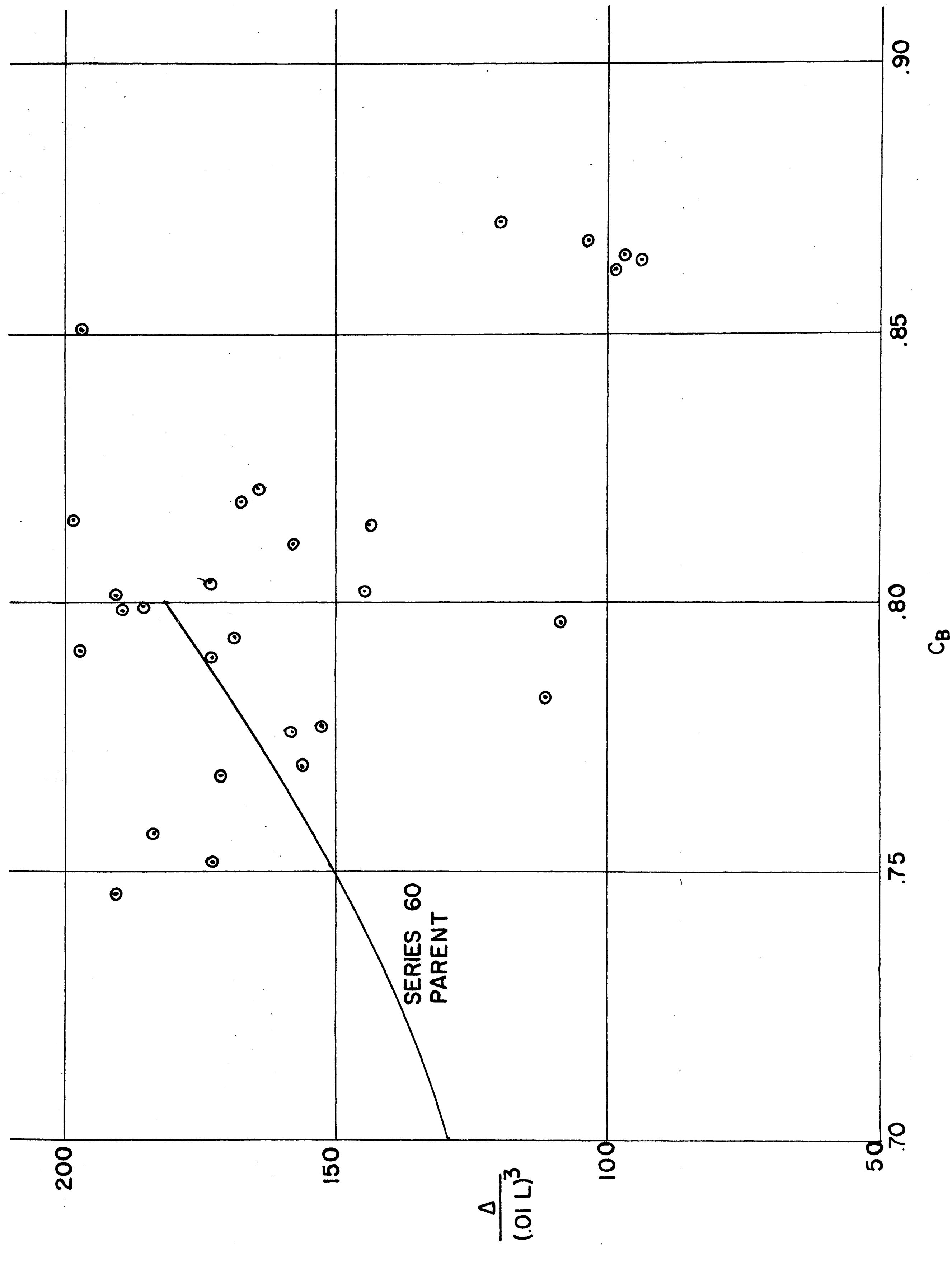


FIGURE 5

FIGURE 6



200
150
100
50
.70
.75
.80
.85
.90
C_B
$\frac{\Delta}{(.01 L)^3}$
SERIES 60
PARENT

