EOARD TR 81-3

LEVEL II

von KARMAN INSTITUTE

FOR FLUID DYNAMICS

AD A099133

GRANT AFOSR 80-0177

Final Scientific Report
1980 May 01-1981 April 30

OPTIMIZATION OF MULTI-ELEMENT AIRFOILS

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM

1. Report Number EOARD TR-81-3	2. Govt Accession No. AD-A099133	3. Recipient's Catalog Number

4. Title (and Subtitle) OPTIMIZATION OF MULTI-ELEMENT AIRFOILS	5. Type of Report & Period Covered Final Scientific Report 01 May 1980 — 30 Apr 1981 6. Performing Org. Report Number VKI-PR-1980-5
7. Author(s) K.P. Misegades	8. Contract or Grant Number Grant AFOSR-80-0177
9. Performing Organization Name and Address von Karman Institute Chaussee de Waterloo, 72 B-1640 Rhode Saint Genese, Belgium	10. Program Element, Project, Task Area & Work Unit Numbers 61102F Program Element 2301D1 Task
11. Controlling Office Name and Address European Office of Aerospace Research and Development Box 14, FPO NY 09510	12. Report Date 30 Apr 1981 13. Number of Pages 66
14. Monitoring Agency Name and Address European Office of Aerospace Research and Development Box 14, FPO NY 09510	15.

16. & 17. Distribution Statement

Approved for public release; distribution unlimited.

18. Supplementary Notes

19. Key Words

airfoils; wing flaps; lift devices; flight optimization

20. Abstract

A review of techniques aimed at maximizing C_l/C_d and C_l for multi-element airfoils showed the need for more exhaustive testing of possible configurations of flap deflection, slot geometry and airfoil angle of attack. For a typical 4-element airfoil, the number of possible configurations can easily be in the billions. A new technique, based on evolution strategy, has been developed for the problem of optimizing a multi-element airfoil with respect to its envelope of maximum C_l/C_d versus C_l. This technique was applied to an airfoil having a slotted leading edge flap and a double-slotted trailing edge flap using an existing computer program for 2D subsonic multi-element airfoils to provide values of aerodynamic coefficients. Although limitations of the program precluded the full determination of the envelope of C_l/C_d vs C_l, the problem of maximizing C_l/C_d for a minimum C_l constraint was solved. The result of testing approximately 400 configurations generated by the random mutation-natural selection procedure of evolution strategy was an 8-fold increase in C_l/C_d with a 12 % increase in C_l

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over the initial geometry. The conclusions reached from this work are 1) evolution strategy applied to the optimization of multi-element airfoils can yield substantial improvements in aerodynamic performance, 2) the number of configurations required to find the optimum can be reduced from the total number possible to a small fraction of the total with the same final result, 3) the inherent simplicity and speed of the technique developed lends itself well to further application in wind tunnels, 4) evolution theory appears to be the best choice for techniques aimed at the optimization of systems defined by a large number of degrees of freedom.

EOARD-TR-81-3

This report has been reviewed by the EOARD Information Office and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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ACKNOWLEDGEMENTS

The author extends his sincerest appreciation to the supervisor of this work, Professor Roland Stuff, who first proposed the application of an evolution strategy - based scheme to the optimization of complex aerodynamic configurations. His enthusiasm and unselfish counsel was largely responsible for the promising results of this work. Also to be recognized is the assistance of Professor John Sandford with regards to the fundamental concepts of multi-element airfoil optimization and to his review of the report manuscript, and to MBB Hamburger Flugzeugbau for the contribution of a realistic aerodynamic design problem.

Finally, the author would like to acknowledge the sponsorship of Detachment 1, Air Force Office of Scientific Research (EOARD/AFSC), USAF.

"But it can't fly, Newtons laws prove it !"

Th. von Karman, early 1900's

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Multi-Element Airfoil Optimization

It is no secret today that competition among civilian and military aircraft manufacturers in the international marketplace is tough. This competition has demanded improved flight efficiency, and as a result a strong emphasis has been placed on design optimization with respect to take-off, cruise, and landing aerodynamic characteristics. Design considerations for take-off and landing aerodynamics are primarily directed towards the reduction of wing area, increase in maximum take-off weight, improved fuel efficiency, reduced field length requirements and lowered ground noise levels. The relative importance of the nondimensional coefficients of lift and drag, C_l and C_d respectively, for take-off and landing are shown in figure (1)[1].

Over the entire regime of flight, the performance at take-off, when aircraft weight and engine noise are at a maximum for the flight, is the most critical factor in the design of lifting surfaces. To achieve the maximum rate or angle of climb, thus reducing runway requirements and noise footprint, maximum C_l/C_d is desired for a given C_l. The envelope of values of maximum C_l/C_d versus C_l for the Boeing 727 wing, obtained from flight measurements, is given in figure (2), and is more or less similar to the envelope obtained for all other airfoils[2].

The complexity of multi-element airfoils, as seen in figure (2) and in more detail in figure (3A), has been dictated by the need for a smooth, and for high-speed transport aircraft shock-free airflow at cruise conditions, combined with the high-lift configurations required at take-off and landing[2,3]. Although significant effort has been devoted to the study of advanced high-lift devices such as those employing blown flaps, jet flaps, boundary layer control or augmentor wings, it is reasonable to expect the continued use of mechanical devices for the next generation of civilian and military aircraft. Indeed, as shown in figure (4), values of $C_{l_{max}}$ for large, high-subsonic aircraft nearly doubled between 1950 and 1970 as a result of improved design of mechanical flap systems[4]. Once the choice of high-lift system and associated flap and airfoil geometries has been made, the relative positioning of the elements must be determined such that the obtainable values of C_l and C_l/C_d are sufficient to meet performance demands (or preflight promises!). The ideal set of configurations would be those that would result in the largest C_l/C_d-vs-C_l envelope. The number of all possible configurations, however, is very large even for the typical case of an airfoil having a double-slotted trailing edge flap and a slotted leading edge flap, as depicted in figure (3B).

1.2 Empirical Methods

The most common means of determining the best airfoil-flap configurations involves many hours of wind tunnel testing for a representative set of variations of slot gap width and overlap, flap deflection and angle of attack. Optimum configurations are then made by adding to the main airfoil the leading and trailing edge devices, whose individual slot geometries have been optimized with respect to only one adjacent element. An example of this empirical method, reproduced from the work of Ljungstrom[5], appears in figure (5). Although this empirical method can greatly improve the aerodynamic performance of a multi-element airfoil, there are two significant disadvantages that must be considered. First, the accuracy of an empirical method is dependent on a large number of test configurations; however, for even the most well-funded design relatively few different configurations are actually tested. For instance, for a 4-element airfoil, 500 test cases is only $5 \cdot 10^{-6}$ % of the number of possible cases, if each of the 10 degrees of freedom can be varied across 10 increments. Increasing the number of test cases comes at the expense of time and direct operating cost of wind tunnels. If wind tunnel time and cost trends increase at the rate depicted in figure (6), however, it is doubtful that empirical methods will produce better results than at the present time, when a great emphasis is being placed on improving high-lift device performance[6]. The second disadvantage of empirical methods is that by combining elements optimized with respect to only adjacent elements, the important viscous interaction between all elements is unaccounted for. This interaction, however, is strong and tests have shown that the combination of individually-optimized components rarely results in an optimum overall configuration[5].

1.3 Self-Optimizing Airfoils

It would be desireable then to have a self-optimizing scheme, where the system seeks its own best configuration without the need for testing every possibility. Far from speculative, such schemes have been used with a good deal of success in several different problems where systems are described by several degrees of freedom and relative 'factors of fitness' result for each variation of parameters. One such application described by Levinsky[7] attempted to maximize C_l for a fixed maximum C_d and minimize C_d for a fixed minimum C_l. For a flexible 2-dimensional airfoil mounted in a transonic intermittant wind tunnel. Results of this work, and results of further investigation of a 3-dimensional flexible airfoil[8] in a transonic continuous wind tunnel are given in figures (7) and (8). In both cases, the hydraulically-actuated leading and trailing edges were modified automatically by on-line computers programmed with a gradient-strategy optimization scheme. This is described in section 2. The only human input was the factor of fitness to be maximized or minimized (C_l,C_d, or volume) and a constraint. Gradient strategy has also been used in the work of Hicks[9], where 2-dimensional transonic airfoils were modified to improve C_l, C_d or maximize volume. Some of the more significant results of this work, performed numerically as opposed to the above mentioned wind tunnel work, are shown in figure (9). Although these examples have resulted in substantial improvements in airfoil performance, the application of their optimization methodology was found to be more cumbersome than the method described in this work. Existing optimization methods are compared below to a new scheme based on 'evolution strategy'. This scheme has been developed to determine the configurations of a 4-element airfoil giving maximum C_l/C_d for each value of C_l, where only the geometry of each element is known initially.

2 THEORY

2.1 Simple Optimization Problem-Existing Solution Methods

Consider the optimization problem faced by an experimentalist standing above a room in which there is a single geographical peak whose location with respect to a 2-dimensional coordinate system is to be determined. In this problem, the 'system', this being the human, has two degrees of freedom, his location with respect to the x-axis and the y-axis. At each x,y coordinate position, the value is determined of the geographical 'fitness factor', or the distance between the x-y plane and the surface below. The most rudimentary method to find the peak would be to make a number of random soundings in order to obtain a rough impression of the surface. In order to improve accuracy, the grid could be divided into a fine mesh and the height is then recorded at each mesh point. Although this scheme guarantees that all possible x,y cobinations have been checked, the number of possible combinations increases with the square of the number of grid divisions and with a power equal to the number of degrees of freedom for higher order systems. Figure (10) depicts these 2 basic schemes along with two gradient-based strategies that were developed to converge to the peak with a reduced amount of effort[10].

In the first of these two gradient-based strategies, known as the Gauss-Seidel Strategy, the experimentalist, trying to find the peak with the least amount of effort, simply proceeds in the direction of the steepest positive gradient, determined at the starting point, until the gradient becomes zero or negative. From this point, he turns in the direction of a new, locally-steepest gradient and continues in this new direction. This procedure is continued until the peak is found, that is, a position has been reached on the x-y plane where no positive gradients exist below. The second of these techniques, known as the 'general gradient strategy', is similar to the first except that at each step the magnitude of gradients in all directions is re-evaluated. Although the second scheme may result in the shorter total distance between the starting point and the peak with respect to the first scheme, it requires more work per step. Clearly, the use of either of the gradient strategies represents a substantial improvement over the inspection of every possible combination of the variable parameters. It is noted that in order to reduce the amount of effort involved in scheme B of figure (10), one is tempted to increase the grid spacing. The danger of this, of course, is that there is a strong possibility that the peak will be completely missed; this is precisely the point mentioned previously related to optimizing airfoils by empirical methods. The danger of using gradient strategies in more complicated systems is that only a relative optimum may be reached, as the smaller of two peaks for the simple problem just described.

2.2 Simple Optimization Problem-Evolution Stategy Solution

A fifth, and relatively new optimization scheme that may further reduce the effort required to improve a system described by a number of degrees of freedom is based on 'evolution strategy'. 'Relatively' new is stressed, because the basis of this strategy is derived from the theories of natural selection first postulated by the 19th century biologist, Charles Darwin. As in biological systems, which in their simplest classifications can be grouped according to a number of parameters, such as size, number of appendages, means of reproduction or mobility, an engineering system survives if the combination of each of its defining parameters results in a 'beast' that is superior to all other combinations. Only recently has this concept been applied to realistic physical problems, the majority of the work to date being attributed to Professor Ingo Rechenberg, of the Technischen Universitat Berlin. In order to describe this scheme, we consider again the task of the experimentalist. Using evolution strategy, as depicted in figure (11A), a number of test points are selected randomly over a region near the starting point. The height is recorded at each point, then the experimentalist moves to the highest of these points. From there, the same number of new points are randomly chosen, and the procedure continues as before.

The distance from one 'high point' to each new point in a successive set is controlled by the previous distance, that is if a large step resulted in a larger height than a smaller step, all new points would be determined using steps approximately equal to the large step. This important factor of evolution strategy allows large steps to be taken early in the optimization process, and decreasing step size as the optimum position is approached. The inclusion of large mutation steps also prevents the convergence to local maxima, a problem associated with gradient strategies. In the case of a local maxima or small barrier in the optimization process, evolution strategy will jump ahead as the result of a large mutation length.

2.3 Evolution Strategy Examples

Several examples of evolution strategy application are shown in figures (11) and (12)[10,11]. As a simple verification test, figure (11B) depicts a segmented plate having 5 degrees of freedom that is mounted in a wind tunnel. The objective is to reduce the overall drag of the plate as measured by the momentum defect between the leading and the trailing edges. From the initial configuration, several new configurations, or cases, were created by random modifications of the angle of each segment with respect to an adjacent segment. After 140 cases, the segmented plate became nearly planar, the expected result. The important result is that 140 cases represents only $4.06 \cdot 10^{-5}\%$ of the total possible, 345 million.

The second example is an attempt to modify a system whose optimum configuration is unknown[11]. In this case, shown in figure (12A), the objective was to maximize the efficiency of a two-phase supersonic nozzle constructed from a number of discs. The optimal configuration is radically different from conventional designs and verifies the ability of evolution strategy to converge to unknown solutions. It is also interesting to note that flow mixing regions seen in the figure have been previously suggested for improving nozzle efficiency.

The third example, that of reducing the head loss for a 90° bend of flexible tubing, also has an unpredictable result. As depicted in figure (12B) the final shape is a subtle change from the initial, a standard circular arc, but the result of 300 mutations is a halving of the head loss[11].

2.4 Selection of Optimization Method

The advantages of using evolution strategy over an exhaustive evaluation of every possible configuration are clear, except perhaps for the case of a system having only one degree of freedom. The advantages of evolution strategy over a 'strictly determined mathematical strategy', such as gradient methods, have been summarized by Rechenberg[10]:

> 1 When a large number of parameters are involved, the evolution strategy attains the desired result more rapidly than the more familiar strictly determined search strategies, assuming the size of the search steps to be the same in both cases. So far, this could only be proved for the case of an n-dimensional hyperplane rising in any arbitrary direction. A more general proof is being attempted.
>
> 2 Whereas the mathematical search strategies used so far

require very small steps (in the sense of the truncation of the Taylor series after the first term), the evolution method can and should operate also with much larger steps which exceed the linear region in the neighborhood. Taking larger steps signifies

(a) in many situations a more rapid advance towards the desired aim, and

(b) a shorter time to decide whether the step taken has been successful or not. (The change in the value of a function will generally be greater in the case of a large parameter change than in the case of a small change.)

3 A so-called "steady signal" in the measurement of the value of a function is a mathematical fiction. Disturbances are always present, which give rise to errors in measurement. The effectiveness of the strictly determined mathematical search strategies is markedly reduced by small errors of measurement. It is of the nature of the evolution method (as a stochastic search method) that small random errors of measurement cannot have a decisive influence on the development of the process.

4 There are cases in which the more familiar mathematical search strategies must reach deadlock. Such cases are frequently observed in physics; examples are hysteresis phenomena and locally limited extremal values. The evolution method can generally cope with such situations without difficulty.

5 The algorithm of the evolution strategy is extraordinarily simple. This implies that the effort required for an automisation of the search process is relatively low.

Since the work associated with this report was strictly numerical, as opposed to experimental, the small error effect noted above related to the use of mathematical strategies could not have any significance; thus an argument could still be made in favor of gradient methods. Rechenberg, however, has found that a cross-over point exists at which search effort for improved configurations using evolution strategy is less than the effort required for gradient strategies[9]. This point is for systems having 5 or more degrees of freedom.

The system of interest in the work described here is a 4-element airfoil described by 10 parameters as shown in figure (13). Three pivot points describe the relative position of adjacent elements. The individual geometry of an element is given with respect to a local coordinate system with the origin on its leading edge. Pivot points 1 and 2 are fixed with respect to element 2 and are variable with respect to elements 1 and 3. Likewise, pivot point 3 is fixed with respect to element 3 and variable with respect to element 4. The two degrees of freedom for each of the pivot points plus the relative deflection between adjacent elements define 9 degrees of freedom. The 10th degree of freedom is the angle of attack between the main airfoil and the freestream velocity vector.

As previously stated, the objective of this optimization is to obtain the best envelope of C_l/C_d-vs-C_l values. The fitness factor for this system is the magnitude of C_l/C_d for each value of C_l, which is equivalent to minimizing C_d for fixed C_l. This implies a series of individual optimizations over all desired values of C_l. The flexible nature of evolution strategy allows a two-step procedure, however. First C_l/C_d is maximized while maintaining C_l above the initial value; the limit of this maximization is a point on the envelope. The second step is then to move along this envelope with moderate mutation lengths, selecting those configurations having the best combination of C_l/C_d and C_l. It is because of this flexibility coupled with the abovementioned aspects of evolution strategy that this method was chosen over gradient strategies as a basis for multi-element airfoil optimization.

3 CALCULATION OF AERODYNAMIC COEFFICIENTS

3.1 Description of Program Theory and Use

Aerodynamic Coefficients are calculated by the program detailed in reference 13. This program is composed of the following task areas:

A. Potential Flow Solution
B. Ordinary Boundary Layer Solution
C. Confluent Boundary Layer Solution
D. Slot-Flow Analysis
E. Combined Solution

The inviscid, potential flow solution makes use of the distributed vortex concept with the vortex singularity comprising the fundamental solution to the Laplace equation. Airfoils, arbitrarily arranged and composed of from one to four elements, have surfaces approximated by a closed polygon whose linear segments are represented by distributed singularities. Airfoil contours are limited to smooth, regular shapes with sharp or pointed trailing edges. The only restriction on the slot formed by two adjacent elements is that the magnitude of flap overlap must be greater than about 1% of the airfoil chord.

The ordinary boundary layer solution is comprised of mathematical models for laminar, transition, and turbulent boundary layers in subsonic flow. The laminar boundary layer model is based on the basic approach of Cohen and Reshotko modified to suit the needs of the program. Laminar stall criterion developed by the author of the program predicts the formation of short or long separation bubbles or bubble burst, a flow condition which causes the termination of further program execution. The transition model, evolving from the instability criteria of Schlicting and Ulrich , establishes limiting conditions for defining the position of transition on the airfoil. Two separate mathematical models for ordinary turbulent boundary layer development are used. The first, an approximate model developed by Goradia, is used in the initial iterative calculations. The second and more accurate model, based on the methods of Nash, determines the turbulent boundary layer in the final, viscous solution.

A significant feature of the program is the inclusion of a confluent boundary layer model that reflects the merging of an upper surface boundary layer with slot efflux. This model, developed from the experimental and analytical work of Goradia, accounts for the highly complex viscous phenomena associated with slotted airfoils. Associated with the confluent boundary layer, a slot-flow model is defined for flow between slot regions.

The final viscous solution uses an iterative technique to combine the inviscid solution with the boundary layer calculations. The geometry of the 'equivalent airfoil', reflecting local boundary layer thicknesses, is successively defined over a variable number of iterations until pressure distributions have converged to a steady condition. As the work described in this report was more of a qualitative nature than quantitative, only one iteration between viscous and inviscid calculations is made, in the interest of reduced computation time. A comparison of predicted and experimental pressure coefficients using the program for a two-element airfoil appears in figure (15). A listing and description of program input is given in appendix (i) for the 4-element airfoil considered in this work.

4 OPTIMIZATION PROCEDURE

4.1 Geometry Modifications

The choice of evolution strategy required the preliminary development of the following:

A. Scheme for Random Geometry Modifications

B. Mutation Length Control

C. Criterion for Convergence to Optimum

D. Initial Airfoil Geometry

Of fundamental importance to the effectiveness of evolution strategy is the combination of large and small mutation lengths. If only small sizes are used, the number of improved cases will be high, but the rate of progress will be slow. On the other hand, if only large sizes are used, the optimum may be entirely skipped over. For this reason, new cases were divided into 3 groups, one having all mutation lengths of a base value, the second group having lengths of 50% of the base value, and the third group having lengths 150% of the base. The control of the value of this base mutation length will be described below. For each new geometry, then, 18 new configurations are generated, divided into 3 groups of 6 cases each. The choice of 18 cases per set was somewhat arbitrary, but it was felt that this would be a good trade-off between effort and resulting improvement. As the optimization procedure was carried out, it was found that 18 cases was a safe choice, as the program used to determine C_l and C_d had certain limitations. In experiment, a smaller number of cases per set might be desireable.

All mutations were generated by a computer program, whose listing appears in appendix (ii) and is described by its logic diagram in figure (16A). The random choice required by this program is made using a random number generator that determines for each case which of the 10 parameters is to be modified, and in the event of a modification, whether the increment is positive or negative. As seen in figure (16C), two columns of mutation lengths are printed. The first gives the three lengths used to modify the x,y position of pivot points. These values represent a percentage of the range defined for each pivot point, as shown in figure (16B). The second column is degrees of mutation for flap deflection and angle of attack.

The Random number generator is a computer system function that returns an even distribution of real values in the range 0.0-1.0. A description of its algorithm is given in appendix (iii).

4.2 Mutation Length Control

As described above, three modification lengths are used for each new set of configurations. The control of the base, or middle length is critical, as rapid convergence to an optimum requires an expansion of mutation size far from the optimum and a compression close to it. In this optimization problem, the base length for a new set was controlled by the best case from the previous set. For instance, if case 1 , a member of the third mutation length group, is the best in its set, its mutation length will be used as the base value for the next set. In this way, increasing lengths will be favored. On the other hand, if case 3 is the most improved, smaller lengths will be favored in the next set. Using this scheme, the optimization strategy self-adjusts to the distance from convergence.

4.3 Convergence Criterion

Concerning the question as to when convergence has been reached, a criterion is used that recognizes that mutation lengths will automatically compress as the point of convergence is approached. When the modification of an improved configuration fails to increase C_l/C_d for a minimum C_l, the airfoil has 'approximately converged'. For absolute convergence, an additional set of configurations is generated, based on the best case of the set that failed to improve over the point of approximate convergence. If again there is no improvement, convergence is said to exist.

The procedure proposed to determine the envelope of aerodynamic coefficients is comprised of the following two basic steps:

1. Maximize C_l/C_d while maintaining C_l greater than $C_{l_{min}}$, the value obtained from the initial geometry
2. Move across the envelope from the maxima point found from step 1 to the maximum C_l limit, when flow separation occurs

Results from this procedure are presented in section 5.

4.4 Initial Airfoil Geometry

The initial airfoil configuration was an arbitrary but realistic placement of elements so as to guarantee good flow conditions through the slots. The value of the 10th parameter, angle of attack, was determined from the polar shown in figure (14). An angle of 0.5° was used as it resulted in the maximum C_l/C_d. This initial configuration and angle of attack thus set the value of $C_{l_{min}}$ at 2.71. In all subsequent program calculations, mach number and Reynolds number, referenced to an airfoil chord of 350mm, were 0.125 and $1.26 \cdot 10^6$, respectively. Element profiles were taken from reference 14, with appropriate modification to meet the requirement of smooth contours.

5 RESULTS

5.1 First Three Configuration Sets

The first step of the optimization procedure, the maximization of C_l/C_d with the constraint of $C_{l_{min}}$, was started at the initial geometry. Figure (17) shows the scatter of data points for the first three sets (54 cases) of airfoil configurations. Some points have been omitted for clarity. Circled data points are best cases for each set; these cases serve as the bases for subsequent modifications. The automatic mutation length control reacts well in these first sets, far from the point of convergence, with an increase in base lengths between sets one and two and a constant base length between sets two and three. As expected, points scattered in the immediate vicinity of the initializing case were from the first mutation length group, and points scattered further away were from the second and third groups. As seen in figure (17), the ratio C_l/C_d appears more sensitive to airfoil modification than C_l. This effect continued for all other sets, with most points located in a narrow C_l band between 2.0 and 3.0 and a scatter of other points in a relatively low C_l/C_d - low C_l region. The tabulation of all configurations (37 sets, 656 cases) is given in Appendix (iv) together with initial and final configuration data.

5.2 Description of Complete Optimization

Figure (18) shows the result of continued maximization of C_l/C_d, plotting the best case for each of 37 sets. Up to set 11, mutation lengths generally expanded or remained constant. Sets 12-14, however, resulted in a compression of lengths, and convergence was thought to be imminent. Beyond set 14, lengths began to expand again until the base value stabilized at approximately 2% and 1° for pivot point location and deflection angles, respectively. This effect was considered to be a 'small barrier' in the optimization process, which the evolution strategy was able to step over with the larger of the three mutation lengths. A gradient strategy-based technique would have converged to such a barrier, or local maximum.

Beyond set 22, the accuracy of the aerodynamic coefficients became questionable, resulting in erratic behavior of the optimization process. When the process was continued without the $C_{l_{min}}$ constraint, large changes in C_l/C_d and C_l occurred for relatively small geometry modifications. As an attempt to return to smaller variations of coefficients, the process was restarted at set 24 with a forced reduction of step sizes, as shown by the dotted lines of figure (18). This reulted in sets 27 and 28 which again were characterized by large variations of coefficients for small modifications. This sequence of forced length compression and optimization restart was continued to the 37th, but by this point values of C_l/C_d were unrealistically high, even for the simplified two-dimensional airfoil model without induced drag or body interference effects. Indeed, during the process of optimization, numerous configurations resulted in unsuccessful program termination or extremely high values of C_l/C_d and in several cases, negative C_d! The reasons for this inaccuracy are thought to be one or a combination of the following:

1 Invalid geometry; i.e., overlap less than 1% of chord

2 Confluent boundary layer or slot flow model failures for small slot cross-sections

3 Inadequate verification of program by authors for 4-element airfoil configurations (note-the frequency and severity of inaccuracies were substantially less for the preliminary optimization of a 2-element airfoil)

In the further presentation of results, sets 21-22 are taken to be the approximate limit of data accuracy, although all points are shown.

C_l/C_d and C_l are shown with respect to set number in figure (19). The points again are from the best cases for each set. As seen in this figure, the result of 22 sets of configurations and 296 total cases, C_l/C_d has been increased from 4.28 to 36.6, a factor of 8.55. At the same time, C_l has been increased from 2.31 to 2.59, a result that evolved by favoring the configuration having the larger C_l when two or more had approcimately the same C_l/C_d. Increasing C_l, however, was not the primary objective of the optimization.

Because of the limit of data accuracy, the optimization process was terminated at the 37th set, thus making it impossible to find the envelope of aerodynamic coefficients and thus carry out the second step of the proposed optimization.

5.3 Initial-Final Configuration Comparison

Figure (20) shows polars generated for the initial configuration and the configurations resulting from the process of C_l/C_d maximization. The resulting dramatic improvement in aerodynamic performance is apparent. During the process of optimization, a number of configurations produced values of C_l/C_d and C_l that when plotted fall to the right of the polar for maximized C_l/C_d. A polar was generated from the point that was furthest to the right and is denoted as the 'optimized C_l configuration'. This configuration, it is interesting to note, was a member of the optimum C_l/C_d set, number 22. The dotted lines have been added to these polars to show the real flow behavior for multi-element airfoils such as shown in figure (2).

A comparison of initial and final configurations is given in figure (21). A noticeable effect of the optimization is the reduction of slot area and improved contour smoothness of the trailing edge flaps. Both of these effects have been shown experimentally to improve aerodynamic performance. The same changes did not occur for the leading edge flap. It was found that the multi-element airfoil program was very sensitive to reduction of slot area of the leading edge device when both trailing edge flaps were present. It is suspected that the reasons for this sensitivity are the same as those mentioned above.

A comparison between the optimum C_l/C_d configuration found using evolution strategy and that suggested by the empirical recommendations of reference 5 was attempted, but the slot geometries required were not capable of being modelled by the airfoil program. Any change from these recommendations so as to suit program input requirements would have resulted in a meaningless comparison.

CONCLUSIONS

Although the inaccuracy of the program used to determine aerodynamic coefficients precluded the full solution of the airfoil performance envelope, the problem of maximizing C_l/C_d was easily handled by the evolution strategy-based optimization technique. A review of existing techniques showed that evolution strategy is the best choice for systems described by 5 or more degrees of freedom, due to its relative incomplexity, flexibility to handle a wide variety of problems, and to the knowledge that the converged solution is an absolute optimum within the range of variation of these degrees of freedom.

The problem experienced with the use of the above-mentioned program reinforces the opinion that as of yet numerical solution methods are severely limited in their range of application to complex engineering systems, such as for a multi-element airfoil with its large number of configurations. The value of numerical methods, however, lies in their ability to provide preliminary results to be used as a starting point for further design refinement in the laboratory. Of course, as long as the limits of numerical methods are not exceeded, experimental optimization may be well predicted.

The next logical step related to the work described here is the application of evolution strategy to optimization in a wind tunnel. A setup is envisioned, similar to those of references 7 and 8, where modifications to the airfoil, analysis of aerodynamic coefficients, and optimization procedure are carried out by on-line computers. The importance of using the wind tunnel is that all configurations of an airfoil are capable of being tested, as opposed to computer model-imposed restrictions such as slot geometry and separation-free flow. An important note is that multi-element airfoils often are designed to perform with separated flow and negative overlap, two conditions that can not exist for the successful use of the program of reference 13.

The effect of increasing C_l/C_d through the modification of slot geometries while at the same time maintaining adequate C_l is best seen for the design trade-off between take-off and cruise flight. Increased C_l/C_d at take-off allows increased rate or angle of climb, decreased overall distance to reach a required screen height, increased take-off weight for the same runway requirement, or a combination of the three. An increase in C_l/C_d at take-off also has a strong influence on cruise flight efficiency through the reduction of the installed power needed for take-off.

By using an evolution-based strategy, the converged optimum is an 'absolute' optimum within the range of variations of the degrees of freedom of a particular system. The question of whether convergence has been obtained or not is thus eliminated; this was not the case for the design of the Boeing 737. This is seen in figure (4) by the 3 increments in $C_{l_{max}}$ for its high-lift devices. At each point, the design was probably considered to be an optimum!

Other areas of aerodynamic design that should lend themselves well to evolution-strategy optimization are the wing-fuselage junction, empennage, supercritical airfoils, engine nacelles, and fuselage rear up-sweep. These design areas are currently approached using procedures similar to those of flap design, the wind tunnel testing of a relatively small number of different configurations. Each of these problems is described by many degrees of freedom, a characteristic that has been shown to be well-suited to evolution strategy. The technique described in this work is by no means restricted to aerodynamic design, however. A wide range of applications can be imagined; the examples included in this report are only a few preliminary cases whose results show promise for this new technique to be used as a powerful tool in the design process.

One can consider the development of evolution strategy as a result of man learning from his observations of nature. Figure (22) depicts what might result if nature learns from the aerodynamic achievements of man.

