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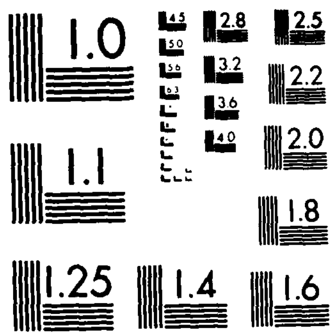

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EXPERIMENTS IN AN ADAPTABLE-WALL WIND TUNNEL FOR V/STOL TESTING

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Wall-adaptation controls in this tunnel are vaned panels in the floor and ceiling of the working section and a variable-angle inlet nozzle. Velocity components are measured by a Laser- Doppler system using a fixed laser and movable optical components.

The test model used in these experiments was a high-wing V/STOL configuration having full-span wing flaps with lower-surface blowing of their inboard portions. In all of the experiments reported here, the combination of angle of attack, flap setting, and flap blowing was such as to produce large flow deflection and severe wall interference in a conventional tunnel.

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It is concluded that these results constitute successful Proof of Concept. Suggestions are made regarding the directions of further development of this type of wind tunnel.

EXPERIMENTS IN AN

ADAPTABLE-WALL WIND TUNNEL FOR V/STOL TESTING

GRANT AFOSR-82-0185

FINAL REPORT * * * * * * 30 SEPTEMBER 1986

UNIVERSITY OF ARIZONA, TUCSON AZ, 85721

Prepared by W.R.Sears & D.C.L.Lee

TABLE OF CONTENTS

ABSTRACT

Experiments were carried out, over a period of two years, in an Adaptable-Wall wind tunnel configured for testing of airplane models at very large lift. The program was intended especially to demonstrate Proof of Concept for this type of wind tunnel, in which the simulated stream vector is inclined appreciably to the tunnel axis. The measured inner flow is matched to the computed, updated outer flow by an iterative process.

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It is concluded that these results constitute successful Proof of Concept. Suggestions are made regarding the directions of further development of this type of wind tunnel.

BACKGROUND

The Adaptable-Wall Wind-Tunnel idea dates from the early 1970's when it was independently invented by Ferri (Reference 1) and Sears (Reference 2). It was an invention intended to solve a persistent problem of wind-tunnel testing, namely boundary interference. The effects of boundaries can be corrected for, in many wind-tunnel tests at low or moderate speeds, but this cannot be done in nonlinear regimes, such as the transonic, especially in ventilated wind tunnels.

In briefest outline, the Adaptable-Wall scheme consists of modifying the tunnel's geometry so as to produce the correct, unconfined flow within the working section, in the presence of the model, by adjustment of "wall controls". This is accomplished by measuring two independent flow-variable distributions at an interface that encloses the model, calculating the outer flow field exterior to this interface (based on the measured values), and progressively reducing the matching-discrepancy at the interface by actuation of the wall controls.

It is clear that when the experimental (inner) and calculated (outer) fields are matched at the interface the whole combined field is correct, for the outer flow is always made to satisfy the far-field boundary conditions; viz., the free-stream conditions, and the model enforces its own boundary conditions in the tunnel.

Thus, an Adaptable-Wall Tunnel needs three special features: (1) wall controls, (2) instrumentation to measure two distributions at the interface, and (3) computer capability to calculate the outer flow for given boundary values at the interface. Several such tunnels have been constructed in various countries.

In the process of pursuing this development in the 1970s, the senior author of this report became aware that the Adaptable-Wall scheme also replaces the customary "calibration" of a wind tunnel; the determination of the stream vector (i.e., the negative of the flight-velocity vector) is made by choosing this vector in the outer-flow calculation and carrying out the elimination of the matching-discrepancy. This may very well turn out to be the most important feature of the Adaptive-Wall Tunnel, since the traditional "calibration", which is carried out with an empty tunnel and then used for tests of models, is notoriously unreliable in both principle and practice -- a very dubious procedure.

Besides the transonic flight regime, another nonlinear regime in which difficulties in wind-tunnel testing are encountered is that of very large lift coefficients, as typified by the low-speed V/STOL regime and powered lift. Here it is principally the floor and ceiling of the working section that interfere with the highly deflected airstream and, especially, the powered, vortical wake. At the University of Arizona, a program of research was undertaken to see whether this persistent problem of the low-speed, high-lift regime could be solved by exploitation of the Adaptable-Wall strategy.

The first three years of this program were devoted to numerical simulations of wind-tunnel tests of high-lift configurations. The first breakthrough came when it was shown that the interface could be a five-sided box with open downstream end and with the vortical wake extending downstream through the open end. The top, bottom, and sides of the interface were modelled as distributed-vortex panels, which have trailing vortices running back from their lateral edges, so that the interface is essentially semi-infinite in length. This made it unnecessary to try to locate the wake and to model it in the outer-flow calculation -- a major simplification.

Next, it was ascertained that the free-stream direction could be chosen to make a large angle to the nominal "tunnel axis" -- such as 40 degrees -- and the scheme of iteration successfully reduced the matching-discrepancy at the interface to negligible values. The results of these studies were published in References 3 and 4, where a radical new type of wind tunnel was proposed, which seemed to offer a solution to the high-lift testing problem: It would be an Adaptable-Wall Tunnel in which the free-stream vector would be sharply inclined with respect to the tunnel floor and would be controlled by the Adaptable-Wall principle; the test model would be mounted nose-down to give the desired angle of attack; and, consequently, the powered vortical wake would trail harmlessly downstream, essentially horizontally.

The resulting wind tunnel was called the "Arizona Wind Tunnel" and was proposed as a solution of the high-lift testing problem described above, characteristic of the V/STOL class of aircraft. The present program is an effort to demonstrate, in a laboratory embodiment, that the concept is sound.

The principle of the Arizona Tunnel, which is to divorce the flight direction from the architecture of the laboratory and the wind tunnel, would also seem to have applications other than testing of high-lift aircraft configurations. There are other categories where it may be more convenient to change angles of pitch and yaw by rotating the free-stream vector than by rotating the model. For example, there are many tests where models are connected to fuel lines, exhaust collectors, etc., and are therefore difficult to move. There is also the case of vehicle models being tested in the presence of a moving ground plane representing a roadway or runway; it may be important to simulate cross-winds in such tests. Nevertheless, the investigations reported here are confined to the testing, at zero yaw, of a typical high-lift airplane model having blown flaps (described later in the report).

OBJECTIVES

Since the major goal of this research has been Proof of Concept, no effort was made to produce a facility suitable for routine testing. Neither the instrumentation nor the wall controls is "on-line". The working section is 20 in. by 20 in. in cross-section. Tunnel speed can be about 70 knots (maximum), but its magnitude, within reason, is not considered to be important. Moreover, three important simplifications have been introduced, which have greatly reduced both cost and complication of this project:

1. No balance system has been provided. This decision was based on the conviction that the basic principles of the Adaptable-Wall scheme have been verified in other embodiments (principally in the transonic regime). Thus, success in iterating to unconfined-flow conditions is measured by the magnitude of the matching-discrepancy distribution, rather than by any attempt to compare test results with results obtained with the same model in a very large tunnel or any other "exact" or "target" results. Clearly, it would be a major extension of this work -- an extension that may be desired at some later date -- to obtain such "target" results.

2. Since balance readings are not available, lift coefficients produced in our tests can only be estimated.

Moreover, operating values of the overall "jet-flap coefficient" for the model are not precisely known. Instead of accurate values of these parameters, we propose that experimentally observed jet-wake geometries be understood to characterize the high-lift regime of the tests. Geometries were measured and are presented here. It is our contention that this characterization is more significant to the reader in evaluating the success of the tunnel scheme than precise knowledge of lift and jet coefficients would be. Our tunnel is intended to permit testing of large-deflection flows, especially those with powered wakes -- rather than flows at any particular lift coefficient or jet-flap coefficient.

3. The working section was provided with only a relatively small number of wall controls -- 16 vaned panels, of which the vane angles can be varied between closed and full open, a variable-angle nozzle leading from the settling chamber to the working section, and a throttling device downstream of the working section, which controls the pressure differences across the top and bottom vaned panels -- 18 controls in all. No controls were provided on the side walls. According to numerical simulations, this array of controls should be adequate to reduce the discrepancy function to satisfactorily small values.

Besides (1) Proof of Concept, major goals of this research have been:

(2) Demonstration of Laser-Doppler Anemometry as an instrumentation system for Adaptive-Wall Wind Tunnels in the fully three-dimensional application. Success in this demonstration confirms the positive results already achieved at Ames Research Center.

(3) Preliminary determination of the performance of wall-control panels consisting of adjustable vanes.

(4) Preliminary determination of the attainable accuracy of simulation of unconfined flow about high-lift models at selected free-stream vectors in wind tunnels of the Arizona type.

(5) Acquisition of preliminary experience in practical operating procedures with tunnels of the Adaptable-Wall type.

EQUIPMENT

Wind Tunnel

The tunnel used in these investigations is shown in Figure 1 and in photographs reproduced at the end of this report. It is an open-return tunnel, powered by a three-phase, induction motor, rated 25 h.p. at 1765 r.p.m., which drives a ventilating blower through a belt drive. The blower is rated at 18200 cubic feet per minute at 1695 r.p.m. Nominal tunnel airspeed is controlled by adjustment of an inlet valve upstream of the blower. This motor/blower combination is observed to run accurately at constant speed (1640 blower r.p.m., plus or minus 4) in all the experiments reported here, regardless of inlet-valve position, model configuration, or settings of the wall controls.

The blower output goes through a coarse screen (0.5 x 0.5-inch mesh) directly into a wide-angle diffuser with splitter plates, then into the settling chamber. There are four screens in the settling chamber, as shown in Figure 1; these are plastic window screening, 14-mesh, seamless.

As seen in Figure 1, the nozzle leading air from the settling chamber into the working section is adjustable in angle; this is one of the "wall-control" organs. Through an extension of the settling chamber, air is also admitted to the working section through control panels in its floor. There are eight panels in the floor and eight in the ceiling; these are rectangular panels made up of vanes of 0.5-inch chord. The vane angle of each panel is variable in angle from fully closed to about 75 degrees open. At the downstream end of the working section, as shown in Figure 1, there is an eighteenth control organ, namely a valve made up of flat aluminum-alloy plates of 3-inch chord, which are turned in alternating directions so as to throttle the airflow.

Each of the vaned panels, as well as the downstream valve, is controlled by a vernier dial/rotator that drives the vane angle through a worm drive. These are accurately controllable to approximately 1/10 degree.

In the first runs made, total-head surveys were made in the empty working section with controls set to produce 30- to 40-degree flow inclination. Not surprisingly, appreciable differences were found between the total pressures of air coming through the nozzle and through the floor panels. Trials were then made with various combinations of screening over the nozzle entrance and over the entrance to the settling-chamber extension that feeds the floor panels. A combination was found that minimized the total-pressure difference and also made the flow in the working section more steady. These screens were permanently installed.

A total-head survey was carried out over a transverse plane just upstream of the test model, with wall-control settings determined for a high-lift model configuration (viz., Experiment 91). Total pressure was found to be uniform to within one percent.

Instrumentation

Instrumentation consists primarily of a Laser-Doppler-Anemometer system (L.D.A.) based upon an argon-ion laser, nominally 2-watt, manufactured by Lexell, TSI optical components and counter, and a traversing frame that moves the focussing lens and appropriate mirrors in three mutually perpendicular directions.

This system is shown in Figure 2.

Being a key element of this research project, the L.D.A. system naturally occupied much of our time and attention as the project was planned and put into operation. It could occupy much of this report, but we will confine it to a rather brief account and some conclusions.

It is a single-component back-scatter system. The laser is fixed in position, together with the collimator, polarization rotator, beam-steering module, beam splitter, signal receptor, and photo-multiplier. As shown in the diagram, the rest of the optical system, namely three mirrors and the focussing lens are mounted on the traversing frame. Thus the measuring volume is translated in three mutually perpendicular directions, say x, y, and z.

As has already been mentioned, the adaptable-wall scheme requires measurement of two velocity components. In our experiments this is accomplished by manually rotating the beam-splitter assembly. In these experiments, involving as they do large inclinations of the undisturbed-flow vector, it has been found that the recognized ambiguity of L.D.A.s near zero velocity does not pose a problem. (The ambiguity arises because the system times the passage of seed particles through the measure volume and does not indicate their direction, unless special equipment is provided.) When the direction of a component is ambiguous, as in a few runs made near zero flow inclination, components at plus and minus 45 degrees were measured, from which horizontal and vertical components were computed; in all other cases these were measured directly.

The process of aligning the optical components of the L.D.A., so that a good signal was obtained at all the points of the working section, was tedious. It was facilitated by removing the back (West) wall of the working section and placing a large vertical board there, upon which the two laser beams impinged and could be monitored -- translated in the x, y, and z directions and rotated about the optical axis. The assistance and advice of Dr. Ari Glezer was invaluable.

After some experimentation, it was found that a liquid seed consisting of 80-percent water and 20-percent glycerine, introduced into the flow at the blower intake, produced a satisfactory back-scatter signal with indicated laser output of 1 watt. It will be appreciated that ours is an open-return tunnel, so that there were severe limitations on the seed that could be used. Pure water was tried, but was found to evaporate before reaching the working section. The water-glycerine mixture used makes no noticeable deposit in the laboratory, even when the tunnel is operated all day. Exposed optical components, namely mirrors, need to be cleaned after about two days of operation. The plate-glass East wall of the working section is the exception: it is found advisable to clean its inner side after every two hours of tunnel running.

From the photo-multiplier, our back-scattered signal goes into a counter manufactured by TSI Inc.; thence, via an interface designed and constructed for this project by H.E. (Dutch) Haldeman of our department, into our Osborne 1 micro-computer.

Other instrumentation includes a counter that monitors blower r.p.m. and a pressure transducer (Setra), with associated digital voltmeter, that monitors the static-pressure difference between settling chamber and laboratory.

Test Model

Except for some empty-tunnel runs, described later, all runs reported here were made with our "generic" STOL airplane model installed. This model, sketched in Figure 3, represents a high-wing transport airplane with lower-surface-blown wing flaps. Although its flaps are full-span, they are blown by flat nozzles mounted on the wing lower surface, which directly affect only the inboard part of the wing. Flap blowing air is piped to the model from the laboratory's compressed-air system ("shop air") through the model-support strut. Pressure gauges are installed in this air line to monitor both the supply pressure and the pressure drop across an orifice in the line.

Tuft surveys showed clearly that, at high angles of attack, with flaps deflected to 60 degrees, the wing is completely stalled, without flap air. When flap air is provided, the wing and flaps are unstalled inboard -- at least 60 percent of the half-span -- but still violently stalled outboard.

PROCEDURES

Measurement of Velocity Components

The flow in the working section of our demonstration tunnel is turbulent and, with the model at the high-lift conditions described above, grossly deflected (as will be shown) and unsteady. Consequently, all readings of velocity components must be mean values; we presume that this is true of all wind-tunnel tests in the high-lift, partially stalled regime. Moreover, we also think that the flow conditions observed in our tunnel are probably characteristic of flight in this regime and that, therefore, the measurement of time-averaged quantities is necessary to obtain meaningful data.

Our test procedures have therefore been developed to measure mean values, averaged over a long enough time-span to represent statistically steady values. At the beginning of the tests, after some trials, we decided that an average over 100 "samples" was adequate to meet this requirement. The TSI counter is designed to accept only those signals (a "signal" being the trace of a particle passing through the interference bands at the field point) that meet minimum specifications regarding number of full cycles and uniformity of cycle frequency. In our tests we set these requirements at eight cycles and not more than seven percent difference between successive cycles within the signal. The word "sample" is used here to mean a signal accepted by the counter.

It required, typically, about 45 seconds to obtain such an average over 100 samples.

As the research progressed, we became aware that the flow in the working section was much steadier at some field points than at others. In particular, the flow at points closer to the wing wake was more unsteady. Accordingly, we devised a procedure of extended averaging that would take more samples at points where the flow was more unsteady.

The following procedure was arrived at:

(1) A "reading" consists of the arithmetic mean value of a number, NSPL, of samples accepted by the TSI counter. Typically, NSPL was put equal to 50.

(2) The computer was programmed to repeat the process of taking readings and to calculate the running average of the readings taken. This process was repeated until four successive averages fell within a specified tolerance, TOL. The last average value was then accepted and recorded as the value of the velocity component. Typically, TOL was set at less than one percent of the nominal resultant stream speed.

It will be seen that the result of this procedure is that each recorded value is the mean of at least 200 samples, and that the number of samples and the time averaged over is larger at points where the flow is unsteady -- i.e., where an increased number of readings is required to bring four successive average values within the specified limit TOL. In our experience to date, the greatest number of readings required by this procedure was ten; i.e., in this case the recorded experimental value was the average of 500 samples.

Typically, 15 to 20 seconds are required to obtain a reading with NSPL equal to 50; hence this procedure of extended averaging consumes 60 to 80 seconds at field points where the flow is relatively smooth and twice as much time at our "rough points" -- at most, in a few cases, about three minutes.

We are sure that the accuracy of our test data was improved when we introduced the extended averaging procedure, but that the data obtained previously, using simply an average over 100 samples, are also acceptable.

The Adaptable-Wall Algorithm

The logic of the adaptable-wall wind-tunnel scheme has been set forth under BACKGROUND, above. It has been converted into a detailed procedure and presented in several papers since it was first proposed in References 1 and 2. (See, for example, References 3 and 4). The version used here follows Reference 4:

> Let f and g be two independent velocity-component distributions at the inner/outer-flow interface, and let the subscript m denote measured values. Now let the notation f[g] denote that a component distribution f, at

the interface, is calculated for the outer field by using the component g, at the interface, as inner boundary data and satisfying the far-field boundary condition (uniform flow at a prescribed angle, in our case). For given f and g, the "mismatch" distribution at the interface is

$$f[g_m] - f_m = Df, \text{ say.} \tag{1}$$

The adaptable-wall strategy is to adjust the tunnel walls and tunnel speed, so as to add a fraction k*Df to the measured values f_m and to repeat the process iteratively until the mismatch is reduced to acceptable magnitude.

The factor k is called a "relaxation factor", and experience shows that it must be less than one to avoid overshoot.

Introducing a superscript notation, namely letting superscript (p) denote values measured in the pth iteration (p = 1,2,...), we have

$$D^{(p)}f = f[g_m^{(p)}] - f_m^{(p)} \tag{2}$$

and $f_m^{(p+1)}$ is adjusted, as closely as possible, to

$$f_m^{(p+1)} = f_m^{(p)} + k*D^{(p)}f \tag{3}$$

The procedure used to set the wall controls as required by Equation (3) will be explained later.

The "Figure of Merit": RMS

In actual experiments it will always be impossible to drive the matching discrepancies, or mismatch values, at the interface to zero, because the number of control organs is finite, the modelling of the outer flow is approximate, and there are other sources of experimental error. The operator of an Adaptable Wind Tunnel must therefore decide upon a "Figure of Merit" that is a measure of how good a matching has been achieved, overall, at the interface, and must undertake to reduce the Figure of Merit to a minimum.

Several suggestions have been made of possible choices for this Figure of Merit, such as the mean matching error, the mean absolute matching error, various weighted averages of the matching error, etc. In this investigation we have chosen the root-mean-square matching error; viz., in the notation used above,

$$RMS = \text{root-mean-square value of } Df$$

$$= SQR((1/N) * \sum_{i=1}^{N} (Df_i)^2) \qquad (4)$$

where N is the number of field points.

Interface & Calculation of Outer Flow

Our interface is similar to the one defined in Reference 4, namely a rectangular box, semi-infinite in length. (See Figure 4 . The coordinate system, x,y,z, is also shown.)

To calculate the outer flow field, singularity-panels are arrayed on the interface. These are distributed-vortex panels on the top, bottom, and sides of the interface and source panels on the front. The use of singularity-panels requires that the velocity components f and g be redefined as perturbations measured from the far-field values of the appropriate velocity components. This does not involve any changes in Equations (1) to (4); it means that the far-field boundary values of f and g are zeros.

These perturbation velocity components, for the experiments reported here, have been defined as follows:

g is, in all cases, the tangential perturbation at the center of the respective panel; thus, at the four front panels g is the vertical (z) component, and at all other panels it is the x component. This component is usually referred to as "V_t" or, in some computer programs, "V_1".

f is, in all cases, a combination of normal and tangential perturbations. At the four front panels it is the normal (x) component at panel center; at the 16 top and bottom panels it is the normal (z) component at panel center; at the 12 side panels it is the x component at a point one inch outboard of the panel center. This component is referred to as "V_θ" or, in some computer programs, "V_2".

In Appendices A and B of this report are reproduced our BASIC programs to calculate the 32-by-32 matrices that relate the distributions V_θ and V_t to the 32 panel strengths; these matrices are called "IntTMatE" and "IntTMatB", respectively. The programs reproduced contain, of course, panel coordinates and dimensions, as well as subroutines that calculate the velocity fields of source panels and distributed-vortex panels.

For the outer flow field defined by these singularity-panels, the calculation designated by f[g], above, consists merely of a matrix multiplication; namely,

$$V_e[V_t] = E * (B_{inv}) * V_t \tag{5}$$

where E and B are the square matrices described above, relating V_e and V_t to the panel strengths, and B_{inv} is the inverse of B. Our procedure, of course, has been to construct the square matrix $E * (B_{inv})$, as in Appendix. C, and provide it on our working disks; it is a function of interface geometry only. The result is that the outer-flow calculation becomes a simple and rapid step in any of our runs.

Control Matrix & Calculation of Control Settings

A crucial step in the adaptable-wall algorithm is the one represented by Equation (3), namely the process of altering the measured velocity components, by adjustment of the wall controls, so as to reduce the matching discrepancy at the interface. Our procedure for this step is to measure the matrix of control effects and undertake to calculate the array of control increments required to satisfy Equation (3). Specifically, since $D^{(p)}f$ in Equation (2) represents $D^{(p)}V_e$, we measure the matrix that relates increments of V_e to increments of control settings.

In general, one must expect that control effects are dependent upon the existing flow in the working section and therefore upon both the model configuration and the existing control settings. To employ a control-effect matrix (or, presumably, any other computational procedure) at this point must imply that the increments involved will be small enough to permit a local linearization of the process. In this report we hope to present data that will cast light on this subject.

Let us proceed under the assumption that this local linearization is possible. An experiment is then carried out in which each control organ, in turn, is given a small increment and the resulting increments of V_θ at all the field points of the interface are measured. The result is an N-by-M matrix, where N is the number of field points and M the number of controls. Let this matrix be called C; its members are the increments of V_θ resulting from unit, positive increments of control settings.

For the vaned-panel controls, a unit deflection is about one-tenth the available vane angle, or about 7.5 degrees.

Our procedure for the measurement of the control matrix involved the same technique of measuring time-averaged velocity components as has been described above. The matrix members were measured by rows; i.e., with the L.D.A. set to measure the appropriate component, usually V_θ, at a given field point of the interface, the wall controls, each in turn, were first given a negative increment (typically -1.0) and then an equal positive increment, and the component was measured. The difference, from which the matrix member is computed, is therefore centered on the nominal control setting. Strictly, each control matrix measured in these experiments pertains to a given model configuration, including angle, and a given array of control settings, but it is expected that such a matrix has validity over a reasonable range of control settings, as mentioned above.

In Appendix D we reproduce one of our BASIC operating programs for the measurement of a control matrix, C. For the full tunnel, N is 32 and M is 18, as has already been pointed out; however, most of our experiments were made with laterally symmetrical model configurations and under the assumption of laterally symmetrical flow, as will be explained below, so that N and M were 16 and 10, respectively. In either case N is greater than M; hence M control settings are over-determined by N values of $k*DV_e$. The control settings are then calculated to give the best fit -- i.e. the least mean-square error -- to the desired values. This "inversion" of matrix C, which we refer to as the "best-mean-square inversion" of C, is programmed as a subroutine in the operating program in Appendix D.

If the result of this "inversion", an M-by-N matrix, is called Y, the formula for the array of control increments required by Equation (3) becomes

$$C.S. = Y * k * DV_e \qquad (6)$$

Dowell's & "RMS-Gradient" Methods"

There are at least two different methods of carrying out the iterative procedures of the adaptive-wall scheme, besides the one presented above, which is based on Equation (3). They have both been tried, at least minimally, in our experiments and therefore will be sketched here.

A. Dowell's Method (See also Appendix G.)

The method described above will be seen to be based on the assumption that, if component f can be adjusted as suggested by the matching discrepancy (Equation (3)), the discrepancy will be reduced, even though component g will also be changed. Dowell, in Reference 5, has pointed out that the change of g can be estimated in the same linear approximation if its control matrix is measured as well as the control matrix of component f. This algorithm is derived in Appendix G.

In one of our experiments we measured both control matrices and tried Dowell's method. The results were not particularly impressive and, in view of the tediousness of measuring two control matrices, rather than one, we returned to the conventional procedure of iterating on a single component, namely V_θ.

B. "RMS-Gradient" (See also Appendix F.)

This is the name we have given to a procedure suggested by Dr. J. C. Erickson of Calspan Corp. at A.E.D.C. It is a very direct attack upon the convergence problem: For any given model and control configuration, a series of runs is made.

similar to those made to measure a control matrix; i.e., in each run one control organ is given a unit increment; both velocity components are measured and the calculation of DV_θ is carried out. If, again, M denotes the number of controls, this procedure obviously leads to a set of M values of RMS, the root-mean-square matching error on the interface (Equation (4)), or to a set of M values of D(RMS), say, the RMS increments resulting from individual control increments. From these, assuming local linearization, the best array of control increments to minimize RMS can be deduced, as in Appendix F.

It will be seen that the process of making M runs, each with a single control increment, is the same as the process of measuring both control matrices in Dowell's method -- the labor is identical. Again the results did not appear to justify the additional expenditure of time and work, and this procedure was not adopted.

(The method of "RMS-gradient" also requires recalculation of the outer flow for each run (each control increment). This is not a serious chore for low-speed testing, as in the present experiments, but can be time-consuming where more difficult computations are involved, such as in transonic flow.)

Summary of "RUN" Procedures

For practical reasons, all of the computations and manipulations described in this report are carried out in terms of V_1 and V_2 (viz. V_t and V_θ), perturbations of the far-field values of the respective velocity components, as has already been pointed out, whereas the components measured by the LDA are actual total velocity components. Our procedure has therefore been to enter the values of the unperturbed (stream) velocity components into the computer at the beginning of each run. When both components were recorded at the last field point, the program proceeded to calculate the outer perturbation flow and to evaluate and print out the distribution DV_θ and RMS. Then, unless interrupted, it used the inverted control matrix called C, above, and then calculated and printed the control increments and resulting control settings for a next iteration.