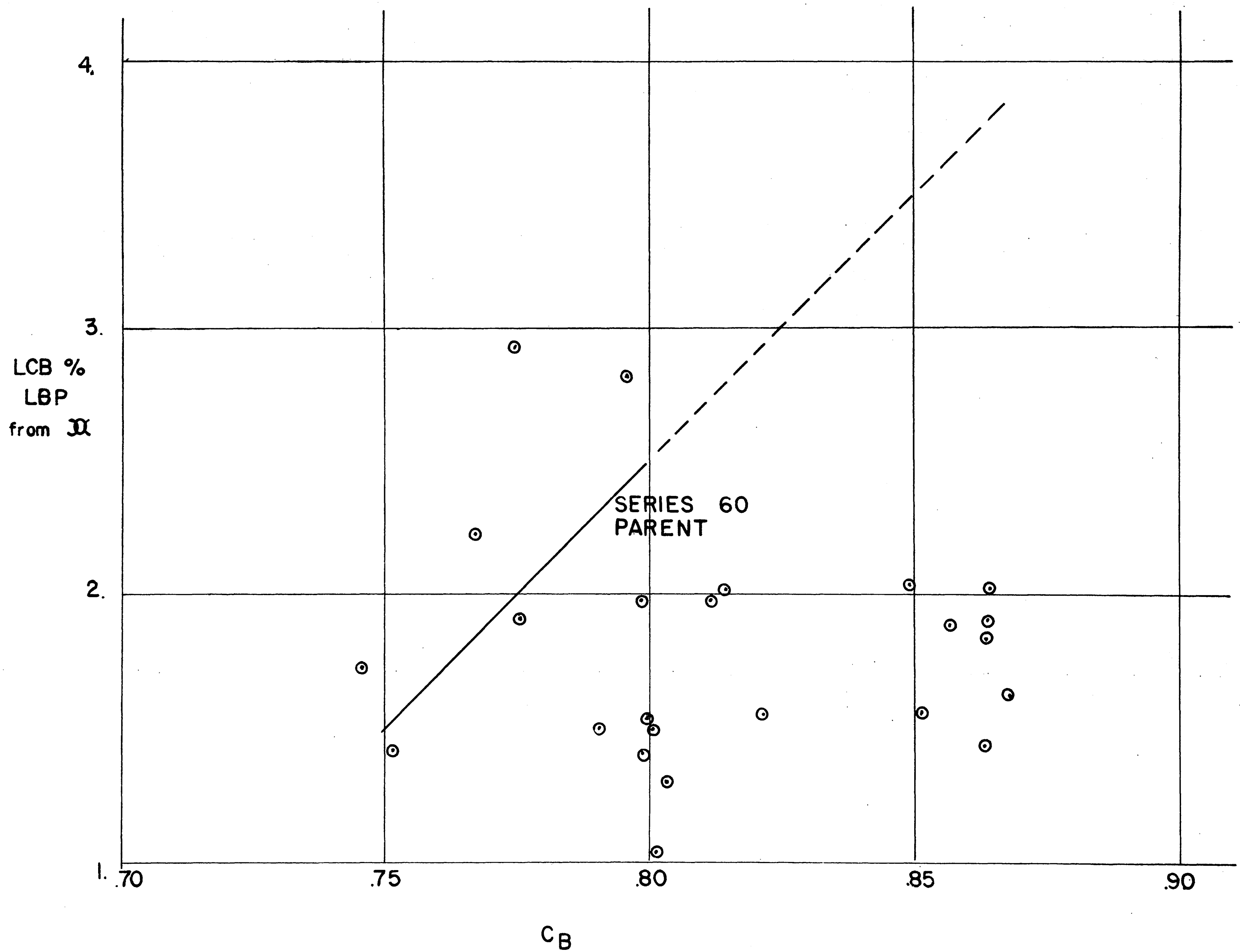


FIGURE 7