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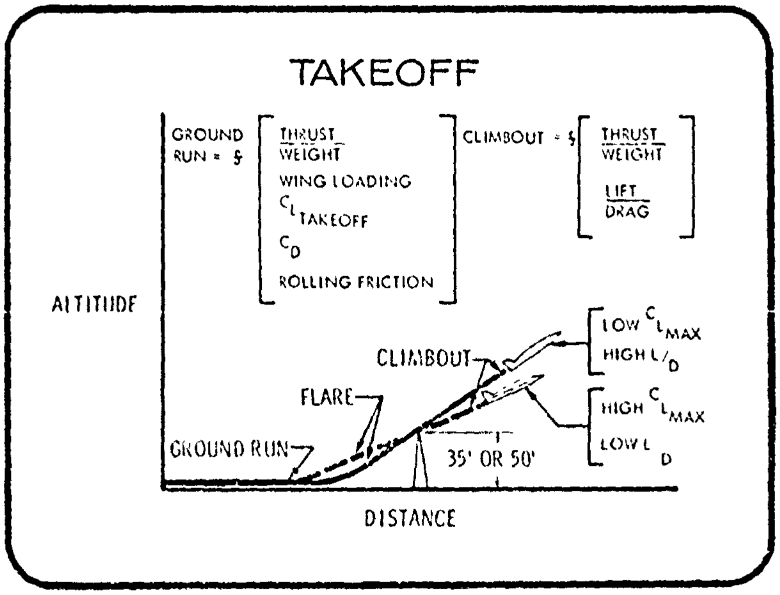
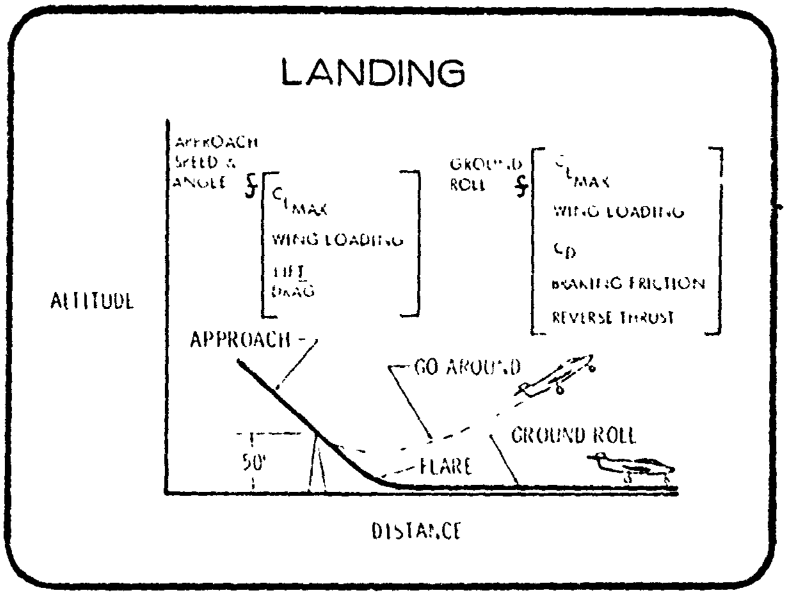
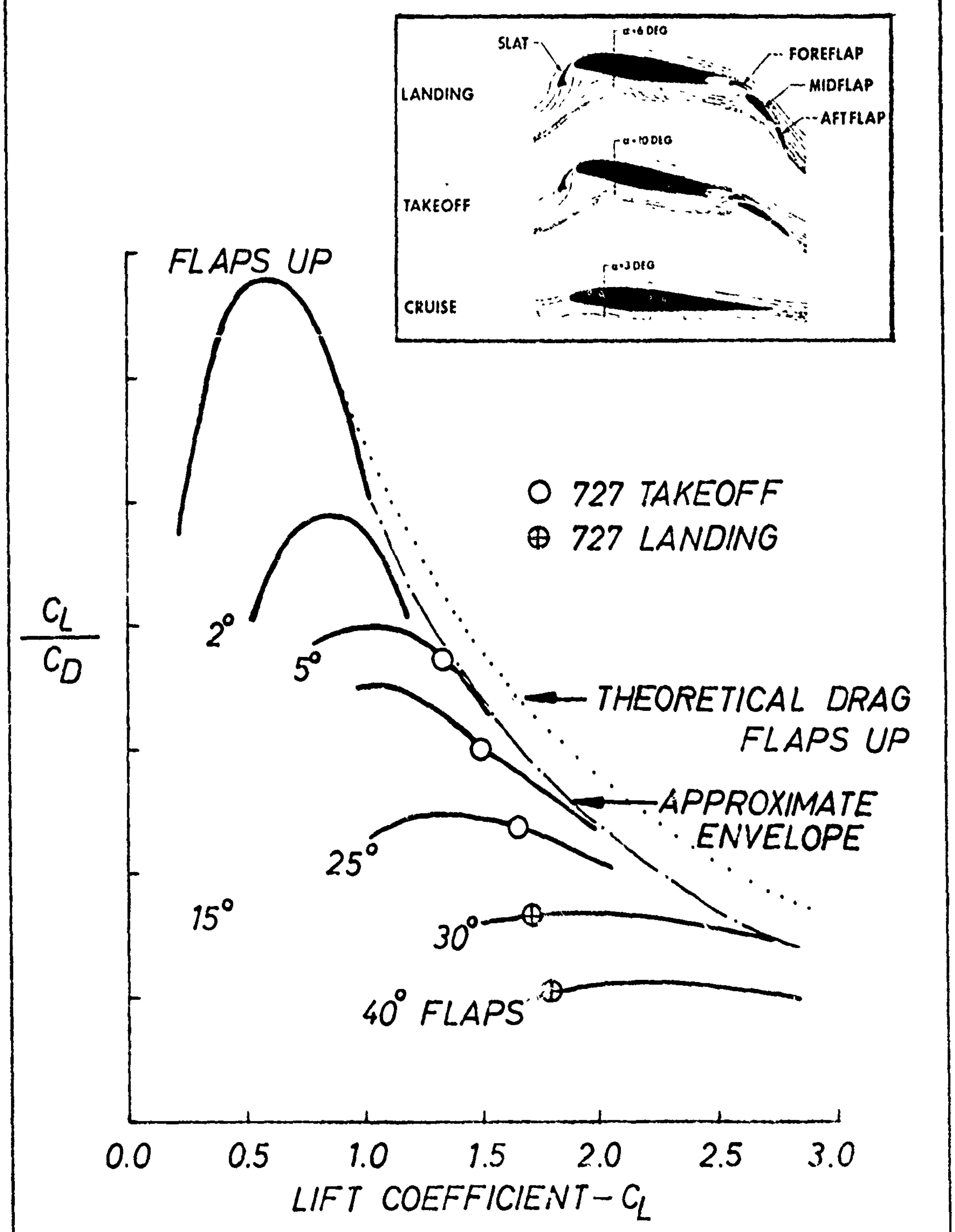


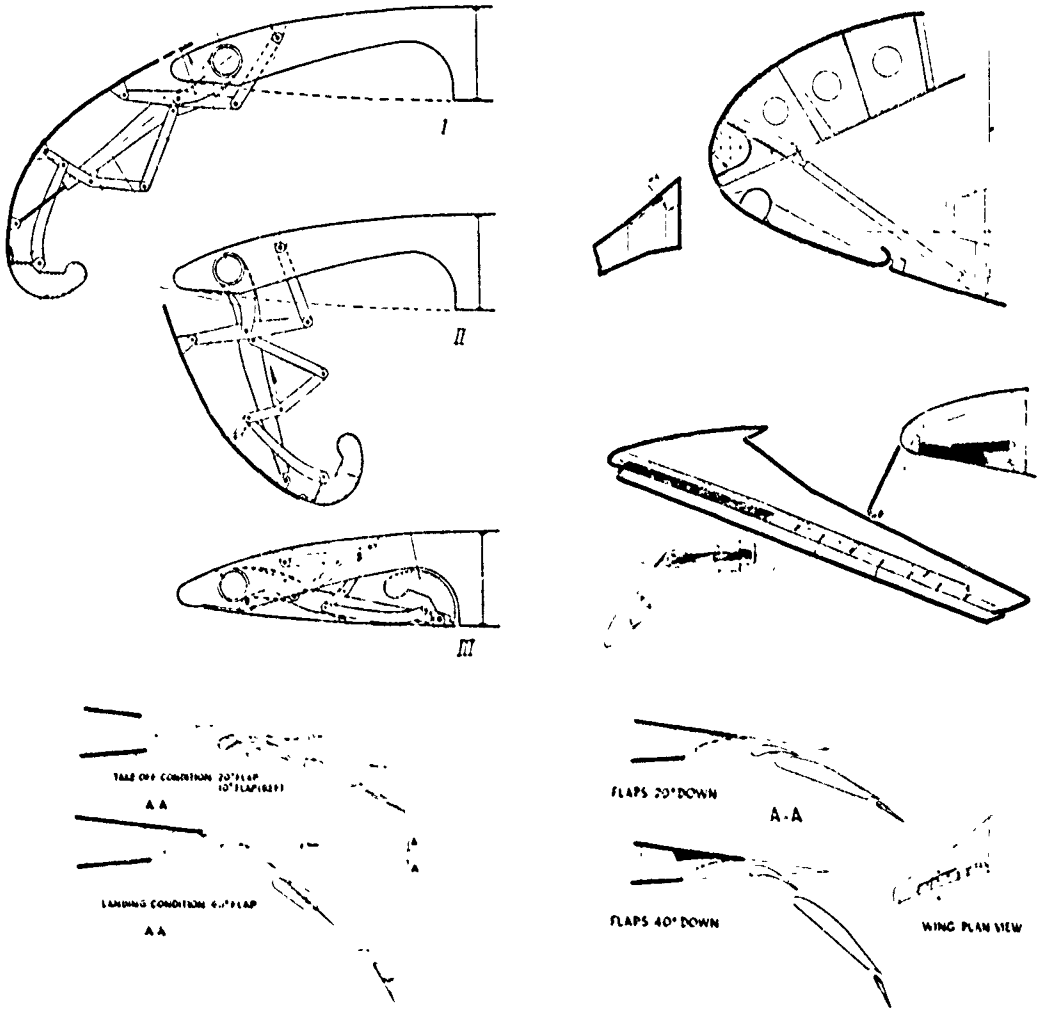


TAKEOFF AND LANDING AERODYNAMICS

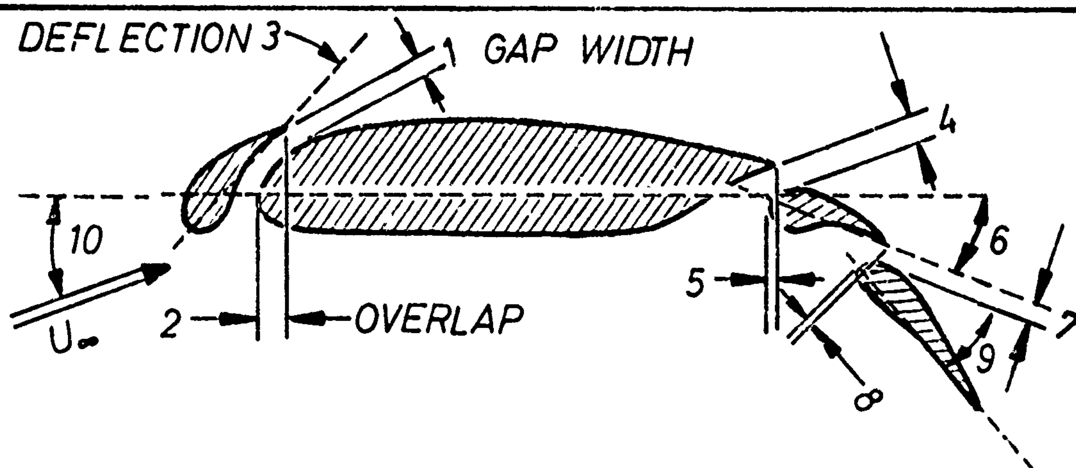
FIGURE 1



BOEING–727 DRAG POLARS	FIGURE 2

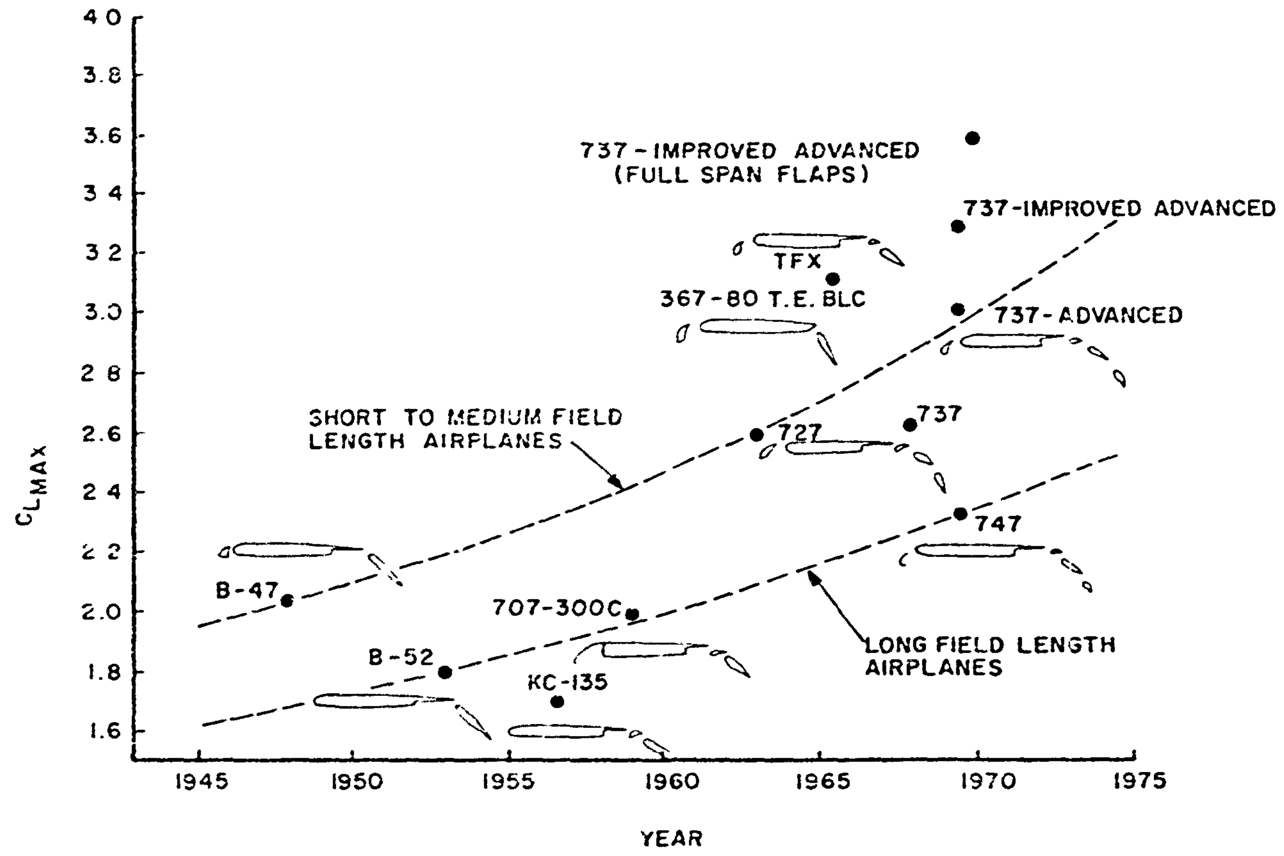


A. HIGH-LIFT DEVICE DETAILS



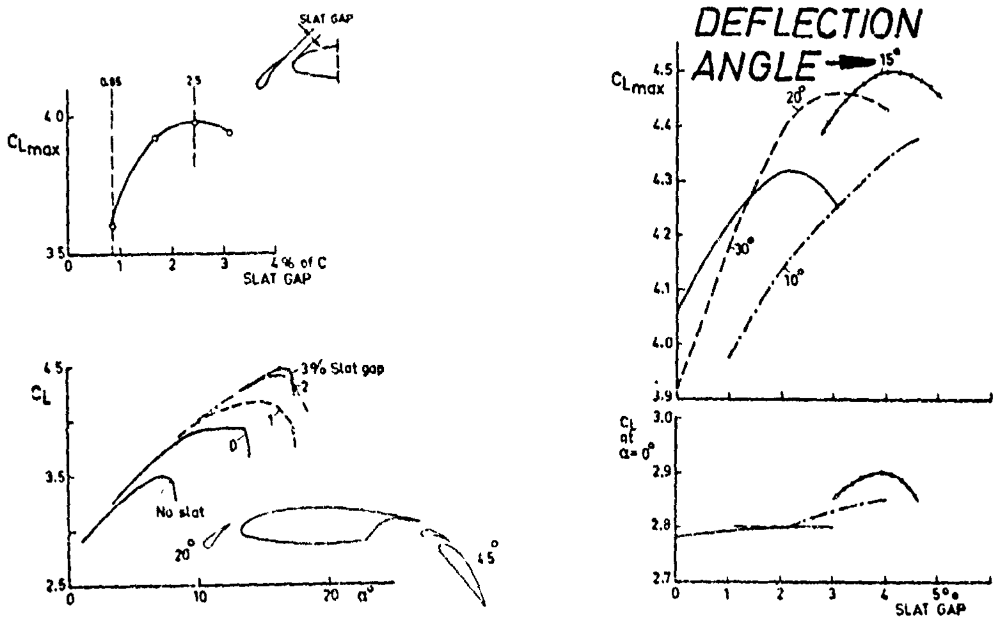
B. AIRFOIL DEGREES OF FREEDOM

MULTI-ELEMENT AIRFOILS	FIGURE 3

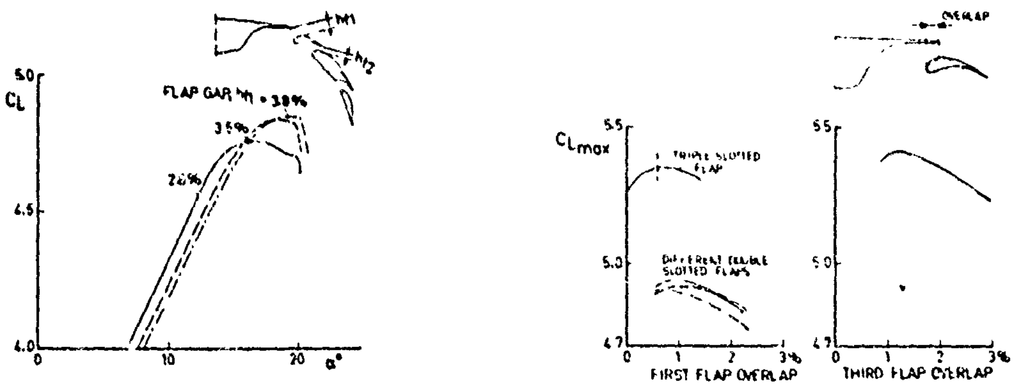


MECHANICAL HIGH LIFT DEVICES
MAXIMUM LIFT CAPABILITY

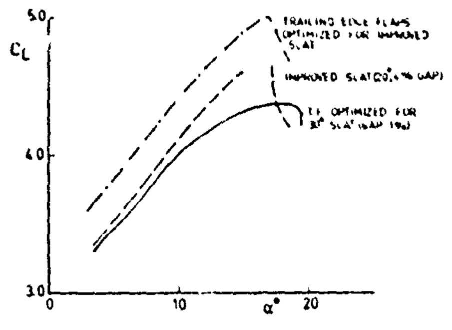
FIGURE 4



L.E. SLAT GAP & DEFLECTION EFFECTS

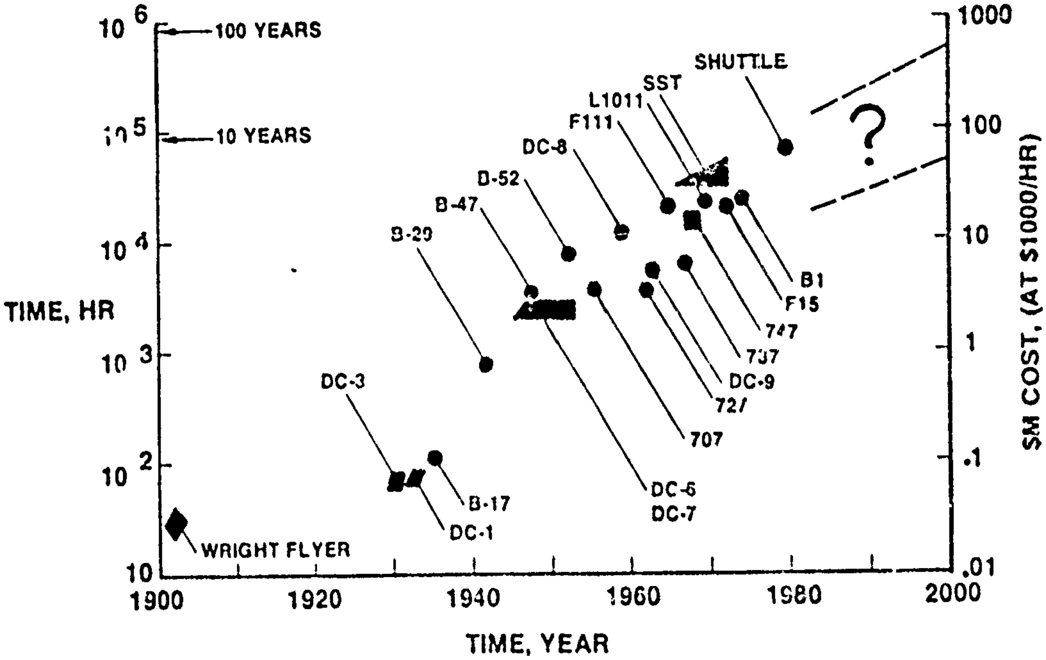


T.E. FLAP GAP & OVERLAP EFFECTS



COMBINED SLAT AND FLAP EFFECTS

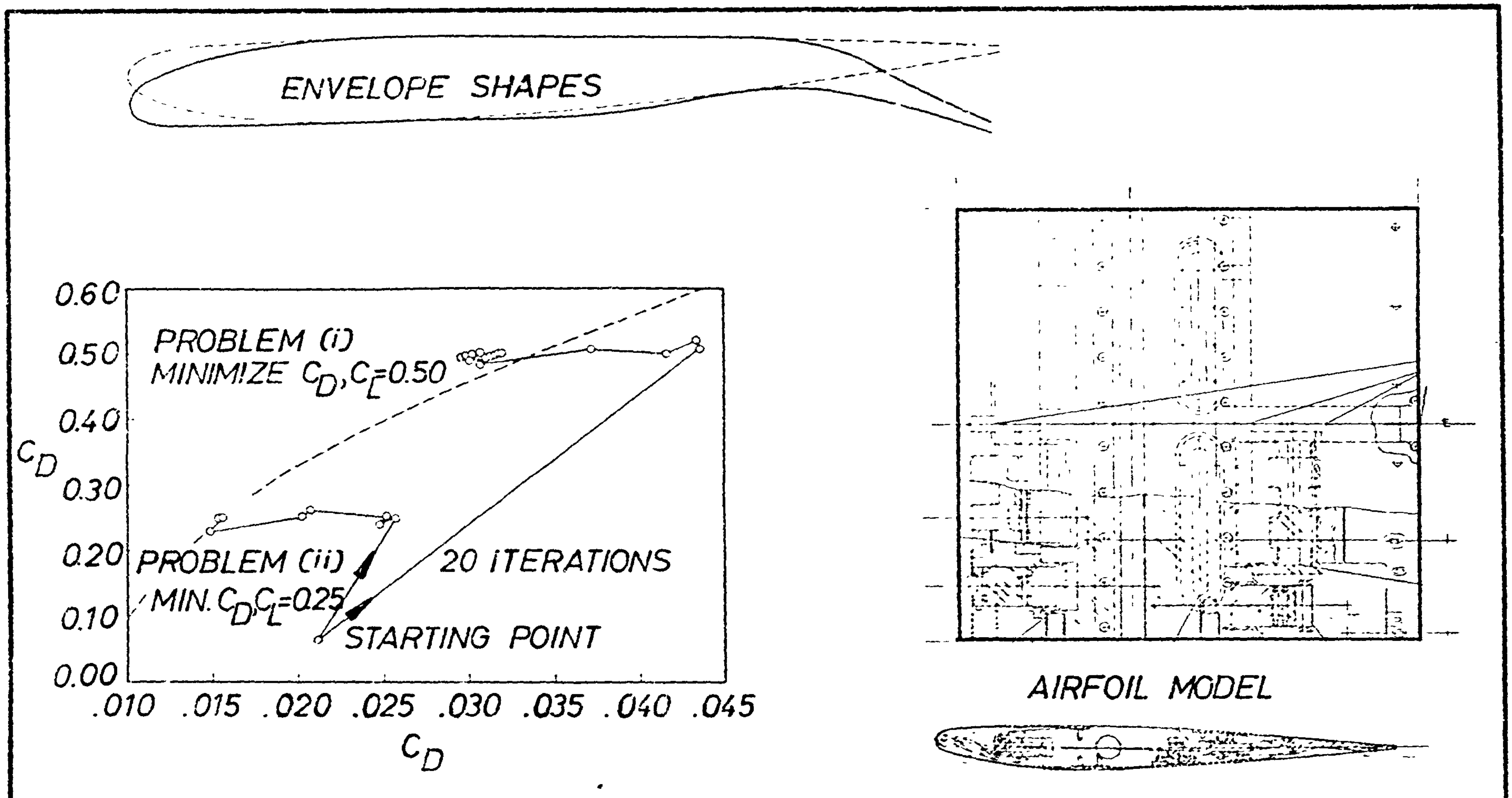
FOUR ELEMENT AIRFOIL OPTIMIZATION BY EMPIRICAL METHOD	FIGURE 5



WHAT PRICE ACCURACY ?

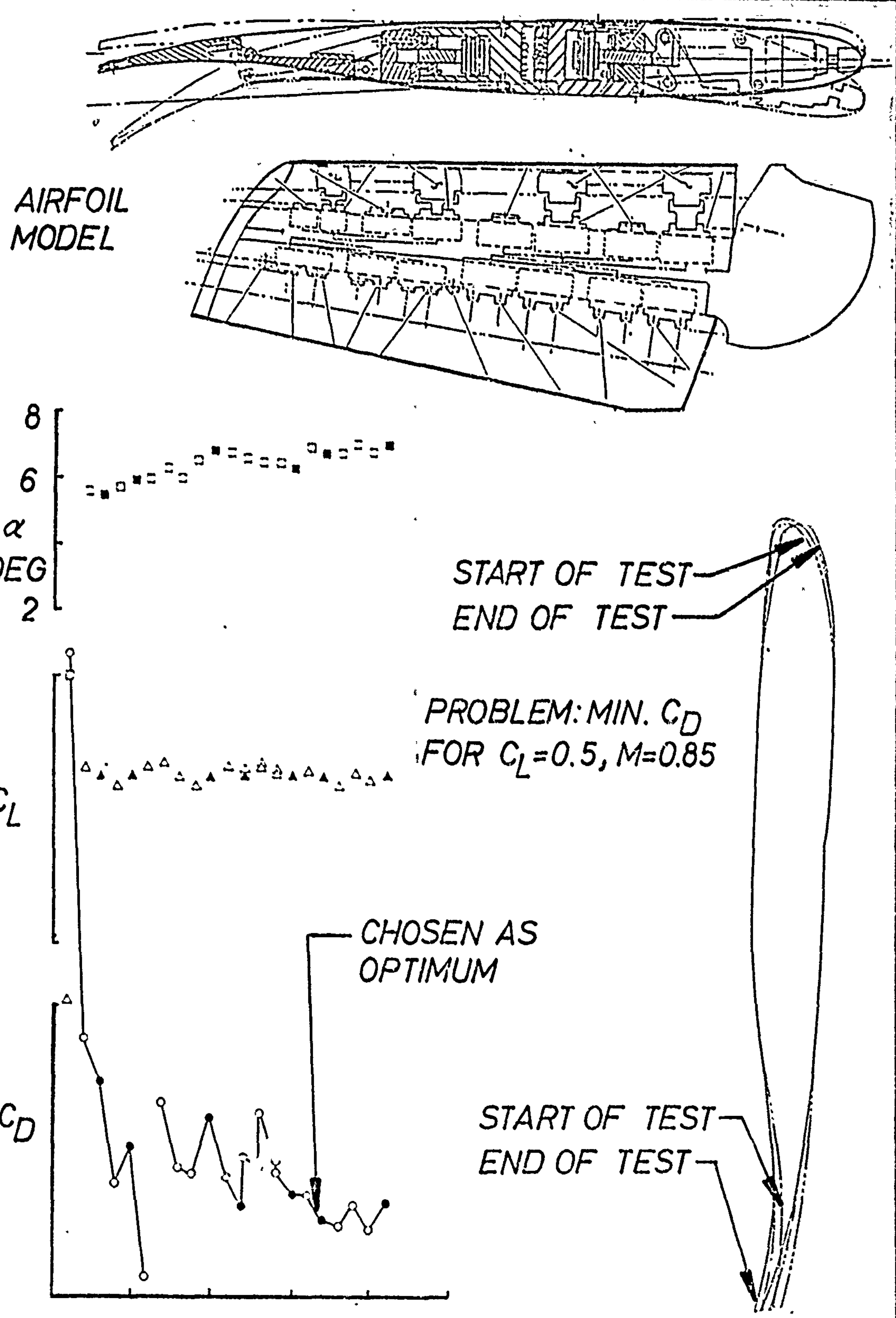
- · · · · 10^{10} CONFIGURATIONS
- · · · · 1 MEASUREMENT/30 SECONDS
- · · · · TOTAL TIME $9.51 \cdot 10^5$ YEARS
- · · · · TOTAL COST $\$ 8.33 \cdot 10^{10}$