A typical computer program used in our experiments -- iterations and/or other runs -- is presented in Appendix E. In it the reader will find the "extended averaging" procedure, calculation of outer flow and DV_θ, "Search" procedures (See below), determination of new control settings, etc., which have been described above.

"SEARCH" Procedures

Clearly, any set of measured data (velocity components) can be interpreted as perturbations from any chosen unperturbed stream components. In the original adaptable-wall scheme, the undisturbed stream vector, say (U,W), is to be chosen, and the iterative procedure is to lead to exact simulation, in the wind tunnel, of flow at this stream vector. (It seems clear that in high-speed testing, for example, one would want to iterate as close as possible to flow at specified Mach

Number and angle.) In our experiments, however, it was observed that a given set of experimental data often matched better -- i.e., gave a smaller RMS -- when interpreted as perturbations from a stream vector other than the one originally specified. In other words, a search could be carried out, varying the two parameters U and W, and a smallest RMS found, for any given set of data (any given run). Inspection of the operating program in Appendix E will disclose the details of this search, which consisted simply of adding constant increments to V_ts and V_θs and recalculating DV_θ and RMS.

For most runs, such searches were carried out, usually the procedure called "SEARCHVV" (See Appendix E), in which the <u>angle</u> of the stream vector, viz. arctan(W/U), was held constant. Our reasoning was that in low-speed tests the speed is of less interest than the angle of the stream, and that a search for the best-fit speed, at constant angle, might therefore be an acceptable procedure. In some cases a full two-parameter search, called SEARCHUW (See Appendix E) was also carried out.

<u>The Assumption of Lateral Symmetry</u>

If the wind tunnel and the model configuration are both laterally symmetrical, it might be expected that the resulting flow would exhibit the same symmetry, in which case measurements would only have to be made in one half of the tunnel and the wall controls would be operated in pairs -- excepting, of course, the variable-angle nozzle and the downstream valve, which are themselves laterally symmetrical. This situation would afford considerable simplification of the experimental procedures and the processing of data. For example, control-effect matrices would become 16-by-10 instead of 32-by-18, with resulting great reduction of time required to measure them.

This symmetry was assumed to exist, and the procedural modifications mentioned here were made, in the early experiments of this program. When the assumption was tested by carrying out full 32-by-18 measurements and calculations, the results were somewhat surprising and disappointing: It appeared that the basic tunnel flow was not accurately symmetrical, and that this asymmetry was amplified by the high-lift model, even in its (nominally) laterally symmetrical configuration. Enough iterations were carried out in the 32-by-18 mode to show that the iteration procedure worked -- i.e., the overall RMS was substantially reduced by iteration.

At that point in the program it was decided that major emphasis should be put on studying our experimental technique and, if possible, learning how to improve the accuracy of the matching; i.e., to reduce minimum RMSs. It seemed unlikely that this effort required staying in the 32-by-18 mode. Our reasoning was that the 16-by-10 half-tunnel, running with a symmetrical model configuration and with controls operated symmetrically, constituted an acceptable demonstration vehicle for the high-lift adaptable-wall scheme. Moreover, its economy of time and labor would allow us to carry out substantially more experiments.

We therefore returned to that mode. Our test volume in that mode is the East half of the tunnel; our measurements and calculations are directed toward control of the flow in that test volume; the West half of the tunnel possesses the same control and model configurations, both of which affect the East half, but we make no claims for the accuracy of the simulation in the West half. It is our conviction that the same techniques that succeed in our half-tunnel would succeed likewise in the full 32-by-18 embodiment.

Wake Surveys

Our procedure for "wake surveys" consisted simply of using a square-ended total-head tube to locate, approximately, the locus of maximum total head in a vertical plane 6.25 inches from the wall of the working section. It was easy to identify the maximum at locations back to about 11 inches behind the wing trailing edge; the jet-wake was more diffuse farther aft. The L.D.A. and its traverse system were used to locate the nose of the total-head tube.

PRESENTATION OF RESULTS

Essentially four different kinds of experiments were carried out in the course of these investigations:

Measurement of control matrices

Interations toward desired flow conditions

Runs at constant control settings, varying angle of attack

Wake surveys

In this section of the report, results will be presented in all of these categories, as well as some miscellaneous data and comparisons that seem to be pertinent to the goals of the research.

Some typical results of control-matrix measurements are presented first. These are graphical presentations of several representative control matrices; i.e., bar graphs showing all of their members.

Next, results of several series of iterations are presented. These series have been chosen to show results in different ranges of the undisturbed-stream vector (angle and magnitude) and angle of attack. What are presented in this category are (a) graphs of control settings and RMS plotted against iteration-number, (b) tabulated values of these data, (c) tabulated details of matching error at the interface, and (d) sketches of measured wake loci. For the runs made at varying angle of attack and constant control settings, the same kind of data is presented (but of course there was no iteration).

The wake surveys were made to determine, at least roughly, the geometry of the energized jet-wake of the wing with its blown flaps. According to the argument presented under OBJECTIVES, above (See "2", pages 6-7), the wake geometry best characterizes the test regime of our tunnel. Wake-survey data are therefore presented for the same cases as results of iterations. They are plots of wake position in a side-view sketch of tunnel and model.

Matrix Measurements

The collected results of all the matrix measurements carried out in these experiments constitute a large volume of data. Here we attempt to present enough of these data to give some idea of the effectivenesses of the various control elements and how they are altered by changes of parameters such as tunnel speed, inclination of the simulated stream, and model configuration. To this end, firstly a series of bar charts (Figures 5.1 to 5.10) is presented, showing all 160 matrix members measured in four different, typical experiments under the assumption of lateral symmetry -- 640 data. These data are collected in such a way as to facilitate comparison between cases. Secondly, similar bar charts (Figures 5.11 to 5.28) are presented for a single "asymmetical" (32-by-18) case -- 576 data. Here the data have been collected in such a way to show the symmetry or asymmetry of the flow; viz., matrix members for each field point and control organ are shown together with those pertaining to the laterally opposite field point and control organ.

Iterations

The results of five experiments are presented. Four of these were carried out under the assumption of laterally symmetric flow, as explained above (See pages 27 - 29). Plots of control settings and RMS are presented, showing how these quantities varied as the iteration was carried out -- from left to right in each plot. (Some further explanation of these graphs is given below.)

Details of the resulting matching-error distribution, DV_e, are presented in the accompanying tables.

The following table is an index to the Figures and Tables related to this series of experiments.

TABLE I

INDEX TO GRAPHS & TABLES OF ITERATION DATA

Exp. Number	Run	Figure Number	Tabular Data (page)	Model Angle (deg.)	Free-stream Vector Speed (m/s)	Inclination (deg.)
34	1	6.1	93	-11	5.69	32.1
(Symm.)	2		94	"	"	"
	3		95	"	"	"
	4		96	"	"	"
	5		97	"	"	"
	6		98	"	"	"
	"		99	"	5.70	31.7
	7		100	"	5.69	32.1
	"		101	"	5.66	31.6
62	1	6.2	103	-18	6.92	38.7
(Symm.)	2		104	"	"	"
	"		105	"	7.18	"
	3		106	"	"	"
	"		107	"	7.31	"
	4		108	"	"	"
	5		109	"	"	"
	6		110	"	"	"
	7		111	"	"	"
	8		112	"	"	"
	"		113	"	7.22	39.1
	9		114	"	7.31	38.7
	"		115	"	7.44	38.2
76	1	6.3	117	-13	7.21	33.7
(Asym.)	2		118	"	"	"
	3		119	"	"	"
	4		120	"	"	"
	"		121	"	7.33	33.4
	5		122	"	7.21	33.7
	6		123	"	7.33	33.4
	"		124	"	7.36	"
	7		125	"	7.33	33.4
	"		126	"	7.39	33.6
	8		127	"	7.33	33.4
	"		128	"	7.38	33.6
	9		129	"	7.33	33.4
	"		130	"	7.34	33.6

TABLE I (continued)

Exp. Number	Run	Figure Number	Tabular Data (page)	Model Angle (deg.)	Free-stream Vector Speed (m/s)	Inclination (deg.)
79 (Symm.)	1	6.4	132	-13	7.21	33.7
	2		133	"	"	"
	3		134	"	"	"
	"		135	"	7.09	35.2
	4		136	"	7.21	33.7
	"		137	"	7.09	35.2
	5		138	"	"	"
	"		139	"	6.96	35.0
	6		140	"	7.09	35.2
	7		141	"	"	"
	8		142	"	"	"
85 (Symm.)	1	6.5	144	-19	2.39	41.1
	"		145	"	2.41	"
	2		146	"	"	"
	"		147	"	2.32	"
	3		148	"	"	"
	"		149	"	2.19	"
	4		150	"	"	"
	"		151	"	2.24	"
	5		152	"	"	"
	"		153	"	2.22	"
	"		154	"	2.26	39.6
	6		155	"	2.22	41.2
	8		156	"	"	"
	7		157	"	"	"

It should be noted that "RUN No." in these tables is not always the same as Iteration Number. The terminology "Iteration from Run ( )" means that control settings were determined by calculation from the results of Run ( ), using an appropriate control matrix, as described under PROCEDURES, and the relaxation factor k indicated; in such cases the data points in the accompanying figure are connected by a line.

In a number of cases, on the contrary, the measured data were "searched" by changing the stream-vector components U and W, as described under PROCEDURES, and the next iteration carried out by calculation from the resulting velocity components. In these cases another point is plotted in the graph of RMS vs. iteration number, but it is not connected to the previous point. If the iteration was continued by calculation of new control settings from the "searched" values, this is indicated by the appropriate connecting line to the next data point. It will be seen that occasionally more than one calculation was made from a given data-set, using different stream vectors and/or (in at least one case) a different value of k.

There is also one instance (in Figure 6.4) where a run was repeated without change of settings; therefore two values of RMS are shown, with the same symbol, at one iteration number. Data are tabulated for both runs (Runs 6 and 8 of Experiment 79).

Repeatability of Data

In pages 162 to 164 the raw data (L.D.A. readings) of these two runs (Experiment 79, Runs 6 and 8) are presented, together with data from two other pairs of "identical" runs as evidence of the repeatability of our experiments.

The following is an index of these data:

TABLE II

INDEX TO TABLES RELATING TO REPEATABILITY OF DATA

Page	Exp. Number	Run	Model Angle (deg.)	Date
162	68	5	-13	14 Oct.85
162	68	8	"	16 Oct.85
163	71	7	-13	4 Nov.85
163	79	1	"	5 Feb.86
164	79	6	-13	10 Feb.86
164	79	8	"	21 Feb.86

Runs at Constant Control Settings, Varying Angle of Attack

The purpose of experiments in this category was to explore the possibility that, having arrived at a "best" control configuration by iteration with a certain model configuration, one could vary the angle of attack without carrying out new iterations, i.e., with unchanged control settings, and still obtain satisfactory simulations as measured by RMS. This might indicate that the control array was not overly dependent upon angle of attack, for given stream angle, flap configuration, etc. Such a conclusion would, of course, afford important time savings in practical wind-tunnel testing.

Two series of runs were made in this category.

as follows:

TABLE III

INDEX TO TABLES OF DATA : RUNS AT CONSTANT CONTROL SETTINGS & VARYING ANGLE OF ATTACK

Exp. Number	Run	Page	Model Angle (deg.)	Free-stream Vector Speed (m/s)	Free-stream Vector Inclination (deg.)	Angle of Attack (deg.)
53	1	165	-26	5.54	32.0	6
52	1	166	-21	5.48	"	11
51	1	167	-16	5.54	"	16
50	2	168	-11	5.51	"	21
91	4	169	-31	7.68	35.1	4
	3	170	-25	7.71	35.4	10
	2	171	-19	7.56	35.5	16
	1	172	-13	7.45	36.4	23

DISCUSSION AND CONCLUSIONS

Let us begin this section of the report by commenting on the data presented, under the same subheadings as in the preceding section.

Matrix Measurements

The bar graphs of normalized control-matrix members show rather clearly, by their general similarity of shape, that control effects are not greatly influenced by changes of model and test-section configurations. This conclusion must be tempered, however, because it does appear that the data of "MtxMdl10" differ from the other matrices appreciably at some points of the interface. The configuration for this case is extreme: both the undisturbed-stream angle and the jet-flap parameter were at maximum values. To maximize the latter, of course, the tunnel speed was at a minimum.

The graphs also show that our control device Number 1, the variable-angle nozzle, is not very effective at any field points. An ineffective control, of course, is a fault in an Adaptable Tunnel. Control Number 3, the farthest upstream ceiling panel, is also of limited effectiveness.

Iterations

The general conclusions to be drawn from the records of iterations are that the process, based on a measured matrix of control effects on V_e, succeeds in reducing the RMS matching-error and that the minimum attainable value of that Figure of

Merit is about three percent of the simulated stream speed, usually reached in about six to eight iterations using a relaxation constant of 0.15. The process is accelerated by using the "Search" technique.

Much of our time was devoted to studying the iteration process and the sources of the apparent limitation of matching accuracy. Such sources would presumably include (1) inaccuracy of measurement of velocity components, (2) limited number of controls, (3) inaccuracies in the determination of control settings to achieve desired V_θs, introduced either by the approximation of local linearity or by the inaccuracy of "best-mean-square inversion" of the control matrix.

Some information about our accuracy of measurement was obtained by carrying out repeated runs, the details of which have been presented above. These data show that our accuracy is about one percent of stream speed. In somewhat greater detail:

(a) The average absolute differences in measured values in Runs 5 and 8 of Experiment 68 (page 162) amount to 0.79 percent and 0.84 percent of nominal stream speed, for V_t and V_θ, respectively. These runs were made before the introduction of the procedure called "extended averaging", as defined in pages 16 and 17.

(b) These values are 0.78 percent and 0.73 percent, respectively, for Runs 6 and 8 of Experiment 79. These runs were made using "extended averaging".

(c) Our third pair of repeated runs consists of Run 7 of Experiment 71 and Run 1 of Experiment 79, which were carried out three months apart. The differences in these data amount to 1.78 percent and 1.56 percent. We do not know the reason that the differences are larger in this case, but suspect that the control settings may not have been identical. Our records show that the control-setting zeros were reset during the intervening period.

It appears that the probable error in our measurement of velocity components, say one percent, is large enough to account for a substantial part of our residual RMS (about three percent).

It is certainly true that the availability of only 18 controls in an asymmetric case, or 10 in a symmetric case, limits the minimum RMS. The decision to use such a modest number of controls was based upon the results of the computer simulations that preceded this experimental investigation (References 3 and 4), which indicated that this limitation would not be too serious.

Evidence of linearity or nonlinearity of control effects was available during each matrix measurement; viz., it could be observed whether the increments of velocity due to positive and negative control increments (See pages 22 - 23) were of nearly the same magnitude. This criterion was well satisfied, within the limits of accuracy discussed above, for most field points, when increments of plus and minus one unit were used (or, for the single case of "Matrix 10", where the tunnel speed was unusually low, plus and minus two units). Attention was given to the magnitudes of control increments made during iterations, and an effort made to be sure that this one-unit limit was not exceeded. The reader will find, by reference to the data pages, that it seldom was. We do not think that departure from local linear behavior was a serious problem in this research.

The errors due to "best-mean-square" fitting in calculating control deflections were evaluated in several typical cases: the measured control matrix was used to calculate the expected V_e increments that should result from our calculated (approximate) control settings, and these were compared with the values desired. In every case the differences were very small -- well within our experimental error. In other words, a best-mean-square fit to 32 points by 18 controls (or to 16 points by 10 controls) is a good approximation. This detail of our procedure is not one of the serious limitations.

Runs at Constant Control Settings, Varying Angle of Attack

These data (pages 165-172) probably need no discussion. It appears that the matching criterion RMS is relatively insensitive to angle of attack, for a given model configuration.

Effects of Matching Discrepancy

Up to this point, the success of the Arizona tunnel has been measured in terms of a rather arbitrary Figure of Merit, the RMS matching discrepancy at the interface. It is interesting to explore the relationship between this Figure of Merit and the accuracy of simulation at the model.

Some data on this relationship can be obtained by a simple numerical calculation, at least for representative cases.

When a distribution of matching-error is present at the interface, the correct boundary conditions are satisfied, both in the far field and at the model, but there is a discontinuity at the interface. If an equal-but-opposite discontinuity is introduced at the interface, the flow field will be continuous and will satisfy the far-field conditions, but conditions at the model will be disturbed by a field of extraneous velocities equivalent to changes of the models geometry and/or angle of attack.

Thus an evaluation of the tunnel's accuracy can be obtained by introducing these discontinuities at the interface and calculating their field of velocities at the model position.

In the present case, when DV_{θ} is known at the field points, the compensating discontinuity distribution consists of (1) source-sink panels of strength $-DV_{\theta}$ at the top, bottom, and front field points and (2) distributed-vortex panels of strength DV_{θ} at points one inch outboard of the side panels. Computer programs have been constructed to calculate the velocity field of this array of singularity-panels, and these have been used to calculate the vertical and horizontal extraneous velocity components at the following locations:

For Symmetric Cases:

Point No.	x	y	z	Comment
1	5	0	0	Wing
2	"	-2.5	0	Location
3	"	-5	0	
4	1	0	0	. . Nose of Body
5	10	0	0	. . Tail of Body
6	"	0	4	. . Empennage
7	"	0	-4	. . Wing Wake

For Asymmetric Cases:

1	5	5	0	
2	"	2.5	0	Wing
3	"	0	0	
4	"	-2.5	0	Location
5	"	-5	0	
6	1	0	0	. . Nose of Body
7	10	0	0	. . Tail of Body
8	"	0	4	. . Empennage
9	"	0	-4	. . Wing Wake

The results of these calculations are presented in pages 173 to 177. The extraneous velocity components at the model appear to be, in most cases, less than one percent of stream speed; there are, however, a few larger values. The values at "Point 4" (or "Point 6 in the asymmetric case), at the nose of the model, are consistently larger; two values are greater than three percent. This observation suggests that, in this tunnel, it might be advisable to locate the test model farther downstream.

Concluding Remarks

The authors of this report believe that their experiments have succeeded in proving that the concept of the Arizona High-Lift Wind Tunnel is sound. The demonstration tunnel used was designed economically; the wall controls employed, as well as the configuration of the blower, diffuser, and settling chamber reflect this economy. Nevertheless, the performance of this tunnel, measured by the matching accuracies obtained, is probably adequate for V/STOL testing.

The use of vaned panels as wall-control devices seems to be quite successful. In further development of this type of wind tunnel, attention should be given to (1) redesign or replacement of the variable-angle nozzle, (2) reconsideration of the geometry and arrangement of the working section and its controls, (3) provision of a steadier, more uniform basic tunnel airflow, which may require redesign of diffuser and settling chamber control devices.

Our success in using the L.D.A. to acquire the interface data required for this type of wind tunnel seems to confirm the experience of NASA personnel at Ames Research Center. The L.D.A., however, is a relatively slow instrument -- at least as it has been used in these experiments. It appears, to the present authors, that production wind tunnels of the Adaptable-Wall category must be provided with <u>on-line</u> instrumentation; we presume that L.D.A.s can be adapted to meet this requirement. Such tunnels will also require on-line computations and on-line setting of wall controls; these requirements do not seem difficult to achieve -- in fact, these features already exist in various forms.

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APPENDIX A

PROGRAM TO CALCULATE OUTSIDE-FLOW MATRIX

OF COMPONENT V_e

```
1 REM *************  IntTMatE.BAS  ******************
5 REM This pgm uses new numbering, viz. 1-4, 5-20, 21-32. 3/12/83
10 REM This is calc. of matrix members; viz. A(32,32) (normal/H-outbd) @ fld. p
s. of Interface "T" due to 4 source panels and 28 vo
rtex panels on T. Constructed  40985 from IntRMatE.BAS


20 DIM X(3,32), R(3,32), D(2), E(2,32), Y(3), W(3), L(3,3,32), Z(32)
30 DIM A(32,32)  'norm./outbd. comp.
40 DIM F(4), G(4), H(4) 'functions used in panel pgms. Symbol F() is used in bo
h panel pgms.
50 INPUT "Input N = no. strips for calc. W(3)"; N
60 INPUT "Input NN = no. strips for vortex panels";NN
70 CC = .0795775
75 GOSUB 3000


80                FOR Q = 5 TO 32
90                L(1,1,Q) = 1 : L(2,2,Q) = 1 : L(3,3,Q) = 1 : L(1,3,Q) = 0 : L(2
3,Q) = 0 : L(1,2,Q) = 0 : L(2,1,Q) = 0
100               NEXT Q
110               FOR Q = 21 TO 32
130               L(2,2,Q) = 0 : L(3,3,Q) = 0 : L(2,3,Q) = -1
140               NEXT Q
150               FOR Q = 1 TO 4
160               L(1,1,Q) = 0 : L(2,2,Q) = 1 : L(3,3,Q) = 0 : L(1,3,Q) = -1 : L(
,3,Q) = 0 : L(1,2,Q) = 0 : L(2,1,Q) = 0
170               NEXT Q
180               FOR Q = 1 TO 32
190               L(3,1,Q) = -L(1,3,Q) : L(3,2,Q) = -L(2,3,Q)
200               NEXT Q : GOTO 600 'as p.o. of L's not needed.
210       FOR J = 1 TO 32
220       LPRINT J;" ";L(1,1,J);" ";L(2,2,J);" ";L(3,3,J);" ";L(1,2,J);" ";L(2,3,
);" ";L(3,1,J);" ";L(1,3,J);" ";L(2,1,J);" ";L(3,2,J
);" ";J
230               NEXT J
240 STOP


600       FOR Q = 1 TO 4 'Front panels
620       D(1) = E(1,Q) : D(2) = E(2,Q)
630               FOR P = 1 TO 4 'Front points
650               GOSUB  6000
660               GOSUB  2000
670               NEXT P
680               FOR P = 5 TO 20 'Pts on top & bottom
700               GOSUB  6000
710               GOSUB 2300
720               NEXT P
```

```
730              FOR P = 21 TO 32 'Pts on sides
750              GOSUB 6000
760              GOSUB 2600
770              NEXT P,Q
800       FOR Q = 5 TO 32 'All vortex panels
820       D(1) = E(1,Q) : D(2) = E(2,Q)
830              FOR P = 1 TO 4
840              GOSUB 4000
850              GOSUB 2000
860              NEXT P
870              FOR P = 5 TO 20
880              GOSUB 4000
890              GOSUB 2300
900              NEXT P
910              FOR P = 21 TO 32
920              GOSUB 4000
930              GOSUB 2600
940              NEXT P,Q
950 GOSUB 1097 'As complete print-out of results is desired.


1000 PRINT "CHANGE DISK IN B" : STOP
1010 RESET
1020 OPEN "O",#1, "B:IntTMatE.DAT"
1030 FOR Q = 1 TO 32 : FOR P = 1 TO 32
1040 PRINT #1, A(P,Q),
1050 NEXT P,Q
1060 CLOSE #1
1070 STOP


1097    LPRINT "Complete P.Q. of A(P,Q) = IntTMatE.DAT"
1098    LPRINT "   Read down columns for Q"
1099    LPRINT : LPRINT
1100    FOR P = 1 TO 32 : LPRINT : LPRINT "P =";P
1105    FOR Q = 1 TO 8 : LPRINT A(P,Q), A(P,Q+8), A(P,Q+16), A(P,Q+24)
1110    NEXT Q,P
1160    RETURN


2000 A(P,Q) = 0
2010 FOR L = 1 TO 3
2020 A(P,Q) = A(P,Q) + L(1,L,Q)*W(L)
2030 NEXT L
2040 RETURN
2300    A(P,Q) = 0
2310    FOR L = 1 TO 3
2320    A(P,Q) = A(P,Q) + L(3,L,Q)*W(L)
2330    NEXT L
2340    RETURN
2600           A(P,Q) = 0
2610           FOR L = 1 TO 3
2620           A(P,Q) = A(P,Q) + L(1,L,Q)*W(L)
2630           NEXT L
2640           RETURN
```

```
3000 REM Pgm to input coords. of  panels on interface T.
3010 FOR Q = 1 TO 4
3020 R(1,Q) = 0 : E(1,Q) = 7.5 : E(2,Q) = 7.5 : Z(Q) = 1
3030 R(2,Q) = -7.5*INT((Q-1)/2)
3040 R(3,Q) = -7.5*(INT(Q/2) - INT((Q-1)/2))
3050 NEXT Q
3055           FOR Q = 5 TO 20
3060           Z(Q) = -1 + 2*(INT((Q-5)/4) -2*INT((Q-5)/8)) : R(2,Q) = -7.5*IN
((Q-5)/8) : R(3,Q) = -6.5*Z(Q)
3065 E(2,Q) = 7.5 : NEXT Q
3072 FOR Q = 5 TO 17 STEP 4 : R(1,Q) = 0 : E(1,Q) = 5 : NEXT Q
3073 FOR Q = 6 TO 18 STEP 4 : R(1,Q) = 5 : E(1,Q) = 5 : NEXT Q
3074 FOR Q = 7 TO 19 STEP 4 : R(1,Q) = 10 : E(1,Q) = 5 : NEXT Q
3075 FOR Q = 8 TO 20 STEP 4 : R(1,Q) = 15 : E(1,Q) = 10 : NEXT Q
3080    FOR Q = 21 TO 32
3090 Z(Q) = 1 - 2*INT((Q-21)/6)  :  R(2,Q) = 6.5*Z(Q) : R(3,Q) = -7.5*(INT((Q-2
)/3) - 2*INT((Q-21)/6)) : E(1,Q) = 5 + 5*(INT((Q+1)/
3)-INT(Q/3)) : E(2,Q) = 7.5
3100    NEXT Q
3110    FOR Q = 21 TO 30 STEP 3 : R(1,Q) = 2.5 : NEXT Q
3120    FOR Q = 22 TO 31 STEP 3 : R(1,Q) = 7.5 : NEXT Q
3130    FOR Q = 23 TO 32 STEP 3 : R(1,Q) = 12.5 : NEXT Q
3140 'GOTO 3330 ' as p.o. of panel coords not needed.
3200           FOR J = 1 TO 32
3210           LPRINT J;" ";R(1,J),R(2,J),R(3,J),Z(J),E(1,J);" ";E(2,J)
3220           NEXT J
3230 STOP


3330 REM This is pgm to input coords of fld pts on "T".
3340 FOR P = 1 TO 4
3350 X(1,P) = 0 : X(2,P) = R(2,P) + 3.75 : X(3,P) = R(3,P) + 3.75
3360 NEXT P
3500    FOR P = 5 TO 20
3510    X(1,P) = R(1,P) + .5*E(1,P) : X(2,P) = R(2,P) + 3.75 : X(3,P) = R(3,P)
3520    NEXT P
3530           FOR P = 21 TO 32
3540           X(1,P) = R(1,P) + .5*E(1,P) :  X(3,P) = R(3,P) + 3.75 : NEXT P
3543           FOR P = 21 TO 26 : X(2,P) = R(2,P) + 1 :  NEXT P
3545           FOR P = 27 TO 32 : X(2,P) = R(2,P) - 1 : NEXT P
3551 ' RETURN ' as p.o. of pt. coords not needed.
3552    FOR I = 1 TO 32
3553    LPRINT I, X(1,I), X(2,I), X(3,I), I
3554    NEXT I
3560 RETURN


4000 'Distributed-vortex panel program.
4010 C = 10000
4020 FOR L = 1 TO 3
4030 Y(L) = 0
4040 FOR K = 1 TO 3
4050 Y(L) = Y(L) + L(K,L,Q)*(X(K,P)-R(K,Q))
4060 NEXT K,L
4070 W(1) = 0 : W(2) = 0 : W(3) = 0
4080 IF Y(3) = 0 AND Y(1)/D(1) < 1 AND Y(1)/D(1) > 0 AND Y(2)/D(2) < 1 AND Y(2)
D(2) > 0 THEN GOTO 4290
4090 H(1) = Y(3)*Y(3)+Y(2)*Y(2) : H(2) = Y(3)*Y(3)+C*C : H(3) = Y(3)*Y(3)+(Y(2)
D(2))*(Y(2)-D(2))
```

```
4100 G(2) = Y(2)/SQR(Y(2)*Y(2)+H(2)) - (Y(2)-D(2))/SQR((Y(2)-D(2))*(Y(2)-D(2))
 H(2))
4110 FOR L = 1 TO NN
4120 Y(1) = X(1,P)-R(1,Q) - (L-.5)*D(1)/NN
4130 H(4) = Y(3)*Y(3) + Y(1)*Y(1)
4140 G(1) = Y(1)/SQR(Y(1)*Y(1)+H(1)) + 1
4150 G(3) = Y(1)/SQR(Y(1)*Y(1)+H(3))+1
4160 G(4) = Y(2)/SQR(Y(2)*Y(2)+H(4))-(Y(2)-D(2))/SQR((Y(2)-D(2))*(Y(2)-D(2))+H(
))
4170 F(1) = 0 : F(2) = 0 : F(3) = 0 : F(4) = 0
4180 IF H(1)<>0 THEN LET F(1)=Y(2)/H(1)
4190 IF H(2)<>0 THEN LET F(2)=C/H(2)
4200 IF H(3)<>0 THEN LET F(3)=(D(2)-Y(2))/H(3)
4210 IF H(4)<>0 THEN LET F(4)=Y(1)/H(4)
4220 IF Y(3)<>0 THEN GOTO 4240
4230 GOTO 4260
4240 W(1) = W(1)+Y(3)*CC/NN*(G(2)/H(2)-G(4)/H(4))*SGN(D(2))
4250 W(2) = W(2)+Y(3)*CC/NN*(G(3)/H(3)-G(1)/H(1))*SGN(D(2))
4260 W(3) = W(3)+CC/NN*(F(1)*G(1)+F(2)*G(2)+F(3)*G(3)+F(4)*G(4))*SGN(D(2))
4270 NEXT L
4280 RETURN
4290 W(1) = .5*Z(Q)/D(1) : W(2) = 0
4300 IF Y(2) <> .5*D(2) OR X(1,P)-R(1,Q) <> .5*D(1) THEN GOTO 4330
4310 W(3) = 4*CC/ABS(D(2))
4320 RETURN
4330 PRINT "W(1)=";W(1), "W(2)=";W(2), "W(3)=?"
4340 STOP


6000     REM Source-panel program
6010     FOR K = 1 TO 3
6020     Y(K) = 0
6030     FOR L = 1 TO 3
6040     Y(K) = Y(K)+L(L,K,Q)*(X(L,P)-R(L,Q))
6050     NEXT L,K
6060     W(1) = 0 : W(2) = 0 : W(3) = 0
6070     F(1) = SQR(Y(1)*Y(1)+Y(2)*Y(2)+Y(3)*Y(3))
6080     F(2) = SQR((Y(1)-D(1))*(Y(1)-D(1))+Y(2)*Y(2)+Y(3)*Y(3))
6090     F(3) = SQR(Y(1)*Y(1)+(Y(2)-D(2))*(Y(2)-D(2))+Y(3)*Y(3))
6100     F(4) = SQR((Y(1)-D(1))*(Y(1)-D(1))+(Y(2)-D(2))*(Y(2)-D(2))+Y(3)*Y(3))
6110     IF ABS (Y(1)) +ABS(Y(3))<>0 OR Y(2) >0 OR Y(2)-D(2)>0 THEN GOTO 6140
6120     W(1) = -CC*LOG ((Y(2)-D(2)+F(4))*ABS (Y(2)-D(2))/(Y(2)+F(2))/ABS (Y(2))
6130     GOTO 6180
6140     IF ABS (Y(1)-D(1))+ ABS (Y(3))<>0 OR Y(2)>0 OR Y(2)-D(2)>0 THEN GOTO 61
0
6150     W(1) = -CC*LOG (ABS (Y(2))*(Y(2)+F(1))/ABS(Y(2)-D(2))/(Y(2)-D(2)+F(3)))
6160     GOTO 6180
6170     W(1) = -CC*LOG((Y(2)-D(2)+F(4))*(Y(2)+F(1))/(Y(2)-D(2)+F(3))/(Y(2)+F(2)
)
6180     IF ABS(Y(2)-D(2))+ABS(Y(3))<>0 OR Y(1)-D(1)>0 OR Y(1)>0 THEN GOTO 6210
6190     W(2) = -CC*LOG(ABS(Y(1))*(Y(1)+F(1))/ABS(Y(1)-D(1))/(Y(1)-D(1)+F(2)))
6200     GOTO 6350
6210     IF ABS(Y(2))+ABS(Y(3))<>0 OR Y(1) > 0 OR Y(1)-D(1) > 0 THEN GOTO 6240
6220     W(2) = -CC*LOG((Y(1)-D(1)+F(4))*ABS(Y(1)-D(1))/(Y(1)+F(3))/ABS(Y(1)))
6230     GOTO 6350
```

```
6240     W(2) = -CC*LOG((Y(1)-D(1)+F(4))*(Y(1)+F(1))/(Y(1)-D(1)+F(2))/(Y(1)+F(3
)
6250     IF Y(3) = 0 THEN GOTO 6270
6260     GOTO 6300
6270     IF Y(2)/D(2) > 1 OR Y(2)/D(2) < 0 OR Y(1)/D(1) > 1 OR Y(1)/D(1) < 0 THE
         GOTO 6350
6280     W(3) = .5*Z(Q)
6290     GOTO 6350
6300     FOR L = 1 TO N
6310     E = Y(1)-(L-.5)*D(1)/N
6320     W(3) = W(3)-Y(3)*D(1)*CC/N/(E*E+Y(3)*Y(3))*((Y(2)-D(2))/SQR(E*E+(Y(2)-D
2))*(Y(2)-D(2))+Y(3)*Y(3))-Y(2)/SQR(E*E+Y(2)*Y(2)+Y(
3)*Y(3)))
6330     NEXT L
6340     W(3) = W(3)*SGN(D(1))*SGN(D(2))
6350     W(2) = W(2)*SGN(D(1))*SGN(D(2))
6360     W(1) = W(1)*SGN(D(1))*SGN(D(2))
6370 RETURN
```