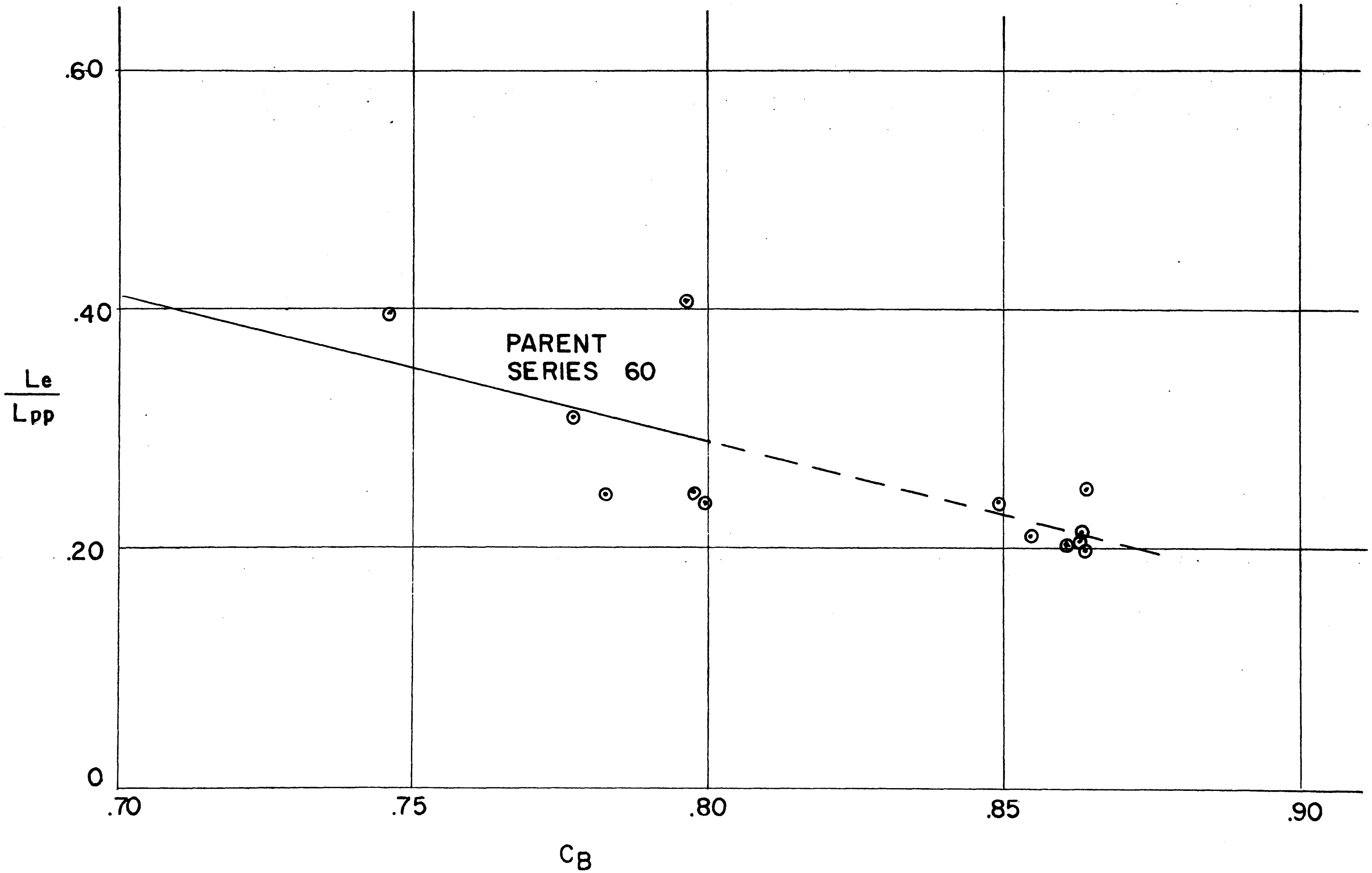


FIGURE 8