WIND TUNNEL TEST PROGRAM TRENDS	FIGURE 6

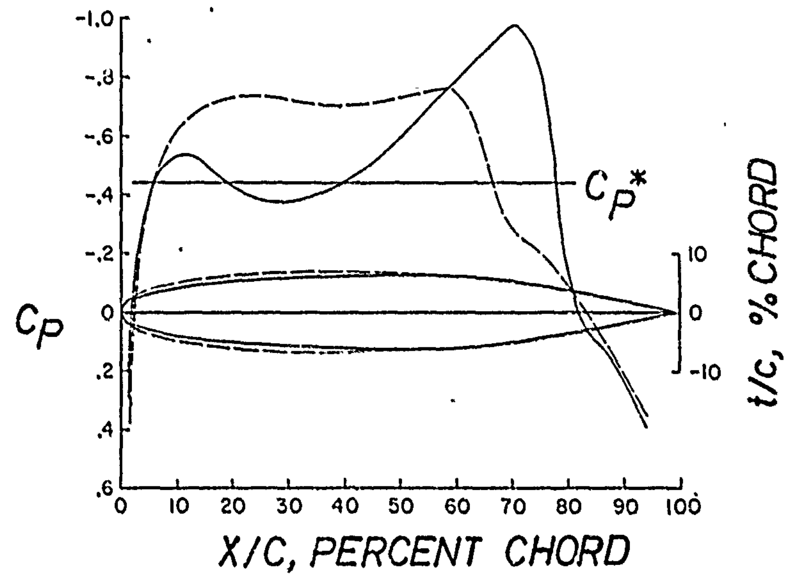


TWO-DIMENSIONAL FLEXIBLE, TRANSONIC AIRFOIL OPTIMIZATION BY GRADIENT STRATEGY

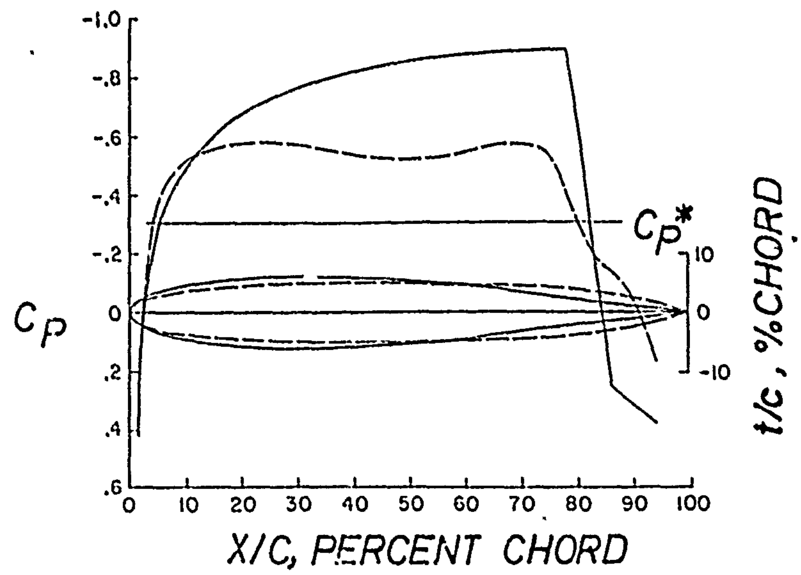
FIGURE 7



THREE-DIMENSIONAL FLEXIBLE AIRFOIL OPTIMIZATION	FIGURE 8

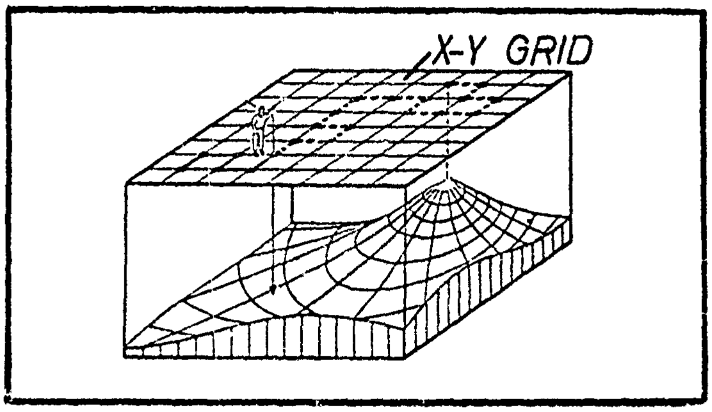


— INITIAL AIRFOIL, C_D= 0.0083, V=0.721
--FINAL AIRFOIL, C_D=0.0009, V=0.756
VOLUME MAXIMIZATION, $C_D \leq 0.001$, C_L=0.0, M=0.8

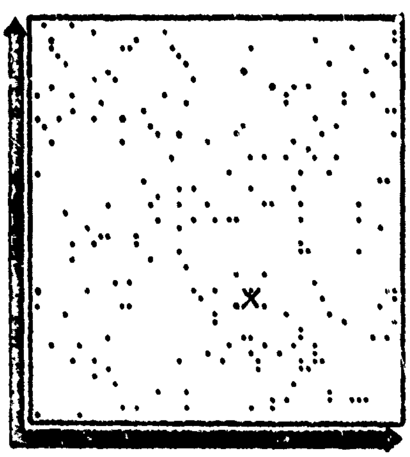


—INITIAL AIRFOIL, C_D=0.0524, V=0.680
--FINAL AIRFOIL, C_D=0.0007, V=0.654
DRAG MINIMIZATION, $V \geq 0.65$, C_L=0.0, M=0.85

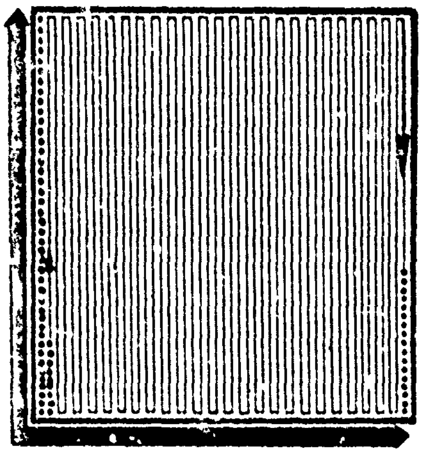
TWO-DIMENSIONAL TRANSONIC AIRFOIL OPTIMIZATION, GRADIENT ST.	FIGURE 9



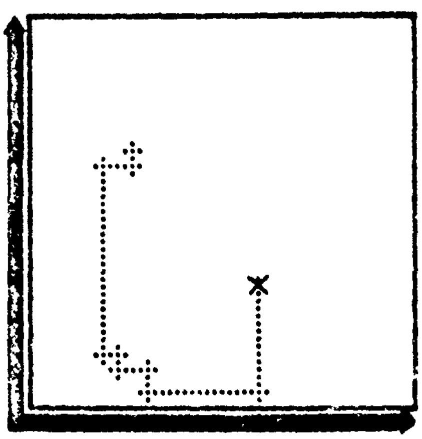
MODEL FOR SIMPLE OPTIMIZATION PROBLEM



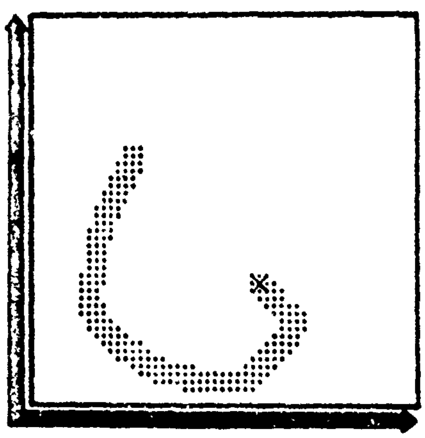
A. RANDOM SOUNDINGS



B. COMPLETE SEARCH

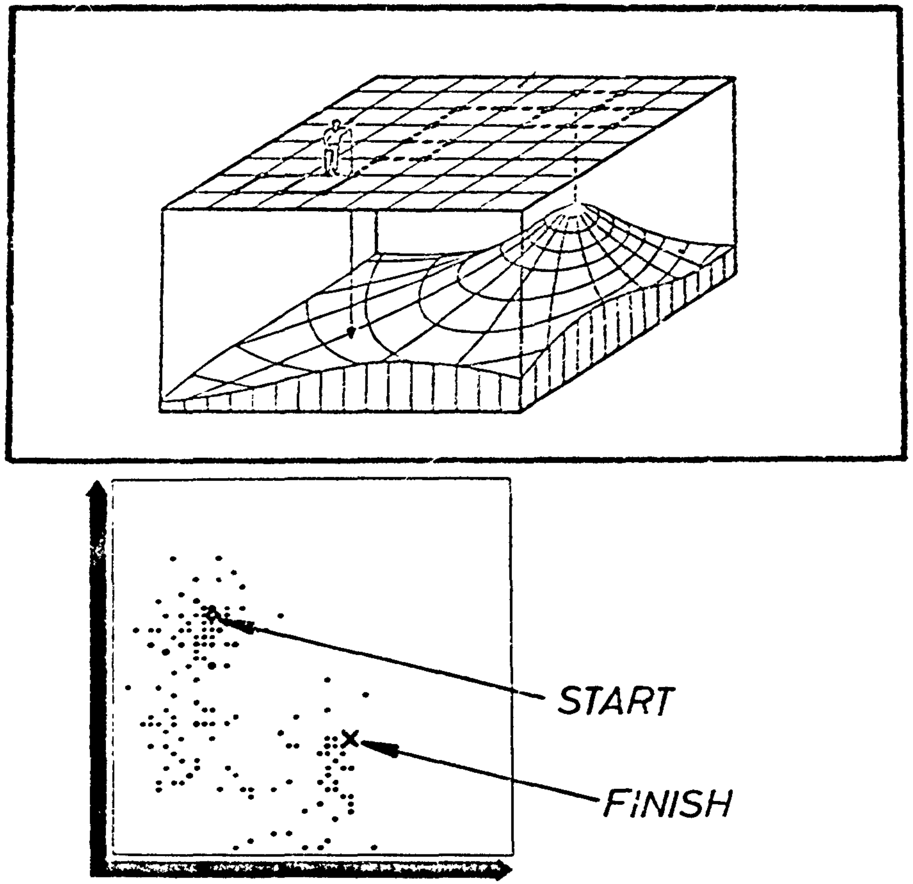


C. GAUSS-SEIDEL STRATEGY

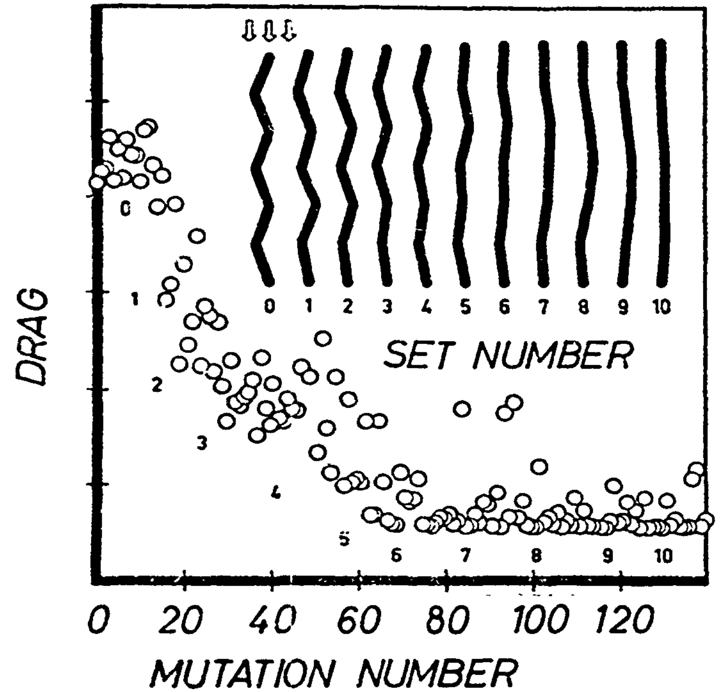


D. GRADIENT STRATEGY

COMPARISON OF OPTIMIZATION STRATEGIES FOR SIMPLE PROBLEM	FIGURE 10



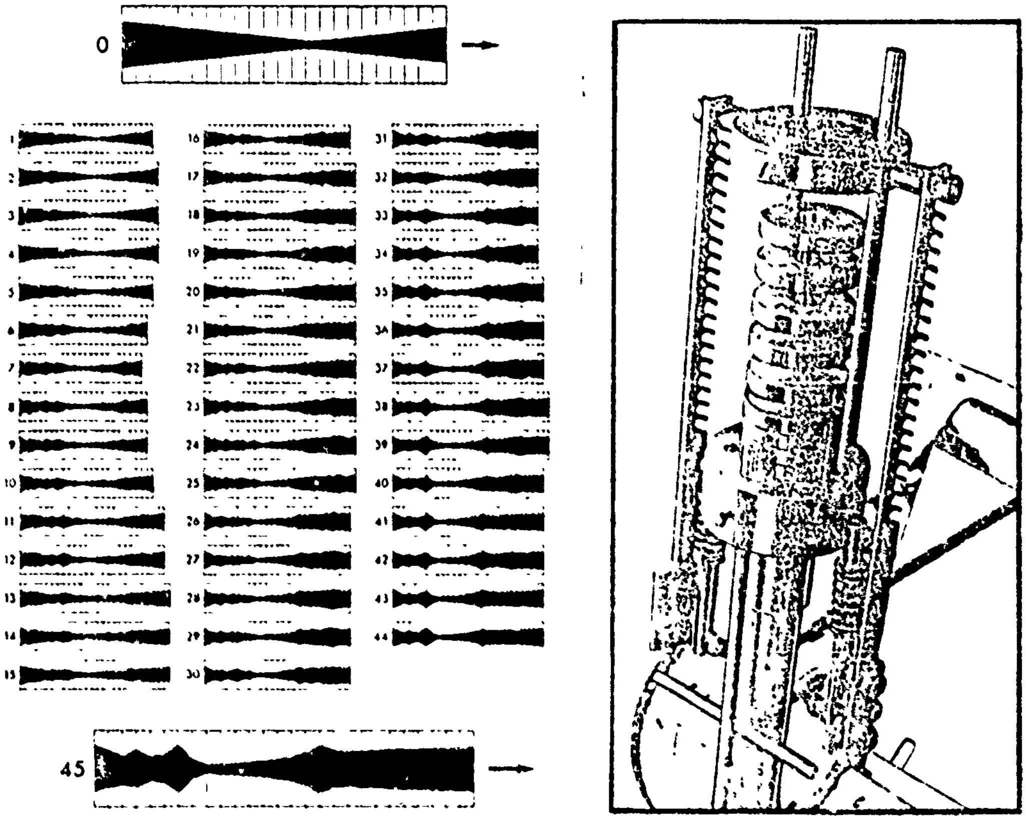
A. SIMPLE PROBLEM



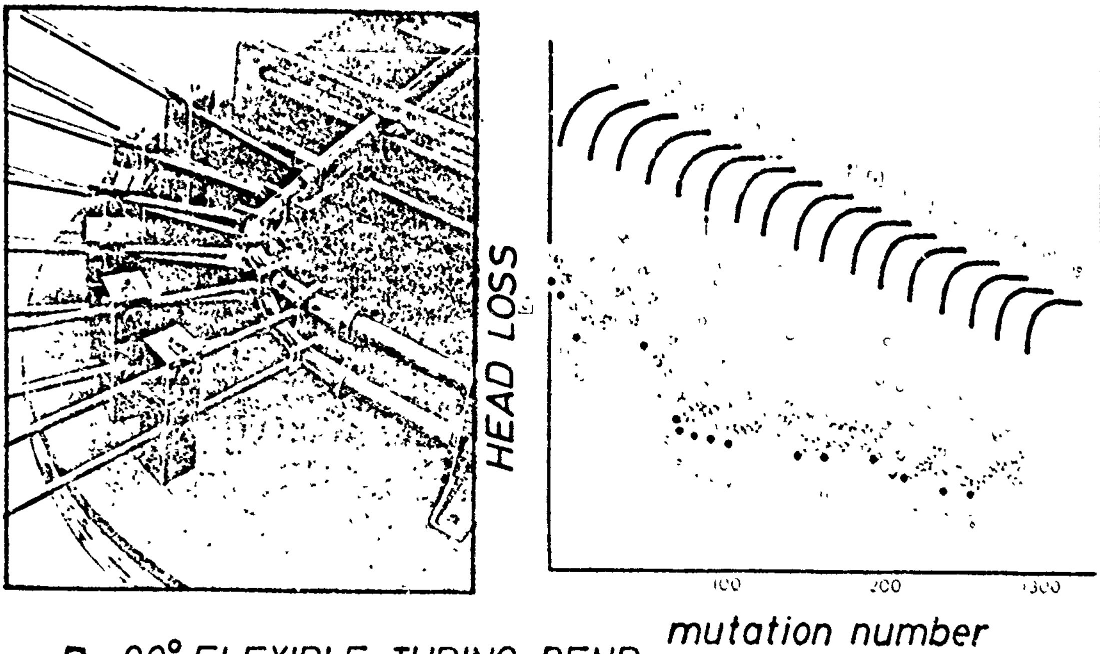
B. SEGMENTED PLATE

EVOLUTION STRATEGY EXAMPLES

FIGURE 11

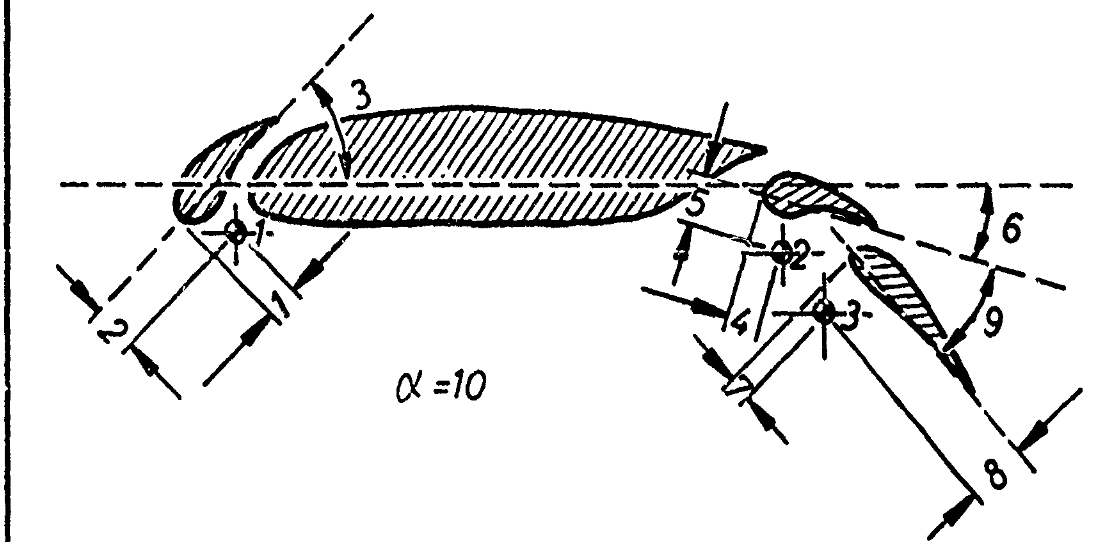


A. TWO-PHASE SUPERSONIC NOZZLE



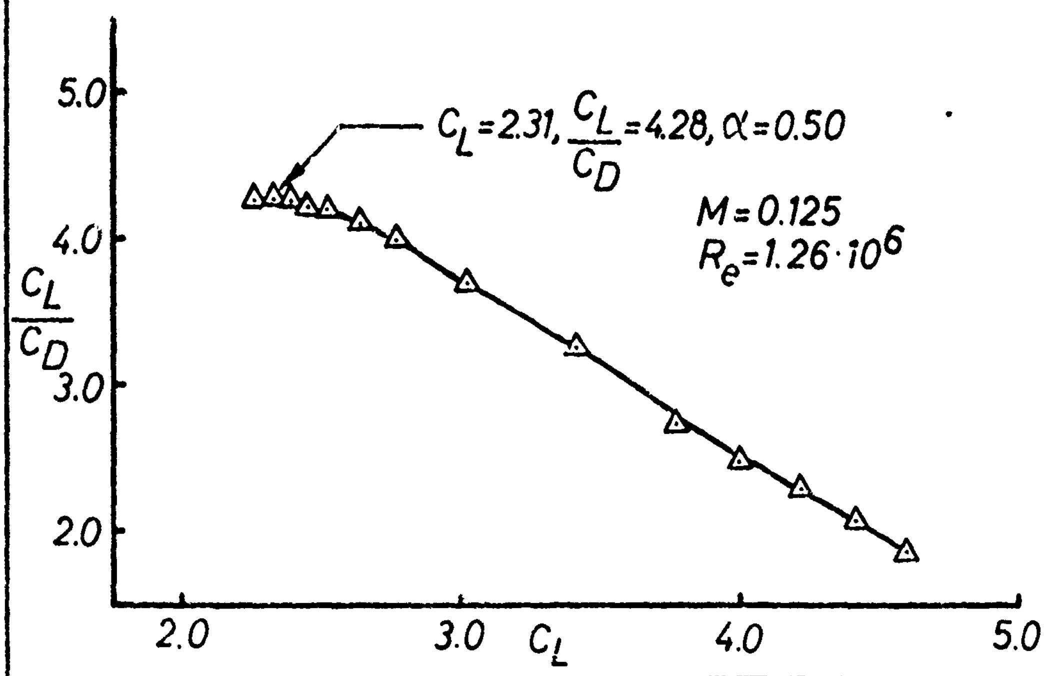
B. 90° FLEXIBLE TUBING BEND

EVOLUTION STRATEGY EXAMPLES (CONTINUED)	FIGURE 12



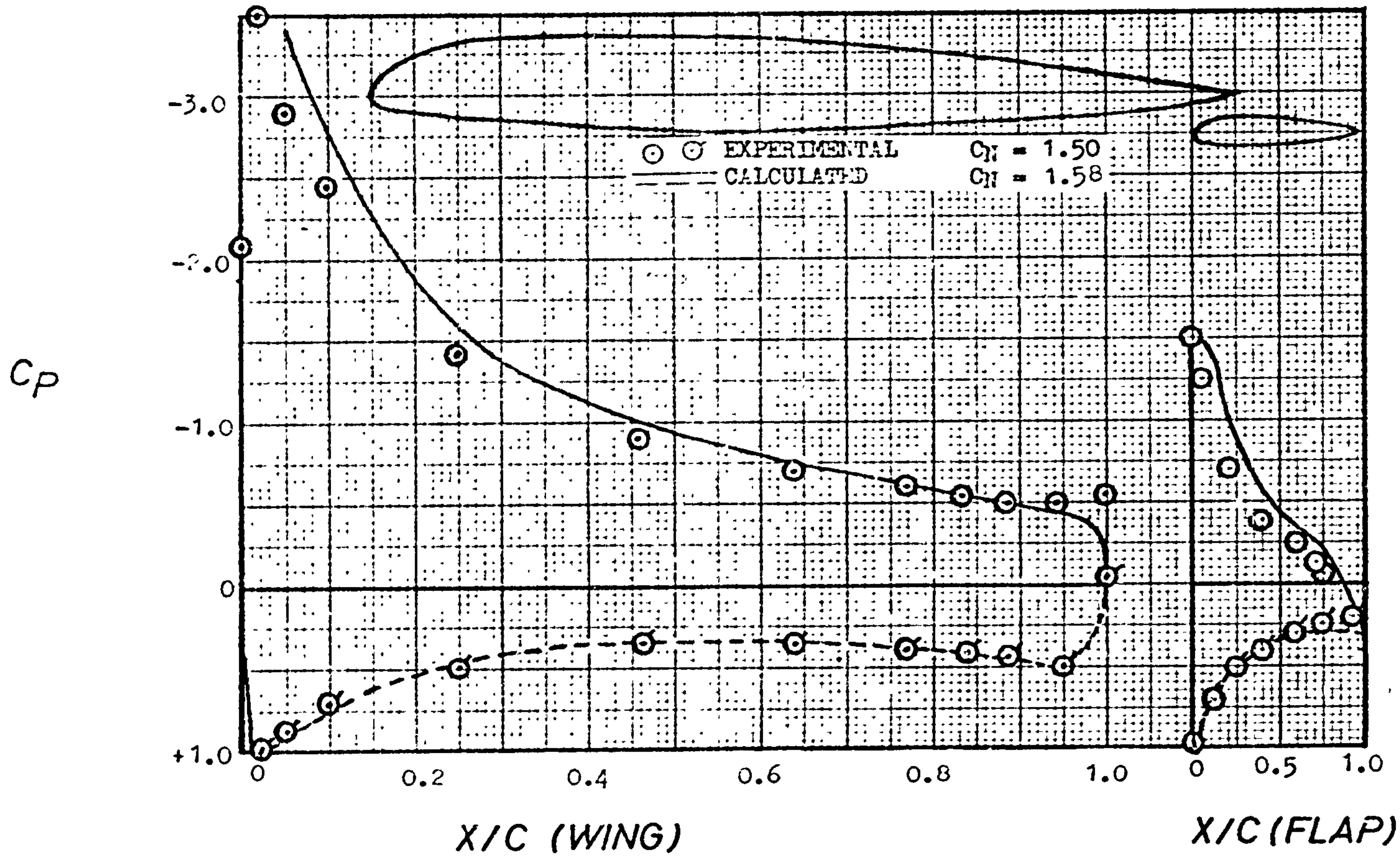
AIRFOIL WITH 10 PARAMETERS

FIGURE 13



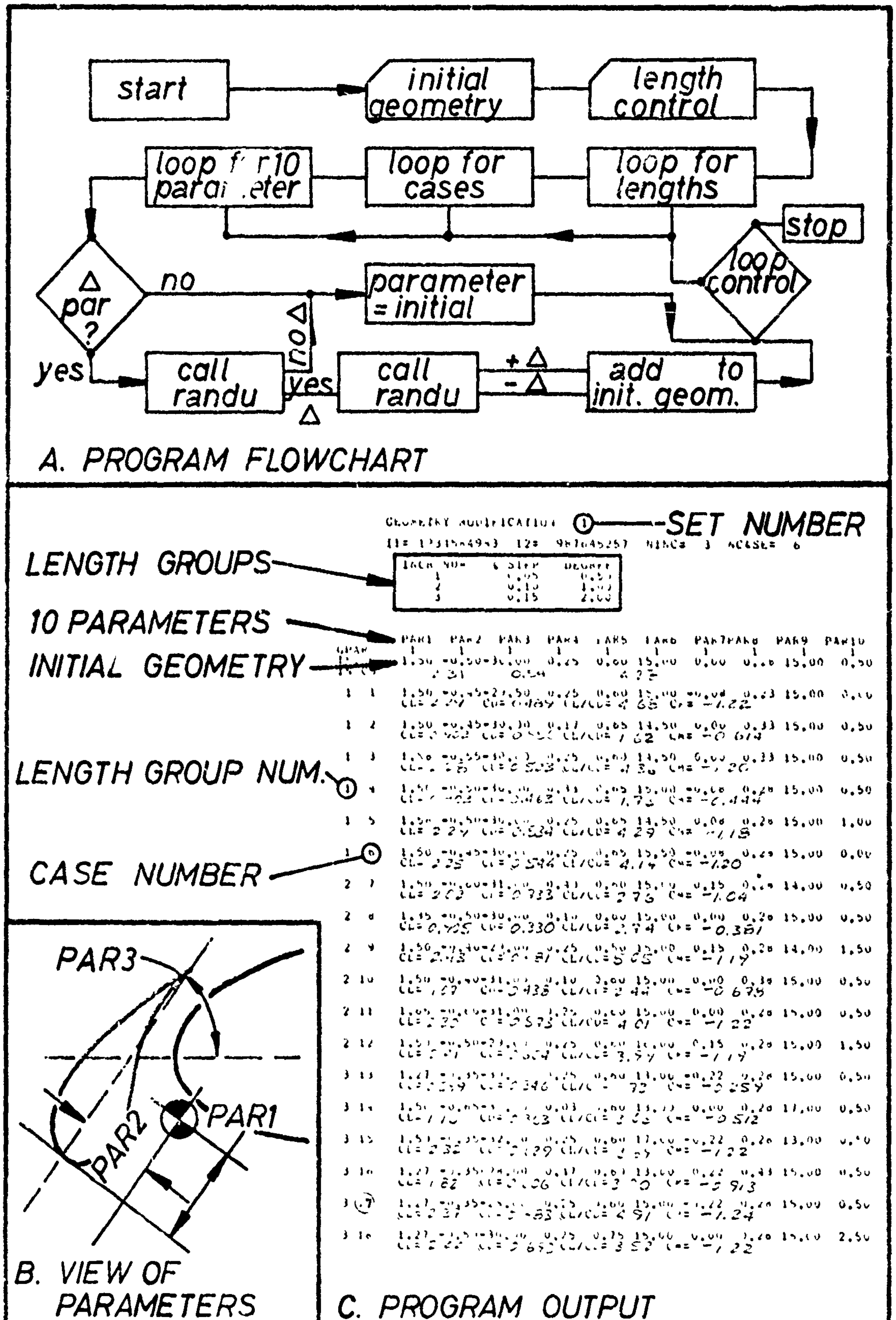
POLAR FOR INITIAL GEOMETRY

FIGURE 14



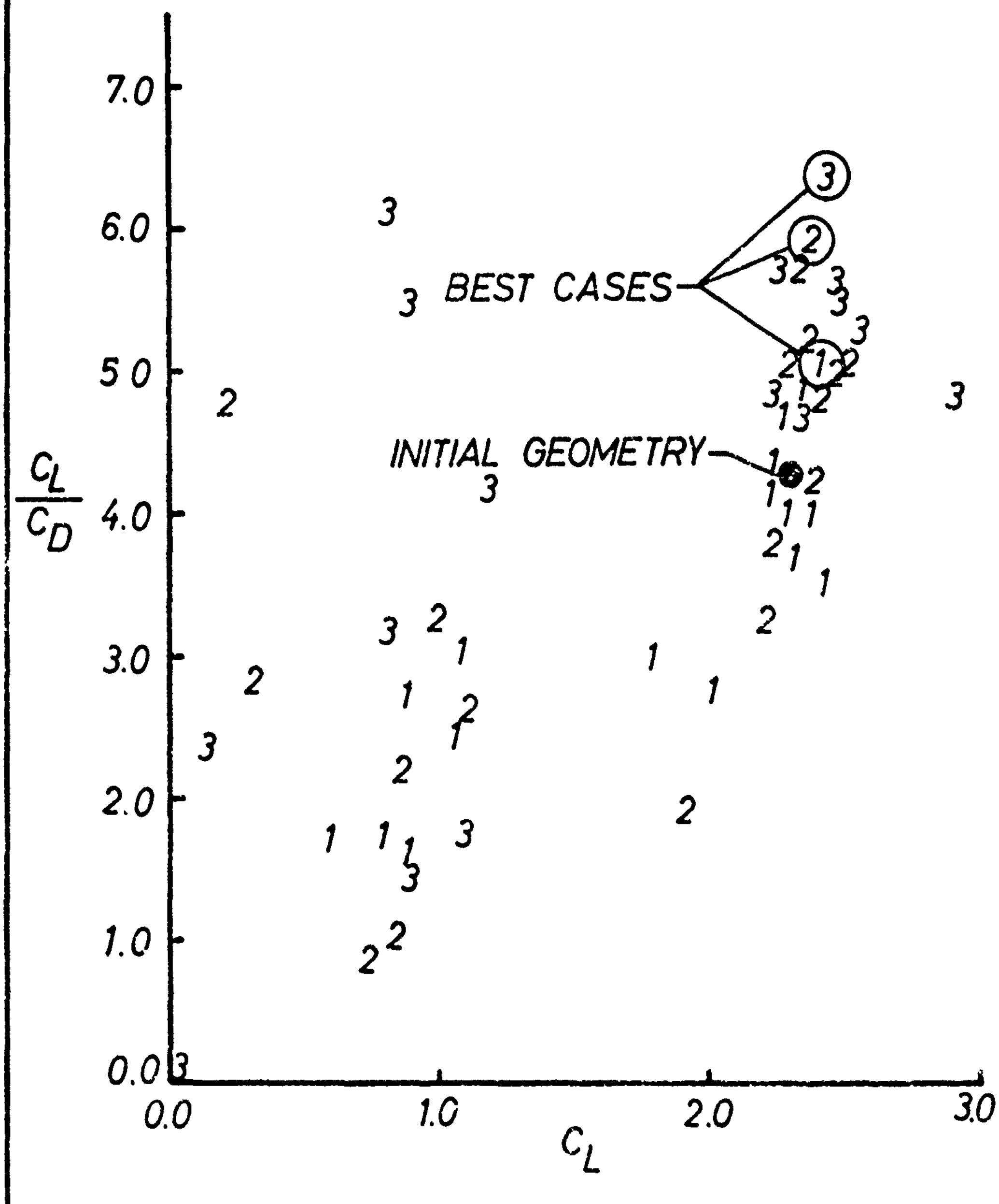
COMPARISON OF EXPERIMENTAL AND PREDICTED PRESSURE DISTRIBUTIONS FOR NACA 23012 AIRFOIL WITH T. EDGE FLAP