APPENDIX B

PROGRAM TO CALCULATE OUTSIDE-FLOW MATRIX

OF COMPONENT V_t

```
1 REM *************  IntTMatB.BAS  ******************
5 REM This pgm uses new numbering, viz. 1-4, 5-20, 21-32. 3/12/83
10 REM This is calc. of matrix members; viz. A(32,32) (tangential) at fld. pts.
of Interface "T" due to 4 source panels and 28 vorte
x panels on T. Constructed 40985 from IntRMatB.BAS .


20 DIM X(3,32), R(3,32), D(2), E(2,32), Y(3), W(3), L(3,3,32), Z(32)
30 DIM A(32,32)  'tangential comp.
40 DIM F(4), G(4), H(4) 'functions used in panel pgms. Symbol F() is used in bo
h panel pgms.
50 INPUT "Input N = no. strips for calc. W(3)"; N
60 INPUT "Input NN = no. strips for vortex panels";NN
70 CC = .0795775
75 GOSUB 3000


80              FOR Q = 5 TO 32
90              L(1,1,Q) = 1 : L(2,2,Q) = 1 : L(3,3,Q) = 1 : L(1,3,Q) = 0 : L(2
3,Q) = 0 : L(1,2,Q) = 0 : L(2,1,Q) = 0
100             NEXT Q
110             FOR Q = 21 TO 32
130             L(2,2,Q) = 0 : L(3,3,Q) = 0 : L(2,3,Q) = -1
140             NEXT Q
150             FOR Q = 1 TO 4
160             L(1,1,Q) = 0 : L(2,2,Q) = 1 : L(3,3,Q) = 0 : L(1,3,Q) = -1 : L(
,3,Q) = 0 : L(1,2,Q) = 0 : L(2,1,Q) = 0
170             NEXT Q
180             FOR Q = 1 TO 32
190             L(3,1,Q) = -L(1,3,Q) : L(3,2,Q) = -L(2,3,Q)
200             NEXT Q : GOTO 600 'as p.o. of L's not needed.
210       FOR J = 1 TO 32
220       LPRINT J;" ";L(1,1,J);" ";L(2,2,J);" ";L(3,3,J);" ";L(1,2,J);" ";L(2,3,
);" ";L(3,1,J);" ";L(1,3,J);" ";L(2,1,J);" ";L(3,2,J
);" ";J
230             NEXT J
240 STOP


600       FOR Q = 1 TO 4 'Front panels
620       D(1) = E(1,Q) : D(2) = E(2,Q)
630             FOR P = 1 TO 4 'Front points
650             GOSUB  6000
660             GOSUB  2000
670             NEXT P
680             FOR P = 5 TO 20 'Pts on top & bottom
700             GOSUB  6000
710             GOSUB 2300
720             NEXT P
```

```
730              FOR P = 21 TO 32 'Pts on sides
750              GOSUB 6000
760              GOSUB 2600
770              NEXT P,Q
800      FOR Q = 5 TO 32 'All vortex panels
820      D(1) = E(1,Q) : D(2) = E(2,Q)
830              FOR P = 1 TO 4
840              GOSUB 4000
850              GOSUB 2000
860              NEXT P
870              FOR P = 5 TO 20
880              GOSUB 4000
890              GOSUB 2300
900              NEXT P
910              FOR P = 21 TO 32
920              GOSUB 4000
930              GOSUB 2600
940              NEXT P,Q
950 GOSUB 1097 'As complete print-out of results is desired.

1000 PRINT "CHANGE DISK IN B" : STOP
1010 RESET
1020 OPEN "O",#1, "B:IntTMatB.DAT"
1030 FOR Q = 1 TO 32 : FOR P = 1 TO 32
1040 PRINT #1, A(P,Q),
1050 NEXT P,Q
1060 CLOSE #1
1070 STOP


1097     LPRINT "Complete P.O. of A(P,Q) = IntRMatB.DAT"
1098     LPRINT "   Read down columns for Q"
1099     LPRINT : LPRINT
1100     FOR P = 1 TO 32 : LPRINT : LPRINT "P =";P
1105     FOR Q = 1 TO 8 : LPRINT A(P,Q), A(P,Q+8), A(P,Q+16), A(P,Q+24)
1110     NEXT Q,P
1160     RETURN


2000 A(P,Q) = 0
2010 FOR L = 1 TO 3
2020 A(P,Q) = A(P,Q) + L(3,L,Q)*W(L)
2030 NEXT L
2040 RETURN
2300     A(P,Q) = 0
2310     FOR L = 1 TO 3
2320     A(P,Q) = A(P,Q) + L(1,L,Q)*W(L)
2330     NEXT L
2340     RETURN
2600             A(P,Q) = 0
2610             FOR L = 1 TO 3
2620             A(P,Q) = A(P,Q) + L(1,L,Q)*W(L)
2630             NEXT L
2640             RETURN
```

```
3000 REM Pgm to input coords. of  panels on interface RS.
3010 FOR Q = 1 TO 4
3020 R(1,Q) = 0 : E(1,Q) = 7.5 : E(2,Q) = 7.5 : Z(Q) = 1
3030 R(2,Q) = -7.5*INT((Q-1)/2)
3040 R(3,Q) = -7.5*(INT(Q/2) - INT((Q-1)/2))
3050 NEXT Q
3055            FOR Q = 5 TO 20
3060            Z(Q) = -1 + 2*(INT((Q-5)/4) -2*INT((Q-5)/8)) : R(2,Q) = -7.5*IN
((Q-5)/8) : R(3,Q) = -6.5*Z(Q)
3065 E(2,Q) = 7.5 : NEXT Q
3072 FOR Q = 5 TO 17 STEP 4 : R(1,Q) = 0 : E(1,Q) = 5 : NEXT Q
3073 FOR Q = 6 TO 18 STEP 4 : R(1,Q) = 5 : E(1,Q) = 5 : NEXT Q
3074 FOR Q = 7 TO 19 STEP 4 : R(1,Q) = 10 : E(1,Q) = 5 : NEXT Q
3075 FOR Q = 8 TO 20 STEP 4 : R(1,Q) = 15 : E(1,Q) = 10 : NEXT Q
3080    FOR Q = 21 TO 32
3090 Z(Q) = 1 - 2*INT((Q-21)/6)  :  R(2,Q) = 6.5*Z(Q) : R(3,Q) = -7.5*(INT((Q-2
)/3) - 2*INT((Q-21)/6)) : E(1,Q) = 5 + 5*(INT((Q+1)/
3)-INT(Q/3)) : E(2,Q) = 7.5
3100    NEXT Q
3110    FOR Q = 21 TO 30 STEP 3 : R(1,Q) = 2.5 : NEXT Q
3120    FOR Q = 22 TO 31 STEP 3 : R(1,Q) = 7.5 : NEXT Q
3130    FOR Q = 23 TO 32 STEP 3 : R(1,Q) = 12.5 : NEXT Q
3140 'GOTO 3330 ' as p.o. of panel coords not needed.
3200            FOR J = 1 TO 32
3210            LPRINT J;" ";R(1,J),R(2,J),R(3,J),Z(J),E(1,J);" ";E(2,J)
3220            NEXT J
3230 STOP


3330 REM This is pgm to input coords of fld pts on "RS".
3340 FOR P = 1 TO 4
3350 X(1,P) = 0 : X(2,P) = R(2,P) + 3.75 : X(3,P) = R(3,P) + 3.75
3360 NEXT P
3500    FOR P = 5 TO 20
3510    X(1,P) = R(1,P) + .5*E(1,P) : X(2,P) = R(2,P) + 3.75 : X(3,P) = R(3,P)
3520    NEXT P
3530            FOR P = 21 TO 32
3540 X(1,P) = R(1,P) + .5*E(1,P) : X(2,P) = R(2,P) : X(3,P) = R(3,P) + 3.75 : N
XT P
3551 ' RETURN ' as p.o. of pt. coords not needed.
3552    FOR I = 1 TO 32
3553    LPRINT I, X(1,I), X(2,I), X(3,I), I
3554    NEXT I
3560 RETURN
```

4000-4340 Distributed-vortex panel program : See Appendix A

6000-6370 Source-panel program: See Appendix A

APPENDIX C

PROGRAM TO CALCULATE OUTER-FLOW MATRIX

Combined Matrix ExBinvT$.BAS

```
10 REM Calc of ExBinvT$
20 INPUT "Input N  ", N
30 DIM A(N,N), B(N,N), C(N,N)
50 OPEN "I", #1, "B:IntT$MtE.DAT
60 FOR J = 1 TO N : FOR I = 1 TO N ' <<<<<<<<<<<<<< BY COLUMNS
70 INPUT #1, A(I,J) : NEXT I,J : CLOSE #1
75 STOP

100      OPEN "I", #1, "B:BinvrsT$.DAT
110      FOR I = 1 TO N : FOR J = 1 TO N   '  <<<<<<<<<<< BY ROWS ! ! ! !
120      INPUT #1, B(I,J) : NEXT J,I : CLOSE #1
125 STOP

150 FOR I = 1 TO N : FOR J = 1 TO N : C(I,J) = 0
160 FOR K = 1 TO N : C(I,J) = C(I,J) + A(I,K)*B(K,J)
170 NEXT K,J,I

200      OPEN "O", #1, "B:ExBinvT$.DAT
210      FOR I = 1 TO N : FOR J = 1 TO N ' <<<<<<   BY ROWS
220      PRINT #1, C(I,J) : NEXT J,I : CLOSE #1
225 STOP

250 LPRINT : LPRINT "Complete P.O. of C(I,J) = ExBinvT$ by rows"
260 LPRINT : LPRINT "Read columns down for increasing J."
270 FOR I = 1 TO N : LPRINT : LPRINT "I =";I
280 FOR J = 1 TO N/4 : LPRINT C(I,J), C(I,J+4), C(I,J+8), C(I,J+12)
290 NEXT J,I
300 PRINT "END" : END
```

APPENDIX D

PROGRAM FOR MEASUREMENT AND "INVERSION" OF CONTROL MATRIX (SYMMETRICAL CASE)

```
5 PRINT ">>>>>>>>>>>>>>>>  MeasMtx5.BAS   <<<<<<<<<<<<<<<<<<<<<<<"
6 PRINT : PRINT " >>>>>>>>>>>>> DOUBLE INCREMENTS, CENTERED  <<<<<<<<<"
10 PRINT : PRINT "             PROGRAM FOR MAKING MATRIX RUNS"
15 PRINT : PRINT "   FULLY SYMMETRICAL CASE: 16 POINTS. 10 CONTROLS"
16 PRINT : PRINT "        Extended averaging     240186"

17 PRINT : INPUT "    Enter NSPL   ",NSPL
18 GOSUB 12000 : TRANSFER=&HC000 : NBTS = 1 : AD = 49408!
19 PRINT : INPUT "    Enter TOL   ",TOL
20 BC=TRANSFER+3:POKE BC,0
30 CALL TRANSFER
40 KKKK=156115!
70 FILES "B:*.*" : PRINT
80 INPUT"Enter experiment No.  ", EX
90 INPUT"Enter date (DDMMYY)  ",DATE
100 DIM V(3,17), I(17)

110 V(3,11) = EX : V(3,13) = DATE
120 PRINT"ENTER INITIAL CONTROL SETTINGS":PRINT
130 FOR K=1 TO 10
140 PRINT"Control setting #"K;:INPUT V(3,K)
150 NEXT K:PRINT:PRINT
160 LPRINT "Initial Control Settings" : LPRINT
170     FOR K = 1 TO 13 : LPRINT , K, V(3,K) : NEXT K
180     LPRINT : LPRINT
190     PRINT "Please check initial control settings."
200     PRINT "To change Kth C.S., write 'V(3,K)=...'"
205     PRINT
210     PRINT "then, to proceed, use ^1" : STOP

300 PRINT : PRINT : INPUT "What kind of run do you want to make?
                             Enter 1 for CHECK, enter
3 for MATRIX.    ", SEL
310 PRINT : PRINT
320 IF SEL = 1 THEN GOTO 500
340 IF SEL = 3 THEN GOTO 3900 ELSE GOTO 300
500 REM ***** SUBROUTINE FOR "CHECK"    ************************
510 INPUT "Enter Run No. (between .001 & .999) ", RX
520 INPUT "What is Number of Field Point"; I
530 PRINT
540 INPUT "Which component are you measuring?
           If I < 11, enter 1 for horiz., 2 for vert
                                   If I > 10, enter 2 for outboard, 1 for i
nboard.  ",CO

550 K = CO
555 INPUT "Enter Chamber pressure SCP1.   ", SCP1
560 IF I < 3 THEN K = K MOD 2 + 1
565 GOSUB 5000
570 GOSUB 7000
580 V(K,I) = CF*AVER
```

```
590  LPRINT : LPRINT "Exp.No.";EX;", Run No.";RX;", Comp.";K;", Fld.Pt.";I
595 LPRINT "SCP =";SCP, "SCP1 =";SCP1, "CF =";CF
600  LPRINT "V(";K;",";I;") =";V(K,I)," ","Standard Dev.=";SD : LPRINT
620 INPUT "Enter 1 if you want to take another reading.
             Enter 0 if you're through.   ", NTHR
630 IF NTHR = 1 THEN GOTO 520
635 IF NTHR = 0 THEN GOTO 640 ELSE GOTO 620
640 LPRINT : LPRINT : GOTO 300

3800 REM **********  PROCEDURE TO MEASURE MATRIX OF Ve  ($ymm. case)  **********
3900                FOR Z = 1 TO 17 : I(Z) = Z : NEXT Z
3910                FOR Z = 7 TO 10 : I(Z) = 17 - Z : NEXT Z
3920                FOR Z = 14 TO 16 : I(Z) = 30 - Z : NEXT Z

3940 PRINT "_______________________________________________________"
3950 PRINT : PRINT "If run must be interrupted,"
3960 PRINT "enter GOTO 13000."
3970 PRINT "REMEMBER THIS!!"
3980 PRINT : PRINT "_____________________________________________ : PRINT : STOP
3990 PRINT : PRINT "If this is continuation of an interrupted run,"
3995 PRINT "enter GOTO 14000.  Otherwise enter ^1." : STOP
4000 PRINT : PRINT

4010 INPUT "Enter Run No. (above 1000) ", RM
4015 INPUT "Enter SCP1   ", SCP1
4020  DIM C(17,13)
4030 FOR J = 1 TO 13 : C(17,J) = V(3,J) : NEXT J
4040 Z = 1 : I = I(Z) : J = 0
4050 OPEN "O", #1, "B:TempMtx.DAT"
4055 ON ERROR GOTO 13000

4060 PRINT : PRINT "     Go to Fld. Pt. #";I;" & set optics"
4070 PRINT "     to measure  HORIZ component." : PRINT
4071 J=J+1 : PRINT :PRINT "DEcrease setting of Control #";J "by an amount ARB."
4072 PRINT
4073  INPUT "     What is this amount, ARB?   ", ARB : IF ARB=0 THEN GOTO 4073

4074 PRINT : PRINT "Setting of Control #";J" should be";V(3,J)-ARB : PRINT
4075 GOSUB 5000
4080 GOSUB 7500
4090 VV = AVER
4110 PRINT : PRINT "INcrease setting of Control #";J;"by 2 times ARB,"
4115 PRINT "namely to";V(3,J)+ARB : PRINT
4120 INPUT "     Proceed, by entering 123, to
                 re-measure HORIZ component.   ", ZW
4125 IF ZW = 123 THEN GOTO 4130 ELSE GOTO 4120
4130 GOSUB 9500
4140 PRINT "Return Control #";J;"to original setting, viz.";V(3,J)","
4145 INPUT "then enter 345 to continue.   ", ZW
4147 IF ZW = 345 THEN GOTO 4150 ELSE GOTO 4145
4150 IF J < 10 THEN GOTO 4071
4160 GOSUB 4570
```

```
4170 Z = Z + 1 : I = I(Z) : J = 0
4180 IF I < 3 THEN GOTO 4060
4190 PRINT : PRINT "      Go to Fld. Pt. #";I;" & set optics"
4200 PRINT "       to measure VERT component." : PRINT
4201 J=J+1 : PRINT : PRINT "DEcrease setting of Control #";J "by an amount ARB."
4202 PRINT
4203 INPUT "     What is this amount, ARB?   ", ARB : IF ARB=0 THEN GOTO 4203
4204 PRINT : PRINT "Setting of Control #";J" should be";V(3,J)-ARB : PRINT
4205 GOSUB 5000
4210 GOSUB 7500
4220 VV = AVER
4240 PRINT : PRINT "INcrease setting of Control #";J;"by 2 times ARB,"
4245 PRINT "namely to";V(3,J)+ARB : PRINT
4250 INPUT "       Proceed, by entering 123, to
                   re-measure VERT component.   ", ZW
4255 IF ZW = 123 THEN GOTO 4260 ELSE GOTO 4250
4260 GOSUB 9500
4270 PRINT "Return Control #";J;"to original setting, viz.";V(3,J)",""
4275 INPUT "then enter 345 to continue.   ", ZW
4277 IF ZW = 345 THEN GOTO 4280 ELSE GOTO 4275
4280 IF J < 10 THEN GOTO 4201
4290 GOSUB 4570
4300 Z = Z + 1 : I = I(Z) : J = 0
4310 IF I < 11 THEN GOTO 4190
4320 PRINT : PRINT "      Go to Fld. Pt. #";I;" & set optics"
4330 PRINT "       to measure OUTboard horiz. component."
4331 J=J+1 : PRINT : PRINT "DEcrease setting of Control #";J" by an amount ARB."
4332 PRINT
4333 INPUT "       What is this amount, ARB?   ", ARB : IF ARB=0 THEN GOTO 4333
4334 PRINT : PRINT "Setting of Control #";J" should be";V(3,J)-ARB : PRINT
4335 GOSUB 5000
4340 GOSUB 7500
4350 VV = AVER
4370 PRINT : PRINT "INcrease setting of Control #";J;"by 2 times ARB,"
4375 PRINT "namely to";V(3,J)+ARB : PRINT
4380 INPUT "       Proceed, by entering 123,
                   to re-measure OUTbd. horiz. comp.
 ", ZW
4385 IF ZW = 123 THEN GOTO 4390 ELSE GOTO 4380
4390 GOSUB 9500
4400 PRINT "Return Control #";J;"to original setting, viz.";V(3,J)","
4405 INPUT "then enter 345 to continue.    ", ZW
4407  IF ZW = 345 THEN GOTO 4410 ELSE 4405
4410 IF J < 10 THEN GOTO 4331
4420 GOSUB 4570
4430 Z = Z + 1 : I = I(Z) : J = 0
4440 IF I < 17 THEN GOTO 4320
4450 GOSUB 4570
4460 CLOSE #1 : ON ERROR GOTO 0


4465 ' ************  COMPLETE PRINT-OUT OF MATRIX OF Ve  ***********************
***
4468 DIM A(17,13)
4470            OPEN "I", #1, "B:TempMtx.DAT"
4480            FOR Z = 1 TO 17 : FOR J = 1 TO 13
4490            INPUT #1, A(Z,J) : NEXT J,Z : CLOSE #1 : STOP
```

```
4491 FOR I = 1 TO 17 : FOR J = 1 TO 13 : C(I,J) = A(I,J) : NEXT J,I
4492 FOR I = 7 TO 10 : FOR J = 1 TO 13 : C(I,J) = A(17-I,J) : NEXT J,I
4494 FOR I = 14 TO 16 : FOR J = 1 TO 13 : C(I,J) = A(30-I,J) : NEXT J,I
4496 OPEN "O", #1, "B:Lt$tMtx.DAT
4497 FOR I = 1 TO 17 : FOR J = 1 TO 13 ' <<<<<<<<< C(17,13) BY ROWS!!!
4498 PRINT #1, C(I,J) : NEXT J,I : CLOSE #1
4500     LPRINT : LPRINT "          P.O. of C(I,J) = Lt$tMtx.DAT"
4510     LPRINT "          viz. latest control matrix" : LPRINT
4520     FOR I = 1 TO 17 : LPRINT : LPRINT  "          I ="; I
4530     FOR J = 1 TO 4 : LPRINT , C(I,J),C(I,J+4),C(I,J+8) : NEXT J
4540     LPRINT , C(I,13) : LPRINT : NEXT I
4550     PRINT "End of complete print-out of matrix Lt$tMtx.DAT"
4555 INPUT "Enter 123 to proceed with 'inversion'.    ", ZW
4557 IF ZW = 123 THEN GOTO 4560 ELSE GOTO 4555


4560 GOTO 6000


4570     C(I,11) = EX : C(I,12) = RM : C(I,13) = DATE
4580     FOR J = 1 TO 13 : PRINT #1, C(I,J) : NEXT J
4585 LCTR = Z
4590             LPRINT : LPRINT
4600             LPRINT : LPRINT "I =";I : LPRINT
4610             FOR J = 1 TO 13
4620             LPRINT C(I,J), : NEXT J
4630             LPRINT : LPRINT
4640             RETURN


5000     INPUT "When LDV is ready, enter 123.    ",  ZW
5010      IF ZW = 123 THEN GOTO 5020 ELSE GOTO 5000
5020     RETURN


6000 REM *********  BEST-MSQ "INVERSION" OF C(16,10) ********************
6010 DIM B(10,10), U(10,10), Y(10,10)
6020 FOR Q = 1 TO 10 : FOR P = 1 TO 10 : B(P,Q) = 0
6030 FOR K = 1 TO 16 : B(P,Q) = B(P,Q) + C(K,P)*C(K,Q) : NEXT K,P,Q
6080     FOR K = 1 TO 10 : FOR J = K TO 10 : U(K,J) = B(K,J)
6090     IF K = 1 THEN GOTO 6110
6100     FOR P = 1 TO K-1 : U(K,J) = U(K,J) - U(K,P)*U(P,J) : NEXT P
6110     NEXT J
6120             FOR I = K+1 TO 10 : U(I,K) = B(I,K)/U(K,K)
6130             IF K = 1 THEN GOTO 6160
6140             FOR P = 1 TO K-1
6150             U(I,K) = U(I,K) - U(I,P)*U(P,K)/U(K,K) : NEXT P
6160             NEXT I,K
6170     FOR J = 1 TO 10 : FOR I = J TO 10
6180     IF I = J THEN D = 1 ELSE D = 0
6190     Y(I,J) = D
6200     IF J > I-1 THEN GOTO 6220
6210     FOR P = J TO I-1 : Y(I,J) = Y(I,J) - U(I,P)*Y(P,J) : NEXT P
6220     NEXT I,J
6230 FOR J = 1 TO 10 : FOR H = J TO 1 STEP -1
6240 IF J = H THEN D = 1 ELSE D = 0
6250 Y(H,J) = D/U(H,H) : IF J < H+1 THEN GOTO 6280
6260 FOR P = H+1 TO J
6270 Y(H,J) = Y(H,J) - U(H,P)*Y(P,J)/U(H,H) : NEXT P
6280 NEXT H,J
```

```
6290     DET = U(1,1) : FOR I = 2 TO 10
6300     DET = DET*U(I,I) : NEXT I
6310     PRINT "DET =";DET
6320               FOR J = 1 TO 10 : FOR I = 1 TO 10 : U(I,J) = 0
6330               FOR K = 1 TO 10
6340               IF K = J THEN YY = 1 ELSE YY = Y(K,J)
6350               IF K < I OR K < J THEN GOTO 6370
6360               U(I,J) = U(I,J) + Y(I,K)*YY
6370               NEXT K,I,J
6380 '   GOSUB 8000  if p.o. of B*Binv is needed
6390 ERASE B, Y : DIM Y(13,16)
6400 FOR I = 1 TO 16 : Y(11,I) = EX : Y(12,I) = RM : Y(13,I) = DATE
6410 FOR J = 1 TO 10 : Y(J,I) = 0
6420 FOR K = 1 TO 10 : Y(J,I) = Y(J,I) + U(J,K)*C(I,K)
6430 NEXT K,J,I

6440     OPEN "O", #1, "B:VEintoC$.DAT" ' <<<<<<<<< Y(13,16) BY COLUMNS!!!
6450     FOR I = 1 TO 16 : FOR J = 1 TO 13
6460     PRINT #1, Y(J,I) : NEXT J,I : CLOSE #1
6470               LPRINT: LPRINT :LPRINT "      Complete p.o. of Y = VEintoC$.DAT"
6480               LPRINT "       Exp.#";EX;"  Run #";RM;"  Date"; DATE
6490               FOR J = 1 TO 10 : LPRINT : LPRINT  "        Control #, J :";J
6500               FOR I = 1 TO 4 : LPRINT , Y(J,I),Y(J,I+4),Y(J,I+8),Y(J,I+12)
6510               NEXT I,J
6540     PRINT "End of complete p.o. of VEintoC$.DAT"
6550     PRINT : PRINT "VEintoC$.DAT is saved on B."
6560 PRINT : INPUT "Enter 123 to return to Line 300,
                   viz., What kind of run ..?    ",
 ZX
6570 IF ZX = 123 THEN GOTO 300
6580 PRINT "END OF RUN" : END

7000 REM *************  Subroutine for CHECK   *****************
7005 GOSUB 10000
7010      INPUT "Enter SCP    ", SCP
7020     CF = SQR(SCP1/SCP)
7025 AVER = W(CR)
7030 PRINT : PRINT : PRINT "Average VEL =";AVER, "Std. Dev. =";SD
7040 PRINT : PRINT "SCP =";SCP, "SCP1 =";SCP1, "CF =";CF
7050 PRINT "Corrected Vel. ="; CF * AVER
7060 PRINT : INPUT "         To proceed, enter 9; to repeat measurement
                     of vel. comp., enter 8
 ", PQ
7070 IF PQ = 9 THEN GOTO 7080
7075 IF PQ = 8 THEN GOTO 7005 ELSE GOTO 7060
7080 PRINT : PRINT "----------------------------------------" : PRINT
7090 RETURN
```

```
7500   ' Subr. for MATRIX  ************************
7505 GOSUB 10000
7507 AVER = W(CR)
7510 PRINT "Average VEL =";AVER, "Std. Dev. =";SD
7515 PRINT "                 --------"
7520 PRINT : INPUT "           To repeat measurement of vel.comp.,
                               enter 8; to proceed, ent
er 9.        ", PQ
7530 IF PQ = 9 THEN GOTO 7540
7535 IF PQ = 8 THEN GOTO 7500 ELSE GOTO 7520
7540 PRINT : PRINT "-----------------------------------------------" : PRINT

7550 RETURN

8000 ' ************* Check of inversion by multiplication ***************
8010 DIM Z(10,10) : FOR J = 1 TO 10 : PRINT "J =";J
8020 FOR I = 1 TO 10 : Z(I,J) = 0 : FOR K = 1 TO 10
8030 Z(I,J) = Z(I,J) + B(I,K)*U(K,J) : NEXT K
8040 PRINT Z(I,J), : NEXT I : PRINT : NEXT J
8050 RETURN

9500 GOSUB 7500
9510 C(I,J) = (AVER - VV)/ARB/2
9520    RETURN
```