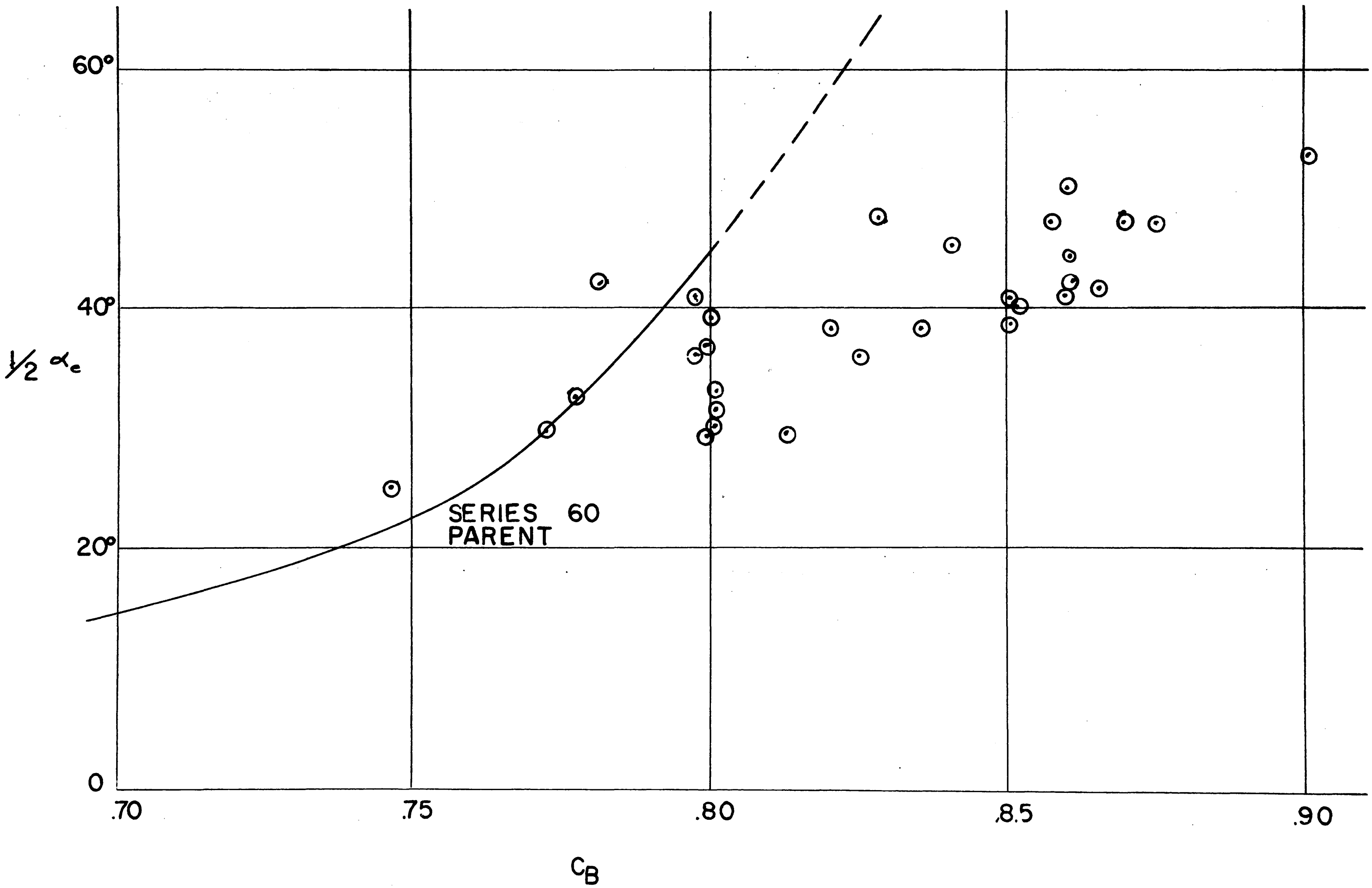


FIGURE 9