FIGURE 15

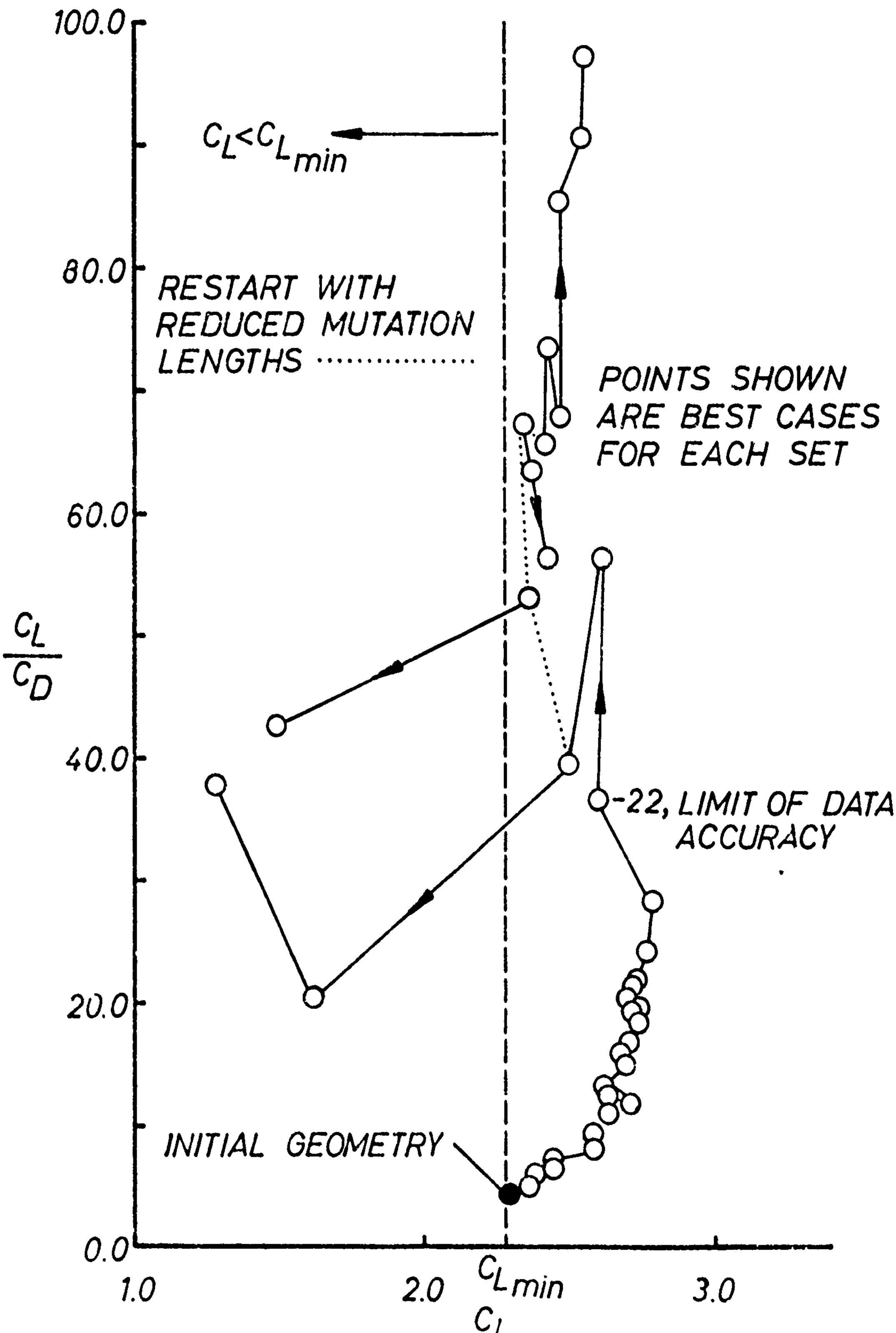


GEOMETRY MODIFICATION PROGRAM

FIGURE 16

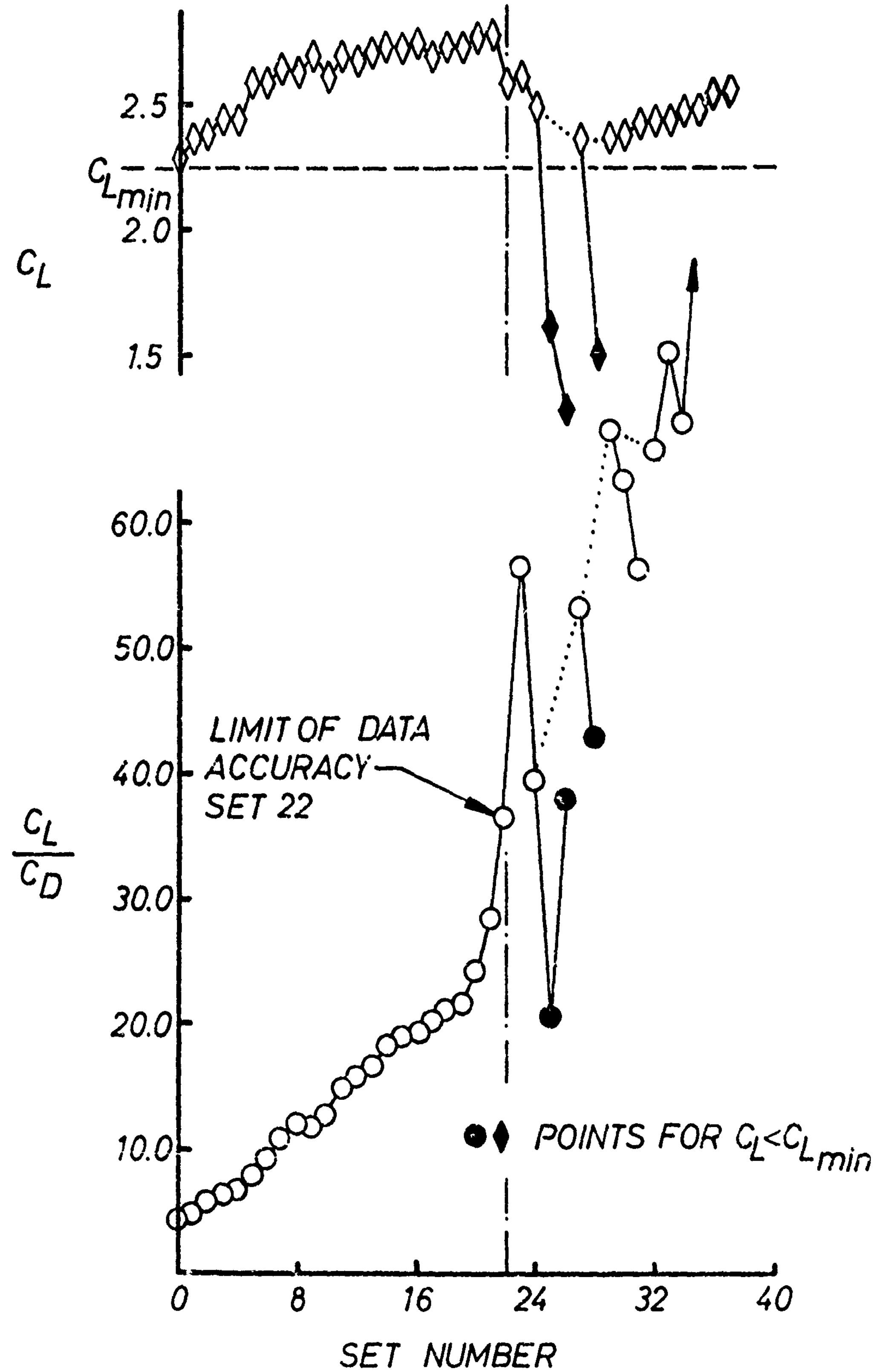


OPTIMIZATION PROCESS FOR FIRST THREE SETS	FIGURE 17

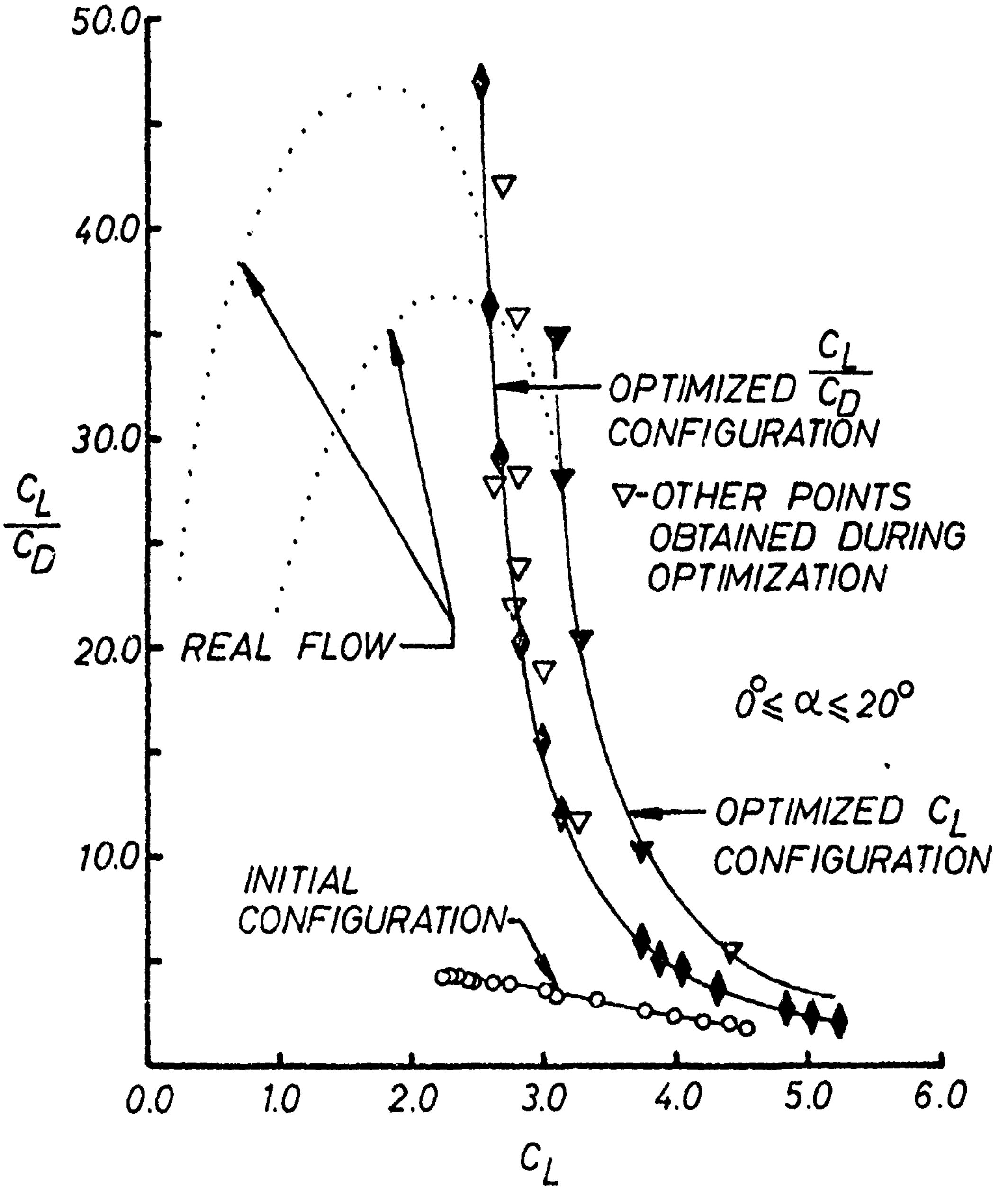


$\frac{C_L}{C_D}$ vs C_L DATA-37 SETS

FIGURE 18

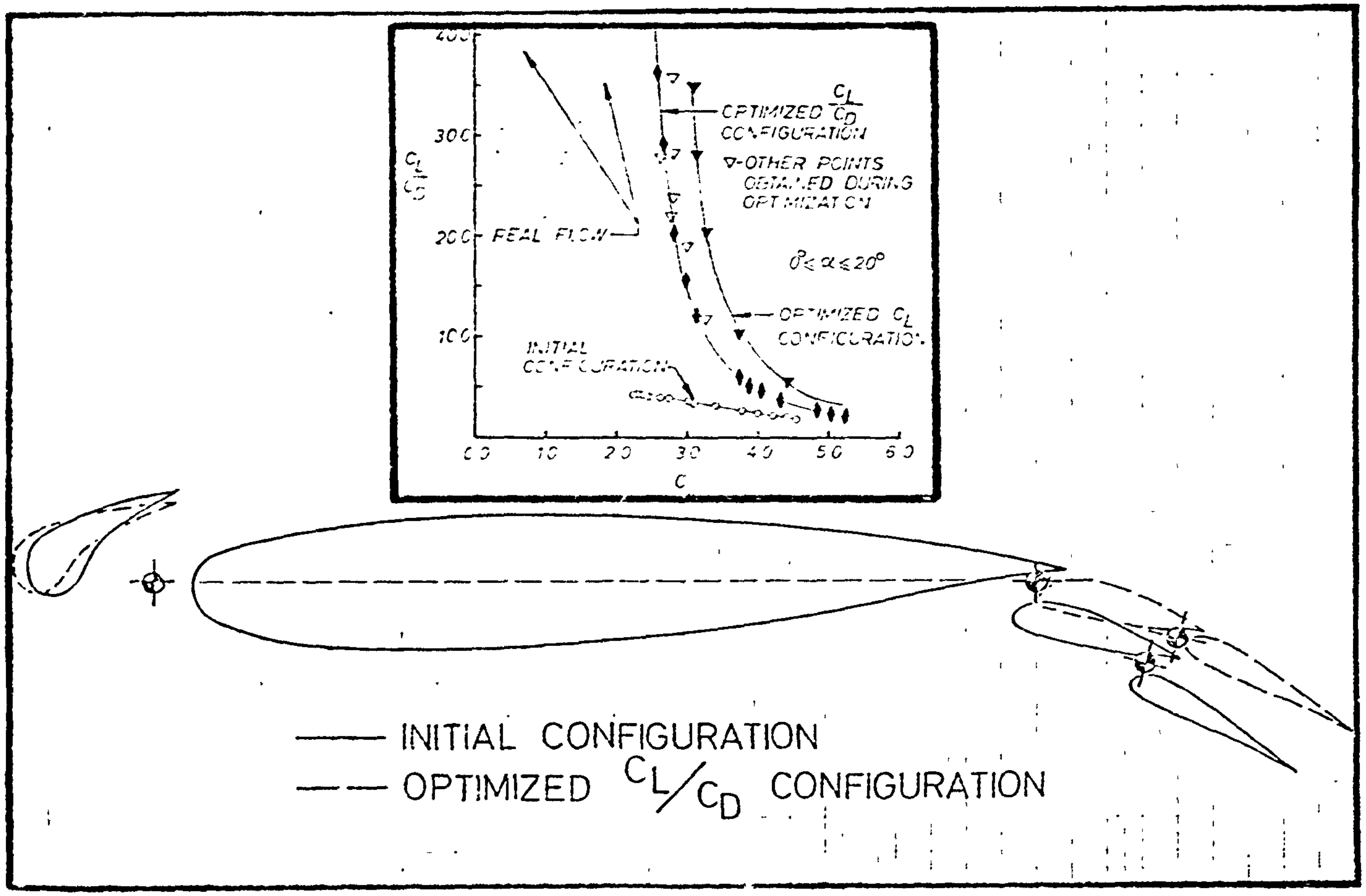


C_L AND $\frac{C_L}{C_D}$ VS. SET NUMBER	FIGURE 19



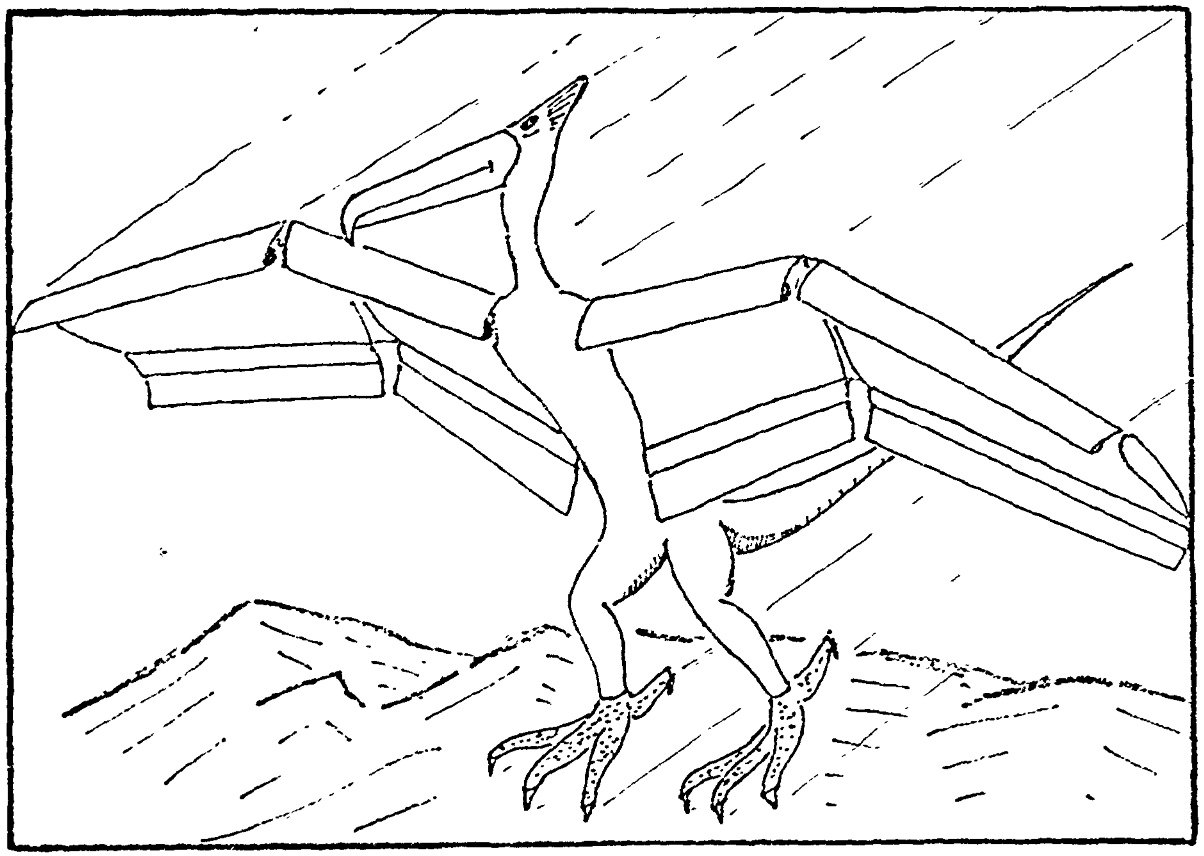
$\frac{C_L}{C_D}$ VS. C_L POLARS FOR INITIAL AND OPTIMIZED CONFIGURATIONS

FIGURE 20



COMPARISON OF INITIAL AND FINAL CONFIGURATIONS

FIGURE 21



EVOLUTION STRATEGY - THE SKY IS THE LIMIT....

FIGURE 22

APPENDIX (i) AERODYNAMIC COEFFICIENT PROGRAM INPUT

```
 100   MBB-PROFILE AI-725-146    SLOTTED KRUEGER  DOUBLE-SLOTTED TE FLAP OPTIMIZATION
 200       4   85     1
 300       1   23    23
 400    1.6100    -0.4200
 500    0.0000     0.0344     0.0689     0.1378     0.2067     0.2756     0.3445     0.4134
 600    0.5512     0.6890     0.8268     0.9646     1.1024     1.2402     1.3780     1.5157
 700    1.6535     1.7913     1.9291     2.0670     2.2047     2.3425     2.4459
 800    0.4134     0.5994     0.6683     0.7441     0.7992     0.8543     0.8819     0.8957
 900    0.9232     0.9232     0.9163     0.9026     0.8888     0.8612     0.8406     0.8130
1000    0.7923     0.7579     0.7303     0.6890     0.6407     0.5925     0.5512
1100    0.0000     0.0344     0.0689     0.1378     0.2067     0.2756     0.3445     0.4134
1200    0.5512     0.6890     0.8268     0.9646     1.1024     1.2402     1.3780     1.5157
1300    1.6535     1.7913     1.9291     2.0670     2.2047     2.3425     2.4459
1400    0.4134     0.2070     0.1378     0.0689     0.0207     0.0069     0.0000     0.0207
1500    0.0965     0.2070     0.2894     0.3445     0.3858     0.4272     0.4616     0.4961
1600    0.5236     0.5443     0.5512     0.5512     0.5512     0.5512     0.5512
1700       2   37    37
1800   -0.5000     0.0000    12.0000     0.0000
1900    0.0000     0.0344     0.1033     0.1722     0.2411     0.3100     0.3789     0.4478
2000    0.5167     0.5856     0.6614     0.8364     1.0486     1.3049     1.6150     1.9898
2100    2.4145     2.9929     3.6571     4.3543     5.3988     6.4433     7.1406     7.7358
2200    8.2181     8.6122     8.9264     9.1951     9.6870    10.1004    10.6033    11.2110
2300   11.5596    11.9110    12.2252    12.5091    12.5394
2400    0.0000     0.1654     0.2632     0.3238     0.3707     0.4079     0.4396     0.4685
2500    0.4919     0.5154     0.5374     0.5843     0.6339     0.6848     0.7372     0.7896
2600    0.8433     0.8929     0.9384     0.9701     0.9894     0.9756     0.9467     0.9067
2700    0.8654     0.8254     0.7896     0.7551     0.6862     0.6228     0.5374     0.4258
2800    0.3596     0.2921     0.2301     0.1791     0.1722
2900    0.0000     0.0344     0.1033     0.1722     0.2411     0.3100     0.3789     0.4478
3000    0.5167     0.5856     0.6614     0.8364     1.0486     1.3049     1.6150     1.9898
3100    2.4445     2.9929     3.6571     4.3543     5.3988     6.4433     7.1406     7.7358
3200    8.2181     8.6122     8.9264     9.1951     9.6870    10.1004    10.6033    11.2110
3300   11.5596    11.9110    12.2252    12.5091    12.5394
3400    0.0000    -0.2287    -0.3514    -0.4203    -0.4713    -0.5140    -0.5484    -0.5787
3500   -0.6063    -0.6311    -0.6559    -0.7069    -0.7606    -0.8157    -0.8681    -0.9163
3600   -0.9577    -0.9894    -1.0031    -0.9921    -0.9396    -0.8392    -0.7427    -0.6476
3700   -0.5650    -0.4974    -0.4437    -0.3982    -0.3142    -0.246[illegible]    -0.1695    -0.0897
3800   -0.0551     0.0344     0.1378     0.1654     0.1722
3900       2   23    23
4000   -0.1000     0.2200     2.0669    -0.1378
4100    0.0000     0.0138     0.0413     0.0896     0.1516     0.2136     0.2756     0.4134
4200    0.5512     0.6890     0.8268     0.9646     1.1024     1.2402     1.3780     1.5157
4300    1.6535     1.7913     1.9291     2.0669     2.2047     2.3425     2.4803
4400    0.0000     0.0965     0.1378     0.1929     0.2343     0.2756     0.3031     0.3445
4500    0.3720     0.3858     0.3927     0.3858     0.3789     0.3583     0.3307     0.3031
4600    0.2756     0.2343     0.1929     0.1516     0.1033     0.0482     0.0000
4700    0.0000     0.0138     0.0413     0.0896     0.1516     0.2136     0.2756     0.4134
4800    0.5512     0.6890     0.8268     0.9646     1.1024     1.2402     1.3780     1.5157
4900    1.6535     1.7913     1.9291     2.0669     2.2047     2.34[illegible]5     2.4803
5000    0.0000    -0.0344    -0.0689    -0.1033    -0.1240    -0.1309    -0.1378    -0.1378
5100   -0.1419    -0.1461    -0.1516    -0.1516    -0.1516    -0.1461    -0.1419    -0.1309
5200   -0.1033    -0.0756    -0.0482    -0.0276    -0.0138    -0.0069     0.0000
5300       1   17    17
5400   -0.1000     0.0000
5500    0.0000     0.0262     0.0524     0.1047     0.1571     0.2094     0.3142     0.4189
5600    0.5236     0.6283     0.8378     1.0472     1.2567     1.3780     1.7913     2.2047
5700    2.7559
5800    0.0000     0.0882     0.1171     0.1557     0.1846     0.2081     0.2425     0.2659
5900    0.2797     0.2880     0.2866     0.2673     0.2343     0.2136     0.1406     0.0799
6000    0.0000
6100    0.0000     0.0262     0.0524     0.1047     0.1571     0.2094     0.3142     0.4189
6200    0.5236     0.6283     0.8378     1.0472     1.2567     1.3780     1.7913     2.2047
6300    2.7559
6400    0.0000    -0.0482    -0.0620    -0.0758    -0.0758    -0.0690    -0.0620    -0.0413
6500   -0.0276    -0.0207    -0.0069     0.0069     0.0138     0.0207     0.0276     0.0207
6600    0.0000
6700    2
6800    1      1      2      1   -22.8700
6900    3      1      2      2    11.5600
7000    4      1      3      2    15.1600
7100    1
7200       0.00
7300    1
7400       0.125
7500    1.1483     0.0833
7600    518.70       1.20      0.710       1.0
7700         0          0          0
7800         0          0          0
7900         0          0          0
8000         0          0          0
8100         0          0          0
8200         0          0          0
8300         0          0          0
8400         0          0          0
8500    1    1    1
8600   THE END
```

ELEMENT GEOMETRY (lines 400–6600)

SLOT DATA (lines 6800–7000)

FLOW PARAMETERS (lines 7600–8400)

APPENDIX (ii) GEOMETRY MODIFICATION PROGRAM

```
C-----------------------------------------------------------------------------
C
C          PROGRAM GEOM2 : RANDOM MODIFICATION OF 1 TO 10 DEGREES
C                          OF FREEDOM
C
C          CAPABILITIES : A. MODIFY 0-10 PARAMETERS
C                         B. MAXIMUM 5 MUTATION LENGTH GROUPS
C                         C. MAXIMUM 10 CASES/LENGTH GROUP
C
C          DEGREES OF FREEDOM/10 PARAMETERS
C                 1   X-LOCATION, 1ST PIVOT POINT
C                 2   Y-LOCATION, 1ST PIVOT POINT
C                 3   DEFLECTION, 1ST FLAP WRT MAIN AIRFOIL
C                 4   X-LOCATION, 2ND PIVOT POINT
C                 5   Y-LOCATION, 2ND PIVOT POINT
C                 6   DEFLECTION, 2ND FLAP WRT MAIN AIRFOIL
C                 7   X-LOCATION, 3RD PIVOT POINT
C                 8   Y-LOCATION, 3RD PIVOT POINT
C                 9   DEFLECTION, 3RD FLAP WRT 2ND FLAP
C                10   ANGLE OF ATTACK, MAIN AIRFOIL
C                 *   ALL DIMENSIONS IN INCHES OR DEGREES  *
C
C          INPUT: VARIABLE       PURPOSE                          FORMAT
C                 NODNUM         MODIFICATION SET NUMBER          I2
C                 I1,I2          INTEGERS USED BY RANDOM          I10,/I10
C                                NUMBER GENERATOR, RETURNED
C                                EACH RUN
C                 NINC           NUMBER OF MUTATION LENGTH        I2
C                                GROUPS, <=5
C                 NCASE          NUMBER CASES/GROUP, <=10         I2
C                 QPAR(I)        MODIFICATION CONTROL             10I2
C                 I=1,10         =1, MODIFY PAR(I)
C                                =0, DO NOT MODIFY PAR(I)
C                 NPAR           NUMBER OF PARAMETERS TO          I2
C                                BE MODIFIED
C                 INCR(I)        INCR(1):INCR(NINC)=MUTATION      NINC*2
C                 I=1,2*NINC     LENGTHS FOR X-Y PIVOT POINT      (F5.2)
C                                LOCATIONS
C                                INCR(NINC+1):INCR(2*NINC)=
C                                DEGREES MUTATION LENGTH FOR
C                                FLAP DEFLECTION, ALPHA
C                 IPAR(I)        INITIAL VALUES OF 10             10(F6.2/)
C                 I=1,10         PARAMETERS
C
C-----------------------------------------------------------------------------
          INTEGER NINC,NCASE,NPAR,QPAR(10),I1,I2,MULT,L1,L2,L3,NODNUM
          INTEGER L4,DNINC
          REAL PAR(5,10,10),IPAR(10),INCR(10),X1,Z1,X2,Z2,X3,Z3,INCR
          REAL SIGNUM
C--------X1,Z1,X2,Z2,X3,Z3 SPECIFY RANGE OF MOTION FOR PIVOT POINTS
C--------IN INCHES, HORIZONTAL AND VERTICAL AXIAL DIRECTIONS, AND
C--------CAN BE MODIFIED TO SUIT USER
          DATA X1,Z1,X2,Z2,X3,Z3,MULT/1.5,1.0,1.5,1.0,1.5,1.0,1.0/
          ACCEPT 100,NODNUM,I1,I2,NINC,NCASE,(QPAR(I),I=1,10),NPAR
 100      FORMAT (I2,/,I10,/,I10,/,I2,/,I2,/,10I2,/,I2)
          DNINC=NINC*2
          DO 150 I=1,DNINC
          ACCEPT 200,INCR(I)
 200      FORMAT (F5.2)
 150      CONTINUE
          ACCEPT 300,(IPAR(I),I=1,10)

 300      FORMAT (F6.2,9(/,F6.2))
C--------LOOP FOR NINC MUTATION LENGTHS
          DO 1000 L1=1,NINC
          INCR(L1)=INCR(L1)*0.01
C--------LOOP FOR NUMBER OF CASES/LENGTH GROUP
          DO 900 L2=1,NCASE
 490      L4=0
C--------LOOP FOR 10 PARAMETERS
          DO 800 L3=1,10
          IF(QPAR(L3).NE.1) GOTO 700
C--------SHOULD PAR(I) BE MODIFIED
 500      MULT=1
C--------CALL RANDOM NUMBER GENERATOR, RANDOM PARAMETER SELECTION
          CALL RANDU(I1,I2,INCRDM)
          IF(INCRDM.GE.0.50) GOTO 600
C--------CALL RANDOM NUMBER GENERATOR, POSITIVE OR NEGATIVE INCREM
          CALL RANDU(I1,I2,SIGNUM)
          IF(SIGNUM.GE.0.50) MULT=-1
C
```

```
C
C
C
      IF(L3.EQ.1) PAR(L1,L2,L3)=IPAR(1)+(MULT*INCR(L1)*X1)
      IF(L3.EQ.2) PAR(L1,L2,L3)=IPAR(2)+(MULT*INCR(L1)*Z1)
      IF(L3.EQ.3) PAR(L1,L2,L3)=IPAR(3)+(MULT*INCR(L1+NINC))
      IF(L3.EQ.4) PAR(L1,L2,L3)=IPAR(4)+(MULT*INCR(L1)*X2)
      IF(L3.EQ.5) PAR(L1,L2,L3)=IPAR(5)+(MULT*INCR(L1)*Z2)
      IF(L3.EQ.6) PAR(L1,L2,L3)=IPAR(6)+(MULT*INCR(L1+NINC))
      IF(L3.EQ.7) PAR(L1,L2,L3)=IPAR(7)+(MULT*INCR(L1)*X3)
      IF(L3.EQ.8) PAR(L1,L2,L3)=IPAR(8)+(MULT*INCR(L1)*Z3)
      IF(L3.EQ.9) PAR(L1,L2,L3)=IPAR(9)+(MULT*INCR(L1+NINC))
      IF(L3.EQ.10) PAR(L1,L2,L3)=IPAR(10)+(MULT*INCR(L1+NINC))
      IF(PAR(L1,L2,10).LT.0.0) GOTO 500
      GOTO 750
600   L4=L4+1
C-------CHECK TO PREVENT DUPLICATION OF INITIAL GEOMETRY
      IF(L4.EQ.NPAR) GOTO 400
700   PAR(L1,L2,L3)=IPAR(L3)
750   CONTINUE
800   CONTINUE
900   CONTINUE
1000  CONTINUE
      WRITE (6,1100) MODNUM,I1,I2,NINC,NCASE
1100  FORMAT (///,7X,'GEOMETRY MODIFICATION',2X,I2,//,7X,'I1= ',
     X I10,2X,'I2= ',I10,2X,'NINC= ',I2,2X,'NCASE= ',I2,//,9X,
     X 'INCR NUM',3X,'% STEP',3X,'DEGREE')
      DO 1240 I=1,NINC
      INCR(I)=INCR(I)*100.0
      WRITE (6,1220) I,INCR(I),INCR(I+NINC)
1220  FORMAT (12X,I2,7X,F5.2,4X,F5.3)
1240  CONTINUE
      WRITE (6,1200) (GPAR(I),I=1,10)
1200  FORMAT (///,9X,'PAR1  PAR2  PAR3  PAR4  PAR5  PAR6  PAR7',
     X '  PAR8  PAR9  PAR10',/,' GPAR      ',10(I1,5X))
      WRITE (6,1300) (IPAR(J),J=1,10)
1300  FORMAT (' IN.GE.',10(F6.2))
      WRITE (6,1400)
1400  FORMAT (' IN CS ')
      DO 1700 L1=1,NINC
      DO 1600 L2=1,NCASE
      L3=(L1-1)*NCASE+L2

      WRITE (6,1500) L1,L3,(PAR(L1,L2,J),J=1,10)
1500  FORMAT (/,X,I2,X,I2,X,10(F6.2),/,9X,'CL= ',6X,
     X 'CD= ',6X,'CL/CD= ',6X,'CM= ')
1600  CONTINUE
1700  CONTINUE
      STOP 'MODIFICATION COMPLETE'
      END
```

APPENDIX (iii) RANDOM NUMBER GENERATOR

D.4.9 RANDU Subroutine

The RANDU subroutine computes a pseudo-random number, as a single precision value uniformly distributed in the range:

    0.0 .LE. value .LT. 1.0

Format:

    CALL RANDU(i1,i2,x)

Arguments:

i1,i2
: INTEGER*2 variables or array elements that contain the seed for computing the random number.

x
: a real variable or array element where the computed random number is stored.