FOR SUBROUTINE TO MEASURE VELOCITY & CALCULATE AVER & STD DEV, SEE APPENDIX E

(Lines 9990 - 12640)

```
13000 ' *************  Error Handling  **************
13010 CLOSE #1
13020 PRINT : PRINT "INTERRUPTED MATRIX RUN"
13030 PRINT "Current I and J are" I " and " J
13040 PRINT : PRINT "The last counter Z for which row"
13050 PRINT "C(Z,J) was stored on disk is";LCTR
13060 END
14000 REM  *******  Procedure for restarting interrupted MATRIX run  ***********
14010 INPUT "Enter value LCTR of aborted run.  ",Z
14020 I = I(Z)
14030 DIM C(17,13)
14040 OPEN "I", #1, "B:TempMtx.DAT
14050 FOR ZZ = 1 TO Z : FOR J = 1 TO 13
14060 INPUT #1, C(ZZ,J) : NEXT J,ZZ : CLOSE #1
14070 PRINT "Check some values of C(ZZ,J), then use ^1 to continue." : STOP
14080 OPEN "O", #1, "B:TempMtx.DAT
14090 ON ERROR GOTO 13000
14100 FOR ZZ = 1 TO Z : FOR J = 1 TO 13
14110 PRINT #1, C(ZZ,J) : NEXT J,ZZ
14120 Z = Z+1 : I = I(Z) : J = 0
14130 IF Z<3 THEN GOTO 4180
14140 IF Z<11 THEN GOTO 4310
14150 IF Z<17 THEN GOTO 4440
```

APPENDIX E

PROGRAM FOR "CHECK" READINGS AND FOR RUNS

```
5 REM >>>>>>>>>>>   WTXp$m18.BAS   <<<<<<<<<<<<<<<<<<<<
6  PRINT "        This is WTXp$m18.BAS - - 230186" : PRINT
7 PRINT "PROGRAM FOR WIND-TUNNEL RUNS: DATA ACQUISITION ETC." : PRINT
8 PRINT "     SYMM. CASE. 16 FLD PTS. 10 CONTROLS" : PRINT
9 PRINT "  with extended averaging of VEL readings." : PRINT

10 PRINT : PRINT "For re-calc. w.o. measurements, GOTO 70" : STOP
15 GOSUB 12000:TRANSFER=&HC000:NBTS=1:AD=49408!
17 PRINT : INPUT "      Enter NSPL     ", NSPL
18 PRINT : INPUT "      Enter TOL    ", TOL
20 BC=TRANSFER+3:POKE BC,0
30 CALL TRANSFER
40 KKKK=156115!
70 PRINT :FILES "B:*.*" : PRINT
80 PRINT : INPUT"Enter experiment No.  ", EX
90 INPUT"Enter date (DDMMYY)  ",DATE
100 DIM V(3,16), I(17), W(25)
105 PRINT : PRINT "For re-calc of data GOTO 3710 or 3000" : STOP : PRINT

110 V(3,11) = EX : V(3,13) = DATE
120 PRINT"ENTER INITIAL CONTROL SETTINGS":PRINT
125 PRINT "(To skip, GOTO 300)" : PRINT : STOP
130 FOR K=1 TO 10
140 PRINT"Control s^tting #"K;:INPUT V(3,K)
150 NEXT K:PRINT:PRINT
160 LPRINT "Initial Control Settings" : LPRINT
170     FOR K = 1 TO 13 : LPRINT K, V(3,K), K  : NEXT K
180     LPRINT : LPRINT
190     PRINT "Please check initial control settings."
200     PRINT "To change Kth C.S., write 'V(3,K)=...'"
210     PRINT "To proceed, use ^1." : STOP

300 INPUT "What kind of run do you want to make?
          Enter 1 for CHECK, enter 2 for RUN  ",SEL
310 PRINT : PRINT
320 IF SEL = 1 THEN GOTO 500
330 IF SEL = 2 THEN GOTO 1000 ELSE GOTO 300

500 REM ***** SUBROUTINE FOR "CHECK"   *************************
510 INPUT "Enter Run No. (between .001 & .999) ", RX
520 INPUT "What is Number of Field Point"; I
530 PRINT
540 INPUT "Which component are you measuring?
          If I < 11, enter 1 for horiz., 2 for vert
.                                    If I > 10, enter 2 for outboard, 1 for i
nboard.  ",CO
```

```
550 K = CO
555 INPUT "Enter Chamber Pressure SCP1.   ", SCP1
560 IF I < 3 THEN K = K MOD 2 + 1
565 GOSUB 5000
570 GOSUB 7000
580 V(K,I) = CF*AVER
590  LPRINT : LPRINT "Exp.No.";EX;", Run No.";RX;", Comp.";K;", Fld.Pt.";I
595 LPRINT "SCP =";SCP, "SCP1 =";SCP1, "CF =";CF , "CR =";CR
600  LPRINT "V(";K;",";I;") =";V(K,I)," ","Standard Dev.=";SD : LPRINT
610 LPRINT
620 INPUT "Enter 1 if you want to take another reading.
             Enter 0 if you're through.   ", NTHR
630 IF NTHR = 1 THEN GOTO 520
635 IF NTHR = 0 THEN GOTO 640 ELSE GOTO 620
640 LPRINT : LPRINT : GOTO 300

1000 REM ******  SUBROUTINE FOR "RUN"  **************
1010 INPUT "Enter Run No. minus 1     ", RN
1020 INPUT "Enter UU = x comp. of stream vel. ", UU
1030 INPUT "Enter WW = z comp. of stream vel. ", WW
1040 INPUT "Enter relax. factor kk.  ", KK
1045 INPUT "Enter SCP1     ", SCP1
1050 RN = RN + 1 : V(3,12) = RN : V(3,14) = UU : V(3,15) = WW
1060 LPRINT "This is Exp. #";EX;", Run #";RN
1065 LPRINT "UU =";UU, "WW =";WW, "k =";KK, "SCP1 =";SCP1 : LPRINT

1070    FOR CTR = 1 TO 3 : I(CTR) = CTR + 10 : NEXT CTR
1071    FOR CTR = 4 TO 6 : I(CTR) = 20 - CTR : NEXT CTR
1072    FOR CTR = 7 TO 8 : I(CTR) = 9 - CTR : NEXT CTR
1073    FOR CTR = 9 TO 12 : I(CTR) = CTR - 6 : NEXT CTR
1074    FOR CTR = 13 TO 16 : I(CTR) = 23 - CTR : NEXT CTR
1080    I(17) = 17

1085 CTR = 1 : I = 11 : K = 1
1090 PRINT "Go to fld. pt. #";I;" to measure HORIZ-INBD comp."
1100 GOSUB 5000
1110 GOSUB 9000
1120 IF K = 1 THEN K = 2 ELSE K = 1
1130 PRINT "Move optics 1 in. OUTboard to  measure HORIZ-OUTBD"
1140 GOSUB 5000
1150 GOSUB 9000
1160 CTR = CTR + 1 : I = I(CTR)
1170 PRINT "Go to fld. pt. #";I;"to measure HORIZ-OUTBD"
1180 GOSUB 5000
1190 GOSUB 9000
1200 IF K = 1 THEN K = 2 ELSE K = 1
1210 PRINT "Move optics 1 in. INbd. to measure HORIZ-INBD comp."
1220 GOSUB 5000
1230 GOSUB 9000
1240 CTR = CTR + 1 : I = I(CTR)
1250 IF I <> 2 THEN GOTO 1090

1255 IF I = 2 THEN K = 2
1260 IF I = 3 THEN K = 1
1270 PRINT "Go to Fld. Pt. #";I;" to measure HORIZ component"
1280 GOSUB 5000
1290 GOSUB 9000
```

```
1300 IF K = 1 THEN K = 2 ELSE K = 1
1310 PRINT "Rotate optics to measure VERT component."
1320 GOSUB 5000
1330 GOSUB 9200
1340 CTR = CTR + 1 : I = I(CTR)
1350 PRINT "Go to fld. pt. #";I;"to measure VERT component."
1360 GOSUB 5000
1370 GOSUB 9200
1380 IF K = 1 THEN K = 2 ELSE K = 1
1390 PRINT "Rotate optics to measure HORIZ component."
1400 GOSUB 5000
1410 GOSUB 9000
1420 CTR = CTR + 1 : I = I(CTR)
1430 IF CTR < 17 THEN GOTO 1255


1435 V(3,14) = UU : V(3,15) = WW
1440    LPRINT "I", "Vt = V(1,I)", "Ve = V(2,I)", "CS = V(3,I)", "I"  : LPRINT
1450     FOR I = 1 TO 16 : LPRINT I, V(1,I), V(2,I), V(3,I), I : NEXT I
1453 BETA = ATN(WW/UU)*57.3
1460    LPRINT : LPRINT : LPRINT "UU =";UU,"WW =";WW,"BETA =";BETA, "k= ";KK
1465 LPRINT : LPRINT : PRINT "To skip saving V(I,J)s,GOTO 2000" : STOP


1470 OPEN "O", #1, "B:TempVel$.DAT"
1480 FOR K = 1 TO 3 : FOR I = 1 TO 16 : PRINT #1, V(K,I)
1490 NEXT I,K : CLOSE #1
1500 PRINT "V(I,J) is saved in B:TempVel$.DAT"
1505 PRINT : PRINT "Change name of TempVel$.DAT?" : STOP
1510 PRINT : PRINT "To continue iteration, GOTO 2000" : STOP


2000 REM *******  CALCULATION OF NEW Ve   **************
2010 DIM L(16,16), D(16), X(13,16), F(16), K(13)
2020 OPEN "I", #1, "A:ExBinvT$.DAT"
2030 FOR I = 1 TO 16 : FOR J = 1 TO 16
2040 INPUT #1, L(I,J) : NEXT J,I : CLOSE #1
2050    LPRINT "I", "D(I)", "Dsrd Ve (k =";KK;")" : LPRINT
2060 FOR I = 1 TO 16 : D(I) = -V(2,I)
2070 FOR J = 1 TO 16
2080 D(I) = D(I) + L(I,J)*V(1,J) : NEXT J,I
2090    MSQ = 0 : FOR P = 1 TO 16
2100    MSQ = MSQ + D(P)*D(P)/16 : NEXT P : RMS = SQR (MSQ)
2110            FOR I = 1 TO 16 : F(I) = V(2,I) + KK*D(I)
2115 VV = SQR(UU*UU+WW*WW)
2120            LPRINT I, D(I), F(I), I : NEXT I : LPRINT
2130 LPRINT "RMS ="; RMS, "VV =";VV, "RMS percent =";RMS/VV*100
2135 LPRINT : LPRINT
2140 PRINT : PRINT "To continue iteration, GOTO 2500."
2150 PRINT : PRINT "To exercize '$EARCHVV', GOTO 3800."
2155 PRINT "To exercise '$EARCHUW', GOTO 3810
2160 STOP
```

```
2500 REM  **********  CALCULATION OF CONTROL INCREMENTS  *************
2510 OPEN "I", #1, "B:CMxMod19.DAT"
2520 FOR I = 1 TO 16 : FOR J = 1 TO 13 : INPUT #1, X(J,I)
2530 NEXT J,I : CLOSE #1
2540 LPRINT "J", "Cntrl.Incr.", "New C.S.", "J" : LPRINT : LPRINT "                (k
=";KK;")" : LPRINT
2550 FOR J = 1 TO 10 : K(J) = 0 : FOR I = 1 TO 16
2560 K(J) = K(J) + X(J,I)*KK*D(I) : NEXT I
2570 V(3,J) = V(3,J) + K(J) : NEXT J
2580 FOR J = 1 TO 13 : LPRINT J, K(J), V(3,J), J : NEXT J : LPRINT
2585 GOSUB 8000
2590 PRINT "Reset Controls; then, to run next iteration,"
2591 PRINT "GOTO 2610." : PRINT
2595 STOP
2610 ERASE L,D,X,K,F ' <<<<<<<<< These are re-DIMed in 2010
2615 GOTO 1050


3000 ' **********  To input known V(I,J)s   ******************************
3010 FOR K = 1 TO 3 : FOR I = 1 TO 16
3020 PRINT "V(";K;",";I;") =";: INPUT V(K,I)
3030 NEXT I,K
3040 STOP
3700 DIM V(3,17)
3710 OPEN "I", #1, "B:TemV1120.DAT
3720 FOR K=1 TO 3 : FOR I=1 TO 16 : INPUT #1, V(K,I)
3730 NEXT I,K : CLOSE #1
3745 PRINT : PRINT "Present UU,WW, & k  are";UU;" ";WW;" & ";KK
3750 PRINT : PRINT "To exercize '$EARCHVV', GOTO 3800." : PRINT
3752 PRINT "To exercise '$EARCHUW', GOTO 3810
3755 PRINT : PRINT "To print-out V(I,J)s, GOTO 1435."
3760 STOP


3800 INPUT "Input new UU   ", UUU
3802 WWW = UUU*TAN(BETA/57.3)
3804 GOSUB 3820
3806 GOTO 3800
3810    INPUT "Input new UU    ", UUU
3812    INPUT "Input new WW    ", WWW
3813    BETA = 57.3*ATN(WWW/UUU)
3814    GOSUB 3820
3816    GOTO 3810
3820 AVHOR = UUU - UU : AVVRT = WWW - WW
3830 GOSUB 4400
3850 UU = UUU : WW = WWW
3860 LPRINT : LPRINT
3870 LPRINT "UU =";UU, "WW =";WW, "BETA ="; BETA
3880 VV = SQR(UU*UU+WW*WW)
4000 FOR I = 1 TO 16 : D(I) = -V(2,I)
4010 FOR J = 1 TO 16
4020 D(I) = D(I) + L(I,J)*V(1,J) : NEXT J,I
4030    MSQ = 0 : FOR P = 1 TO 16
4040    MSQ = MSQ + D(P)*D(P)/16 : NEXT P : RMS = SQR(MSQ)
4050    LPRINT "RMS =";RMS, "VV =";VV, "RMS percent =";RMS/VV*100
4060 RETURN
```

```
4400     FOR I = 1 TO 2 : A = 1 ; B = 2 : GOSUB 4600 : NEXT I
4410     FOR I = 3 TO 10 : A = 2 : B = 1 : GOSUB 4600 : NEXT I
4420     FOR I = 11 TO 16 : V(1,I)=V(1,I)-AVHOR : V(2,I) = V(2,I)-AVHOR : NEXT I
4430 RETURN
4600             V(B,I) = V(B,I)-AVHOR : V(A,I) = V(A,I)-AVVRT
4610             RETURN


5000     INPUT "When LDV is ready, enter 123.     ",  ZW
5010      IF ZW = 123 THEN GOTO 5020 ELSE GOTO 5000
5020     RETURN


7000 REM ************** Subr. for CHECK & RUN  ******************
7005 GOSUB 10000
7010      INPUT "Enter SCP    ", ZYX
7015     IF ZYX = 0 THEN GOTO 7020
7017     SCP = ZYX
7020     CF = SQR(SCP1/SCP)
7025 AVER = W(CR)
7030 PRINT : PRINT : PRINT "Average VEL =";AVER, "Std. Dev. =";SD
7040 PRINT : PRINT "SCP =";SCP, "SCP1 =";SCP1, "CF =";CF
7050 PRINT : PRINT "          >>>>>>  Corrected Vel. =";CF*AVER"  <<<<<"
7055         PRINT "                                   -------"
7060 PRINT : INPUT "      To repeat measurement of vel. comp., enter 8;
                      to proceed, enter 9.     "
, PQ
7070 IF PQ = 9 THEN GOTO 7080
7075 IF PQ = 8 THEN GOTO 7000 ELSE GOTO 7060
7080 PRINT : PRINT "-----------------------------------------------" : PRINT
7090 RETURN


9000 GOSUB 7000
9010 V(K,I) = CF*AVER - UU
9020     RETURN

9200 GOSUB 7000
9210 V(K,I) = CF*AVER - WW
9220     RETURN


9990 REM ***********  SUBR TO MEASURE VEL & CALC AVER ETC. *************
10000 CR = 0 : SUM3 = 0
10010 CR = CR + 1
10012 SUM = 0 : SUM2 = 0
10015 FOR LOOP=AD TO (AD+(3*NSPL)-1) STEP 3
10016 HB=INT(LOOP/256):LB=LOOP-(HB*256)
10017 POKE 49185!,LB:POKE 49186!,HB
10020 POKE BC,NBTS
10030 CALL TRANSFER
10035 NEXT LOOP
```

```
10040 FOR LOOP=AD TO (AD+(3*NSPL)-1) STEP 3
10050 MANT=256*(PEEK(LOOP+1) AND 15)+PEEK(LOOP)
10060 XPON=INT(PEEK(LOOP+1)/16)
10070 C=PEEK(LOOP+2)
10080 VEL=(C/(MANT*(2^(XPON-3))*2E-09))/KKKK
10085 ' PRINT VEL
10090 SUM=SUM+VEL
10100 SUM2=SUM2+(VEL*VEL)
10110 NEXT LOOP
10120 AVER=SUM/NSPL
10122   SUM3 = SUM3 + AVER
10123   W(CR) = SUM3/CR
10124   PRINT CR, AVER, W(CR)
10125   IF ABS(W(CR)-W(CR-1))<TOL THEN GOTO 10126 ELSE GOTO 10010
10126   IF ABS(W(CR)-W(CR-2))<TOL THEN GOTO 10127 ELSE GOTO 10010
10127   IF ABS(W(CR)-W(CR-3))<TOL THEN GOTO 10130 ELSE GOTO 10010
10128 ' (Omit for 4 rdgs)IF ABS(W(CR)-W(CR-4))<TOL THEN GOTO 10130 ELSE GOTO 10
10
10130 SD=SQR(ABS((SUM2/NSPL)-(AVER*AVER)))
10170 PRINT : RETURN


12000 FOR LK=49152! TO 49267!
12010 READ VL:POKE LK,VL:NEXT LK
12020 RETURN
12030 REM <<<<< MAIN SECTION (63 BYTES LONG) >>>>>
12040 DATA 62,0             :REM  LD A,00H
12050 DATA 6,0              :REM  LD B,BCNT
12060 DATA 184              :REM  CP A,B
12070 DATA 32,25            :REM  JR NZ,SAMPLE
12080 DATA 14,3             :REM  LD C,03H
12090 DATA 205,63,192       :REM  CALL SCREG
12100 DATA 14,117           :REM  LD C,75H
12110 DATA 205,63,192       :REM  CALL SCREG
12120 DATA 33,0,0           :REM  LD HL,0000H
12130 DATA 62,255           :REM  LD A,FFH
12140 DATA 35               :REM  INC HL
12150 DATA 188              :REM  CP A,H
12160 DATA 32,252           :REM  JR NZ,LOOP1
12170 DATA 14,21            :REM  LD C,15H
12180 DATA 205,63,192       :REM  CALL SCREG
12190 DATA 201              :REM  RET
12200 DATA 33,0,193         :REM  LD HL,A200H
12210 DATA 14,85            :REM  LD C,55H
12220 DATA 205,63,192       :REM  CALL SCREG
12230 DATA 205,84,192       :REM  CALL RSIN
12240 DATA 113              :REM  LD (HL),C
12250 DATA 35               :REM  INC HL
12260 DATA 205,84,192       :REM  CALL RSIN
12270 DATA 113              :REM  LD (HL),C
12280 DATA 35               :REM  INC HL
12290 DATA 205,84,192       :REM  CALL RSIN
12300 DATA 113              :REM  LD (HL),C
```

```
12310 DATA 35                  :REM  INC HL
12320 DATA 16.239              :REM  DJNZ LOOP2
12330 DATA 14,21               :REM  LD C,15H
12340 DATA 205,63,192          :REM  CALL SCREG
12350 DATA 201                 :REM  RET
12360 REM <<<<< SUBROUTINE SCREG (21 BYTES LONG) >>>>>
12370 DATA 243                 :REM  DI
12380 DATA 62,0                :REM  LD A, 00H
12390 DATA 211,0               :REM  OUT 00H
12400 DATA 50,8,239            :REM  LD (EF08H),A
12410 DATA 121                 :REM  LD A,C
12420 DATA 50,0,42             :REM  LD (2A00H),A
12430 DATA 62,1                :REM  LD A,01H
12440 DATA 211,1               :REM  OUT 01H
12450 DATA 50,8.239            :REM  LD (EF08H),A
12460 DATA 251                 :REM  EI
12470 DATA 201                 :REM  RET
12480 REM <<<<< SUBROUTINE RSIN (27 BYTES LONG) >>>>>
12490 DATA 243                 :REM  DI
12500 DATA 62,0                :REM  LD A,00H
12510 DATA 211,0               :REM  OUT 00H
12520 DATA 50,8,239            :REM  LD (EF08H),A
12530 DATA 58,0,42             :REM  LD A,(2A00H)
12540 DATA 31                  :REM  RRA
12550 DATA 48,250              :REM  JR NC,TEST
12560 DATA 58,1,42             :REM  LD A,(2A01H)
12570 DATA 79                  :REM  LD C,A
12580 DATA 62,1                :REM  LD A,01H
12590 DATA 211,1               :REM  OUT 01H
12600 DATA 50,8,239            :REM  LD (EF08H),A
12610 DATA 251                 :REM  EI
12620 DATA 201                 :REM  RET
12630 DATA 0,0,0,0,0,0,0,0
12640 END
```

APPENDIX F

FORMULAS FOR RMS-GRADIENT METHOD

For brevity, let RMS, our Figure of Merit, be called R, and let the control-deflection array be called X; i.e., X is a vector of M components, X_i ($i = 1,2,\ldots,M$).