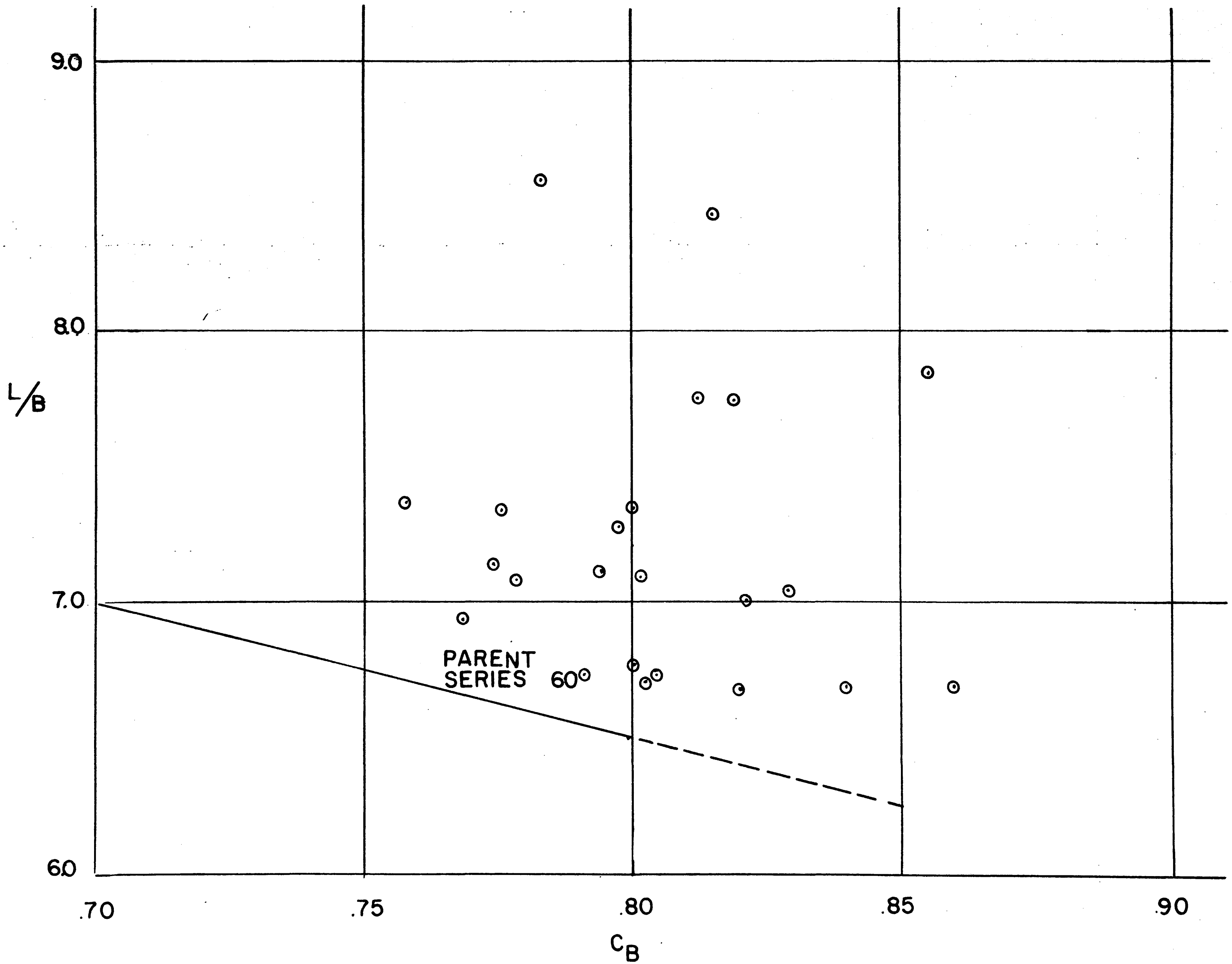


FIGURE 10