Notes:

1. The values of i1 and i2 are updated during the computation to contain the updated seed.

2. The algorithm for computing the random number value is as follows:

   If I1=0, I2=0, set generator base

   X(n+1) = 2**16 + 3

   otherwise

   X(n+1) = (2**16+3) * X(n)mod 2**32

   Store generator base X(n+1) in I1,I2.

   Result is X(n+1) scaled to a real value Y(n+1), for 0.0 .LE. Y(n+1) .LT. 1.

GEOMETRY MODIFICATION 1

I1= 1234584983 I2= 987645257 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.	0.50
2	10.	1.00
3	15.	2.00

GPAR IN.GE.	IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM
		1	1	1	1	1	1	1	1	1	1				
		1.50	-0.50	-30.00	0.25	0.60	15.00	0.00	0.28	15.00	0.50	2.31	0.54	4.26	
1	1	1.50	-0.45	-29.50	0.25	0.60	15.00	-0.08	0.23	15.00	[illegible]	2.27	0.487	4.68	-1.22
1	2	1.50	-0.45	-30.00	0.17	0.65	14.50	0.00	0.33	15.00	0.50	0.902	0.556	1.62	-0.614
1	3	1.50	-0.55	-30.00	0.25	0.60	14.50	0.00	0.33	15.00	0.50	2.28	0.523	4.36	-1.20
1	4	1.50	-0.50	-30.00	0.33	0.65	15.00	-0.08	0.28	15.00	0.50	0.803	0.463	1.73	-0.444
1	5	1.50	-0.50	-30.00	0.25	0.65	14.50	0.08	0.28	15.00	1.00	2.29	0.534	4.29	-1.18
1	6	1.50	-0.45	-30.00	0.25	0.65	15.50	-0.08	0.28	15.00	0.00	2.25	0.544	4.14	-1.20
2	7	1.50	-0.60	-31.00	0.40	0.60	15.00	0.15	0.28	14.00	0.50	2.02	0.733	2.76	-1.04
2	8	1.35	-0.50	-30.00	0.10	0.60	15.00	0.00	0.28	15.00	0.50	0.905	0.330	2.74	-0.381
2	9	1.50	-0.40	-29.00	0.25	0.50	15.00	0.15	0.28	14.00	1.50	2.43	0.481	5.05	-1.19
2	10	1.50	-0.40	-31.00	0.10	0.60	15.00	0.00	0.38	15.00	0.50	1.07	0.438	2.44	-0.678
2	11	1.65	-0.60	-31.00	0.25	0.60	15.00	0.00	0.28	15.00	0.50	2.30	0.573	4.01	-1.22
2	12	1.50	-0.50	-29.00	0.25	0.60	16.00	0.15	0.28	15.00	1.50	2.41	0.604	3.99	-1.19
3	13	1.27	-0.35	-30.00	0.25	0.60	13.00	-0.22	0.28	15.00	0.50	0.599	0.346	1.73	-0.259
3	14	1.50	-0.65	-30.00	0.03	0.60	13.00	0.00	0.28	17.00	0.50	1.10	0.363	3.03	-0.512
3	15	1.50	-0.35	-32.00	0.25	0.60	17.00	-0.22	0.28	13.00	0.50	2.32	0.629	3.69	-1.22
3	16	1.27	-0.35	-28.00	0.47	0.60	13.00	0.22	0.43	15.00	0.50	1.82	0.606	3.00	-0.913
3	(17)	1.27	-0.35	-28.00	0.25	0.60	15.00	-0.22	0.28	15.00	0.50	2.37	0.483	4.91	-1.24
3	18	1.27	-0.50	-30.00	0.25	0.75	15.00	0.00	0.28	15.00	2.50	2.44	0.693	3.52	-1.22

GEOMETRY MODIFICATION 2

I1= 1234583843 I2= 987645569 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.	0.50
2	10.	1.00
3	15.	2.00

GPAR IN.GE.	IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM
		1	1	1	1	1	1	1	1	1	1				
		1.27	-0.35	-28.00	0.25	0.60	15.00	-0.22	0.28	15.00	0.50	2.37	0.483	4.91	-1.24
1	1	1.14	-0.40	-27.50	0.17	0.60	15.00	-0.14	0.28	15.50	0.00	0.332	0.117	2.84	-0.003
1	2	1.27	-0.35	-28.50	0.17	0.65	15.00	-0.14	0.28	15.00	0.50	2.36	0.469	5.03	-1.25
1	3	1.27	-0.35	-28.00	0.25	0.55	15.50	-0.22	0.33	15.50	0.50	2.42	0.505	4.79	-1.25
1	4	1.27	-0.40	-28.00	0.33	0.55	14.50	-0.22	0.28	15.50	0.50	0.748	0.856	0.874	-0.425
1	5	1.35	-0.35	-27.50	0.17	0.60	15.50	-0.14	0.28	14.50	0.50	0.986	0.301	3.28	-0.461
1	6	1.27	-0.40	-28.50	0.33	0.65	15.00	-0.14	0.33	15.50	0.50	2.24	0.590	3.80	-1.17
2	7	1.27	-0.45	-28.00	0.10	0.60	15.00	-0.22	0.38	15.00	1.50	2.52	0.496	5.08	-1.28
2	8	1.12	-0.45	-28.00	0.25	0.60	15.00	-0.22	0.28	14.00	0.50	0.863	0.822	1.05	-0.414
2	9	1.27	-0.35	-29.00	0.40	0.60	15.00	-0.37	0.28	16.00	0.50	2.22	0.682	3.26	-1.14
2	10	1.27	-0.25	-28.00	0.25	0.60	15.00	-0.37	0.28	15.00	0.50	2.38	0.462	5.15	-1.24
2	11	1.12	-0.35	-27.00	0.25	0.60	15.00	-0.22	0.28	16.00	0.50	1.09	0.423	2.58	-0.552
2	(12)	1.42	-0.35	-27.00	0.25	0.60	14.00	-0.22	0.28	16.00	0.50	2.39	0.403	5.92	-1.23
3	13	1.27	-0.20	-30.00	0.25	0.75	15.00	0.00	0.28	13.00	2.50	2.39	0.561	4.26	-1.17
3	14	1.50	-0.50	-30.00	0.25	0.75	13.00	-0.22	0.28	15.00	0.50	0.878	0.398	2.21	-0.462
3	15	1.27	-0.20	-26.00	0.25	0.75	13.00	0.00	0.28	13.00	0.50	0.235	0.049	4.80	+0.132
3	16	1.50	-0.35	-26.00	0.25	0.75	15.00	-0.22	0.43	13.00	2.50	2.44	0.486	5.02	-1.16
3	17	1.50	-0.35	-26.00	0.47	0.60	17.00	0.00	0.43	15.00	2.50	1.92	1.00	1.92	-0.699
3	18	1.27	-0.35	-28.00	0.25	0.45	15.00	0.00	0.28	13.00	0.50	2.34	0.409	5.72	-1.19

GEOMETRY MODIFICATION 3

I1= 1231585967 I2= 987630419 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.	0.50
2	10.	1.00
3	15.	2.00

OPAR	IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM	
		1	1	1	1	1	1	1	1	1	1					
		1.42	-0.35	-27.00	0.25	0.60	14.00	-0.22	0.26	16.00	0.50	2.39	0.403	5.93	-1.23	
1	1	1.50	-0.35	-27.00	0.25	0.65	14.00	-0.14	0.26	16.50	0.50	2.36	0.412	5.73	-1.21	2:59 61
1	2	1.50	-0.40	-27.50	0.25	0.60	14.00	-0.14	0.33	16.00	0.00	0.0298	0.324	0 092	0.113	3:03.20
1	3	1.42	-0.30	-27.50	0.25	0.65	14.00	-0.22	0.26	16.00	0.00	2.28	0.398	5.72	-1.21	3:03.46
1	4	1.50	-0.30	-27.50	0.25	0.65	13.50	-0.22	0.26	16.00	1.00	0.904	0.165	5.48	-0.472	3:01.74
1	5	1.42	-0.35	-26.50	0.25	0.60	14.00	-0.22	0.33	16.00	1.00	0.150	0.063	2.38	0.183	3:01.82
1	6	1.42	-0.30	-27.00	0.17	0.60	13.50	-0.22	0.26	16.50	0.50	0.832	0.261	3.19	-0.328	3:00.96
2	7	1.57	-0.35	-26.00	0.10	0.50	14.00	-0.07	0.18	16.00	~~[illegible]~~ 0.55	0.833	0.135	6.17	-0.216	
2	8	1.42	-0.45	-26.00	0.40	0.50	13.00	-0.37	0.26	16.00	0.50	2.24	0.469	4.78	-1.15	2:56.20
2	(9)	1.42	-0.45	-26.00	0.25	0.60	13.00	-0.22	0.28	15.00	1.50	2.45	0 383	6.40	-1.21	2:58.38
2	10	1.42	-0.35	-26.00	0.10	0.70	14.00	-0.22	0.18	16.00	1.50	1.10	0.621	1.77	-0.436	3:06.47
2	11	1.57	-0.35	-28.00	0.25	0.60	14.00	-0.22	0.38	16.00	1.50	2.47	0 449	5.50	-1 224	3:00.96
2	12	1.42	-0.25	-28.00	0.40	0.50	13.00	-0.22	0.38	16.00	1.50	2 360	0.487	4.85	-1.14	2:59.07
3	13	1.42	-0.50	-27.00	0.25	0.45	16.00	-0.22	0.28	16.00	2.50	2.92	0.616	4.74	-1.37	3:20.00
3	14	1.19	-0.20	-29.00	0.25	0.45	14.00	-0.44	0.26	16.00	0.50	2.46	0.434	5.67	-1.28	
3	15	1.64	-0.35	-25.00	0.25	0.60	16.00	-0.44	0.28	18.00	0.50	2.58	0.486	5.37	-1.28	
3	16	1.42	-0.50	-29.00	0.47	0.60	12.00	-0.22	0.26	16.00	2.[illegible]	0.0568	0.605	0.0939	+0.250	
3	17	1.42	-0.20	-27.00	0.03	0.45	12.00	-0.44	0.26	16.00	0.50	1 20	0.285	4.21	-0.912	
3	18	1.64	-0.20	-27.00	0.25	0.60	14.00	-0.22	0.13	16.00	0.50	0.916	0.629	1.46	-0.287	

GEOMETRY MODIFICATION 4

I1= 1234592385 I2= 987682355 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	3.	0.50
2	5.	1.00
3	0.10.	2.00

OPAR	IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM	
		1	1	1	1	1	1	1	1	1	1					
		1.42	-0.45	-26.00	0.25	0.60	13.00	-0.22	0.28	15.00	1.50	2.45	0.383	6.40	-1.21	
1	1	1.42	-0.45	-26.00	0.21	0.58	13.00	-0.26	0.31	15.00	2.00	2.54	0.387	6.56	-1.24	2:58.85
1	2	1.38	-0.45	-26.50	0.25	0.60	13.00	-0.22	0.31	15.00	1.50	0.401	0.129	3.11	0.0219	3:01.77
1	3	1.42	-0.47	-26.50	0.25	0.60	13.50	-0.26	0.28	15.50	2.00	1.37	0.368	3.72	-0.916	3:00.98
1	4	1.42	-0.45	-25.50	0.25	0.63	13.00	-0.22	0.31	15.50	1.00	2.38	0 368	6.47	-1.21	2:56.55
1	5	1.38	-0.45	-26.00	0.25	0.63	13.00	-0.22	0.25	15.00	1.50	2.45	0.391	6.27	-1.22	2:57.21
1	(6)	1.42	-0.42	-25.50	0.21	0.63	13.00	-0.22	0.31	15.00	1.50	2.45	0.358	6.84	-1.22	2:57.13
2	7	1.42	-0.45	-27.00	0.25	0.60	13.00	-0.22	0.33	15.00	2.50	0.695	0.0568	12.2	-0.130	3:01.74
2	8	1.42	-0.40	-27.00	0.33	0.60	13.00	-0.30	0.33	14.00	~~2.50~~ 2.55	0.997	0.314	3.18	-0.492	3:09.89
2	9	1.34	-0.45	-25.00	0.25	0.60	12.00	-0.30	0.28	15.00	1.50	0.762	0.572	1.33	-0.291	3:01.13
2	10	1.34	-0.45	-26.00	0.17	0.55	13.00	-0.22	0.33	16.00	2.50	2.66	0.431	6.17	-1.27	2:57.72
2	11	1.34	-0.40	-26.00	0.25	0.60	12.00	-0.14	0.23	15.00	1.50	0.607	0.189	3.21	-0.194	3:01.74
2	12	1.42	-0.40	-26.00	0.25	0.60	13.00	-0.14	0.28	15.00	2.50	2.58	0.411	6.28	-1.22	2:57.15
3	13	1.42	-0.45	-26.00	0.40	0.70	13.00	-0.37	0.18	17.00	1.50	0.855	0.274	3.12	-0.324	3:00.95
3	14	1.42	-0.45	-28.00	0.40	0.60	11.00	-0.07	0.38	13.00	1.50	2.10	0.392	5.36	-1.06	2:57.67
3	15	1.42	-0.55	-24.00	0.25	0.60	15.00	-0.37	0.28	15.00	1.50	2.56	0.469	5.46	-1.25	2:56.78
3	16	1.57	-0.35	-26.00	0.25	0.70	11.00	-0.22	0.28	15.00	1.50	0.868	0.642	1.35	-0.568	2:59.13
3	17	1.57	-0.55	-26.00	0.25	0.60	15.00	-0.22	0.16	15.00	1.50	0.608	0.875	0.695	-0.125	3:01.89
3	18	1.42	-0.45	-26.00	0.10	0.70	13.00	-0.37	0.38	17.00	~~3.50~~ 3.55	0.744	0.0832	8.94	-0.111	3:09.30

GEOMETRY MODIFICATION 5

I1= 1234575874 I2= 987636259 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.00	0.25
2	10.00	0.50
3	15.00	0.75

OPAR IN.GE.	IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM	
		1	1	1	1	1	1	1	1	1	1					
		1.42	-0.42	-25.50	0.21	0.63	13.00	-0.22	0.31	15.00	1.50	2.45	0.358	6.84	-1.22	
1	1	1.42	-0.42	-25.50	0.28	0.63	13.00	-0.22	0.30	14.75	~~1.75~~ 1.80	2.43	0.394	6.15	-1.19	2:59.20
~~1~~	~~2~~	1.50	-0.37	-25.75	0.28	0.63	13.00	-0.22	0.31	15.25	~~1.75~~ 1.80					
1	3	1.42	-0.42	-25.75	0.21	0.68	12.75	-0.22	0.31	15.00	1.75	2.44	0.376	6.49	-1.21	2:59.53
1	4	1.34	-0.42	-25.50	0.21	0.63	13.00	-0.22	0.31	15.25	1.75	2.49	0.382	6.52	-1.23	2:58.14
~~1~~	~~5~~	1.42	-0.37	-25.50	0.13	0.58	13.00	-0.22	0.31	14.75	~~1.75~~ 1.80					
1	6	1.31	-0.47	-25.50	0.13	0.68	13.00	-0.22	0.31	14.75	1.50	0.462	0.135	3.42	-0.0419	3:05.86
2	7	1.42	-0.52	-25.50	0.21	0.63	13.00	-0.07	0.31	15.00	2.00	1.07	0.251	4.26	-0.456	3:02.30
2	8	1.42	-0.42	-25.50	0.06	0.63	13.50	-0.22	0.41	15.00	1.50	0.0948	0.216	0.439	+0.252	3:02.37
2	9	1.27	-0.32	-25.50	0.36	0.73	13.00	-0.22	0.31	15.50	1.50	0.0590	0.565	0.104	0.169	3:02.72
2	10	1.47	-0.42	-25.50	0.36	0.53	13.00	-0.37	0.31	15.00	1.50	0466	0.368	0.127	0.286	3:00.58
2	11	1.27	-0.32	-25.00	0.36	0.53	13.00	-0.22	0.31	15.00	1.50	0.470	0.0436	10.8	-0.0134	3:02.84
2	(12)	1.42	-0.42	-25.00	0.06	0.53	13.50	-0.22	0.31	15.50	1.50	2.59	0.319	8.12	-1.27	2:58.84
3	13	1.42	-0.42	-25.50	-0.02	0.63	12.25	-0.22	0.46	15.00	0.75	2.30	0.282	8.16	-1.20	3:01.08
3	14	1.19	-0.42	-24.75	0.21	0.63	13.00	-0.22	0.46	14.25	0.75	2.25	0.349	6.45	-1.16	2:57.36
3	15	1.42	-0.27	-25.50	0.21	0.63	13.00	0.00	0.46	15.00	1.50	2.25	0.328	7.16	-1.14	2:59.71
3	16	1.64	-0.27	-25.50	-0.02	0.63	13.00	-0.22	0.31	14.25	0.75	0.130	0.320	0.406	+0.237	3:02.60
3	17	1.42	-0.57	-24.75	0.44	0.48	13.00	-0.44	0.31	15.75	0.75	2.19	0.558	3.92	-1.08	2:56.96
~~3~~	~~18~~	1.42	-0.42	-24.75	-0.02	0.63	13.00	-0.22	0.46	14.25	0.75	-0.128	0.0349		+0.291	3:02.84

GEOMETRY MODIFICATION 6

I1= 1234593716 I2= 987660723 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.00	0.25
2	10.00	0.50
3	15.00	0.75

OPAR IN.GE.	IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL	CD	CL/CD	CM
		1	1	1	1	1	1	1	1	1	1				
		1.42	-0.42	-25.00	0.06	0.53	13.50	-0.22	0.31	15.50	1.50	2.59	0.319	8.12	-1.27
~~1~~	~~1~~	1.50	-0.47	-25.00	0.06	0.53	13.75	-0.22	0.31	15.25	~~1.25~~ 1.30				
1	2	1.50	-0.42	-25.00	-0.02	0.53	13.75	-0.30	0.26	15.50	1.50	1.03	0.193	5.34	-0.444
1	3	1.42	-0.42	-25.25	-0.02	0.58	13.75	-0.30	0.26	15.75	1.25	0.985	0.180	5.47	-0.416
1	4	1.50	-0.37	-24.75	0.06	0.58	13.25	-0.22	0.36	15.50	1.75	2.60	0.323	8.05	-1.30
1	5	1.50	-0.37	-25.25	0.06	0.48	13.25	-0.22	0.36	15.75	1.75	1.44	0.285	5.05	-0.970
1	(6)	1.50	-0.42	-24.75	-0.02	0.53	13.50	-0.14	0.26	15.25	1.25	2.58	0.273	9.45	-1.27
2	7	1.27	-0.52	-25.50	-0.09	0.53	13.00	-0.07	0.21	16.00	~~1.50~~ 1.55	0.786	0.0815	9.64	-0.150
2	8	1.27	-0.42	-25.00	0.21	0.53	14.00	-0.37	0.41	15.50	1.50	2.53	0.41	6.17	-1.25
2	9	1.42	-0.37	-24.50	-0.09	0.63	14.00	-0.07	0.31	15.00	2.00	0.632	0.103	6.14	-0.0749
2	10	1.57	-0.52	-24.50	0.21	0.53	14.00	-0.37	0.31	15.50	1.50	2.60	0.387	6.72	-1.26
~~2~~	~~11~~	1.57	-0.42	-25.00	0.06	0.53	13.50	-0.22	0.21	15.50	~~1.50~~ 1.55				
2	12	1.27	-0.42	-25.00	0.21	0.63	13.50	-0.37	0.31	15.50	~~1.40~~ 1.05	0.429	0.525	0.817	-0.0772
3	13	1.42	-0.12	-25.00	0.26	0.53	13.50	-0.22	0.46	14.75	0.75	2.33	0.362	6.44	-1.17
3	14	1.64	-0.42	-25.00	0.06	0.38	13.50	0.00	0.31	15.50	2.25	2.72	0.445	6.11	-1.24
3	15	1.64	-0.42	-24.25	0.00	0.53	14.25	-0.22	0.16	15.50	1.50	0.690	0.850	0.812	-0.0878
3	16	1.64	-0.27	-25.00	-0.16	0.53	13.50	0.00	0.31	14.75	1.50	1.02	0.244	4.18	-0.346
3	17	1.42	-0.27	-24.25	-0.16	0.68	13.50	-0.44	0.46	14.75	2.25	2.63	0.323	8.14	-1.28
3	18	1.19	-0.42	-25.75	0.06	0.38	12.75	-0.22	0.46	15.50	1.50	0.508	0.149	3.41	-0.125

GEOMETRY MODIFICATION 7

I1= 1234585947 I2= 987684723 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.50	0.13
2	5.00	0.25
3	7.50	0.38

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=	
	1	1	1	1	1	1	1	1		1					
	1.50	-0.42	-24.75	-0.02	0.53	13.50	-0.14	0.26	15..5	1.25	2.58	0.273	9.45	-1.27	
1 1	1.46	-0.44	-24.63	-0.02	0.53	13.50	-0.10	0.28	15.13	~~1.30~~ 1.40	1.09	0.218	5.00	-0.560	3:01.29
1 2	1.50	-0.34	-24.75	-0.02	0.55	13.50	-0.10	0.23	15.38	1.38	2.59	0 285	9 09	-1 27	2:56.38
1 3	1.50	-0.42	-24.75	0.02	0.53	13.50	-0.14	0.23	15.38	1.25	2.59	0.281	9.22	-1.27	3:01.21
1 4	1.46	-0.42	-24.75	-0.02	0.50	13.50	-0.18	0.26	15.38	1.13	2.58	0 268	9 63	-1.27	2:54.84
1 5	1.54	-0.44	-24.75	-0.02	0.53	13.38	-0.10	0.26	15.25	1.38	0.902	0.148	6.09	-0.361	3:02.19
1 6	1.54	-0.42	-24.88	0.02	0.53	13.63	-0.14	0.26	15.25	1.38	2 59	0.288	8.99	-1 26	2:58.35
2 7	1.42	-0.47	-24.75	0.06	0.56	13.50	-0.14	0.21	15.00	1.25	2.53	0 310	8.16	-1 25	2:55.68
2 8	1.58	-0.42	-25.00	-0.02	0.58	13.50	-0.06	0. 1	15.25	1.25	2.56	0.279	9.18	-1.26	3:03.47
2 9	1.58	-0.42	-24.75	-0.10	0.58	13.25	-0.14	0.21	15.25	~~1.50~~ 1.55	0.749	0.0446	16 80	-0 162	3:03.24
2 (10)	1.58	-0.37	-24.75	-0.02	0.48	13.75	-0.14	0.21	15.25	1.25	2.65	0 245	10 82	-1.28	2:56.33
2 11	1.50	-0.42	-24.75	0.06	0.53	13.50	-0.14	0.31	15.25	~~1.00~~ 1.05	2.51	0.282	8.90	-1.24	2:58.26
2 12	1.50	-0.37	-24.75	-0.10	0.53	13.25	-0.06	0.31	15.50	1.25	1.09	0.213	5.12	-0.573	3:02.59
3 13	1.39	-0.49	-24.75	-0.02	0.60	13.13	-0.25	0.19	15.25	~~[illegible]~~	0.728	0.518	1.40	-0.226	3:00.90
3 14	1.50	-0.42	-24.38	0.09	0.53	13.13	-0.03	0.26	15.25	0.88	1.27	0.191	6.65	- 0.555	3:03.04
3 15	1.39	-0.42	-24.75	-0.02	0.53	13.50	-0.14	0.25	15.25	1.25	2 57	0.223	9.08	-1.27	2:58.92
3 16	1.39	-0.34	-25.13	-0.02	0.53	13.50	-0.25	0.19	15.63	1.25	0.976	0 488	2 00	-0.342	3:03.04
3 17	1.50	-0.42	-24.38	0.09	0.45	13.50	-0.14	0.33	15.25	~~1.13~~ 1.00	2 61	0 287	9 09	-1.24	3:05.29
3 18	1.50	-0.42	-24.38	-0.02	0.60	13.13	-0.14	0.33	14.88	1.25	0.828	-0 0538	15.29	-0.412	3:04.97

GEOMETRY MODIFICATION 8

I1= 1234586320 I2= 987630883 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.50	0.13
2	5.00	0.25
3	7.50	0.38

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.58	-0.37	-24.75	-0.02	0.48	13.75	-0.14	0.21	15.25	1.25	2.65	0.245	10.82	-1.28
1 1	1.62	-0.37	-24.75	-0.06	0.48	13.75	-0.18	0.18	15.38	~~1.25~~ 1.30	0.967	1 03	0.939	-0.415
1 2	1.54	-0.37	-24.75	0.02	0.45	13.75	-0.14	0.18	15.38	1.25	1.43	0.273	5.24	-0.925
1 3	1.58	-0.40	-24.63	-0.02	0.50	13.75	-0.14	0.18	15.13	1.13	1.83	0.465	3.94	-1.56
1 4	1.58	-0.34	-24.75	-0.02	0.45	13.75	-0.18	0.21	15.25	1.13	1.17	0.691	1.69	-0.650
~~1 5~~	1.62	-0.40	-24.88	-0.06	0.50	13.88	-0.18	0.18	15.13	~~1.13~~ 1 30				
1 6	1.58	-0.40	-24.63	-0.06	0.48	13.75	-0.14	0.18	15.13	1.13	0.722	0.0149	48.5	- 0.145
2 (7)	1.66	-0.37	-24.50	-0.10	0.48	13.75	-0.14	0.16	15.00	1.00	2.64	0.213	12.4	-1.29
2 8	1.58	-0.37	-25.00	0.06	0.48	13.75	-0.06	0.26	15.25	~~1.50~~ 1.55	2.63	0.277	9.49	-1.25
2 9	1.66	-0.37	-24.75	-0.02	0.53	14.00	-0.22	0.21	15.25	~~1.25~~ 1.30	1.07	0.660	1.62	-0.404
2 10	1.66	-0.32	-25.00	-0.02	0.53	13.75	-0.06	0.21	15.25	1.25	2.61	0.246	10.6	-1.26
~~2 11~~	1.58	-0.32	-24.75	0.06	0.43	13.75	-0.14	0.21	15.25	~~1.00~~ 1.05				
2 12	1.58	-0.37	-25.00	-0.10	0.48	13.75	-0.22	0.26	15.50	1.50	1.34	0.519	2.58	-0.853
3 13	1.69	-0.37	-24.75	-0.02	0.48	14.13	-0.25	0.21	15.63	0.88	2.65	0.249	10.6	-1.30
~~3 14~~	1.69	-0.44	-24.75	-0.13	0.41	13.38	-0.14	0.28	15.25	~~0.88~~ 0.90				
~~3 15~~	1.69	-0.37	-24.75	-0.02	0.48	13.75	-0.25	0.21	15.25	~~0.88~~ 0.90				
3 16	1.47	-0.37	-24.38	-0.02	0.56	13.75	-0.03	0.21	15.25	1.25	1.16	0.207	5.60	-0.407
3 17	1.69	-0.30	-24.38	0.09	0.41	13.75	-0.25	0.21	14.88	1.25	0.930	0.254	3.66	-0.290
3 18	1.47	-0.37	-24.38	-0.13	0.48	13.38	-0.25	0.21	15.25	1.25	1.17	0.220	5.32	-0.488

GEOMETRY MODIFICATION 9

I1= 1234579954 I2= 987671283 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.50	0.125
2	5.00	0.250
3	7.50	0.375

GEAR IN.GE. IN.CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.66	-0.37	-24.50	-0.10	0.48	13.75	-0.14	0.16	15.00	1.00	2.64	0.213	12.4	-1.29
1 1	1.66	-0.37	-24.50	-0.06	0.48	13.75	-0.16	0.13	14.88	1.00	0 899	0.905	0.993	-0.253
1 2	1.62	-0.34	-24.50	-0.06	0.50	13.75	-0.14	0.19	15.13	0.88	2.60	0.215	12.1	-1.27
1 3	1.66	-0.40	-24.50	-0.10	0.45	13.75	-0.16	0.16	15.00	1.00	0.705	0.557	1.27	-0.0287
1 4	1.70	-0.40	-24.50	-0.06	0.48	13.63	-0.14	0.16	15.00	1.00	0.768	-0.0471		-0.101
1 5	1.70	-0.37	-24.50	-0.14	0.45	13.63	-0.16	0.13	15.00	1.13	0.830	0.484	1.71	-0.0804
1 6	1.66	-0.37	-24.38	-0.06	0.45	13.75	-0.14	0.19	15.00	1.00	1.40	0.249	5 62	-0.964
2 7	1.60	-0.37	-24.75	-0.10	0.43	13.75	-0.22	0.11	15.00	1.25	0.903	0.00159	568	-0.166
2 8	1.66	-0.37	-24.75	-0.18	0.53	13.75	-0.22	0.11	15.00	1.25	0.811	0.163	4 98	-0.0561
2 9	1.66	-0.37	-24.50	-0.16	0.48	13.75	-0.14	0.10	15.00	1.00	2 65	0.219	12.1	-1.31
~~[illegible]~~	1.66	-0.32	-24.25	-0.10	0.43	14.06	-0.14	0.21	15.00	~~1.00~~ 1.05				
2 11	1.74	-0.42	-24.50	-0.02	0.48	13.50	-0.14	0.16	15.00	0.75	2.57	0.218	11.8	-1.26
2 12	1.58	-0.37	-24.75	-0.02	0.48	13.75	-0.22	0.15	15.00	1.00	0.768	0.762	1.01	-0.182
3 13	1.77	-0.37	-24.50	-0.21	0.41	13.75	-0.03	0.16	15.00	1.00	1.18	-0.0794		-0.569
~~[illegible]~~	1.77	-0.30	-24.13	-0.10	0.41	14.13	-0.14	0.16	15.00	~~1.00~~ 1.05				
3 15	1.66	-0.37	-24.13	0.01	0.48	14.13	-0.14	0.16	15.00	1.00	1.11	0.0986	11.3	-0.490
3 16	1.66	-0.44	-24.50	-0.10	0.41	13.75	-0.25	0.09	15.00	1.38	2.76	0.371	7 44	-1.33
3 (17)	1.77	-0.44	-24.13	0.01	0.41	13.75	-0.03	0.09	15.00	1.38	2.71	0.228	11.9	-1.28
3 18	1.55	-0.44	-24.50	-0.10	0.56	14.13	-0.03	0.09	14.63	0.63	2.55	0.238	10.7	-1.28