When we make M runs, measure the effects on RMS of the M control increments, and divide these effects by the amounts of the control increments, we have determined the gradient, of R, viz. grad R, in the M-dimensional X-space. Its components are $\partial R/\partial X_i$. We know that its direction in X-space is the direction of most rapid change of R.

Let δX denote an increment of X in X-space (i.e., an array of control increments). The general formula for the effect on R is

$$\delta R = \delta X \cdot \text{grad } R \qquad \text{(F1)}$$

If δX is a unit vector in the direction of grad R, we have

$$\delta X = \text{grad } R \,/\, |\text{grad } R| \qquad \text{(F2)}$$

and

$$\begin{aligned}\delta R &= \text{grad } R \cdot \text{grad } R \,/\, |\text{grad } R| \\ &= |\text{grad } R| \qquad \text{(F3)}\end{aligned}$$

Suppose we want an increment of R equal to $-kR$, where k is arbitrary (a relaxation constant, say), and R is the present value of RMS. We want δR to be $-kR/|\text{grad } R|$ times the vale in Eq.(F3), so we must use a δX equal not to the value in Eq.(F2) but equal to

$$-kR/|\text{grad}R| \text{ times grad } R \;/\; |\text{grad } R|$$

which is

$$-kR \text{ grad } R \;/\; |\text{grad } R|^2 \tag{F4}$$

or $$-kR \text{ grad } R \Big/ \sum_{j=1}^{M} \left(\frac{\partial R}{\partial X_j} \right)^2 \tag{F5}$$

This is a control-increment array whose members are

$$\left(-kR/\sum_{j=1}^{M}\left(\frac{\partial R}{\partial X_j}\right)^2\right) \frac{\partial R}{\partial X_i} \qquad i = 1,2,\ldots,M \tag{F6}$$

APPENDIX G

FORMULAS FOR "DOWELL'S METHOD"

Following the notation used earlier in this report, viz. in the section entitled "PROCEDURES", let the control matrix of the component f (which denotes V_e) be called C. Let the analogous control matrix of component g (which denotes V_t) be called D.

Then the estimated effects of any array of control-setting increments, say δX, are

$$\delta f = C * \delta X \tag{G1}$$

$$\delta g = D * \delta X \tag{G2}$$

and

$$\begin{aligned} \delta(Df) &= (\text{new } Df) - (\text{old } Df) \\ &= f[g + \delta g] - f - \delta f \\ &\qquad - f[g] + f \end{aligned} \tag{G3}$$

In the same local-linear approximation that has been used earlier, this becomes

$$\delta(Df) = f[\delta g] - \delta f \tag{G4}$$

Here we return to our more descriptive notation, as in Equation (5), and substitute for δf and δg from Equations (G1) and (G2) above:

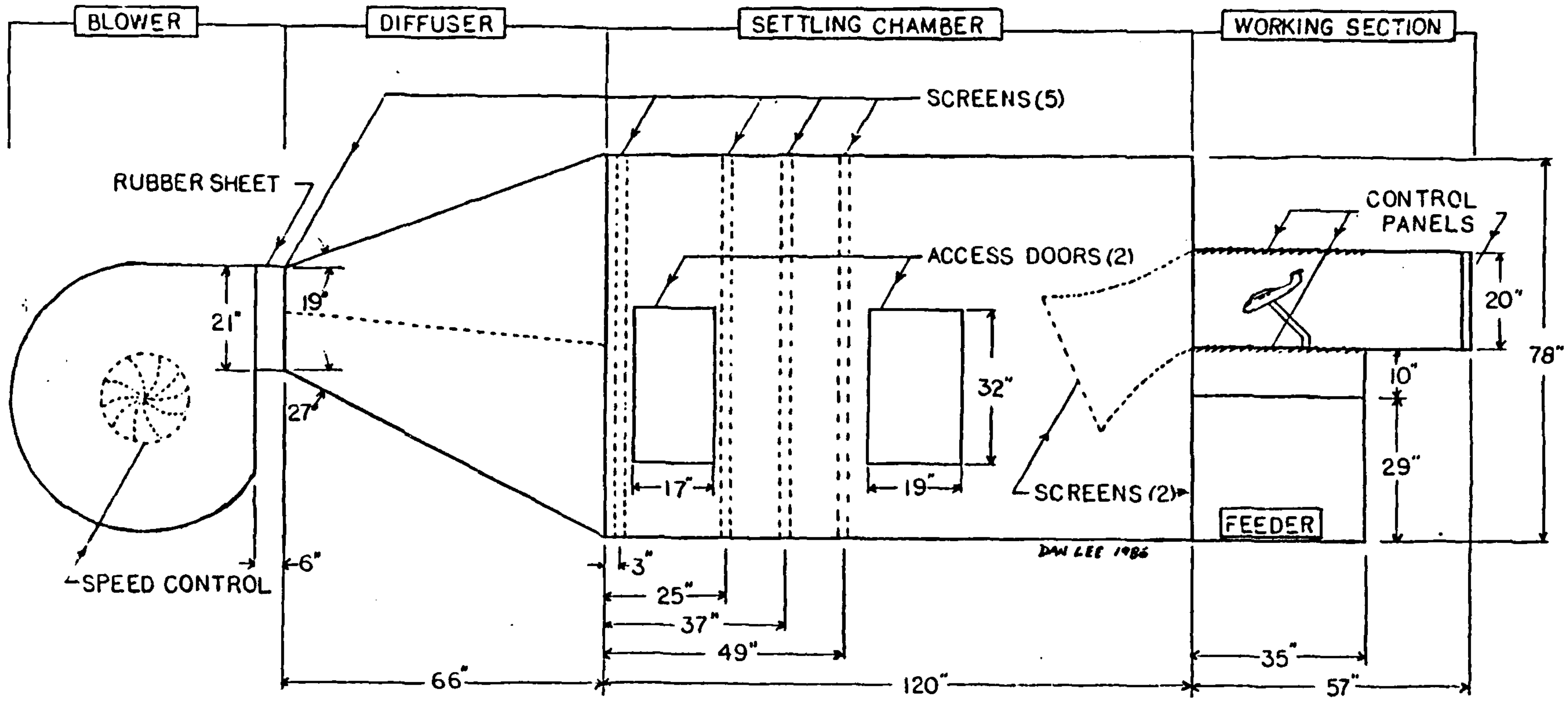
$$\delta(Df) \text{ or } \delta(DV_e) = E * B_{inv} * D * \delta X - C * \delta X \tag{G5}$$

$$= (E * B_{inv} * D - C) \quad * \quad \delta X \qquad (G6)$$

Therefore, to achieve a change of DV equal to -kDV , say, we should introduce the following array of control-setting increments:

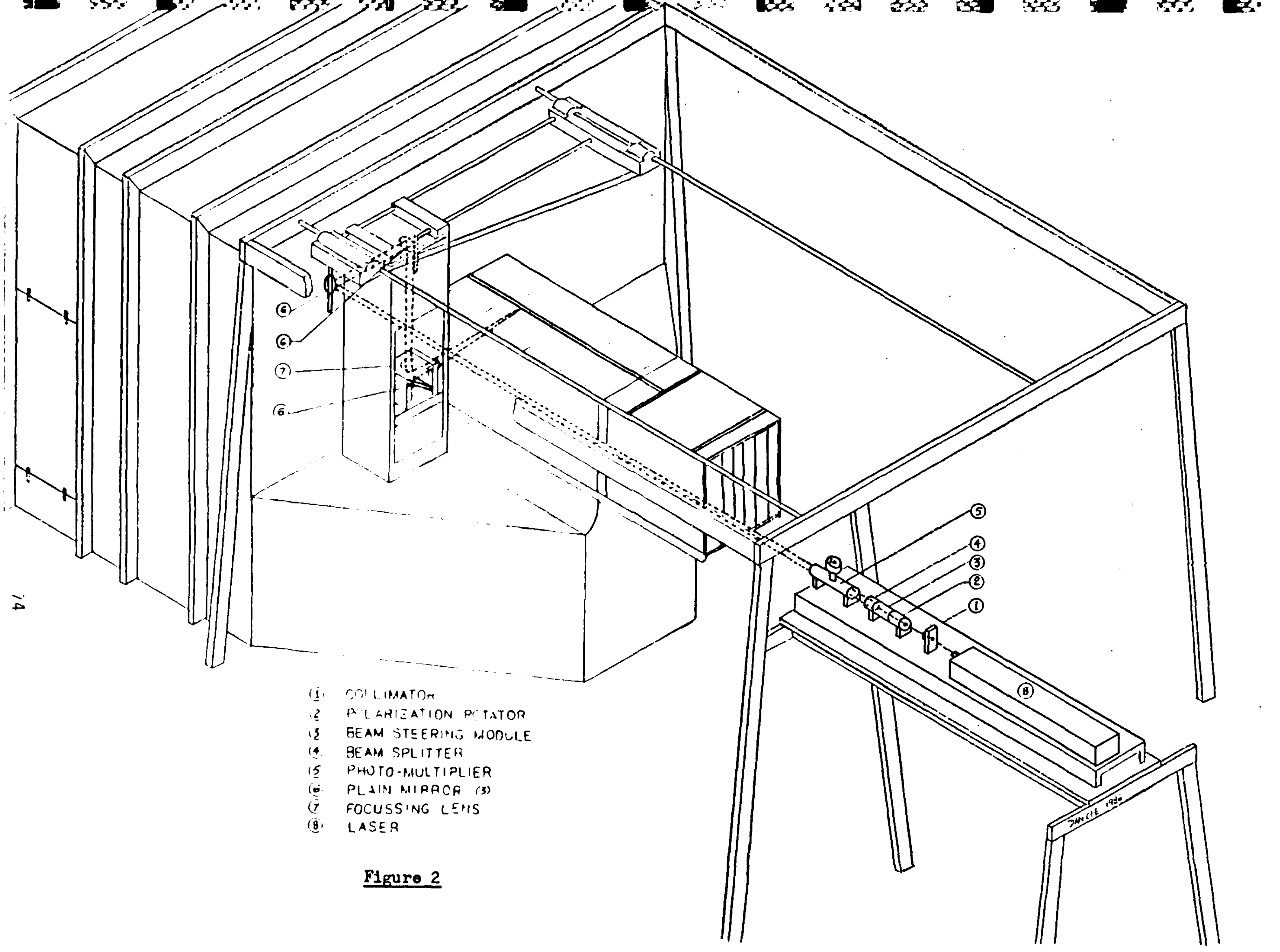
$$\delta X \text{ or } \delta(C.S.) = (C - E * B_{inv} * D)^{-1} * kDV_e \qquad (G7)$$

This is the counterpart of Equation (6) when the procedure we call "Dowell's" is used. It is clear that our regular procedure (Equation (6)) results from neglecting the second term inside the parentheses in Equation (G7). It is a "secondary" term, probably smaller than the first term in low-speed flow. Its neglect might be expected to slow down the convergence of the iterative process.



BLOWER
DIFFUSER
SETTLING CHAMBER
WORKING SECTION
SCREENS (5)
RUBBER SHEET
CONTROL PANELS
ACCESS DOORS (2)
21"
19"
27°
32"
20"
78"
10"
29"
17"
19"
SCREENS (2)
FEEDER
SPEED CONTROL
6"
3"
25"
37"
49"
66"
120"
35"
57"
DAN LEE 1986

Figure 1



6
6
7
6
5
4
3
2
1
8
(1) COLLIMATOR
(2) POLARIZATION ROTATOR
(3) BEAM STEERING MODULE
(4) BEAM SPLITTER
(5) PHOTO-MULTIPLIER
(6) PLAIN MIRROR (3)
(7) FOCUSSING LENS
(8) LASER

Figure 2

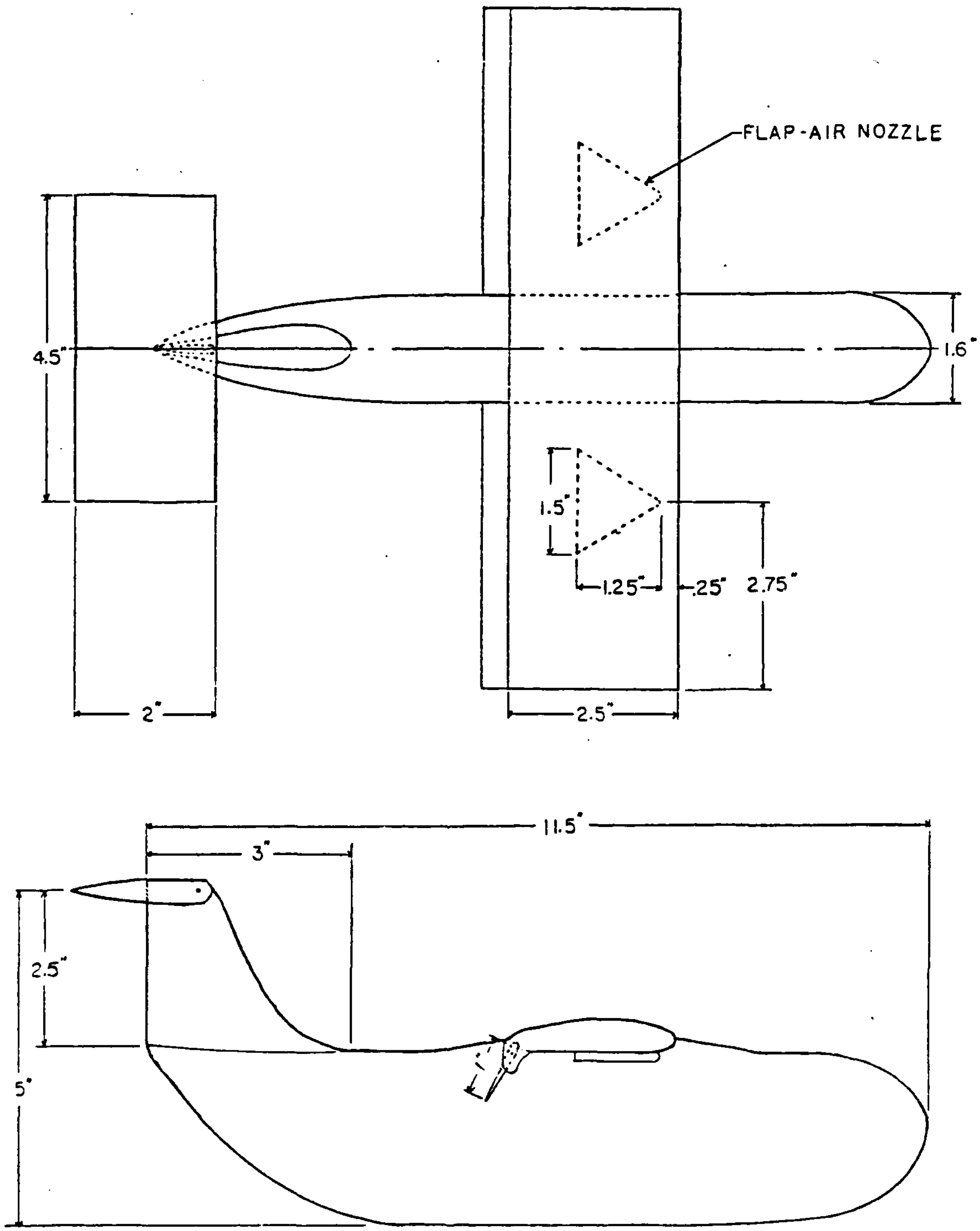


Figure 3

Figure 3 continued

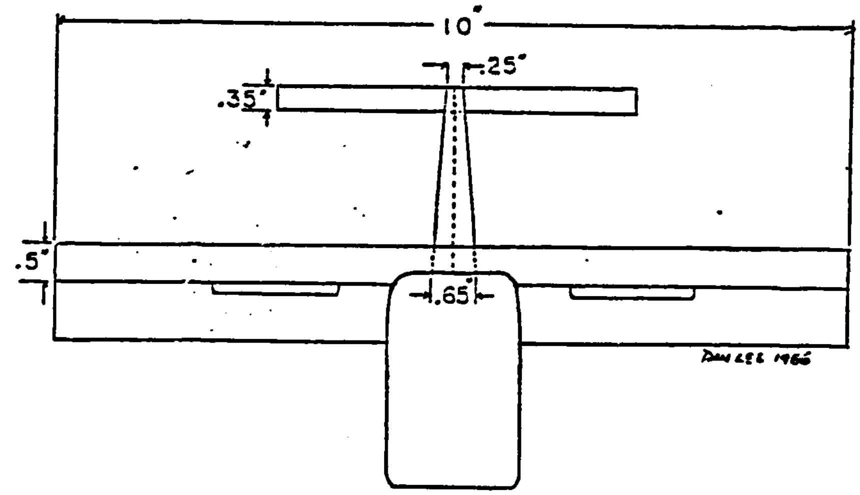
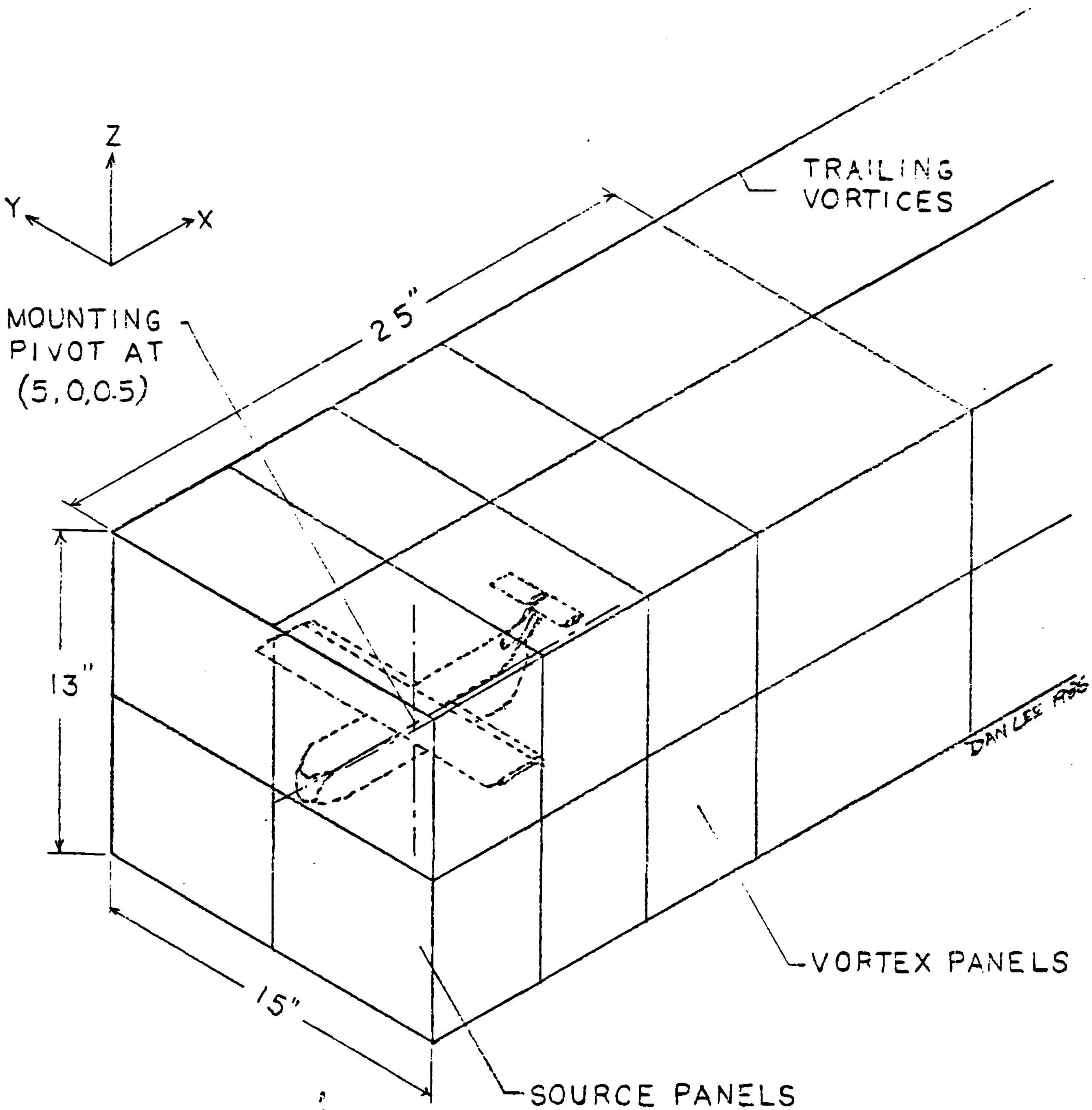