GEOMETRY MODIFICATION 10

I1= 1234585673 I2= 987682009 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	3.75	0.200
2	7.50	0.400
3	11.25	0.600

GEAR IN.GE. IN.CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.77	-0.44	-24.13	0.01	0.41	13.75	-0.03	0.09	15.00	1.38	2.71	0.228	11.9	-1.28
1 1	1.77	-0.44	-24.13	0.01	0.41	13.75	-0.03	0.09	14.80	1.38	2.70	0.226	11.9	-1.27
1 2	1.71	-0.46	-23.93	0.07	0.41	13.75	-0.09	0.09	14.80	1.18	2.68	0.236	11.4	-1.27
1 3	1.77	-0.44	-24.13	0.07	0.41	13.95	-0.09	0.05	15.00	1.38	2.73	0.244	11.2	-1.28
1 4	1.71	-0.45	-23.93	0.01	0.41	13.75	-0.03	0.09	15.20	1.58	2.75	0.622	4.42	-1.29
1 5	1.77	-0.44	-23.93	0.07	0.37	13.55	-0.03	0.13	15.00	1.18	2.66	0.216	12.3	-1.24
1 6	1.71	-0.44	-24.13	0.01	0.37	13.75	-0.03	0.13	15.00	1.58	2.73	0.608	4.49	-1.27
2 7	1.88	-0.51	-24.13	0.01	0.48	13.35	-0.14	0.02	15.00	1.78	2.74	0.303	9.04	-1.29
2 8	1.66	-0.44	-24.13	0.01	0.41	14.15	-0.14	0.17	15.40	1.38	2.74	0.396	6.92	-1.30
2 9	1.88	-0.51	-24.13	0.01	0.41	13.75	-0.03	0.09	14.60	1.38	2.69	0.240	11.2	-1.27
2 10	1.77	-0.51	-24.53	0.01	0.41	13.75	-0.03	0.09	15.00	1.38	2.70	0.740	3.65	-1.28
~~2 11~~	1.66	-0.44	-24.13	-0.10	0.41	13.75	-0.03	0.09	15.00	1.38				
2 12	1.66	-0.44	-24.13	-0.10	0.41	13.35	-0.14	0.02	15.00	1.38	1.15	0.166	6.93	-0.379
~~[illegible]~~	1.77	-0.44	-24.73	-0.16	0.41	13.15	-0.03	0.09	15.60	0.78				
~~[illegible]~~	1.60	-0.44	-24.73	0.18	0.30	13.75	-0.03	-0.02	15.00	1.38				
3 15	1.94	-0.44	-23.53	0.01	0.41	14.35	-0.03	0.09	15.60	1.38	2.79	0.251	11.1	-1.30
~~[illegible]~~	1.60	-0.33	-24.73	-0.16	0.52	14.35	0.14	-0.02	15.00	1.38				
3 (17)	1.77	-0.44	-24.13	0.01	0.41	13.75	-0.03	0.09	15.00	0.76	2.62	0.203	12.9	-1.26
~~[illegible]~~	1.94	-0.44	-24.13	0.01	0.41	13.75	-0.03	-0.02	14.40	1.38				

GEOMETRY MODIFICATION 11

I1= 1234595927 I2= 987652473 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.60	0.300
2	11.25	0.600
3	16.90	0.900

GPAR INCGE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.77	-0.44	-24.13	0.01	0.4[illegible]	13.75	-0.03	0.09	15.00	0.78	2.62	0.202	12.9	-1.26
1 1	1.69	-0.50	-24.13	0.09	0.41	13.75	0.05	0.15	15.00	1.08	2.57	0.250	10.4	-1.23
~~(struck out)~~	1.77	-0.50	-24.13	-0.07	0.35	13.45	-0.03	0.15	15.00	~~0.78~~ 0.80				
~~(struck out)~~	1.69	-0.38	-24.13	0.01	0.47	13.75	-0.11	0.03	15.30	~~1.08~~ [illegible]				
1 4	1.77	-0.50	-24.13	0.01	0.41	13.45	-0.03	0.15	15.00	1.08	2.63	0.219	12.0	-1.26
1 5	1.77	-0.38	-23.83	-0.07	0.41	13.75	-0.11	0.09	15.00	0.78	2.67	0.178	15.0	-1.29
1 6	1.77	-0.50	-23.83	-0.07	0.35	14.05	-0.03	0.09	14.70	0.78	2.68	0.191	14.0	
2 7	1.77	-0.55	-24.73	0.01	0.52	13.15	-0.03	0.20	15.60	0.78	2.51	0.264	9.51	-1.24
2 8	1.77	-0.33	-24.13	-0.16	0.30	13.15	-0.20	0.09	15.00	0.78	1.09	0.325	3.35	-0.308
2 9	1.77	-0.44	-24.73	0.01	0.52	14.35	-0.03	0.09	15.00	0.78	2.61	0.257	10.2	-1.28
2 10	1.60	-0.33	-24.73	0.01	0.52	14.35	-0.03	0.09	14.40	0.78	2.58	0.223	11.6	-1.26
2 11	1.94	-0.33	-24.73	0.18	0.41	14.35	-0.20	-0.02	15.00	0.78	2.67	0.261	10.2	-1.27
2 (12)	1.77	-0.44	-24.13	0.01	0.30	13.75	-0.03	0.09	15.60	0.78	2.70	0.182	14.8	-1.28
3 13	1.77	-0.44	-24.13	0.26	0.24	13.75	-0.03	0.09	15.00	0.78	2.35	0.289	8.13	-0.968
~~3 14~~	2.02	-0.27	-24.13	0.01	0.58	12.65	-0.03	-0.08	15.00	0.78				
~~3 15~~	1.77	-0.44	-25.03	0.01	0.41	13.75	-0.28	-0.08	15.90	~~0.78~~ 0.80				
3 16	1.77	-0.27	-23.23	0.26	0.41	13.75	-0.03	0.09	15.90	~~0.78~~ 0.80	2.65	0.236		-1.23
3 17	1.77	-0.27	-24.13	-0.24	0.58	13.75	-0.03	0.09	15.00	1.08	2.73	0.237	11.5	-1.30
3 18	1.77	-0.61	-24.13	0.01	0.41	13.75	-0.03	0.26	15.00	~~0.78~~ 0.80	2.54	0.257		-1.24

GEOMETRY MODIFICATION 12

I1= 1234598170 I2= 987653643 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	5.60	0.300
2	11.25	0.600
3	16.90	0.900

GPAR INCGE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.77	-0.44	-24.13	0.01	0.30	13.75	-0.03	0.09	15.60	0.78	2.70	0.182	14.8	-1.28
1 1	1.69	-0.50	-24.13	-0.07	0.30	13.45	-0.11	0.09	15.30	1.08	2.74	0.436	6.28	-1.32
1 2	1.69	-0.50	-23.83	-0.07	0.30	13.75	0.05	0.09	15.30	0.78	2.69	0.173	15.55	-1.29
1 3	1.85	-0.50	-24.13	0.01	0.24	13.45	-0.11	0.09	15.30	0.78	2.70	0.174	15.52	-1.28
~~(struck out)~~	1.65	-0.50	-24.13	-0.07	0.24	13.75	-0.03	0.09	15.60	0.78 0.80				
1 5	1.77	-0.50	-24.13	-0.07	0.30	13.45	-0.11	0.03	15.90	0.78 [illegible]	1.49	-0.62		-0.853
1 (6)	1.69	-0.44	-24.13	0.01	0.30	14.05	-0.03	0.03	15.30	0.48	2.68	0.170	15.8	-1.29
2 7	1.60	-0.33	-24.73	0.01	0.30	13.75	-0.20	0.20	15.60	~~1.38~~ 1.40	1.06	0.746	1.42	-0.376
2 8	1.60	-0.44	-24.13	-0.16	0.30	14.35	-0.20	0.20	15.60	0.78	1.44	0.491	2.93	-0.593
2 9	1.77	-0.44	-23.53	0.01	0.41	14.35	-0.20	0.20	15.60	1.38	1.05	0.944	1.11	-0.588
2 10	1.77	-0.55	-24.13	0.18	0.19	13.15	-0.03	0.09	15.60	0.18	2.36	0.303	7.79	-1.04
2 11	1.91	-0.55	-23.53	0.18	0.30	13.15	-0.20	0.09	16.20	0.78	2.65	0.242	10.95	-1.23
2 12	1.77	-0.55	-24.13	0.18	0.30	13.15	-0.03	0.20	16.20	0.78	2.56	0.254	10.1	-1.19
~~3 13~~	2.02	-0.44	-23.23	0.01	0.47	12.65	-0.03	-0.08	16.50	~~0.78~~ 0.80				
3 14	1.77	-0.44	-24.13	0.26	0.47	12.85	-0.03	0.09	15.60	0.78	2.53	0.261	9.69	-1.22
~~3 15~~	2.02	-0.44	-24.13	0.26	0.30	13.75	0.22	0.09	15.60	~~0.78~~ 0.80				
3 16	1.77	-0.27	-24.13	0.01	0.47	13.75	0.22	0.26	16.50	0.78	2.49	0.256	9.73	-1.17
3 17	1.77	-0.44	-24.13	0.01	0.30	14.65	-0.28	0.26	16.50	0.78	0.806	0.459	1.76	-0.206
~~3 18~~	2.02	-0.27	-25.03	-0.24	0.30	14.65	0.22	-0.08	16.50	0.78 0.80				

GEOMETRY MODIFICATION 13

I1= 1234592541 I2= 987608531 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.80	0.150
2	5.60	0.300
3	8.40	0.450

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.09	-0.44	-24.13	0.01	0.30	14.05	-0.02	0.03	15.30	0.48	2.68	0.170	15.8	-1.29
1 1	1.09	-0.47	-24.13	0.01	0.27	14.20	-0.07	0.03	15.30	0.33	2.68	0.171	15.7	-1.29
~~1 2~~	1.05	-0.47	-24.13	0.01	0.33	13.90	-0.03	0.00	15.45	0.63				
1 3	1.73	-0.44	-24.13	0.01	0.27	14.05	-0.03	0.03	15.15	0.63	2.71	0.170	15 9	-1 29
1 4	1.09	-0.44	-24.70	0.05	0.27	13.90	-0.07	0.00	15.30	0.03	2.70	0 178	15 2	-1 28
1 5	1.09	-0.44	-24.13	0.01	0.30	14.05	-0.07	0.03	15.30	0.33	2 68	0.120	15 76	-1.30
1 (6)	1.05	-0.44	-24.28	-0.03	0.27	13.90	-0.03	0.00	15.30	0.63	2.71	0.162	16.7	-1.31
	1.09	-0.44	-24.43	-0.07	0.30	14.35	-0.11	0.03	15.30	0.78				
2 8	1.01	-0.44	-24.43	-0.07	0.30	14.05	-0.03	0.03	15.00	0.48	2.73	0 170	16.1	-1.34
	1.77	-0.36	-24.13	-0.07	0.30	14.15	0.05	-0.03	15.00	0.48				
	1.01	-0.50	-23.83	0.01	0.30	13.75	-0.11	-0.03	15.00	0.18				
2 11	1.09	-0.50	-24.13	0.01	0.24	14.05	-0.03	0.03	15.00	0.18	2 69	0.161	16.7	-1.31
2 12	1.77	-0.44	-24.43	0.09	0.30	14.35	-0.03	0.03	15.30	0.78	2.70	0.215	12 56	-1.26
3 13	1.09	-0.44	-24.58	0.14	0.30	14.05	-0.03	0.03	14.85	0.93	2.65	0.614	4 32	-1.23
3 14	1.69	-0.52	-24.13	0.01	0.30	13.60	0.10	0.11	15.30	0.48	2.57	0.196	13.1	-1.23
~~3 15~~	1.56	-0.44	-24.13	-0.12	0.30	14.05	-0.03	-0.05	15.30	0.48				
	1.82	-0.44	-24.13	0.14	0.30	14.50	-0.10	-0.05	14.85	0.03				
3 17	1.09	-0.44	-24.13	0.01	0.30	14.05	-0.03	0.11	15.30	0.03	2.59	0.163	15.9	-1.27
	1.09	-0.44	-24.58	-0.12	0.38	13.60	-0.03	0.11	14.85	0.48				

GEOMETRY MODIFICATION 14

I1= 1234595832 I2= 987637921 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.40	0.075
2	2.80	0.150
3	4.20	0.225

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.05	-0.44	-24.28	-0.03	0.27	13.90	-0.03	0.00	15.30	0.63	2.71	0.162	16.7	-1.31
	1.65	-0.43	-24.28	-0.05	0.28	13.90	-0.03	0.00	15.38	0.63				
	1.67	-0.44	-24.28	-0.03	0.27	13.90	-0.05	-0.01	15.30	0.63				
	1.63	-0.35	-24.20	-0.01	0.28	13.90	-0.03	0.00	15.38	0.70				
	1.65	-0.43	-24.20	-0.03	0.26	13.90	-0.03	0.01	15.30	0.63				
1 5	1.63	-0.45	-24.20	-0.01	0.27	13.90	-0.05	0.00	15.38	0.63	2 73	0.172	15.87	-1.32
1 (6)	1.65	-0.44	-24.28	-0.05	0.26	13.90	-0.05	0.00	15.30	0.50	2.74	0.149	18.39	-1.33
2 7	1.65	-0.44	-24.28	-0.03	0.27	14.05	-0.07	0.00	15.30	0.63	2.74	0 160	17 1	-1.33
	1.69	-0.44	-24.28	0.01	0.27	14.05	-0.03	-0.03	15.15	0.63				
2 9	1.65	-0.41	-24.13	0.01	0.30	14.05	0.01	-0.03	15.15	0.63	2.66	0.176	15.1	-1.26
2 10	1.69	-0.44	-24.28	0.01	0.24	13.90	0.01	-0.03	15.15	0.63	2.67	0.171	15.6	-1.26
2 11	1.65	-0.47	-24.13	0.01	0.27	14.05	-0.03	0.03	15.30	0.63	2.71	0.179	15.1	-1.29
2 12	1.65	-0.44	-24.28	-0.07	0.30	13.75	-0.07	0.03	15.15	0.63	2.71	0.160	16 94	-1.32
3 13	1.65	-0.41	-24.28	-0.09	0.27	13.90	-0.03	0.04	15.30	0.63	2 74	0.165	17.1	-1.33
3 14	1.71	-0.48	-24.06	-0.09	0.31	13.67	0.03	0.00	15.07	0.63	2 64	0.161	16.4	-1.26
3 15	1.65	-0.48	-24.51	-0.09	0.23	13.90	0.03	0.04	15.30	0.86	2.77	0.156	17.8	-1.33
3 16	1.59	-0.44	-24.06	-0.03	0.23	13.90	0.03	0.00	15.30	0.63	2 68	0.150	17.9	-1.26
3 17	1.59	-0.46	-24.06	-0.09	0.31	13.90	0.03	-0.04	15.07	0.86	2.706	0 181	14.95	-1.30
	1.59	-0.44	-24.06	0.03	0.23	13.90	-0.03	0.00	15.07	0.63				

GEOMETRY MODIFICATION 15

I1= 1234583582 I2= 987636955 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.70	0.040
2	1.40	0.080
3	2.10	0.120

OPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.65	-0.44	-24.28	-0.05	0.26	13.90	-0.05	0.00	15.30	0.56	2 74	0 149	18.39	
1 1	1.65	-0.41	-24.37	-0.06	0.26	13.90	-0.05	0.01	15.30	0.60	2 743	0.1471	18 66	-1.33
1 2	1.65	-0.44	-24.28	-0.05	0.25	13.94	-0.05	0.01	15.30	0.52	2 737	0.1467	18 657	-1 332
	1.65	-0.45	-24.32	-0.04	0.27	13.94	-0.04	0.00	15.30	0.52				
1 4	1.65	-0.43	-24.32	-0.05	0.26	13.90	-0.04	0.01	15.34	0.56	2 742	0.1478	18 552	-1.322
	1.65	-0.45	-24.28	-0.06	0.26	13.94	-0.06	-0.01	15.34	0.56				
1 6	1.66	-0.45	-24.26	-0.04	0.25	13.90	-0.06	0.00	15.30	0.56	2.740	0.1503	18.230	-1.333
	1.65	-0.44	-24.20	-0.03	0.26	13.90	-0.05	-0.01	15.22	0.56				
	1.65	-0.44	-24.28	-0.05	0.25	13.90	-0.05	0.00	15.22	0.48				
	1.63	-0.43	-24.28	-0.05	0.26	13.90	-0.05	-0.01	15.30	0.46				
	1.65	-0.44	-24.28	-0.03	0.27	13.90	-0.05	0.01	15.30	0.56				
2 11	1.67	-0.45	-24.28	-0.03	0.25	13.90	-0.07	-0.01	15.22	0.48	2.729	0.144	18 951	-1 328
2 (12)	1.67	-0.44	-24.28	-0.05	0.26	13.90	-0.07	0.00	15.22	0.48	2 728	0.143	19 077	-1 329
	1.65	-0.42	-24.28	-0.02	0.24	13.90	-0.08	-0.02	15.30	0.44				
3 14	1.68	-0.44	-24.28	-0.08	0.28	13.90	-0.02	0.00	15.18	0.44	2.692	0.144	18 69	-1 316
	1.65	-0.44	-24.28	-0.05	0.26	13.78	-0.05	0.00	15.18	0.68				
3 16	1.65	-0.42	-24.40	-0.08	0.28	13.78	-0.02	0.00	15.18	0.56	2 705	0.142	19 05	-1 319
	1.65	-0.44	-24.28	-0.05	0.26	13.90	-0.05	0.00	15.18	0.68				
	1.62	-0.42	-24.40	-0.02	0.28	13.90	-0.02	0.00	15.18	0.56				

GEOMETRY MODIFICATION 16

I1= 1234574671 I2= 987686681 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.70	0.040
2	1.40	0.080
3	2.10	0.120

OPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.67	-0.44	-24.28	-0.05	0.26	13.90	-0.07	0.00	15.22	0.48				
1 1	1.67	-0.45	-24.28	-0.04	0.26	13.94	-0.07	0.01	15.22	0.52	2.722	0.155	17 56	-1 32
1 2	1.67	-0.44	-24.32	-0.05	0.25	13.94	-0.06	0.00	15.22	0.52	2.754	0.145	18 99	-1 34
	1.66	-0.44	-24.32	-0.04	0.26	13.86	-0.07	0.00	15.22	0.52				
	1.67	-0.45	-24.24	-0.05	0.27	13.86	-0.08	-0.01	15.22	0.48				
1 5	1.66	-0.44	-24.26	-0.05	0.25	13.90	-0.06	0.01	15.22	0.52	2 732	0.142	19 24	-1.33
1 6	1.66	-0.43	-24.26	-0.05	0.26	13.86	-0.07	0.01	15.26	0.48	2 721	0.144	18.90	-1.33
	1.67	-0.44	-24.28	-0.07	0.26	13.90	-0.05	0.00	15.22	0.56				
	1.69	-0.43	-24.28	-0.07	0.27	13.90	-0.09	-0.01	15.22	0.56				
	1.65	-0.44	-24.36	-0.07	0.26	13.82	-0.05	0.01	15.22	0.46				
	1.65	-0.44	-24.20	-0.05	0.27	13.90	-0.07	0.01	15.22	0.48				
	1.65	-0.44	-24.20	-0.03	0.26	13.90	-0.07	0.00	15.22	0.48				
2 12	1.67	-0.45	-24.26	-0.05	0.26	13.82	-0.07	0.00	15.14	0.40	2 697	0 147	18.35	-1.319
3 13	1.70	-0.43	-24.40	-0.02	0.28	13.90	-0.07	0.00	15.22	0.48	2.708	0.156	17 36	-1 317
	1.64	-0.44	-24.28	-0.02	0.26	13.90	-0.04	0.00	15.22	0.60				
3 15	1.67	-0.46	-24.26	-0.02	0.24	13.90	-0.07	0.00	15.22	0.36	2.703	0.144	18 77	-1.318
	1.67	-0.44	-24.26	-0.02	0.26	13.90	-0.04	0.02	15.34	0.48				
3 (17)	1.67	-0.42	-24.28	-0.05	0.26	13.78	-0.07	0.00	15.22	0.60	2.738	0.141	19.42	-1.328
	1.67	-0.42	-24.40	-0.05	0.28	14.02	-0.07	-0.02	15.22	0.36				

GEOMETRY MODIFICATION 17

I1= 1234597592 I2= 987665801 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.05	0.060
2	2.10	0.120
3	3.15	0.180

OPAR IN.GE.	IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
		1.67	-0.42	-24.28	-0.05	0.26	13.78	-0.07	0.00	15.22	0.60	2.738	0141	19.42	-1.328
1	1	1.67	-0.41	-24.22	-0.03	0.26	13.78	-0.07	0.01	15.22	0.60	2 732	0141	19 38	-1.318
1	2	1.67	-0.43	-24.22	-0.07	0.27	13.64	-0.09	0.01	15.22	0.60				
1	3	1.69	-0.42	-24.28	-0.03	0.26	13.84	-0.07	0.00	15.22	0.54				
1	4	1.65	-0.42	-24.28	-0.05	0.25	13.78	-0.05	0.01	15.22	0.54				
1	5	1.67	-0.43	-24.22	-0.05	0.26	13.78	-0.07	0.00	15.16	0.60	2 754	0 144	19 12	-1.34
1	6	1.67	-0.42	-24.28	-0.07	0.26	13.78	-0.07	0.00	15.22	0.60				
2	(7)	1.67	-0.44	-24.28	-0.08	0.26	13.66	-0.10	0.00	15.22	0.48	2 699	0.133	20 29	-1.318
2	8	1.67	-0.42	-24.40	-0.05	0.26	13.78	-0.10	0.00	15.34	0.72	2 736	0.147	18 61	-1.316
2	9	1.64	-0.44	-24.16	-0.08	0.28	13.66	-0.04	-0.02	15.22	0.72	2 743	0.140		-1.321
2	10	1.70	-0.40	-24.28	-0.05	0.26	13.78	-0.10	-0.02	15.34	0.60	2 743	0.140	19.59	-1 321
2	11	1.67	-0.42	-24.16	-0.05	0.26	13.78	-0.10	0.00	15.22	0.72	2.770	0.148	18.72	-1 337
2	12	1.67	-0.40	-24.16	-0.05	0.26	13.78	-0.10	0.02	15.10	0.46				
3	13	1.67	-0.42	-24.28	-0.05	0.26	13.78	-0.12	-0.03	15.04	0.78				
3	14	1.67	-0.42	-24.28	0.00	0.26	13.78	-0.07	0.00	15.40	0.42	2.717	0.144	16 87	-1 319
3	15	1.67	-0.42	-24.46	-0.10	0.26	13.78	-0.02	0.00	15.22	0.78	2 755	0.145	19.00	-1.334
3	16	1.67	-0.45	-24.46	-0.05	0.26	13.78	-0.07	-0.03	15.22	0.60				
3	17	1.62	-0.42	-24.28	-0.10	0.23	13.96	-0.12	0.00	15.04	0.42				
3	18	1.67	-0.42	-24.46	-0.05	0.29	13.96	-0.12	0.03	15.04	0.60				

GEOMETRY MODIFICATION 18

I1= 1234568993 I2= 987660657 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.05	0.060
2	2.10	0.120
3	3.15	0.180

OPAR IN.GE.	IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
		1.67	-0.44	-24.28	-0.08	0.26	13.66	-0.10	0.00	15.22	0.46	2699	0.133	20.29	-1.318
1	1	1.67	-0.43	-24.22	-0.10	0.27	13.72	-0.10	0.01	15.22	0.48	2 601	0 343	7 58	-1.229
1	2	1.65	-0.44	-24.22	-0.10	0.26	13.66	-0.08	0.00	15.22	0.54	2 732	0 1452	18 82	-1.338
~~1~~	~~3~~	1.67	-0.44	-24.28	-0.08	0.27	13.66	-0.10	0.00	15.28	0.48				
1	~~4~~	1.65	-0.45	-24.22	-0.06	0.27	13.66	-0.10	-0.01	15.22	0.42	2.692	0.1407	19.13	-1.316
1	~~5~~	1.65	-0.44	-24.34	-0.10	0.26	13.66	-0.10	0.00	15.22	0.42	2.716	0 1457	18.64	-1.338
~~1~~	~~6~~	1.67	-0.45	-24.28	-0.10	0.27	13.66	-0.10	0.00	15.22	0.48				
~~1~~	~~7~~	1.70	-0.44	-24.40	-0.05	0.28	13.78	-0.10	0.02	15.10	0.60				
2	(~~8~~)	1.67	-0.44	-24.16	-0.08	0.24	13.66	-0.10	0.00	15.22	0.48	2.725	0.128	21.3	-1.330
2	~~9~~	1.67	-0.44	-24.28	-0.08	0.26	13.54	-0.07	0.00	15.10	0.48	2.694	0.145	18 58	-1.320
2	~~10~~	1.64	-0.40	-24.16	-0.11	0.24	13.54	-0.10	0.00	15.10	0.48	2.714	0.1305	20.8	-1.334
~~2~~	~~11~~	1.70	-0.44	-24.40	-0.11	0.26	13.78	-0.10	0.02	15.34	0.60				
~~2~~	~~12~~	1.67	-0.44	-24.40	-0.08	0.28	13.78	-0.07	0.02	15.10	0.48				
3	13	1.67	-0.41	-24.46	-0.08	0.26	13.66	-0.10	0.00	15.22	0.66	1.249	0.0318	39.3	-0.631
~~3~~	~~14~~	1.72	-0.47	-24.46	-0.03	0.26	13.66	-0.05	0.00	15.22	0.30				
~~3~~	~~15~~	1.72	-0.44	-24.28	-0.03	0.26	13.66	-0.10	0.00	15.40	0.48				
3	16	1.67	-0.44	-24.28	-0.13	0.29	13.66	-0.15	0.00	15.04	0.66	1 259	0 0917	13.7	-0.480
~~3~~	~~17~~	1.67	-0.44	-24.26	-0.08	0.26	13.48	-0.10	0.00	15.22	0.30				
~~3~~	~~18~~	1.67	-0.41	-24.46	-0.13	0.23	13.48	-0.10	0.00	15.04	0.30				

GEOMETRY MODIFICATION 19

I1= 1234569406 I2= 987666089 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.05	0.060
2	2.10	0.120
3	3.15	0.180

OPAR IN.GR. IN.CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
	1.67	-0.44	-24.10	-0.08	0.24	13.66	-0.10	0.00	15.22	0.46	2.725	0 128	21 30	-1 320
1 1	1.69	-0.44	-24.16	-0.10	0.25	13.60	-0.08	0.00	15.28	0.48	2.732	0.127	21.51	-1.340
1 2	1.67	-0.44	-24.10	-0.08	0.23	13.60	-0.08	0.00	15.16	0.42	2.7105	0.127	19 78	-1 322
1 3	1.67	-0.44	-24.10	-0.10	0.24	13.66	-0.10	-0.01	15.22	0.54	2.74 6	0.127	21 60	-1.329
	1.67	-0.44	-24.22	-0.08	0.23	13.66	-0.08	0.01	15.16	0.42				
1 5	1.69	-0.43	-24.22	-0.08	0.24	13.66	-0.10	0.00	15.16	0.48	2.729	0 126	21 66	-1 333
1 6	1.65	-0.45	-24.16	-0.06	0.23	13.66	-0.12	0.01	15.22	0.54	1 237	-0.007		0 0633
	1.70	-0.46	-24.04	-0.05	0.24	13.78	-0.13	0.00	15.10	0.60				
2 8	1.67	-0.42	-24.16	-0.05	0.24	13.54	-0.10	0.00	15.22	0.48	2.709	0.125	21 67	-1 317
2 9	1.04	-0.42	-24.04	-0.05	0.24	13.66	-0.13	0.02	15.22	0.48	1 08	-0 033		-0.238
	1.64	-0.42	-24.04	-0.08	0.26	13.78	-0.07	0.02	15.10	0.46				
	1.67	-0.44	-24.28	-0.11	0.26	13.66	-0.07	0.00	15.10	0.46				
	1.70	-0.42	-24.16	-0.05	0.26	13.66	-0.10	0.02	15.34	0.36				
3 13	1.72	-0.41	-24.34	-0.06	0.27	13.76	-0.10	-0.03	15.04	0.46	2 655	0.151	[illegible]	-1. 28
	1.67	-0.47	-24.10	-0.13	0.21	13.84	-0.10	-0.03	15.22	0.48				
3 15	1.67	-0.47	-24.34	-0.13	0.21	13.84	-0.10	-0.03	15.04	0.46	2.718	0.143	19 00	-1.330
	1.62	-0.47	-23.98	-0.08	0.27	13.46	-0.10	-0.03	15.40	0.60				
	1.72	-0.44	-23.98	-0.13	0.27	13.66	-0.10	0.00	15.22	0.66				
3 18	1.62	-0.44	-23.98	-0.08	0.24	13.46	-0.05	0.00	15.22	0.66	2.743	0.131	20.94	-1.33

GEOMETRY MODIFICATION 20

I1= 1234592992 I2= 987652913 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.50	0.030
2	1.00	0.060
3	1.50	0.090

OPAR IN.GR. IN.CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
	1.69	-0.43	-24.22	-0.08	0.24	13.66	-0.10	0.00	15.16	0.48	2.729	0.126	21.66	-1.333
1 1	1.68	-0.44	-24.22	-0.08	0.24	13.66	-0.09	0.00	15.13	0.51	2.722	0.128	21.27	-1.327
1 2	1.69	-0.43	-24.19	-0.08	0.24	13.66	-0.10	0.00	15.16	0.45	2.725	0.125	21.80	-1.332
1 3	1.70	-0.44	-24.19	-0.08	0.24	13.63	-0.09	0.00	15.16	0.45	2 723	0.138	19 73	-1.331
1 4	1.70	-0.43	-24.25	-0.09	0.23	13.63	-0.09	0.00	15.13	0.48	2.730	0.122	22.38	-1.33
1 5	1.79	-0.44	-24.25	-0.08	0.23	13.66	-0.09	0.00	15.16	0.48	2.738	0.126	21.73	-1.337
1 6	1.70	-0.43	-24.19	-0.07	0.24	13.69	-0.11	0.00	15.19	0.51	2.724	0.142	19.18	-1.322
2 7	1.69	-0.43	-24.22	-0.08	0.24	13.72	-0.10	-0.01	15.16	0.42	2.717	0.123	22.09	-1.33
2 8	1.69	-0.42	-24.27	-0.06	0.25	13.60	-0.09	0.00	15.16	0.44	2.714	0.127	21.37	-1.321
2 9	1.71	-0.44	-24.16	-0.08	0.24	13.72	-0.12	0.00	15.10	0.54	2.736	0.133	20.57	-1.331
2 10	1.58	-0.44	-24.16	-0.08	0.24	13.72	-0.10	0.01	15.16	0.42	1.087	-0.002		-0.528
2 11	1.67	-0.44	-24.28	-0.08	0.24	13.66	-0.12	0.00	15.16	0.54	3.282	0.280	11.72	-1.610
2 12	1.68	-0.43	-24.27	-0.06	0.24	13.60	-0.10	0.01	15.22	0.42	2.705	0.128	21.13	-1.321
3 13	1.69	-0.42	-24.22	-0.10	0.22	13.66	-0.10	0.00	15.16	0.48	2.773	0.115	24.11	-1.362
3 14	1.67	-0.43	-23.13	-0.10	0.24	13.57	-0.08	0.00	15.07	0.48	2.714	0.119	22.81	-1.328
3 15	1.69	-0.43	-24.22	-0.08	0.24	13.66	-0.12	0.00	15.16	0.48	3.262	0.274	11.91	-1.600
3 16	1.71	-0.43	-24.31	-0.08	0.24	13.66	-0.10	-0.01	15.07	0.48	2.718	0.125	21.74	-1.325
	1.69	-0.43	-24.31	-0.10	0.22	13.66	-0.12	0.00	15.07	0.57				
	1.69	-0.43	-24.22	-0.08	0.24	13.66	-0.10	0.01	15.16	0.57				

GEOMETRY MODIFICATION 21

I1= 123459330h I2= 987691833 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.75	0.450
2	1.50	0.900
3	2.25	1.350

OPAR INCR. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.69	-0.42	-24.22	-0.10	0.22	13.66	-0.10	0.00	15.16	0.46	2.773	0.115	24.11	-1362
1 1	1.70	-0.41	-24.67	-0.09	0.21	14.11	-0.10	-0.01	15.61	0.48				
1 2	1.69	-0.42	-24.67	-0.10	0.21	13.66	-0.10	0.01	14.71	0.46	2 708	0.127	21 32	-1.33
1 3	1.70	-0.42	-24.67	-0.10	0.23	13.71	-0.10	-0.01	15.16	0.03	2 637	0.101	26 11	-1319
	1.69	-0.41	-24.22	-0.10	0.22	14.11	-0.10	-0.01	15.61	0.03				
	1.68	-0.42	-24.67	-0.11	0.22	14.11	-0.09	0.01	15.16	0.03				
	1.69	-0.42	-23.77	-0.10	0.22	13.71	-0.09	-0.01	14.71	0.46				
2 7	1.71	-0.42	-24.22	-0.10	0.22	13.66	-0.08	0.00	15.16	0.46	2 756	0.112	24.61	-1 350
	1.69	-0.42	-25.12	-0.12	0.23	13.66	-0.10	0.01	16.06	1.36				
2 9	1.67	-0.43	-24.22	-0.12	0.22	13.66	-0.08	0.00	15.16	0.46	2 760	0.114	24.21	-1 36
	1.67	-0.42	-24.22	-0.12	0.23	13.66	-0.0	-0.01	14.26	0.48				
	1.69	-0.43	-24.22	-0.10	0.23	13.66	-0.10	0.00	15.16	0.4-				
	1.71	-0.43	-24.22	-0.10	0.22	14.56	-0.08	0.00	15.16	1.36				
	1.69	-0.42	-25.57	-0.10	0.22	15.01	-0.07	0.00	15.16	0.48				
	1.72	-0.42	-22.87	-0.10	0.20	13.66	-0.13	-0.02	16.51	1.83				
3 (15)	1.66	-0.42	-22.87	-0.10	0.22	13.66	-0.10	0.00	15.16	0.48	2,788	0.0987	28 25	-1.35
	1.66	-0.40	-25.57	-0.10	0.22	13.66	-0.13	0.02	15.16	0.48				
	1.69	-0.40	-25.57	-0.13	0.22	13.66	-0.13	0.02	16.51	0.48				
	1.66	-0.42	-24.22	-0.07	0.20	15.01	-0.07	0.02	13.81	0.48				

GEOMETRY MODIFICATION 22

I1= 1234584332 I2= 987690347 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.10	0.700
2	2.20	1.400
3	3.30	2.100

OPAR INCR. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.66	-0.42	-22.87	-0.10	0.22	13.66	-0.10	0.00	15.16	0.48	2.788	0.0987	28.25	-1.35
	1.66	-0.42	-22.87	-0.10	0.21	12.96	-0.10	0.00	15.86	0.48				
1 2	1.66	-0.41	-22.87	-0.08	0.23	14.36	-0.08	0.00	15.16	0.46	2.793	0.128	21 82	-1.339
1 3	1.66	-0.42	-23.57	-0.10	0.22	13.66	-0.10	-0.01	15.16	0.48	2.765	0.105	26 33	-1.35
	1.66	-0.42	-23.57	-0.08	0.23	12.96	-0.12	-0.01	15.86	0.46				
	1.66	-0.42	-23.57	-0.08	0.22	12.96	-0.10	-0.01	15.86	0.48				
1 6	1.66	-0.42	-22.87	-0.12	0.22	14.36	-0.12	0.00	14.46	0.46	2 772	0.112	24 75	-1.34
	1.63	-0.42	-22.87	-0.10	0.22	12.26	-0.10	0.02	13.76	0.48				
	1.69	-0.42	-24.27	-0.10	0.22	12.26	-0.07	0.00	15.16	1.88				
2 9	1.66	-0.42	-22.87	-0.10	0.22	12.26	-0.13	0.00	13.76	0.48	3.084	0.088	35 05	-1.520
2 10	1.66	-0.42	-24.27	-0.10	0.22	13.66	-0.10	0.02	13.76	1.86	2.877	0.305	9 43	-1.341
2 11	1.69	-0.44	-24.27	-0.10	0.22	13.66	-0.13	0.00	15.16	1.88	3.134	0.1406	22.29	-1.674
	1.66	-0.42	-21.47	-0.07	0.22	15.06	-0.10	0.00	15.16	0.46				
3 (13)	1.61	-0.42	-22.87	-0.10	0.22	11.56	-0.10	0.00	15.16	0.48	2.592	0.0708	36.61	-1.27
3 14	1.65	-0.45	-22.87	-0.10	0.25	15.76	-0.15	0.03	17.26	0.46	3.002	0.191	15.72	-1.44
	1.66	-0.45	-22.87	-0.15	0.19	11.56	-0.10	0.03	15.16	0.48				
	1.66	-0.42	-24.97	-0.15	0.22	13.66	-0.10	-0.03	13.06	0.48				
	1.66	-0.42	-20.77	-0.05	0.22	13.66	-0.05	0.03	15.16	0.48				
	1.66	-0.39	-24.97	-0.05	0.22	13.66	-0.10	0.03	15.16	0.48				

GEOMETRY MODIFICATION 23

I1= 1234594919 I2= 987656035 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.65	1.050
2	3.30	2.100
3	4.95	3.150

OPAR INC.NO.	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
IN CS	1.01	-0.42	-22.87	-0.10	0.22	11.56	-0.10	0.00	15.16	0.48	2.592	0 0706	36 61	-1 27
	1.59	-0.42	-22.87	-0.10	0.24	12.41	-0.08	0.00	16.21	0.48	—	—	—	—
	1.01	-0.42	-23.92	-0.10	0.22	10.51	-0.12	0.00	15.16	0.48	—	—	—	—
	1.01	-0.42	-22.87	-0.12	0.20	11.56	-0.10	0.00	16.21	1.53	—	—	—	—
1 4	1.03	-0.42	-21.82	-0.08	0.22	11.56	-0.09	0.00	15.16	0.48	2.611	0 0487	53 61	-1.260
	1.03	-0.42	-23.92	-0.10	0.20	12.41	-0.10	-0.02	14.11	0.48	—	—	—	—
1 6	1.01	-0.40	-22.87	-0.10	0.21	10.51	-0.16	0.00	15.16	0.48	2 508	0.0559	44 87	-1.221
	1.66	-0.42	-21.97	-0.05	0.19	13.46	-0.10	-0.03	17.26	0.48	—	—	—	—
	1.66	-0.42	-20.77	-0.05	0.22	9.46	-0.15	0.03	13.06	2.56	—	—	—	—
2 9	1.66	-0.45	-22.87	-0.10	0.19	9.46	-0.15	0.03	15.16	2.56	1 302	0.983	1.325	+ 0.0744
2 10	1.66	-0.42	-22.87	-0.10	0.19	9.46	-0.15	0.00	17.26	2.58	2 904	0.197	14.74	-1.316
	1.01	-0.39	-21.97	-0.05	0.19	13.66	-0.10	0.03	15.16	0.48	—	—	—	—
	1.66	-0.42	-22.87	-0.10	0.22	11.56	-0.10	-0.03	15.16	0.48	—	—	—	—
	1.54	-0.42	-22.87	-0.10	0.17	14.71	-0.10	-0.05	18.31	3.53	—	—	—	—
3 14	1.01	-0.47	-26.07	-0.10	0.27	11.56	-0.10	0.00	15.16	0.48	2.543	0.126	18 70	-1.286
3 (15)	1.01	-0.42	-19.72	-0.10	0.27	11.56	-0.10	0.00	15.16	0.48	2.620	0.0465	56.34	-1.248
3 16	1.01	-0.42	-22.87	-0.10	0.22	11.56	-0.17	0.00	12.01	0.48	2.402	0.0617	28 93	-1.181
3 17	1.54	-0.42	-22.87	-0.03	0.22	11.56	-0.10	0.05	12.01	3.63	1 974	0.173	11 41	-1.125
3 18	1.54	-0.37	-22.87	-0.03	0.17	14.71	-0.10	0.00	18.31	0.18	2.478	0.164	15.11	-1.243

GEOMETRY MODIFICATION 24

I1= 1234567848 I2= 987674721 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.50	1.600
2	5.00	3.200
3	7.50	4.800

OPAR INC.NO.	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
I. CS	1.01	-0.42	-19.72	-0.10	0.27	11.56	-0.10	0.00	15.16	0.48	2.620	0.0465	56 34	-1.248
	1.05	-0.44	-18.12	-0.06	0.30	9.96	-0.06	-0.03	13.56	0.48	—	—	—	—
	1.05	-0.42	-19.72	-0.10	0.27	11.56	-0.10	0.00	15.16	2.08	—	—	—	—
1 3	1.01	-0.42	-21.32	-0.06	0.30	13.16	-0.14	0.00	15.16	0.48	1.148	0.0551	20 83	-0.388
1 4	1.05	-0.39	-18.17	-0.10	0.27	9.96	-0.14	0.00	13.56	2.08	2.657	0.0742	35.81	-1.167
	1.05	-0.42	-19.72	-0.10	0.25	11.56	-0.10	0.03	15.16	2.08	—	—	—	—
1 6	1.57	-0.39	-19.72	-0.10	0.27	13.16	-0.14	0.00	13.56	0.48	2.625	0.0770	34.09	-1.238
	1.01	-0.37	-22.92	-0.10	0.22	14.76	-0.02	0.00	11.96	0.48	—	—	—	—
2 8	1.01	-0.37	-16.52	-0.02	0.32	14.76	-0.18	0.00	11.96	0.48	2 637	0.112	23.54	-1.189
2 (9)	1.53	-0.37	-22.92	-0.10	0.27	8.36	-0.18	0.05	18.36	0.48	2.502	0.0635	39.40	-1.240
	1.53	-0.42	-19.72	-0.02	0.22	11.56	-0.10	0.00	15.16	0.48	—	—	—	—
	1.01	-0.37	-22.92	-0.02	0.27	11.56	-0.18	0.00	15.16	0.48	—	—	—	—
2 12	1.59	-0.47	-19.72	-0.02	0.32	11.56	-0.18	-0.05	18.36	0.48	2.778	0.109	25.49	-1.312
3 13	1.01	-0.42	-14.92	-0.21	0.27	11.56	0.01	0.00	10.36	0.18	2 318	0.00771	300 65	-1.055
	1.01	-0.49	-19.72	0.01	0.34	16.36	0.01	0.00	15.16	0.48	—	—	—	—
3 15	1.50	-0.47	-24.52	-0.10	0.34	6.76	0.01	0.00	15.16	0.48	2.095	0.0557	37 61	-1.050
	1.01	-0.34	-19.72	-0.10	0.27	11.56	0.01	-0.07	10.36	0.48	—	—	—	—
3 17	1.72	-0.42	-24.52	-0.21	0.34	11.56	-0.10	0.00	15.16	5.28	3.251	0.749	4.34	-1.377
	1.01	-0.42	-19.72	0.01	0.27	11.56	-0.10	0.07	19.96	5.28	—	—	—	—

GEOMETRY MODIFICATION 25

I1= 1234589740 I2= 987650675 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	2.50	1.600
2	5.00	3.200
3	7.50	4.800

OPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.53	-0.37	-22.92	-0.10	0.27	8.36	-0.18	0.05	18.36	0.48	2.502	0.0635	39.40	-1.240
1 1	1.49	-0.37	-22.92	-0.10	0.30	6.76	-0.22	0.08	19.96	2.08	1.036	0.315	3.29	-0.28
1 2	1.57	-0.40	-22.92	-0.14	0.25	9.96	-0.14	0.08	18.36	0.48	1.529	0.125	12.31	-0.730
1 (3)	1.53	-0.40	-22.92	-0.14	0.30	9.96	-0.18	0.05	19.96	2.08	1.623	0.0796	20.39	-0.637
———	1.53	-0.40	-21.52	-0.06	0.27	8.36	-0.18	0.05	19.96	0.48				
———	1.53	-0.40	-21.32	-0.14	0.27	6.76	-0.22	0.03	18.36	0.48				
———	1.53	-0.37	-22.92	-0.06	0.27	8.36	-0.18	0.03	18.36	2.08				
2 7	1.61	-0.42	-22.92	-0.02	0.37	5.16	-0.16	0.10	18.36	3.68	1.127	0.441	2.578	-0.269
———	1.45	-0.42	-22.92	-0.02	0.27	5.16	-0.16	0.00	18.36	3.68				
———	1.53	-0.42	-22.92	-0.10	0.22	8.36	-0.18	0.05	15.16	0.48				
———	1.61	-0.37	-22.92	-0.10	0.22	8.36	-0.11	0.00	18.36	3.68				
2 11	1.61	-0.37	-20.12	-0.18	0.32	11.56	-0.18	0.05	18.36	0.48	0.991	-0.007		-0.204
———	1.61	-0.42	-20.12	-0.02	0.22	11.56	-0.25	0.10	15.16	3.68				
———	1.64	-0.30	-21.72	-0.10	0.27	13.16	-0.18	0.13	18.36	0.48				
3 14	1.53	-0.44	-21.72	-0.21	0.27	8.36	-0.18	0.05	18.36	0.48	1.373	0.174	7.89	-0.649
3 15	1.53	-0.44	-22.92	0.01	0.20	13.16	-0.16	0.03	18.36	0.48	1.214	0.168	7.226	-0.361
3 16	1.53	-0.37	-22.92	0.01	0.20	13.16	-0.07	0.13	23.16	0.48	1.791	0.351	5.411	-1.066
———	1.53	-0.37	-18.12	-0.10	0.20	13.16	-0.07	0.05	18.36	5.28				
3 18	1.64	-0.37	-22.92	-0.10	0.34	8.36	-0.29	0.13	23.16	0.48	2.709	0.140	19.35	-1.34

GEOMETRY MODIFICATION 26

I1= 1234597399 I2= 987643233 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.25	0.800
2	2.50	1.600
3	3.75	2.400

OPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.53	-0.40	-22.92	-0.14	0.30	9.96	-0.18	0.05	19.96	2.08	1.623	0.0796	20.39	-0.637
1 1	1.53	-0.41	-22.92	-0.14	0.29	9.96	-0.18	0.05	20.76	2.88	2.123	0.172	12.34	-0.872
1 2	1.53	-0.40	-23.72	-0.14	0.31	9.16	-0.18	0.05	19.96	2.88	1.753	0.110	15.94	-0.684
———	1.53	-0.40	-22.12	-0.14	0.29	9.16	-0.18	0.05	19.16	2.08				
1 4	1.53	-0.41	-22.92	-0.14	0.31	9.16	-0.18	0.06	19.16	1.28	1.628	-0.0712		-0.673
———	1.51	-0.40	-22.12	-0.12	0.31	9.96	-0.18	0.05	19.16	2.08				
1 6	1.51	-0.40	-22.72	-0.12	0.31	10.76	-0.20	0.05	19.96	2.08	1.724	0.109	15.82	-0.689
2 7	1.53	-0.43	-22.92	-0.14	0.33	9.96	-0.14	0.05	19.96	3.68	3.180	0.302	10.53	-1.398
2 8	1.49	-0.38	-22.92	-0.14	0.30	8.36	-0.18	0.03	19.96	0.48	1.251	0.0852	14.68	-0.520
2 9	1.57	-0.43	-22.92	-0.14	0.30	11.56	-0.16	0.05	18.36	2.08	1.474	0.0430	34.28	-0.462
2 10	1.53	-0.40	-22.92	-0.14	0.28	11.56	-0.22	0.05	19.96	2.08	1.708	0.0871	19.61	-0.684
———	1.49	-0.40	-22.92	-0.10	0.30	5.96	-0.14	0.06	19.96	0.48				
2 12	1.49	-0.40	-24.52	-0.14	0.28	9.56	-0.22	0.08	21.56	2.08	1.710	0.186	9.19	-0.724
3 13	1.53	-0.44	-22.92	-0.06	0.34	9.96	-0.24	0.09	22.36	2.08	1.734	0.137	12.66	-0.727
———	1.47	-0.44	-20.52	-0.14	0.26	12.36	-0.27	0.05	19.96	4.48				
3 (15)	1.59	-0.36	-22.92	-0.08	0.34	9.96	-0.18	0.05	19.96	2.08	1.291	0.0341	37.86	-0.358
3 16	1.59	-0.40	-22.92	-0.08	0.26	7.56	-0.12	0.09	22.36	2.08	1.594	0.233	6.841	-0.878
3 17	1.47	-0.36	-22.92	-0.08	0.30	12.36	-0.18	0.09	19.96	2.08	1.616	0.162	9.98	-0.661
3 18	1.59	-0.40	-22.92	-0.20	0.30	12.36	-0.18	0.09	22.36	2.08	1.535	0.100	15.35	-0.550

GEOMETRY MODIFICATION 27

I1= 1234590259 I2= 987633875 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.25	0.800
2	2.50	1.600
3	3.75	2.400

QPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.53	-0.37	-22.92	-0.10	0.27	8.36	-0.18	0.05	18.36	0.48				
1 1	1.51	-0.37	-22.92	-0.08	0.27	8.36	-0.18	0.00	19.16	0.48	1 726	0 0927	18.42	-0 803
1 2	1.53	-0.37	-23.72	-0.12	0.26	8.36	-0.16	0.05	18.36	0.48	1 244	0 1418	15 55	-0.4495
1 3	1.51	-0.37	-23.72	-0.10	0.27	9.16	-0.18	0.05	18.36	0.48	1 409	0 0715	19 71	-0 625
1 4	1.51	-0.36	-22.92	-0.10	0.26	8.36	-0.18	0.05	17.56	0.48	1 244	0 0800	15 55	-0.542
1 5	1.53	-0.37	-22.12	-0.12	0.27	6.36	-0.18	0.00	19.16	0.48	1 229	0 0847	14 51	-0 526
1 6	1.51	-0.36	-23.72	-0.10	0.26	6.36	-0.20	0.00	18.36	0.48	1 361	0 204	6.67	-0 6[illegible]
2 7	1.57	-0.37	-24.52	-0.10	0.30	8.36	-0.18	0.05	16.76	0.48	1 465	0 178	8.23	-0 658
2 8	1.53	-0.37	-21.32	-0.10	0.30	6.76	-0.14	0.08	16.76	0.48	0 912	0 566	1.61	-0 262
	1.53	-0.34	-21.32	-0.06	0.25	6.36	-0.22	0.03	19.96	2.08				
	1.53	-0.37	-24.52	-0.06	0.27	6.36	-0.22	0.03	19.96	2.08				
2 11	1.53	-0.34	-22.92	-0.14	0.27	6.76	-0.18	0.05	18.36	0.48	1 249	0 0603	20 71	-0 546
2 12	1.57	-0.34	-21.32	-0.10	0.25	8.36	-0.22	0.08	19.96	0.48	1.247	0.0777	16 05	-0 512
3 13	1.59	-0.37	-22.92	-0.16	0.23	6.36	-0.18	0.05	18.36	0.48	1.496	0 0951	15.73	-0 658
3 14	1.53	-0.37	-22.92	-0.10	0.23	8.36	-0.18	0.01	18.36	2.88	680	0.0522	32.18	-0 593
3 15	1.47	-0.37	-22.92	-0.04	0.27	8.36	-0.18	0.05	16.36	2.88	1.539	0.114	13.50	-0 574
3 (16)	1.53	-0.37	-22.92	-0.10	0.27	6.36	-0.18	0.01	15.96	0.48	2 370	0 0447	53.02	-1.177
	1.47	-0.33	-22.92	-0.16	0.27	5.96	-0.24	0.05	16.36	0.48				
3 18	1.59	-0.41	-25.32	-0.10	0.27	8.36	-0.12	0.01	20.76	0.48	2 626	0.117	22 44	-1.322

GEOMETRY MODIFICATION 26

I1= 1234595421 I2= 987656385 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	1.90	1.160
2	3.80	2.360
3	5.70	3.560

QPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.53	-0.37	-22.92	-0.10	0.27	8.36	-0.18	0.01	15.96	0.48	2 37	0.0447	53 02	-1 177
	1.56	-0.39	-22.92	-0.07	0.27	9.52	-0.18	0.03	15.96	0.48				
	1.53	-0.37	-22.92	-0.10	0.25	7.20	-0.18	-0.01	15.96	0.48				
	1.50	-0.35	-21.76	-0.10	0.29	9.52	-0.18	0.01	15.96	0.48				
	1.56	-0.39	-21.76	-0.10	0.25	7.20	-0.21	0.01	15.96	1.64				
1 (5)	1.53	-0.35	-22.92	-0.10	0.27	7.20	-0.15	0.01	15.96	0.48	1.505	0.0352	42 76	-0.650
1 6	1.53	-0.37	-22.92	-0.10	0.25	8.36	-0.21	0.01	14.80	0.48	1.242	0.0798	15.56	-0.563
	1.53	-0.41	-25.28	-0.10	0.23	6.00	-0.24	0.01	15.96	0.48				
	1.53	-0.33	-20.56	-0.10	0.23	10.72	-0.18	0.01	15.96	0.48				
	1.47	-0.37	-22.92	-0.10	0.31	6.36	-0.12	0.01	13.60	0.48				
2 10	1.53	-0.37	-22.92	-0.16	0.31	8.36	-0.12	0.01	18.32	2.84	2 12	0.128	16.56	-0.946
	1.47	-0.37	-20.56	-0.04	0.23	6.00	-0.24	0.05	15.96	0.48				
	1.53	-0.33	-20.56	-0.04	0.31	6.00	-0.18	0.05	15.96	0.48				
3 13	1.53	-0.31	-26.48	-0.19	0.33	11.92	-0.18	0.01	15.96	4.04	3.136	0.317	9 89	-1.403
3 14	1.62	-0.37	-26.48	-0.19	0.33	8.36	-0.18	-0.05	12.40	4.04	2 579	0.2775	9.29	-1.148
3 15	1.44	-0.37	-26.48	-0.19	0.33	8.36	-0.18	0.07	15.96	0.48	1.176	0.137	8.58	-0.545
3 16	1.62	-0.37	-22.92	-0.10	0.21	11.92	-0.09	0.01	12.40	4.04	3.015	0.215	14.02	-1.276
	1.53	-0.31	-22.92	-0.01	0.33	8.36	-0.18	0.01	19.52	4.04				
	1.44	-0.31	-19.36	-0.19	0.21	8.36	-0.09	-0.05	19.52	0.48				

GEOMETRY MODIFICATION 29

I1= 1234597436 I2= 987671553 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.95	0.600
2	1.90	1.200
3	2.85	1.800

GPAR IN.GR. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.53	-0.37	-22.92	-0.10	0.27	8.36	-0.18	0.01	15.96	0.48	2 37	0 0447	53 02	-1.177
1 1	1.52	-0.36	-22.32	-0.10	0.27	7.76	-0.18	0.01	16.56	0.48	1 143	0 0586	19.51	-0.433
1 2	1.52	-0.36	-23.52	-0.10	0.27	7.76	-0.19	0.01	16.56	0.48	1 814	0 101	17 96	-0 845
1 (3)	1.54	-0.37	-22.32	-0.10	0.27	8.36	-0.19	0.01	15.36	0.48	2 356	0.0350	67 31	-1 168
1 4	1.53	-0.36	-22.92	-0.10	0.28	8.36	-0.19	0.01	15.96	0.48	1 208	0 0545	22.16	-0.462
~~1 5~~	1.54	-0.38	-22.32	-0.11	0.26	8.36	-0.18	0.01	15.96	0.48				
1 6	1.53	-0.37	-22.92	-0.11	0.27	8.96	-0.18	0.00	15.96	0.48	2 426	0 0527	46.03	-1 204
2 7	1.53	-0.35	-24.12	-0.13	0.27	8.36	-0.15	-0.01	15.96	0.48	2 362	0 0534	44 73	-1 185
~~2 8~~	1.53	-0.37	-22.92	-0.07	0.25	7.16	-0.21	-0.01	15.96	0.48				
2 9	1.50	-0.37	-22.92	-0.10	0.29	8.36	-0.21	0.03	15.96	0.48	1.085	0.0653	16.62	-0.423
~~2 10~~	1.50	-0.39	-21.72	-0.07	0.27	8.36	-0.21	0.03	17.16	1.68				
2 11	1.53	-0.35	-22.92	-0.10	0.27	8.36	-0.16	0.01	14.76	0.48	2.293	0.0337	67 64	-1.139
2 12	1.53	-0.39	-22.92	-0.10	0.29	8.36	-0.18	0.01	14.76	0.48	1 217	0.136	8.95	-0.433
~~3 13~~	1.53	-0.37	-24.72	-0.10	0.27	8.36	-0.18	-0.02	14.16	0.48				
3 14	1.57	-0.37	-21.12	-0.10	0.30	6.56	-0.14	0.04	14.16	0.48	1 583	0 125	12.66	-1.062
3 15	1.49	-0.40	-2?.92	-0.10	0.30	8.36	-0.14	0.01	17.76	0.48	1.295	0 0830	15.60	-0.510
3 16	1.57	-0.37	-21.12	-0.06	0.24	8.36	-0.16	0.04	15.96	0.48	1.195	0.0445	26 85	-0.453
3 17	1.57	-0.37	-22.92	-0.10	0.30	10.16	-0.14	0.01	15.96	0.48	2.501	0.0691	36.19	-1.232
~~3 18~~	1.53	-0.40	-24.72	-0.10	0.24	8.36	-0.22	0.01	15.96	0.48				

GEOMETRY MODIFICATION 30

I1= 1234591243 I2= 987678795 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.50	0.300
2	1.00	0.600
3	1.50	0.900

GPAR IN.GR. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.54	-0.37	-22.32	-0.10	0.27	8.36	-0.19	0.01	15.36	0.48	2.356	0.0350	67.31	-1.168
~~1 1~~	1.53	-0.37	-22.32	-0.10	0.27	8.66	-0.20	0.00	15.66	0.78				
1 2	1.54	-0.37	-22.32	-0.09	0.27	8.06	-0.19	0.01	15.36	0.78	1.136	0.0424	26 79	-0.390
~~1 3~~	1.5?	-0.37	-22.02	-0.09	0.27	8.36	-0.19	0.01	15.06	0.48				
~~1 4~~	1.53	-0.38	-22.02	-0.09	0.28	8.06	-0.18	0.01	15.36	0.48				
1 5	1.53	-0.37	-22.62	-0.10	0.28	8.36	-0.20	0.01	15.36	0.48	1.514	0.0914	16.56	-0.663
~~1 6~~	1.54	-0.37	-22.32	-0.10	0.27	8.36	-0.20	0.01	15.36	0.76				
2 7	1.52	-0.37	-22.92	-0.10	0.28	8.36	-0.19	0.01	15.36	0.48	0 0072	0.0237	0.304	0.167
~~2 8~~	1.52	-0.37	-22.92	-0.09	0.27	8.96	-0.20	0.00	15.96	0.48				
2 9	1.54	-0.36	-22.32	-0.10	0.27	8.36	-0.17	0.00	14.76	1.08	2.393	0.0461	51.91	-1.152
2 10	1.54	-0.37	-21.72	-0.12	0.26	8.36	-0.20	0.02	15.36	0.48	1.324	0.136	9.74	-0.548
2 (11)	1.55	-0.36	-22.32	-0.10	0.26	8.96	-0.19	0.01	15.36	0.48	2.389	0.0377	63.34	-1.175
2 12	1.54	-0.37	-21.72	-0.10	0.27	8.96	-0.20	0.01	15.96	0.48	1.055	0.0436	24.20	-0.338
3 13	1.52	-0.36	-23.22	-0.12	0.26	8.36	-0.21	0.03	15.36	1.38	1.312	0.0682	19.24	-0.516
3 14	1.56	-0.37	-21.42	-0.10	0.28	9.26	-0.19	0.01	15.36	0.48	2.410	0.0385	62.03	-1.176
3 15	1.54	-0.38	-23.22	-0.10	0.28	8.36	-0.21	0.01	16.26	0.48	1 374	0.0692	19.86	-0.595
3 16	1.54	-0.36	-23.22	-0.12	0.28	8.36	-0.19	0.03	16.26	0.48	1.484	0.0727	20.41	-0.669
~~3 17~~	1.54	-0.37	-22.32	-0.12	0.28	8.36	-0.21	0.01	14.46	0.48				
3 18	1.54	-0.38	-23.22	-0.12	0.28	8.36	-0.19	0.01	16.26	0.48	1.349	0.0752	17 94	-0.561