Figure 4



INTERFACE S

Figure 5.1

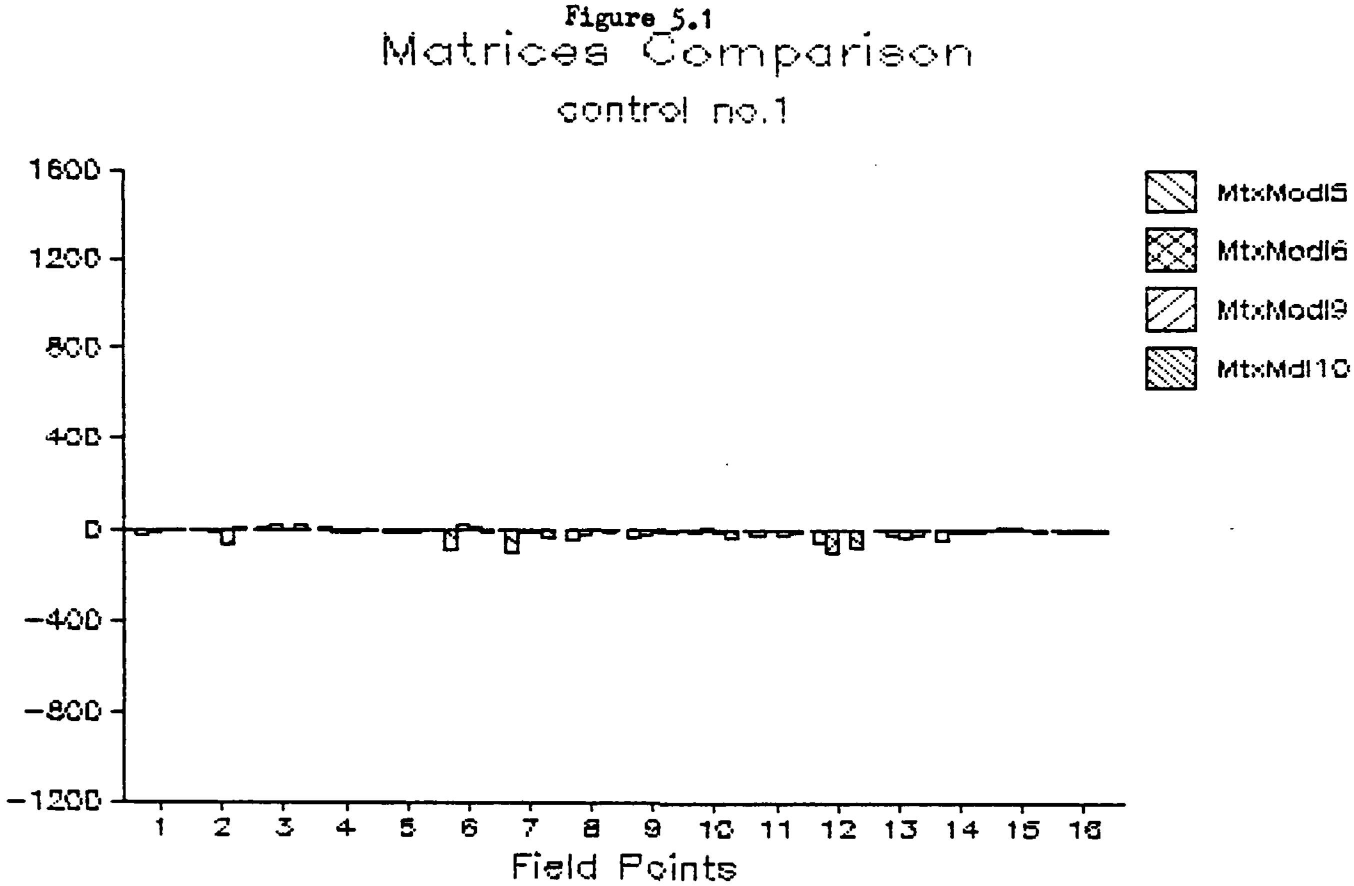


Figure 5.2

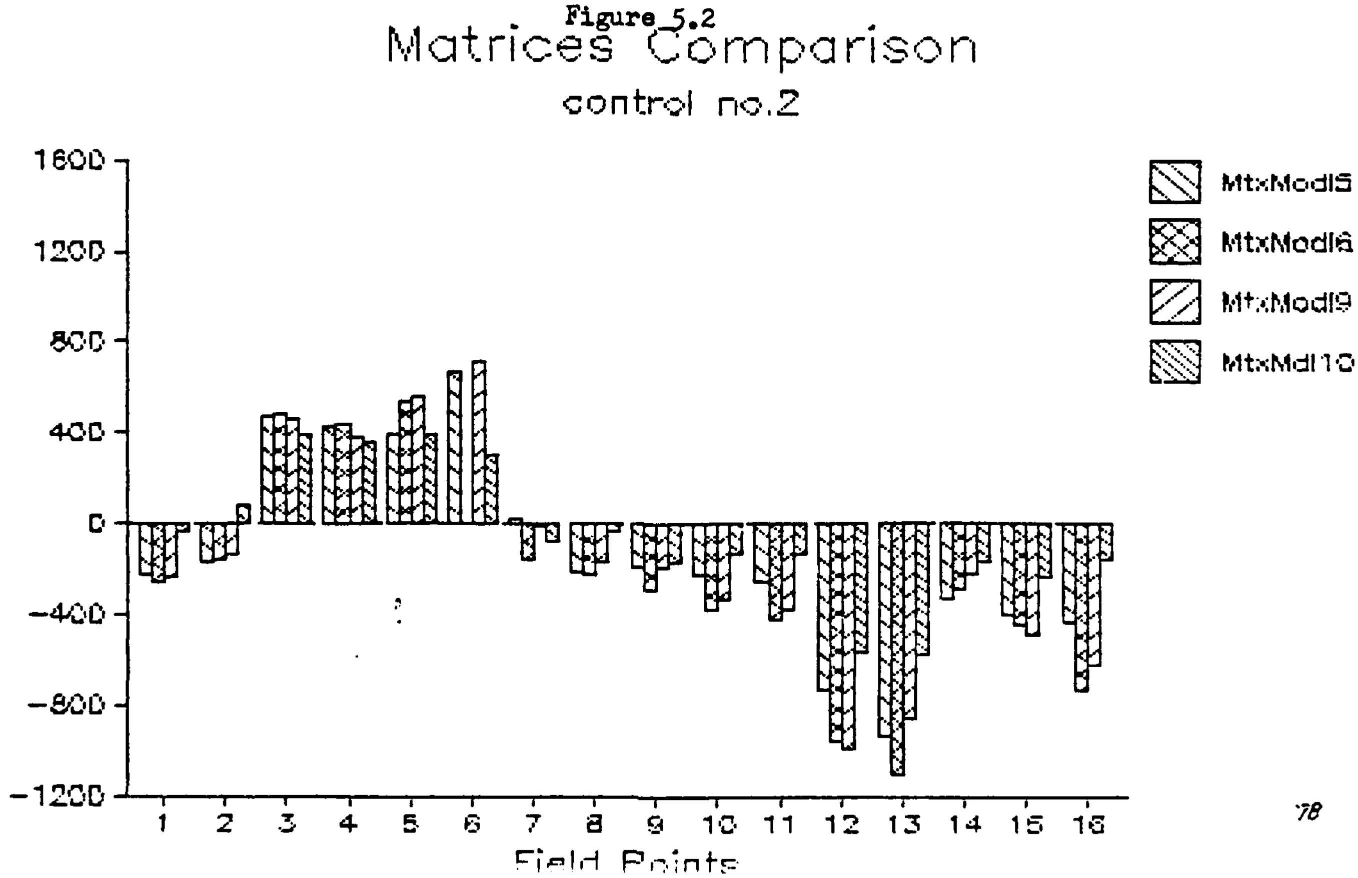


Figure 5.3

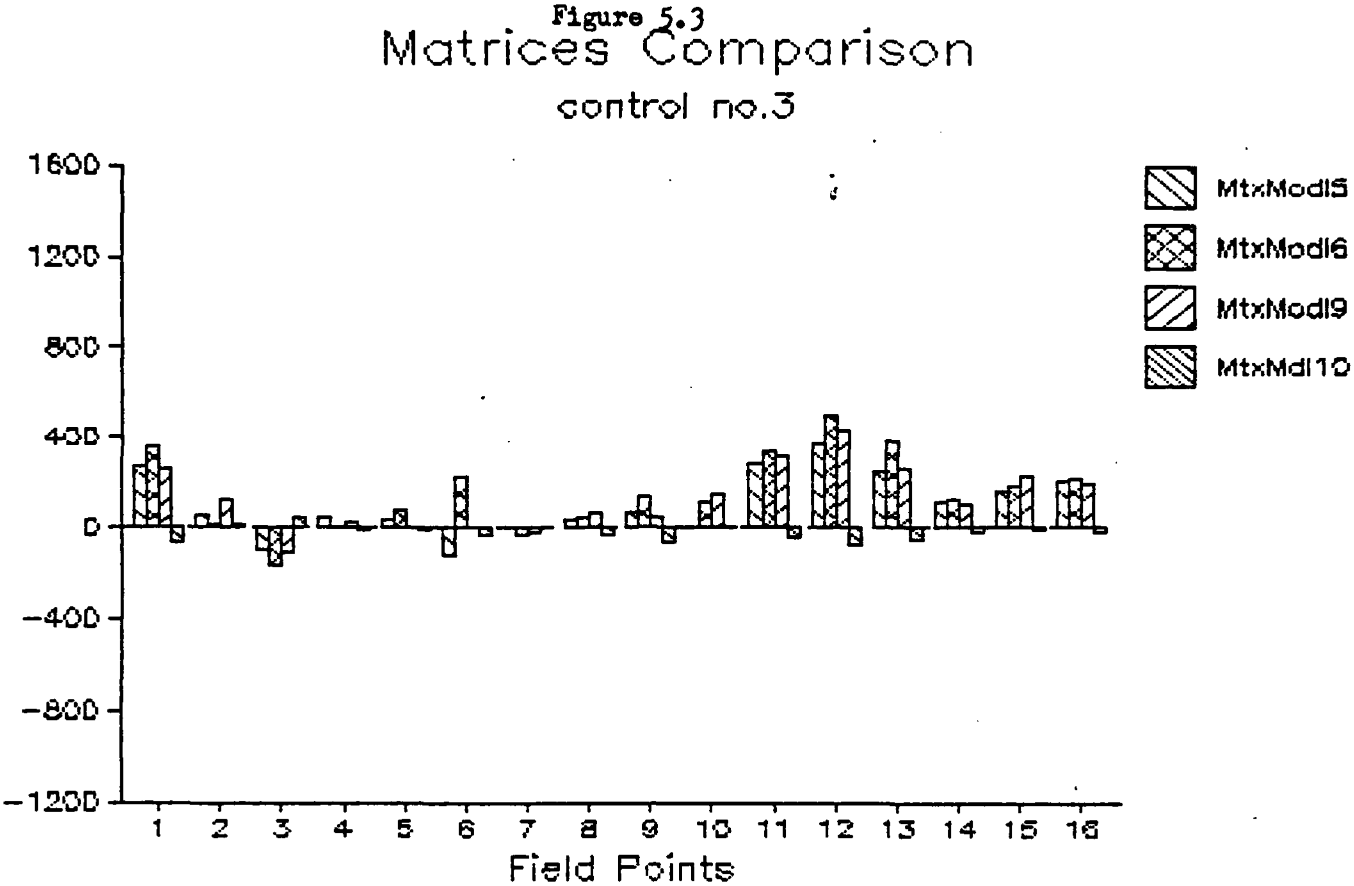


Figure 5.4

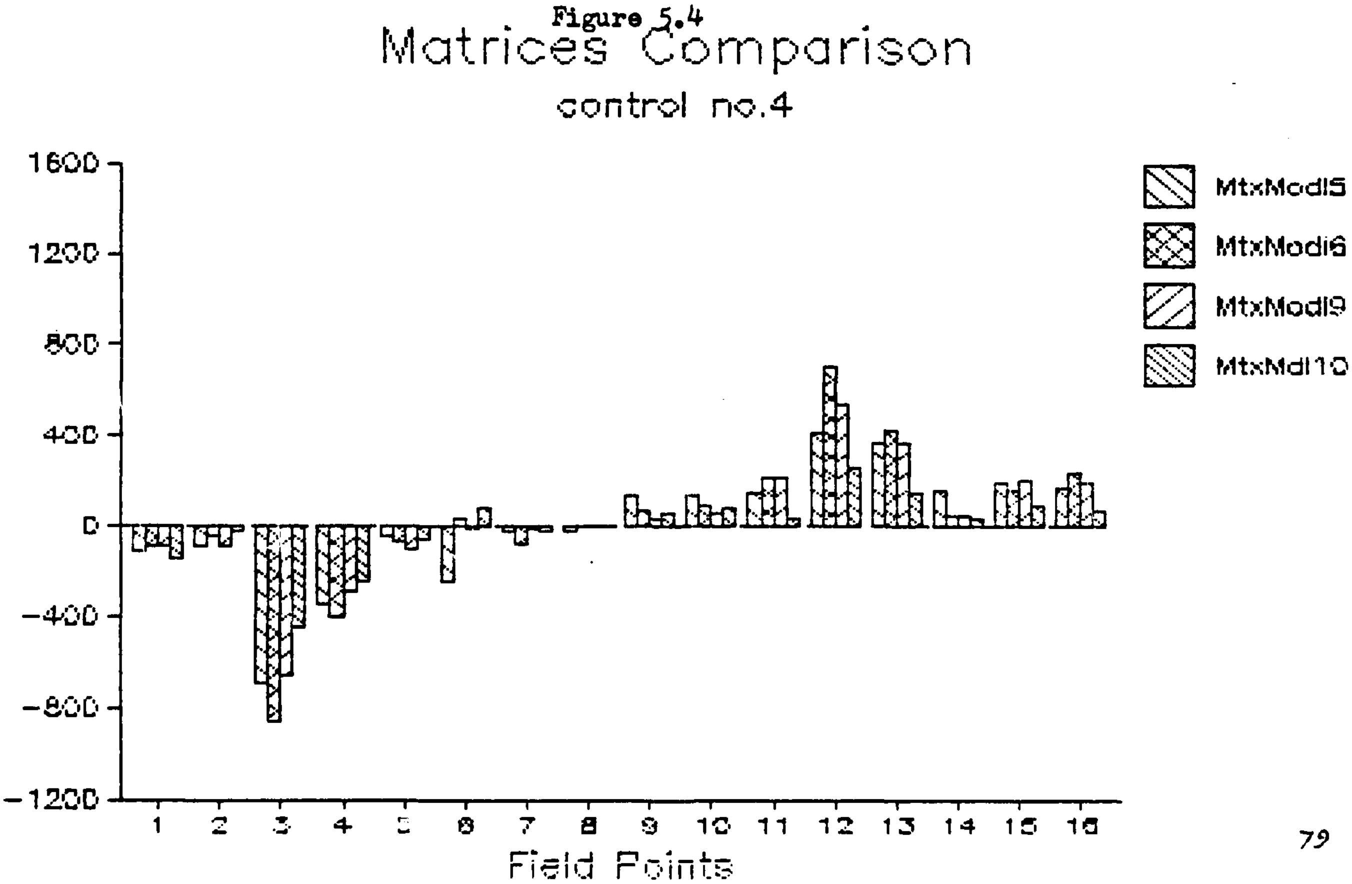


Figure 5.5

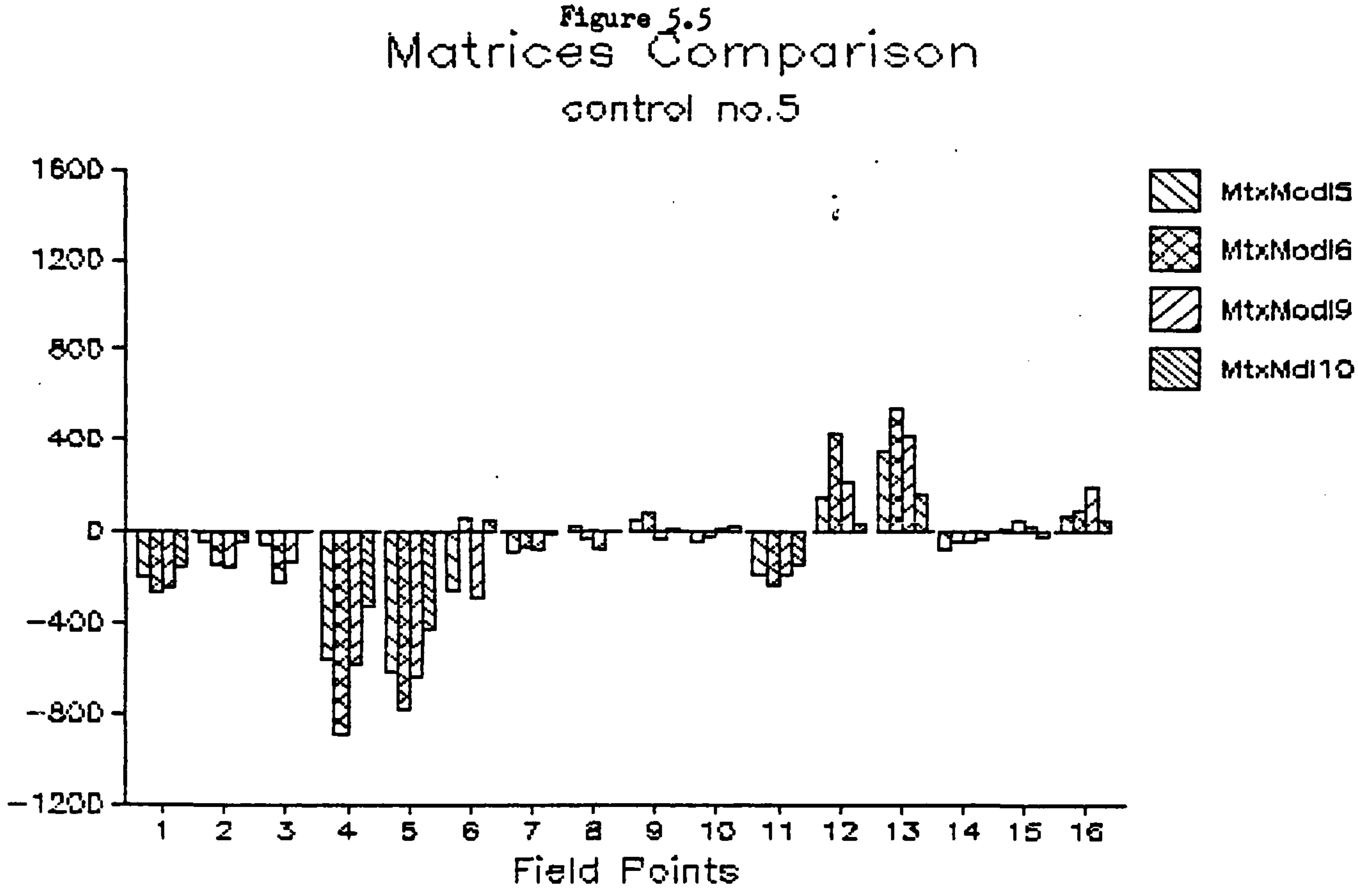


Figure 5.6

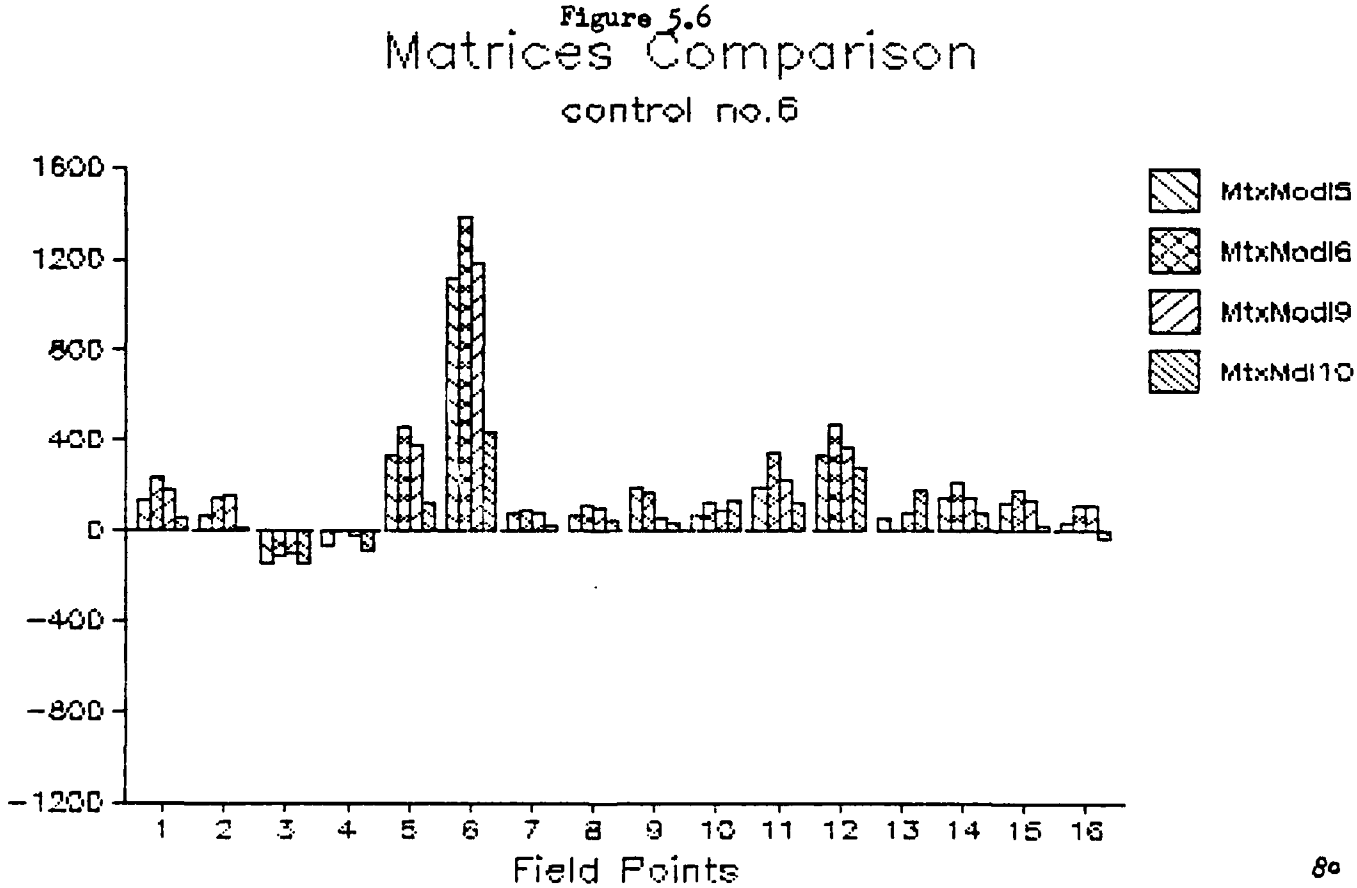


Figure 5.7

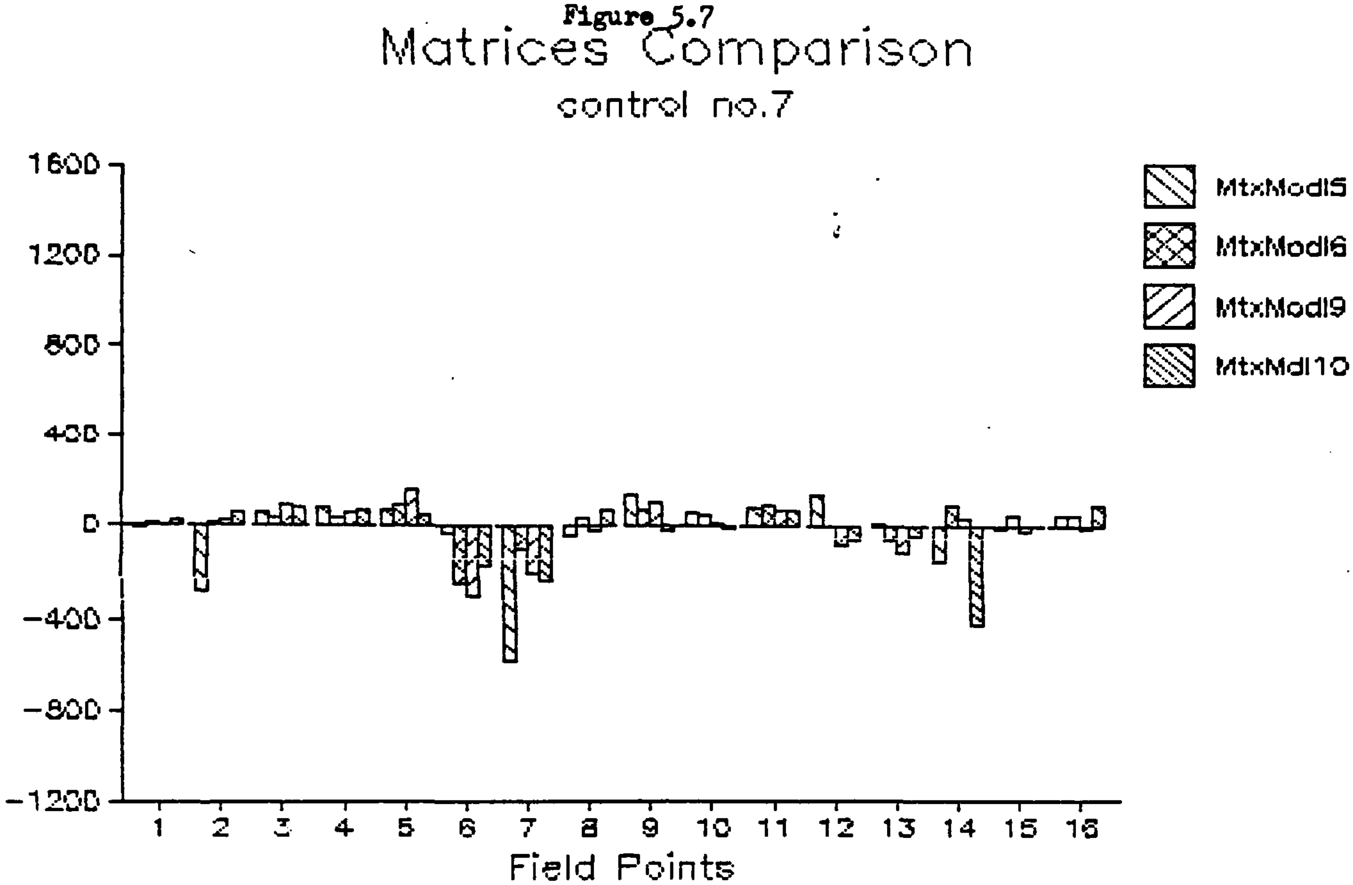


Figure 5.8

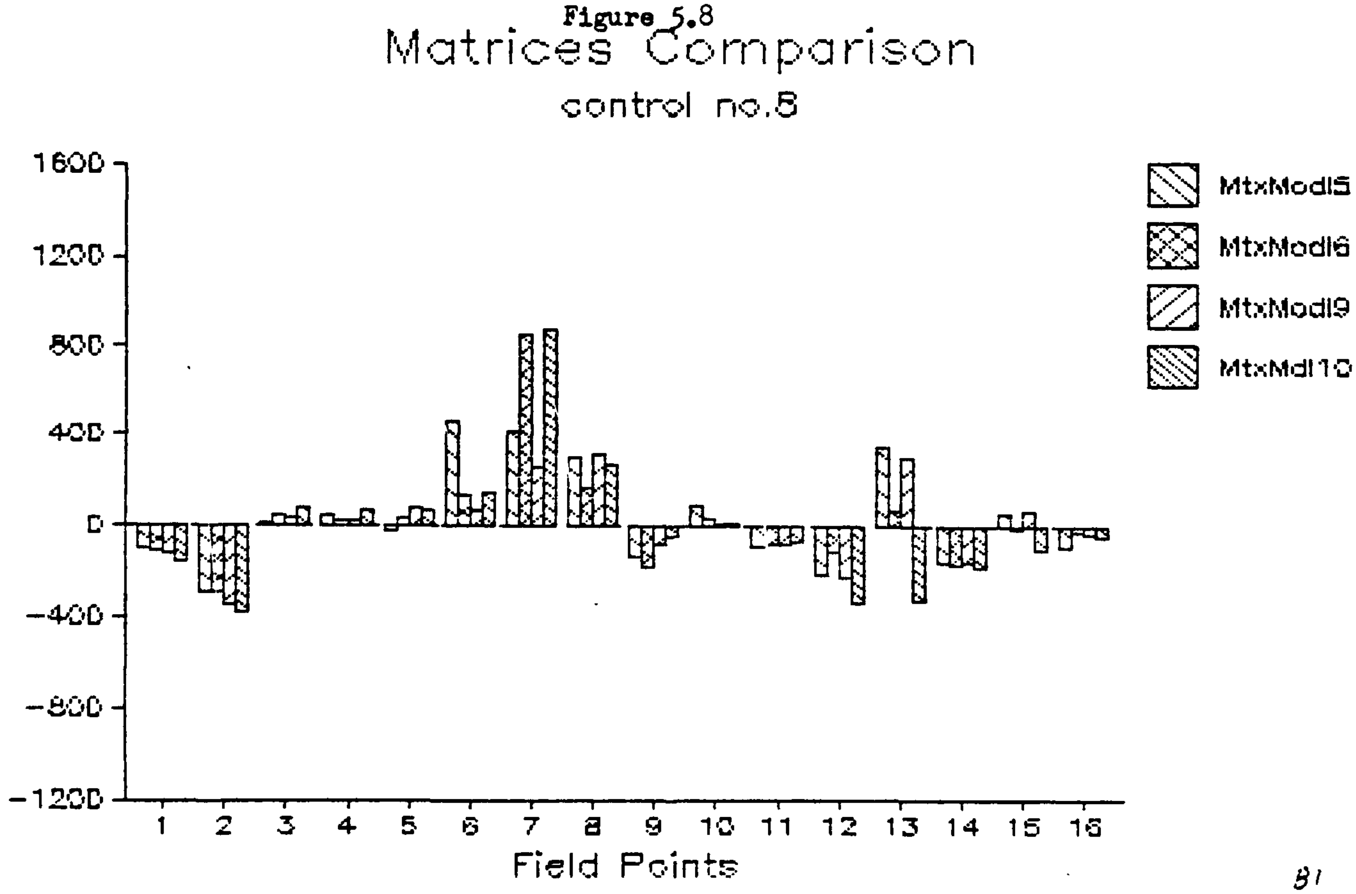


Figure 5.9

Matrices Comparison

control no.9

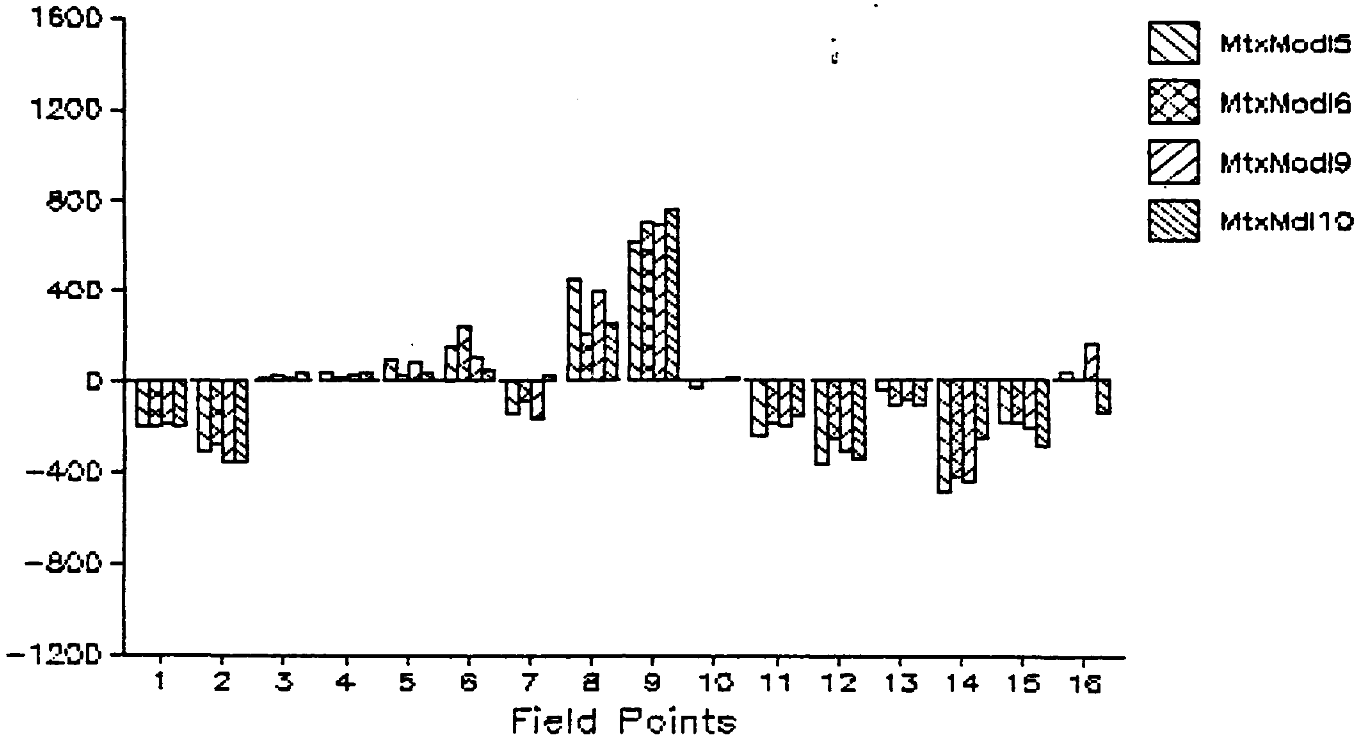


Figure 5.10

Matrices Comparison

control no.10

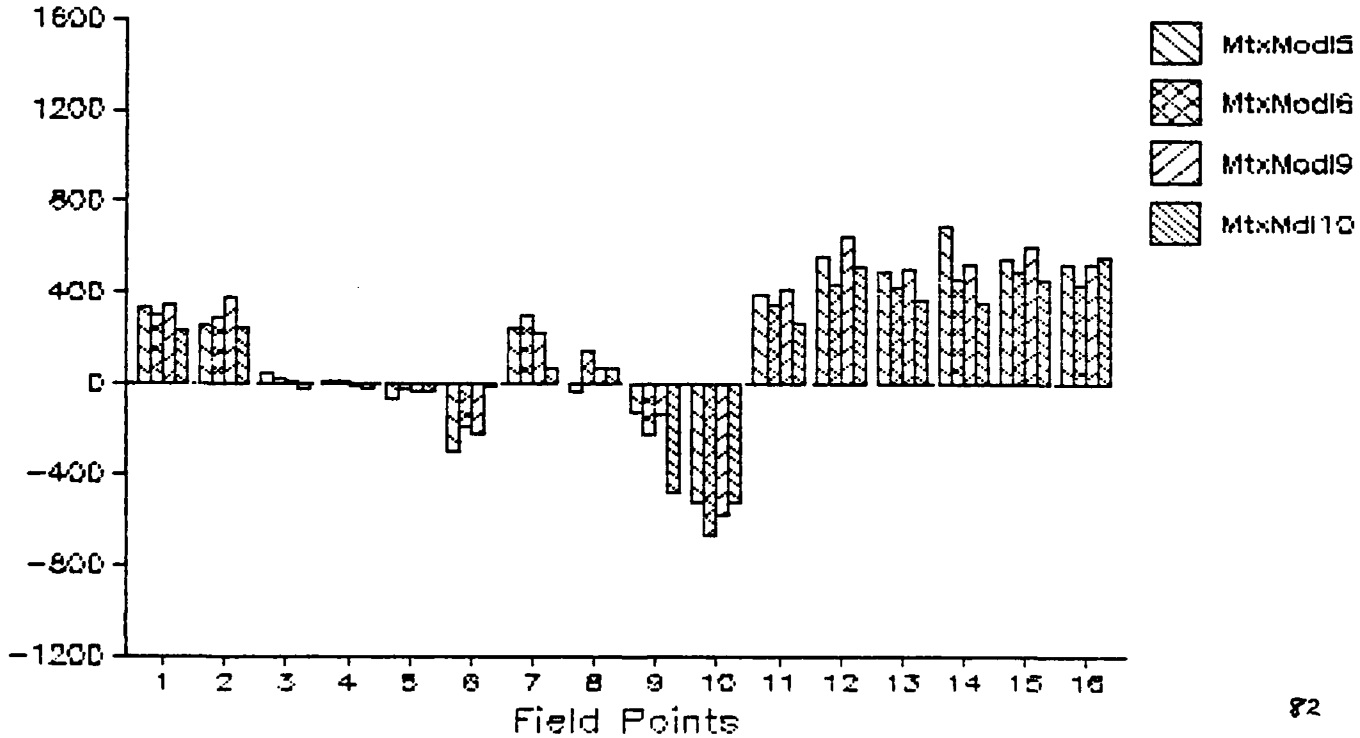


Figure 5.11

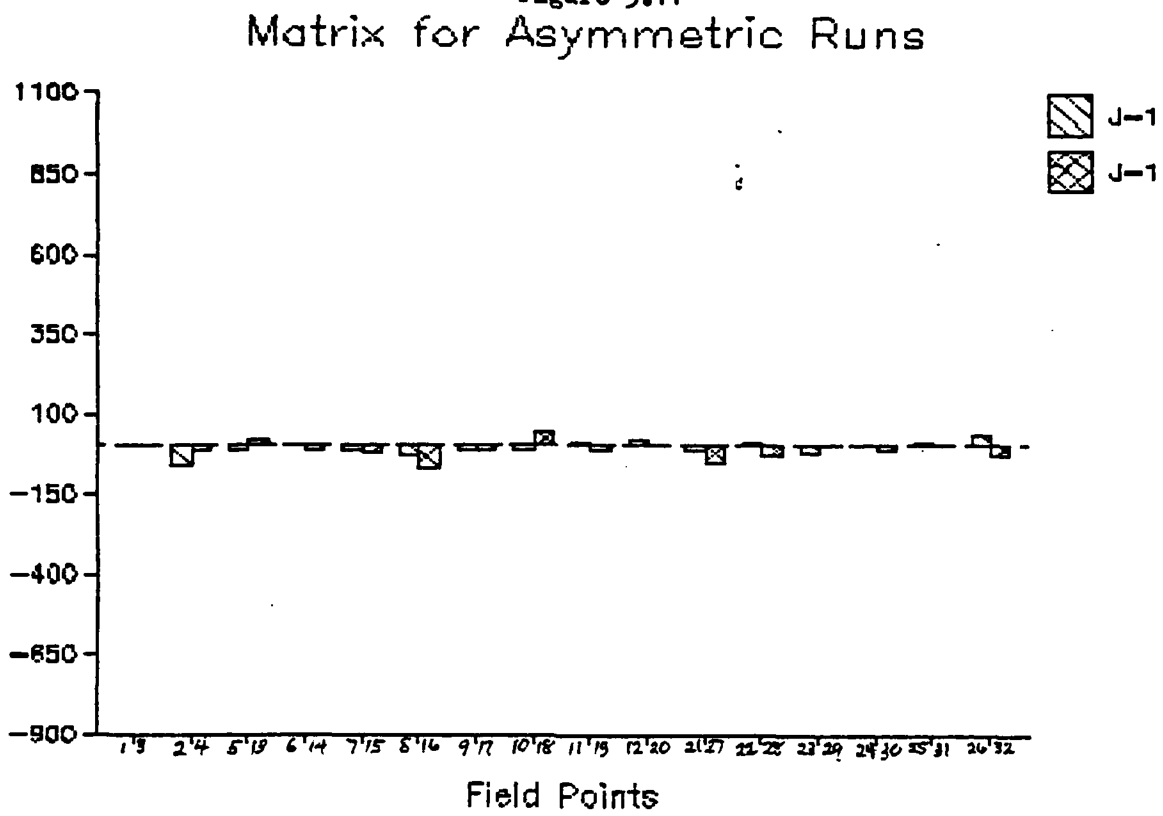


Figure 5.12

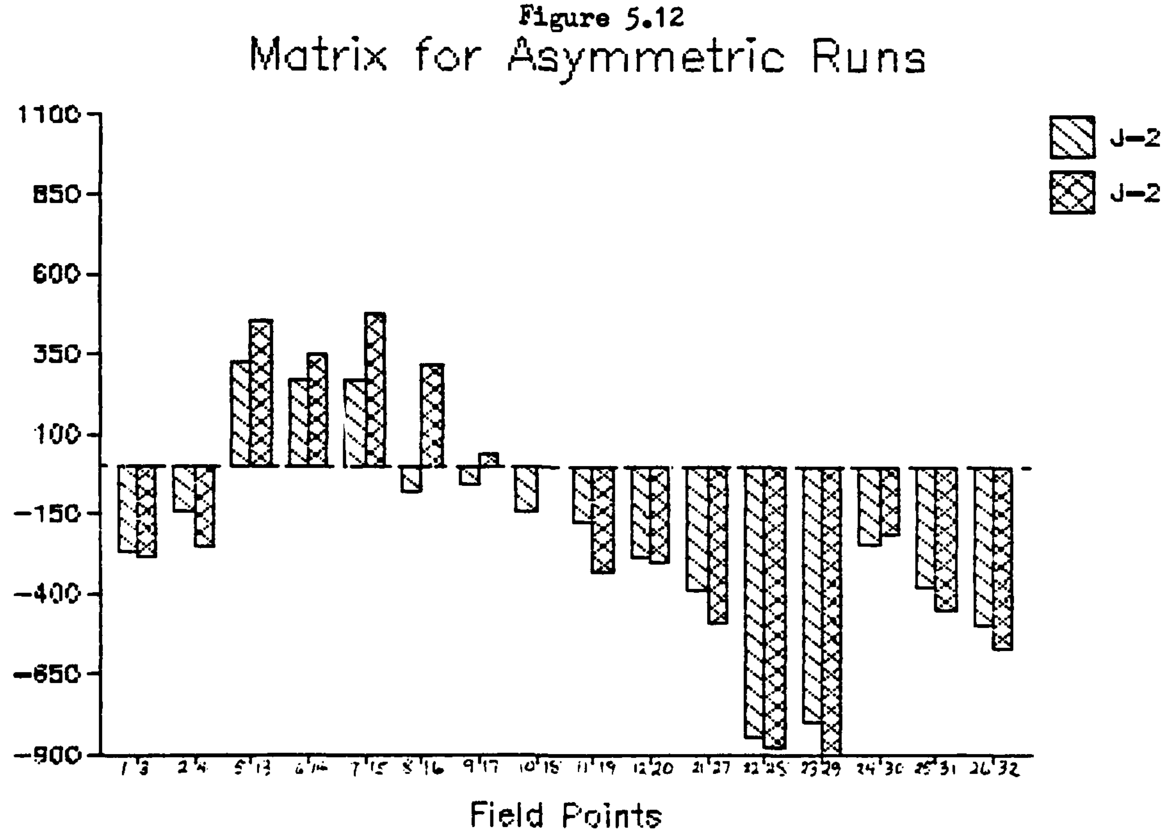


Figure 5.13

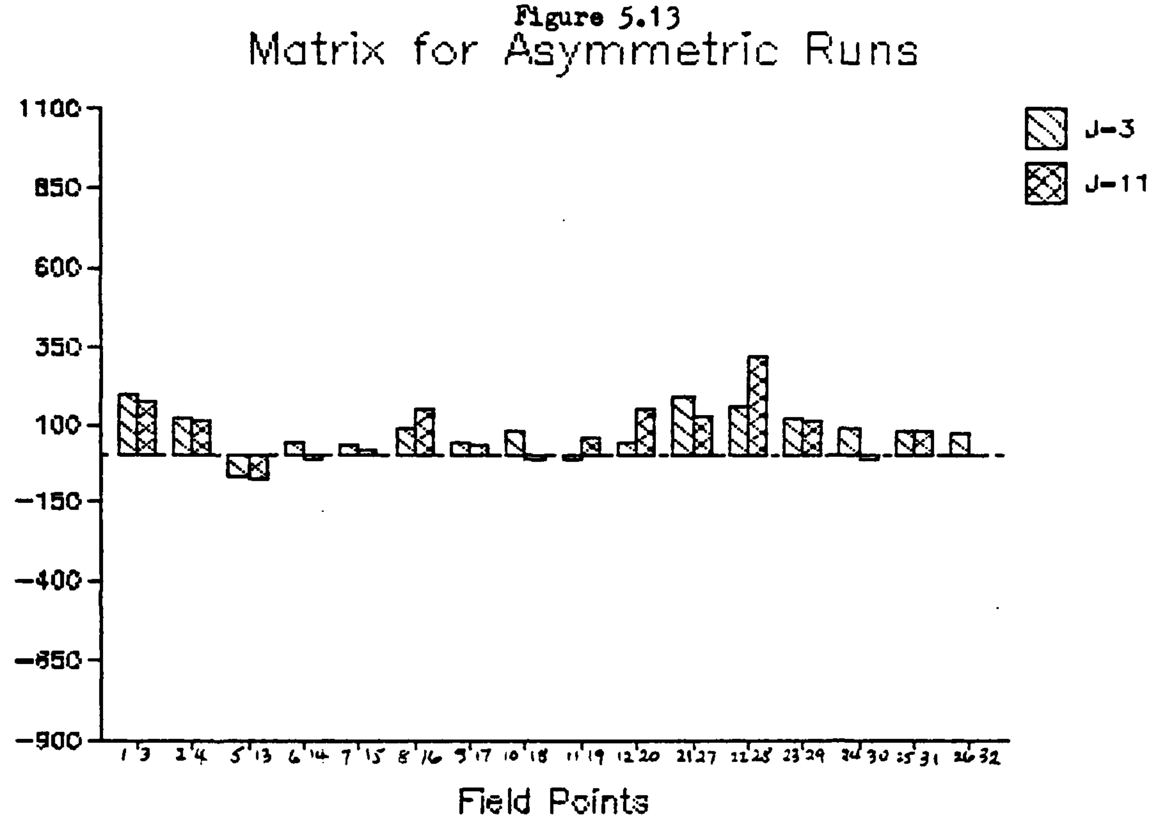


Figure 5.14

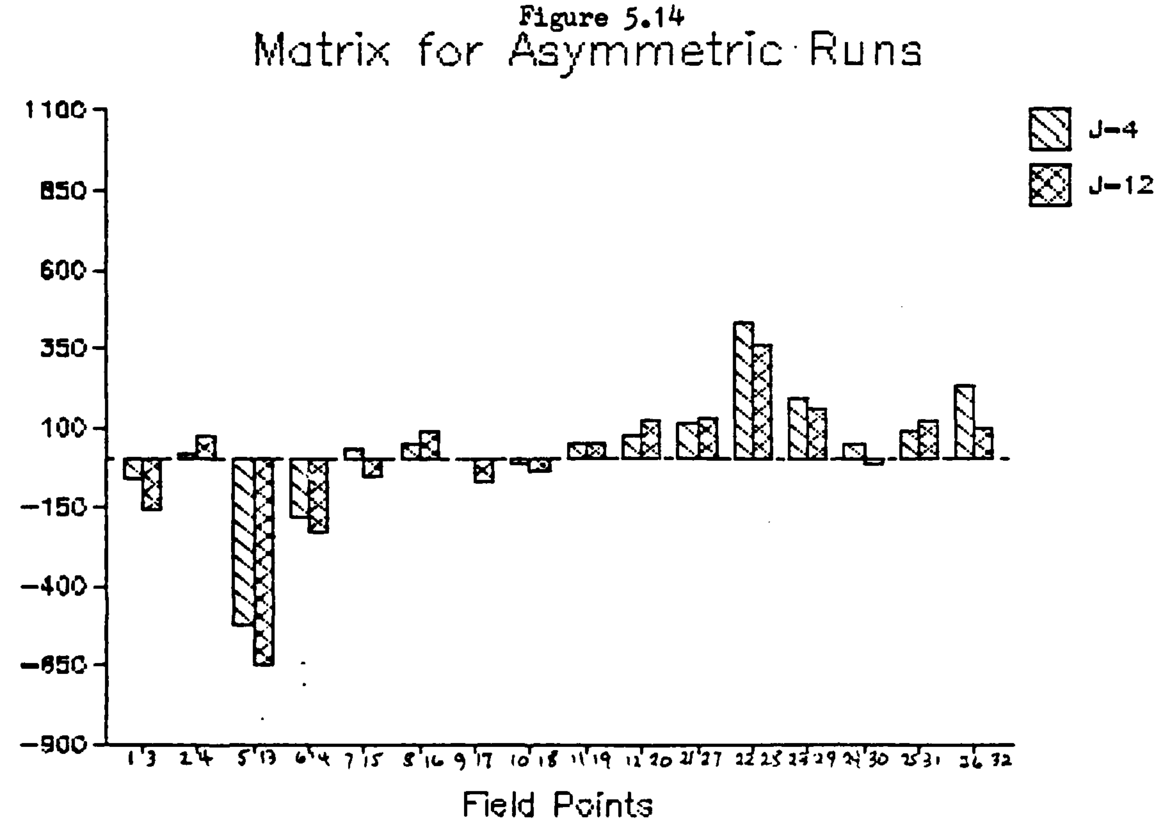


Figure 5.15

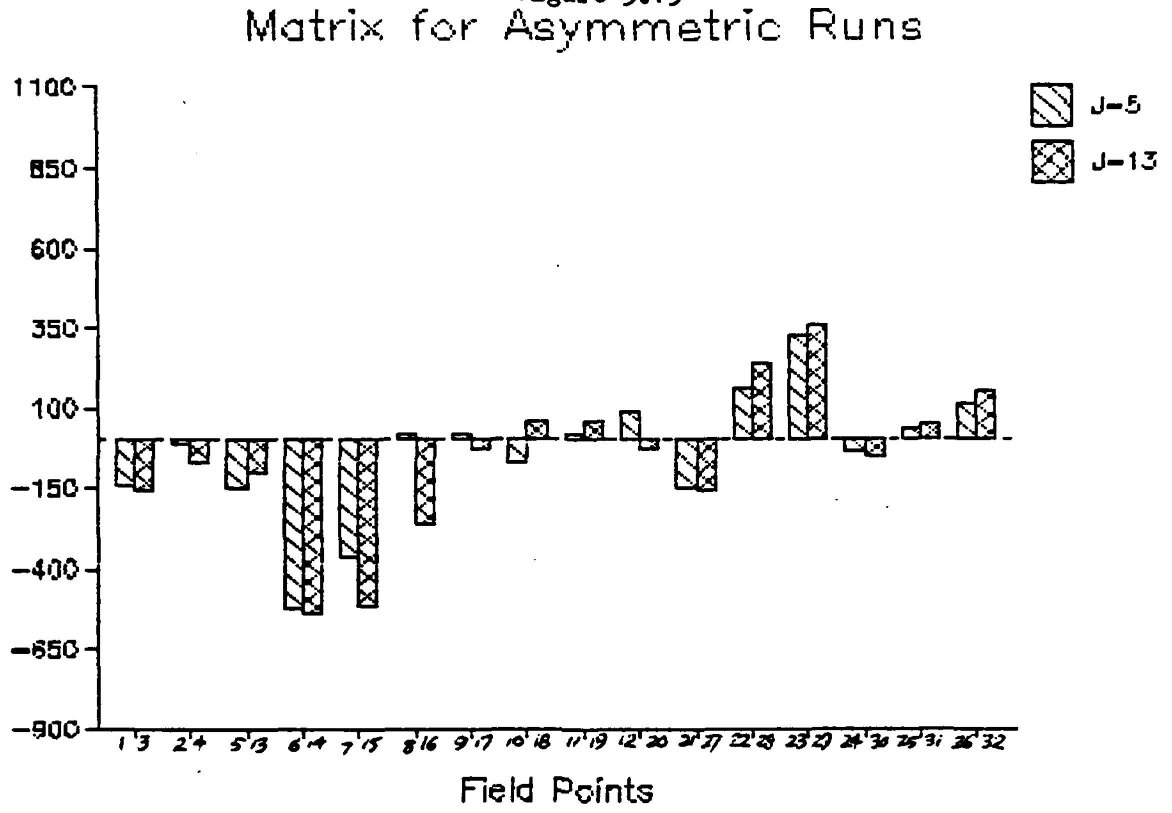


Figure 5.16

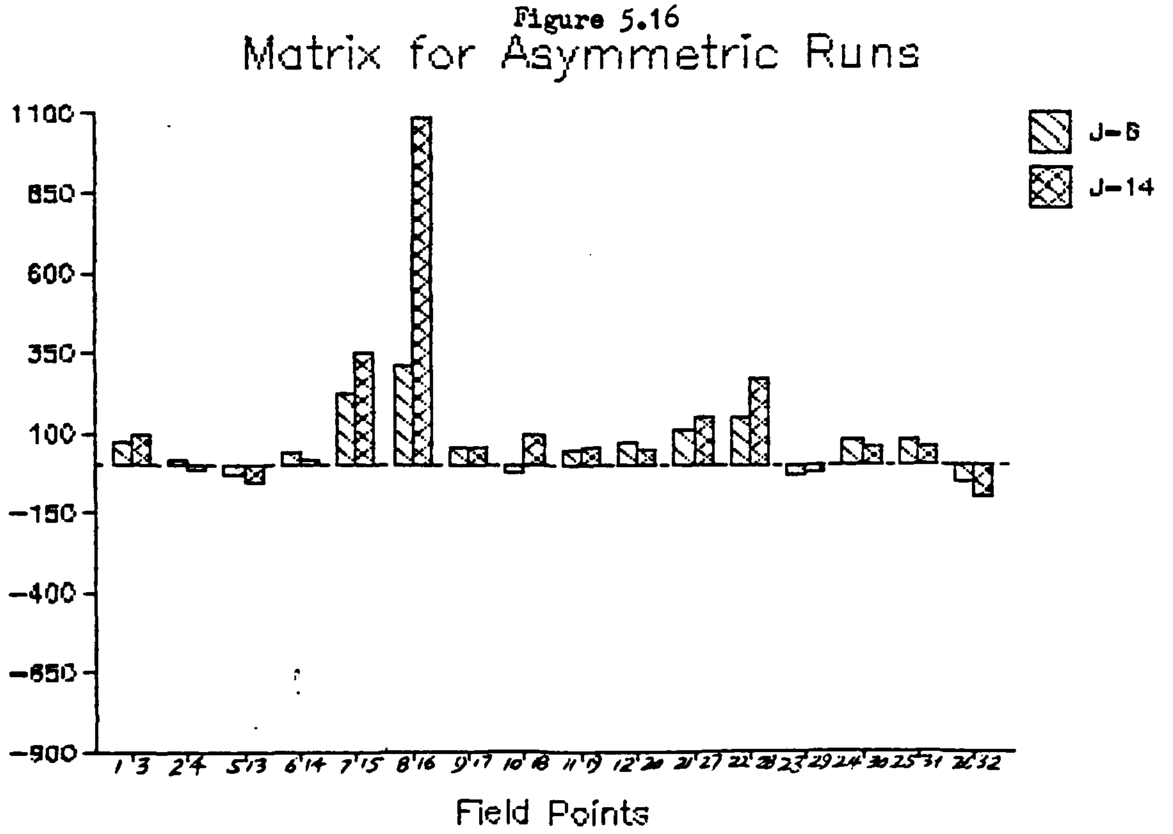


Figure 5.17

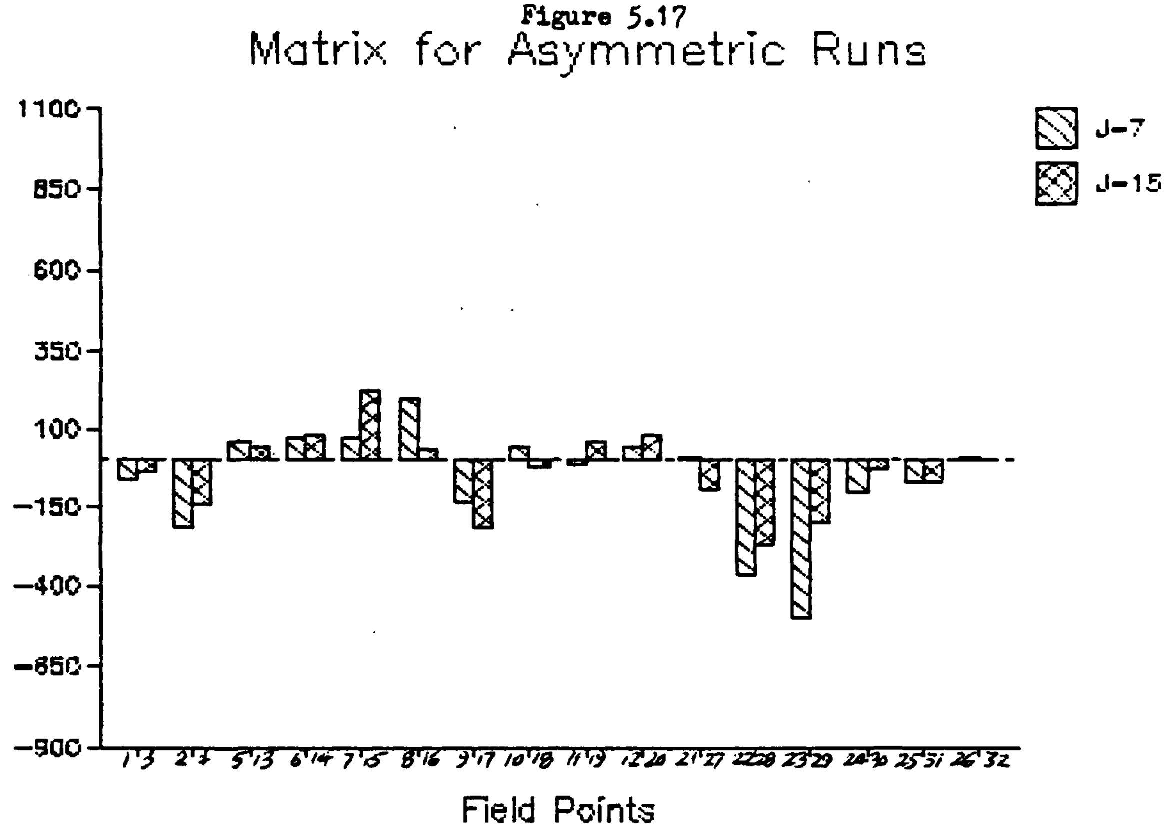


Figure 5.18

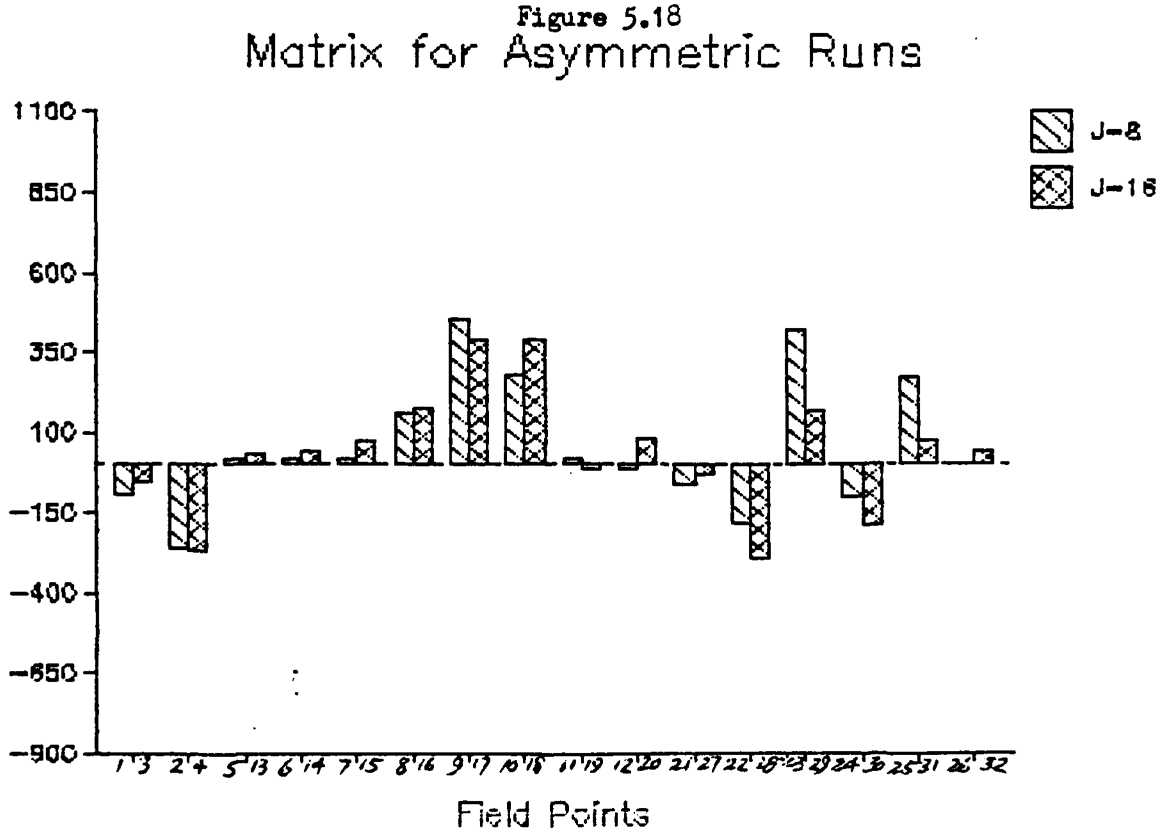


Figure 5.19

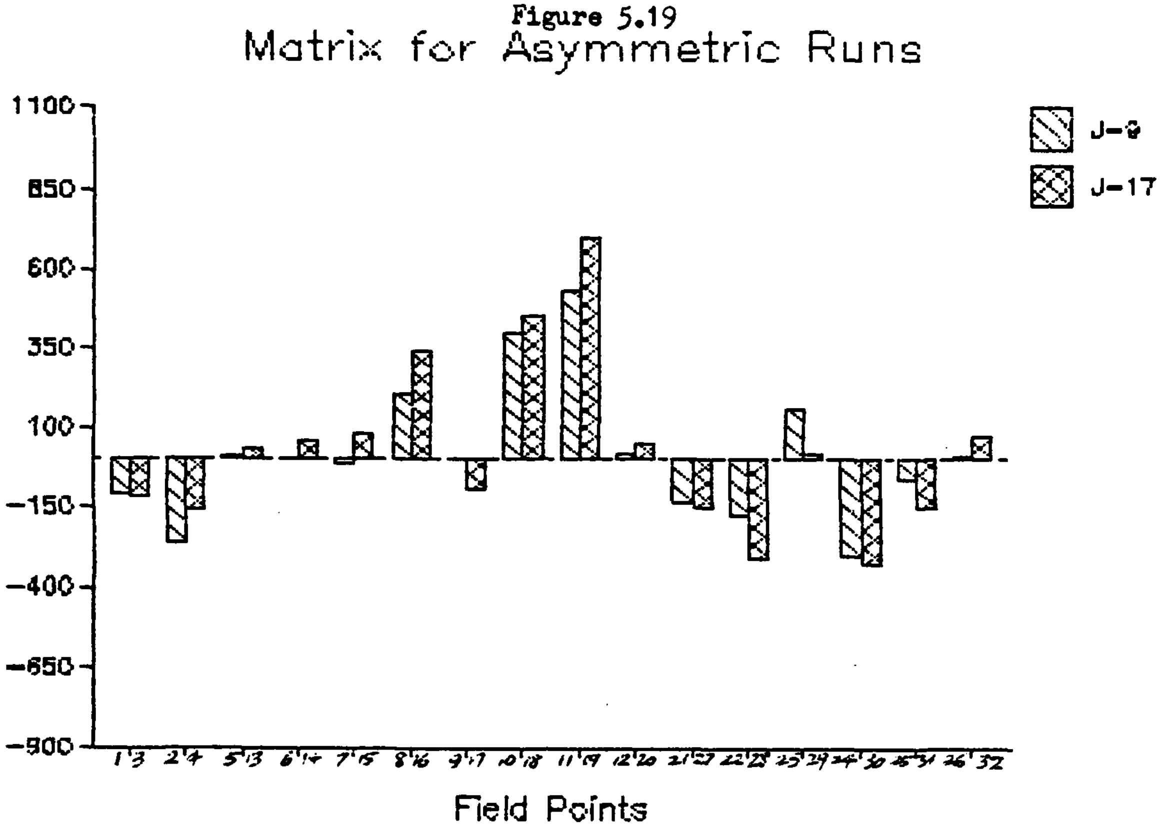


Figure 5.20

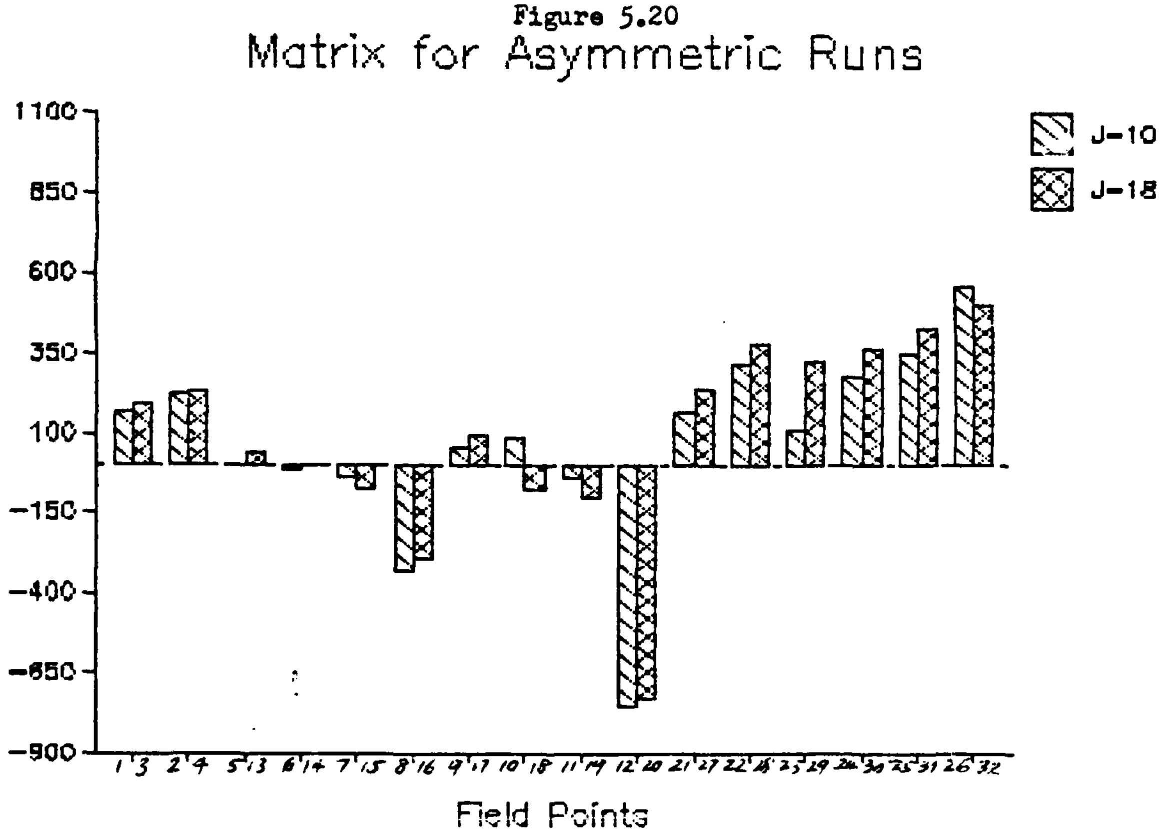


Figure 5.21

Matrix for Asymmetric Runs

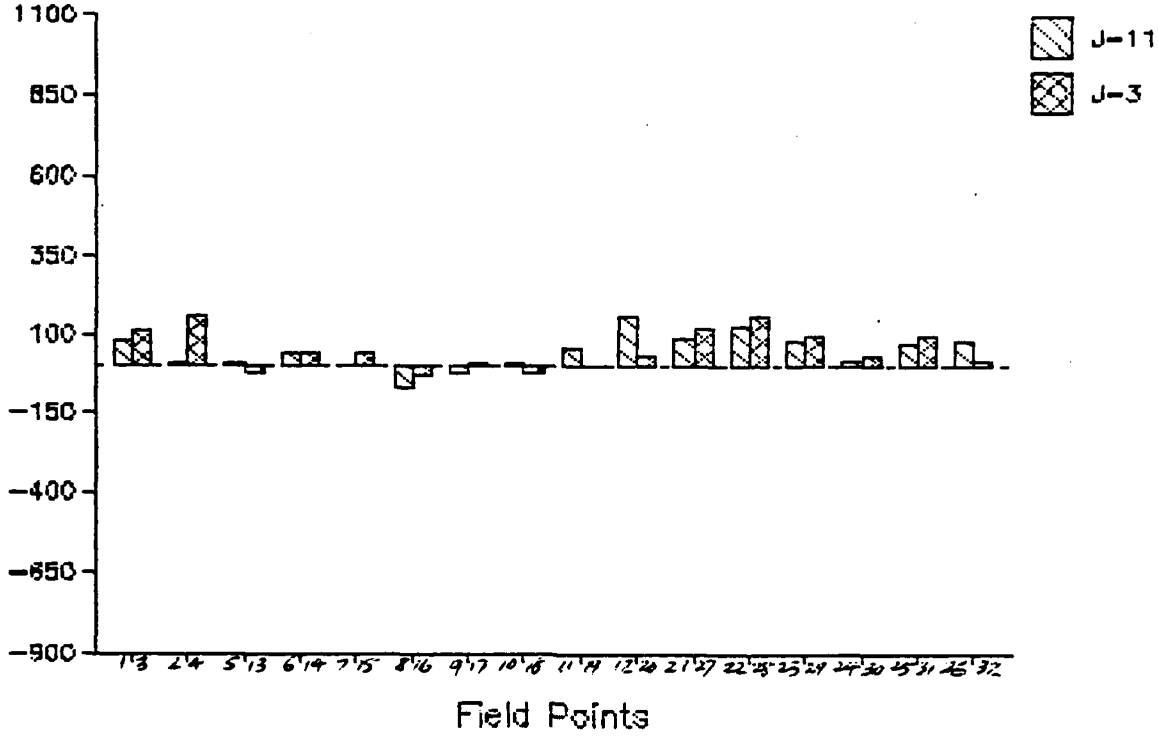


Figure 5.22