GEOMETRY MODIFICATION 31

I1= 1234598300 I2= 987692065 NINC= 3 NCASE= 0

INCR NUM	% STEP	DEGREE
1	0.50	0.300
2	1.00	0.600
3	1.50	0.900

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.55	-0.36	-22.32	-0.10	0.26	8.96	-0.19	0.01	15.36	0.46	2.387		62.27	
1 1	1.55	-0.37	-22.32	-0.11	0.26	9.26	-0.19	0.01	15.66	0.76	1.268	0.0561	20.60	-0.456
1 2	1.55	-0.36	-22.32	-0.11	0.26	9.26	-0.20	0.01	15.06	0.46	1.252	0.0478	26.21	-0.450
	1.55	-0.36	-22.32	-0.10	0.26	9.26	-0.20	0.01	15.36	0.76				
	1.56	-0.36	-22.02	-0.10	0.26	8.66	-0.19	0.00	15.06	0.46				
	1.55	-0.37	-22.32	-0.10	0.26	8.66	-0.19	0.00	15.36	0.46				
	1.55	-0.36	-22.62	-0.09	0.25	8.96	-0.16	0.01	15.36	0.76				
2 7	1.53	-0.35	-22.32	-0.10	0.26	8.96	-0.19	0.01	14.76	1.06	2.445	0.0346	70.62	-1.17
	1.55	-0.35	-21.72	-0.09	0.27	9.56	-0.19	0.01	15.36	0.46				
	1.53	-0.36	-22.92	-0.09	0.27	8.96	-0.19	0.01	15.96	0.46				
	1.55	-0.35	-22.32	-0.12	0.26	8.36	-0.17	0.00	14.76	1.06				
	1.56	-0.36	-22.32	-0.09	0.25	8.96	-0.19	0.01	15.96	0.46				
2 (12)	1.55	-0.37	-22.32	-0.10	0.26	8.96	-0.20	0.01	15.96	0.46	2.420	0.0432	56.25	-1.176
	1.55	-0.36	-23.22	-0.12	0.26	9.86	-0.19	0.00	15.36	0.46				
	1.55	-0.36	-23.22	-0.10	0.27	9.86	-0.17	0.00	14.46	0.46				
3 15	1.55	-0.36	-22.32	-0.10	0.27	8.96	-0.17	0.01	16.26	0.46	1.057	0.00815	129.7	-0.298
	1.53	-0.38	-23.22	-0.10	0.26	9.86	-0.19	0.00	15.36	1.36				
3 17	1.57	-0.36	-21.42	-0.10	0.26	9.86	-0.21	0.01	15.36	1.36	0.637	-0.0101		-0.0107
	1.55	-0.36	-22.32	-0.12	0.27	8.96	-0.19	0.03	16.26	0.46				

GEOMETRY MODIFICATION 32

I1= 1234594648 I2= 987660275 NINC= 3 NCASE= 6

SELECT ONLY CL > 1.5

INCR NUM	% STEP	DEGREE
1	0.50	1.000
2	1.00	2.000
3	1.50	3.000

OPAR IN.GE. IN CS	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7	PAR8	PAR9	PAR10	CL=	CD=	CL/CD=	CM=
	1	1	1	1	1	1	1	1	1	1				
	1.54	-0.37	-22.32	-0.10	0.27	8.36	-0.19	0.01	15.36	0.50	2.356	0.0350	67.31	-1.168
	-1.54	-0.37	-22.32	-0.09	0.27	8.36	-0.20	0.01	15.36	0.50				
	1.55	-0.37	-22.32	-0.11	0.27	8.36	-0.18	0.01	14.36	0.50				
1 3	1.55	-0.37	-21.32	-0.11	0.28	9.36	-0.20	0.00	16.36	0.50	2.497	0.0458	54.52	-1.216
	1.55	-0.37	-22.32	-0.09	0.27	8.36	-0.18	0.01	14.36	0.50				
1 (5)	1.55	-0.37	-21.32	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.433	0.0371	65.58	-1.18
	1.54	-0.37	-22.32	-0.09	0.28	8.36	-0.18	0.01	15.36	0.50				
2 7	1.52	-0.37	-24.32	-0.12	0.26	10.36	-0.19	0.01	17.36	0.50	1.062	-0.026		-0.296
2 8	1.54	-0.36	-22.32	-0.10	0.27	8.36	-0.20	0.00	17.36	2.50	2.784	0.132		-1.265
2 9	1.57	-0.37	-20.32	-0.12	0.28	10.36	-0.20	0.01	17.36	2.50	1.325	0.0377	35.15	-0.315
2 10	1.52	-0.37	-22.32	-0.12	0.27	8.36	-0.19	0.01	15..6	0.50	1.431	0.136	10.52	-0.604
	1.55	-0.38	-22.32	-0.12	0.27	8.36	-0.19	0.01	13.36	2.50				
2 12	1.54	-0.36	-24.32	-0.10	0.27	8.36	-0.19	0.01	15.36	0.50	2.339	0.0610	38.34	-1.179
	1.56	-0.37	-19.32	-0.12	0.26	8.36	-0.17	0.02	15.36	0.50				
	1.54	-0.37	-22.32	-0.12	0.28	5.36	-0.19	0.00	15.36	0.50				
	1.56	-0.36	-22.32	-0.10	0.27	8.36	-0.17	0.03	12.36	3.50				
3 16	1.54	-0.37	-22.32	-0.10	0.28	11.36	-0.17	0.03	15.36	0.50	1.120	-0.026	14.80	-0.316
	1.56	-0.37	-22.32	-0.08	0.26	5.36	-0.19	0.03	12.36	0.50				
3 18	1.52	-0.36	-25.32	-0.10	0.26	8.36	-0.17	0.03	18.36	3.50	1.806	0.122	14.80	-0.682

GEOMETRY MODIFICATION 33 FROM 5/32

I1= 1234590425 I2= 987646065 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.25	0.500
2	0.50	1.000
3	0.75	1.500

GPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.55	-0.37	-21.32	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.423	0.0371	65.28	-1.180
1 1	1.55	-0.37	-21.32	-0.11	0.27	9.36	-0.16	0.00	15.36	0.00	2.354	0.0206	114.27	-1.169
1 2	1.55	-0.37	-21.32	-0.11	0.27	9.36	-0.16	0.00	15.36	0.00	2.354	0.0206	114.27	-1.169
	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.18	0.00	14.86	0.00				
1 (4)	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.439	0.0331	73.69	-1.180
1 5	1.55	-0.37	-21.82	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.427	0.0421	57.65	-1.185
	1.55	-0.37	-21.32	-0.11	0.27	9.36	-0.18	0.00	14.86	0.50				
2 7	1.55	-0.37	-20.32	-0.11	0.27	9.36	-0.18	0.00	15.36	1.50	2.605	0.0692	37.64	-1.203
	1.55	-0.38	-22.32	-0.10	0.27	10.36	-0.19	0.00	14.36	0.50				
	1.55	-0.38	-21.32	-0.10	0.27	9.36	-0.18	0.00	15.36	0.50				
2 10	1.54	-0.37	-20.32	-0.11	0.27	9.36	-0.18	0.00	15.36	1.50	2.605	0.0692	37.59	-1.203
	1.54	-0.38	-21.32	-0.12	0.27	8.36	-0.17	0.00	15.36	1.50				
	1.55	-0.37	-20.32	-0.12	0.27	8.36	-0.17	0.00	16.36	0.50				
	1.56	-0.36	-19.82	-0.10	0.26	10.86	-0.18	-0.01	15.36	0.50				
	1.55	-0.37	-19.82	-0.10	0.27	7.86	-0.17	-0.01	15.36	0.50				
	1.55	-0.37	-22.82	-0.10	0.28	9.36	-0.17	0.00	13.86	0.50				
3 16	1.56	-0.37	-22.82	-0.11	0.28	9.36	-0.17	0.00	15.36	0.50	2.415	0.0538	44.89	-1.191
	1.56	-0.36	-21.32	-0.12	0.26	10.36	-0.18	-0.01	16.86	0.50				
3 18	1.54	-0.38	-21.32	-0.10	0.27	7.86	-0.18	0.00	13.86	0.50	2.210	0.0120	184.2	-1.084

GEOMETRY MODIFICATION 34

I1= 1234591658 I2= 987669081 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.12	0.250
2	0.25	0.500
3	0.37	0.750

GPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL=	CD=	CL/CD=	CM=
	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.439	0.0331	73.69	-1.180
	1.55	-0.37	-21.07	-0.11	0.27	9.61	-0.18	0.00	15.11	0.25				
1 2	1.55	-0.37	-20.82	-0.11	0.27	9.11	-0.18	0.00	15.61	0.75	2.478	0.0381	65.04	-1.188
1 3	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.139	0.0331	73.69	-1.180
	1.55	-0.37	-20.82	-0.11	0.27	9.61	-0.18	0.00	15.61	0.25				
1 5	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.36	0.50	2.439	0.0331	73.69	-1.180
1 6	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.11	0.50	2.423	0.0315	76.92	-1.173
	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	14.86	1.00				
	1.55	-0.37	-20.32	-0.11	0.27	9.36	-0.18	0.00	15.36	1.00				
	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.18	0.00	15.86	0.50				
2 10	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.86	0.00	2.392	0.0191	125.2	-1.183
2 (11)	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.16	0.00	15.86	0.50	2.471	0.0364	67.86	-1.196
	1.55	-0.37	-20.32	-0.11	0.27	9.86	-0.18	0.00	15.86	1.00				
	1.56	-0.37	-21.57	-0.11	0.27	8.61	-0.18	0.00	15.36	1.25				
3 14	1.56	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	16.11	1.25	2.618	0.0689	38.00	-1.230
	1.56	-0.37	-21.57	-0.11	0.27	10.11	-0.19	0.00	14.61	1.25				
3 16	1.56	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	16.11	0.50	2.499	0.0381	65.59	-1.211
	1.56	-0.37	-20.07	-0.12	0.27	9.36	-0.17	0.00	16.11	1.25				
	1.55	-0.37	-21.57	-0.12	0.27	8.61	-0.18	0.00	16.11	0.50				

GEOMETRY MODIFICATION 35

I1= 123458936Z I2= 987628401 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.12	0.250
2	0.25	0.500
3	0.37	0.750

GEAR INC.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
	1.55	-0.37	-20.82	-0.11	0.27	9.80	-0.18	0.00	15.86	0.50	2.471	0.0364	67.86	-1.196
	1.55	-0.37	-20.82	-0.11	0.27	9.80	-0.18	0.00	16.11	0.50				
	1.55	-0.37	-20.82	-0.11	0.27	9.80	-0.18	0.00	15.61	0.75				
	1.55	-0.37	-20.82	-0.11	0.27	9.61	-0.18	0.00	15.61	0.25				
	1.55	-0.37	-20.82	-0.11	0.27	9.80	-0.18	0.00	15.86	0.75				
	1.55	-0.37	-20.57	-0.11	0.27	10.11	-0.18	0.00	16.11	0.25				
	1.55	-0.37	-20.82	-0.11	0.27	10.11	-0.18	0.00	15.86	0.25				
	1.55	-0.37	-20.82	-0.11	0.27	10.36	-0.18	0.00	16.36	0.00				
	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.18	0.00	15.86	1.00				
	1.55	-0.37	-21.32	-0.11	0.27	10.36	-0.18	0.00	15.86	0.50				
2 10	1.55	-0.37	-20.82	-0.11	0.27	9.36	-0.18	0.00	15.86	0.50	2.477	0.0364	67.87	-1.196
	1.55	-0.37	-20.32	-0.11	0.27	10.36	-0.18	0.00	15.36	1.00				
	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.18	0.00	16.36	1.00				
3 (13)	1.54	-0.37	-20.82	-0.11	0.27	9.11	-0.17	0.00	15.86	0.50	2.479	0.0290	85.48	-1.208
	1.55	-0.37	-20.82	-0.11	0.27	9.86	-0.19	0.00	15.86	0.50				
	1.56	-0.37	-21.57	-0.10	0.27	10.61	-0.18	0.00	15.86	0.50				
	1.55	-0.37	-21.57	-0.12	0.27	9.86	-0.18	0.00	15.86	0.50				
	1.54	-0.37	-20.82	-0.11	0.27	9.86	-0.19	0.00	15.86	0.50				
	1.55	-0.37	-21.57	-0.11	0.27	9.66	-0.18	0.00	15.86	1.25				

GEOMETRY MODIFICATION 36

I1= 123459U453 I2= 987081281 NINC= 3 NCASE= 6

INCR NUM	% STEP	DEGREE
1	0.20	0.400
2	0.40	0.800
3	0.60	1.200

GEAR INC.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1	CL	CD	CL/CD	CM
	1.54	-0.37	-20.82	-0.11	0.27	9.11	-0.17	0.00	15.86	0.50	2.479	0.0290	85.48	-1.208
1 1	1.54	-0.37	-20.42	-0.11	0.27	8.71	-0.17	0.00	16.26	0.50	2.451	0.028	191.5	-1.137
	1.54	-0.37	-21.22	-0.11	0.27	9.11	-0.17	0.00	15.46	0.50				
1 3	1.54	-0.37	-20.82	-0.11	0.27	9.51	-0.17	0.00	15.46	0.50	2.463	0.0339	72.65	-1.194
1 4	1.54	-0.37	-21.22	-0.11	0.27	9.11	-0.17	0.00	15.86	0.50	2.474	0.0326	75.89	-1.210
1 5	1.53	-0.37	-20.82	-0.11	0.27	9.51	-0.17	0.00	16.26	0.10	2.453	0.0252	97.34	-1.209
	1.54	-0.37	-20.82	-0.11	0.27	9.11	-0.17	0.00	15.46	0.10				
2 7	1.54	-0.37	-21.62	-0.10	0.27	9.91	-0.17	0.00	16.66	1.30	1.638	0.0911	17.98	-0.668
	1.53	-0.37	-21.02	-0.12	0.27	9.11	-0.17	0.00	15.86	0.50				
	1.54	-0.37	-20.82	-0.11	0.27	8.31	-0.17	0.00	15.06	0.50				
2 10	1.53	-0.37	-20.82	-0.11	0.27	9.91	-0.18	0.00	15.06	0.50	[illegible]	0.230	3.90	-0.259
	1.54	-0.37	-20.02	-0.11	0.27	9.91	-0.16	0.00	15.86	0.50				
2 12	1.55	-0.37	-20.42	-0.10	0.27	9.11	-0.17	0.00	15.86	0.50	0.995	0.0706	14.09	-0.196
3 (13)	1.54	-0.37	-19.62	-0.11	0.27	9.11	-0.17	-0.01	17.06	0.50	2.550	0.0262	90.43	-1.224
3 14	1.54	-0.38	-20.82	-0.12	0.27	9.11	-0.18	0.00	17.06	1.70	1.616	0.0232	69.66	-0.650
	1.54	-0.36	-20.82	-0.12	0.26	7.91	-0.17	0.00	17.06	0.50				
	1.54	-0.37	-20.82	-0.11	0.26	10.31	-0.16	0.01	14.66	1.70				
	1.54	-0.37	-20.82	-0.12	0.26	7.91	-0.17	0.00	15.86	0.50				
	1.54	-0.36	-22.02	-0.11	0.28	9.11	-0.18	-0.01	15.86	1.70				

GEOMETRY MODIFICATION 37

I1= 1234566926 I2= 987624365 NINC= 3 NCASE= 6

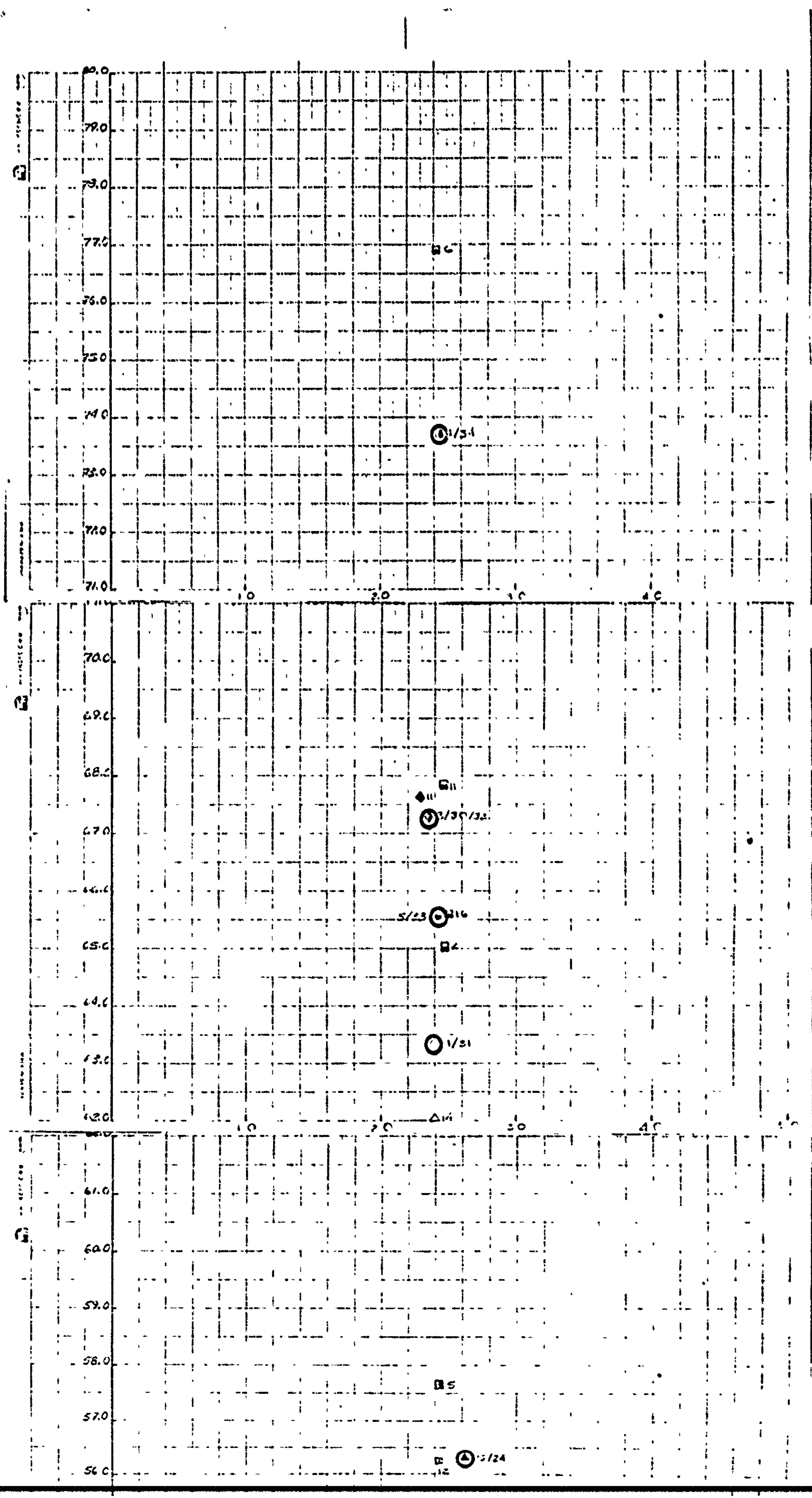
INCR NUM	% STEP	DEGREE
1	0.30	0.600
2	0.60	1.200
3	0.90	1.800

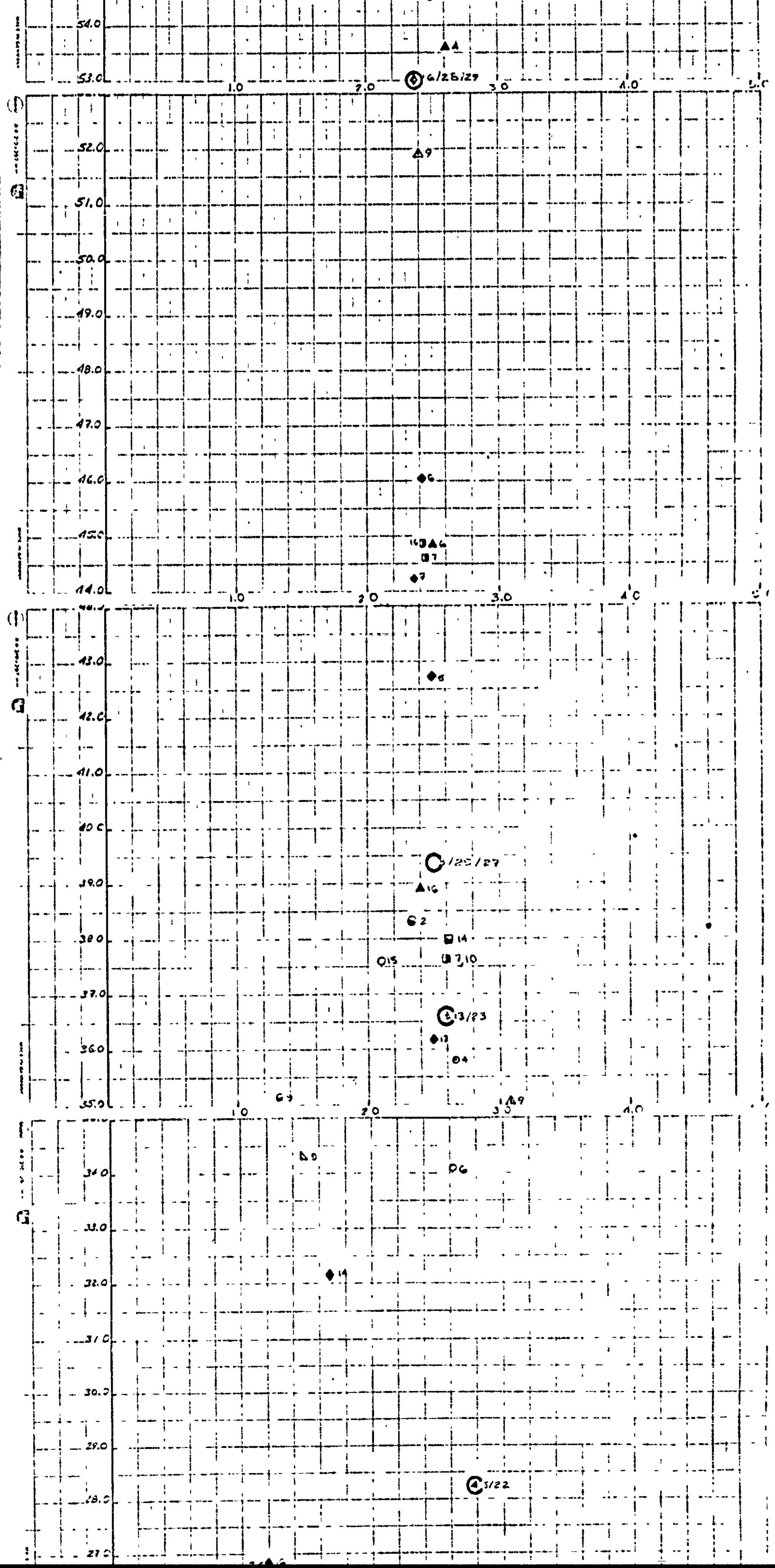
IPAR IN.GE. IN CS	PAR1 1	PAR2 1	PAR3 1	PAR4 1	PAR5 1	PAR6 1	PAR7 1	PAR8 1	PAR9 1	PAR10 1
	1.54	-0.37	-19.62	-0.11	0.27	9.11	-0.17	-0.01	17.06	0.50
	2.550		0.0782		90.43		-1.224			
1 1	1.54	-0.37	-19.67	-0.11	0.27	9.71	-0.17	-0.01	16.46	0.50
	CL= 2.561		CD= 0.0332		CL/CD= 77.14		CM= -1.226			
1 2	1.54	-0.37	-20.22	-0.11	0.27	9.71	-0.17	-0.01	17.66	0.50
	CL= 2.620		CD= 0.0465		CL/CD= 56.56		CM= -1.265			
1 3	1.54	-0.37	-19.67	-0.11	0.27	9.71	-0.17	-0.01	17.06	1.10
	CL= 2.691		CD= 0.0634		CL/CD= 42.44		CM= -1.255			
	1.54	-0.37	-20.22	-0.11	0.27	8.51	-0.17	-0.01	17.06	0.50
	CL=		CD=		CL/CD=		CM=			
1 5	1.54	-0.37	-20.22	-0.11	0.27	9.11	-0.17	-0.01	17.06	1.10
	CL= 2.639		CD= 0.0575		CL/CD= 45.90		CM= -1.242			
1 6	1.54	-0.37	-20.22	-0.11	0.27	9.11	-0.17	-0.01	17.06	0.50
	CL= 2.543		CD= 0.0320		CL/CD= 79.47		CM= -1.227			
	1.53	-0.36	-18.42	-0.11	0.27	7.91	-0.17	-0.02	15.86	0.50
	CL=		CD=		CL/CD=		CM=			
	1.54	-0.37	-19.62	-0.11	0.26	7.91	-0.17	-0.02	15.86	1.70
	CL=		CD=		CL/CD=		CM=			
	1.53	-0.36	-20.82	-0.10	0.27	10.31	-0.16	-0.01	17.06	0.50
	CL=		CD=		CL/CD=		CM=			
	1.53	-0.36	-18.42	-0.11	0.27	10.31	-0.17	-0.01	15.86	0.50
	CL=		CD=		CL/CD=		CM=			
	1.55	-0.36	-19.62	-0.12	0.28	7.91	-0.18	-0.02	18.26	1.70
	CL=		CD=		CL/CD=		CM=			
	1.53	-0.36	-19.62	-0.10	0.26	10.31	-0.17	0.00	15.86	0.50
	CL=		CD=		CL/CD=		CM=			
3 13	1.54	-0.36	-19.62	-0.12	0.27	10.91	-0.17	0.00	17.06	2.30
	CL= 2.968		CD= 0.157		CL/CD= 18.90		CM= -1.317			
3 14	1.54	-0.37	-21.42	-0.11	0.27	10.91	-0.16	0.00	17.06	0.50
	CL= 2.663		CD= 0.0737		CL/CD= 36.13		CM= -1.287			
3 (15)	1.54	-0.36	-19.62	-0.11	0.27	9.11	-0.17	-0.02	17.06	0.50
	CL= 2.557		CD= 0.0263		CL/CD= 97.22		CM= -1.228			
	1.55	-0.36	-19.62	-0.11	0.28	9.11	-0.17	-0.01	17.06	2.30
	CL=		CD=		CL/CD=		CM=			
3 17	1.55	-0.37	-19.62	-0.11	0.27	10.91	-0.17	0.00	18.86	0.50
	CL= 2.792		CD= 0.0775		CL/CD= 36.03		CM= -1.323			
	1.54	-0.38	-19.62	-0.12	0.27	9.11	-0.16	-0.02	17.06	2.30
	CL=		CD=		CL/CD=		CM=			

APPENDIX (iv-b) INITIAL AND FINAL CONFIGURATION POLAR DATA

ANGLE OF ATTACK	INITIAL GEOMETRY		FINAL GEOMETRY	
Degrees	C_l	C_l/C_d	C_l	C_l/C_d
0.0	2.26	4.25	2.52	47.0
0.5	2.33	4.26	2.60	36.3
1.0	2.39	4.25	2.67	29.2
1.5	2.45	4.22	-	-
2.0	2.52	4.20	2.83	20.4
3.0	2.64	4.10	2.99	15.5
4.0	2.77	3.99	3.14	12.2
5.0	-	-	-	-
6.0	3.03	3.70	-	-
7.0	3.11	3.57	-	-
8.0	-	-	3.76	5.97
9.0	3.41	3.25	3.90	5.27
10.0	3.48	3.11	4.05	4.84
12.0	3.77	2.73	4.33	3.91
14.0	4.00	2.48	4.60	3.29
16.0	4.22	2.29	4.84	2.82
18.0	4.41	2.06	5.06	2.44
20.0	4.59	1.87	5.25	2.14

APPENDIX (iv-c) C_l/C_d - C_l PLOT FOR ALL CONFIGURATIONS





54.0
53.0
6/25/29
52.0
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
1/25/27
39.0
38.0
37.0
13/23
36.0
35.0
34.0
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5/22
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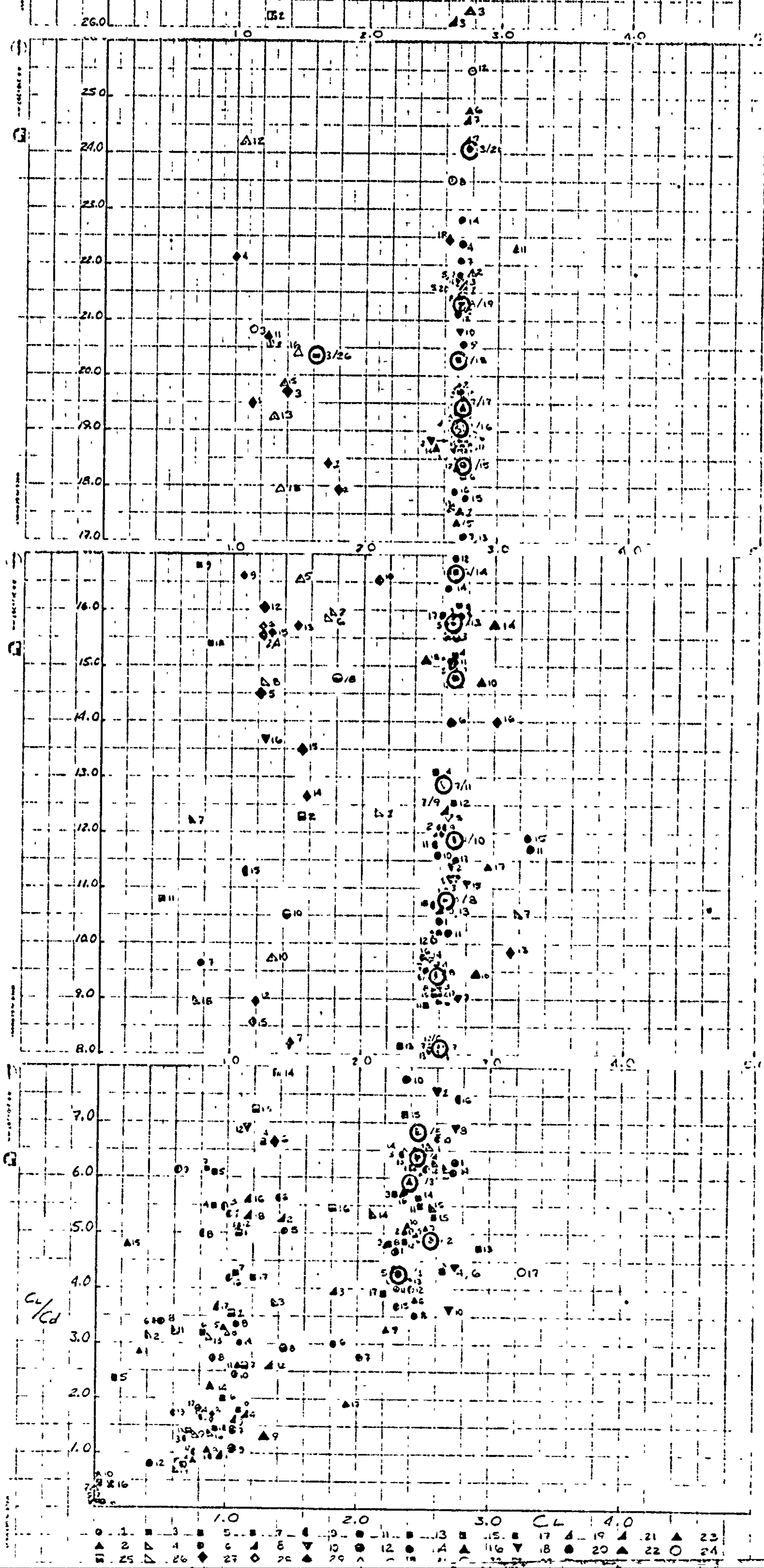
2.0
3.0
4.0



CL/Cd
CL
1.0
2.0
3.0
4.0