Matrix for Asymmetric Runs

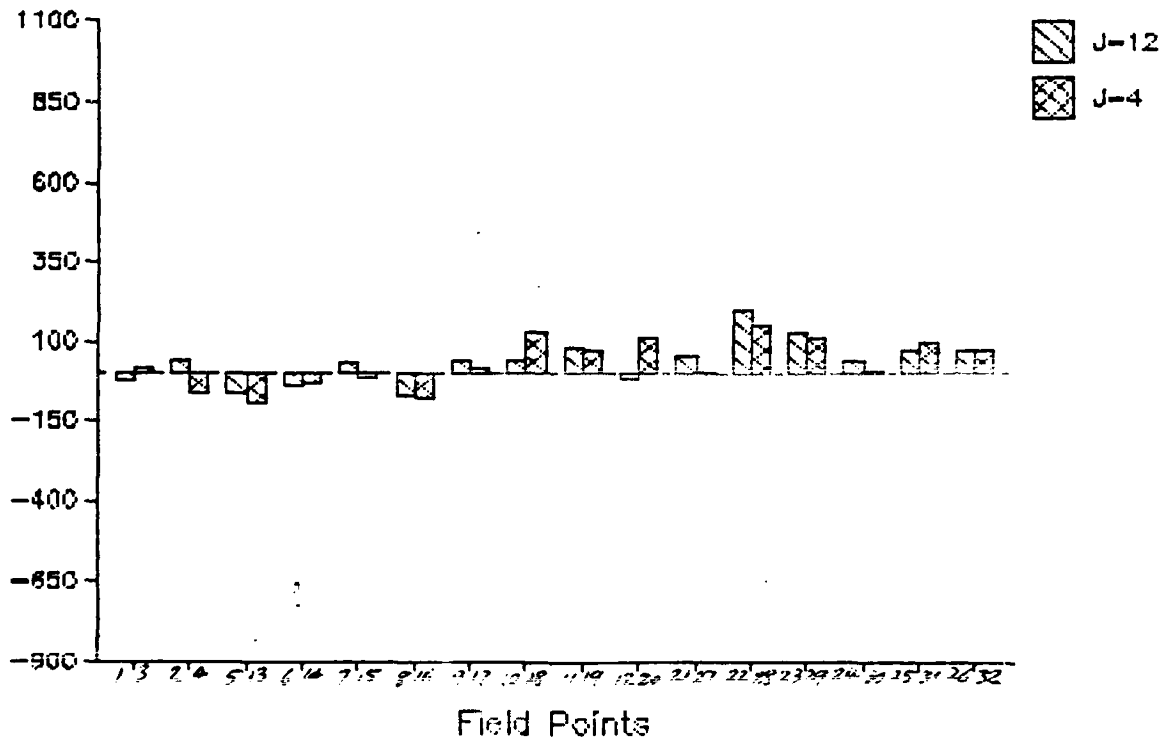


Figure 5.23

Matrix for Asymmetric Runs

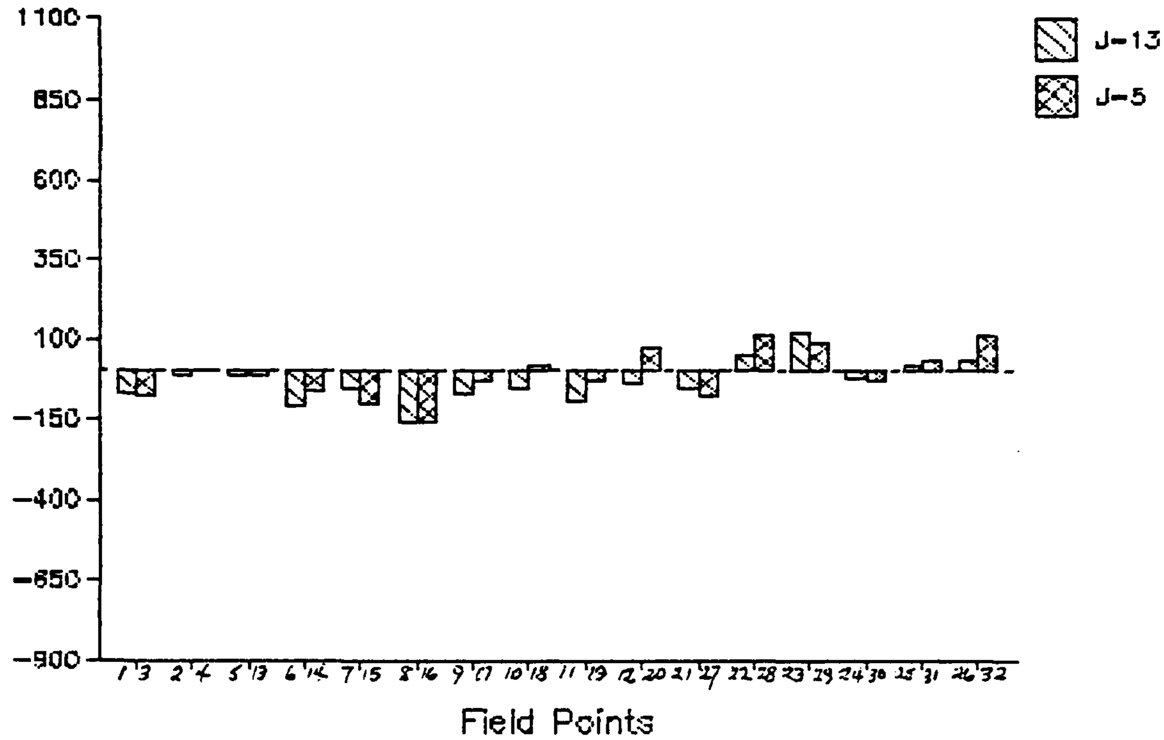
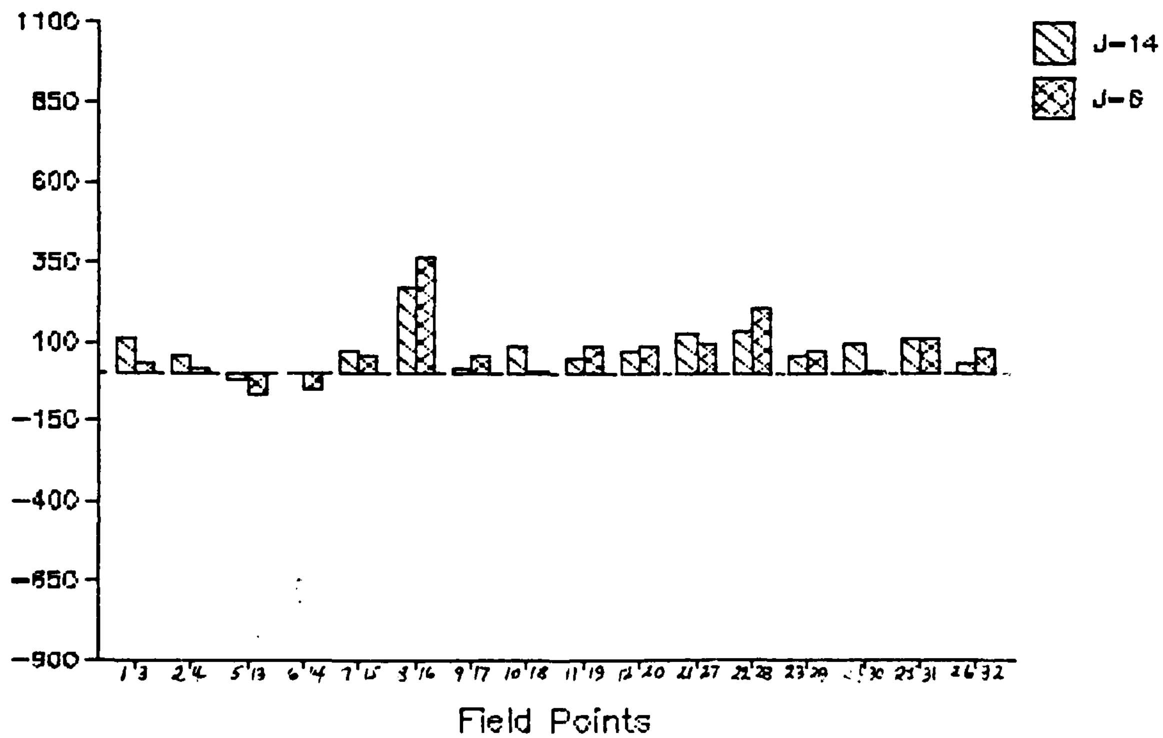
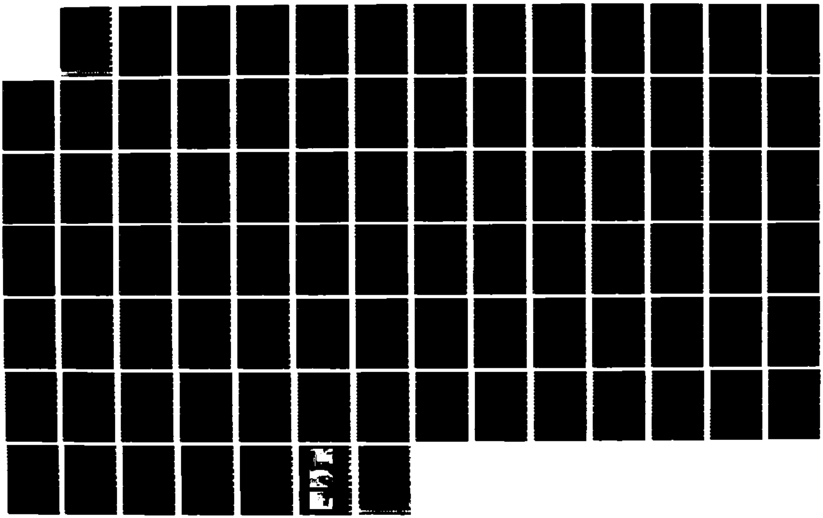


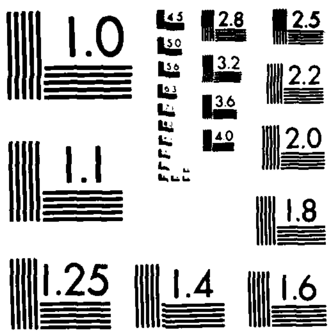
Figure 5.24

Matrix for Asymmetric Runs



AD-A174 900 EXPERIMENTS IN AN ADAPTABLE-WALL WIND TUNNEL FOR V/STOL 2/2
TESTING(U) ARIZONA UNIV TUCSON ENGINEERING EXPERIMENT
STATION W R SEARS ET AL 30 SEP 86 AFOSR-TR-86-2088
UNCLASSIFIED AFOSR-82-0185 F/G 14/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Figure 5.25

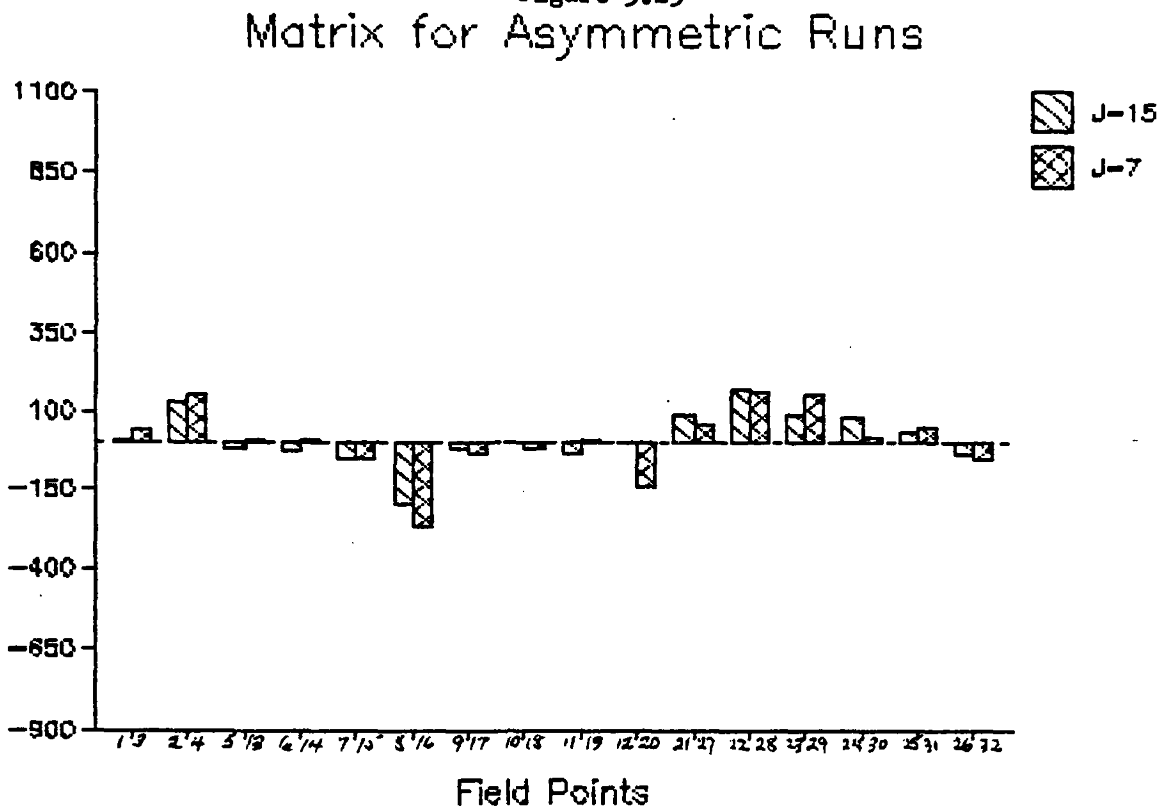


Figure 5.26

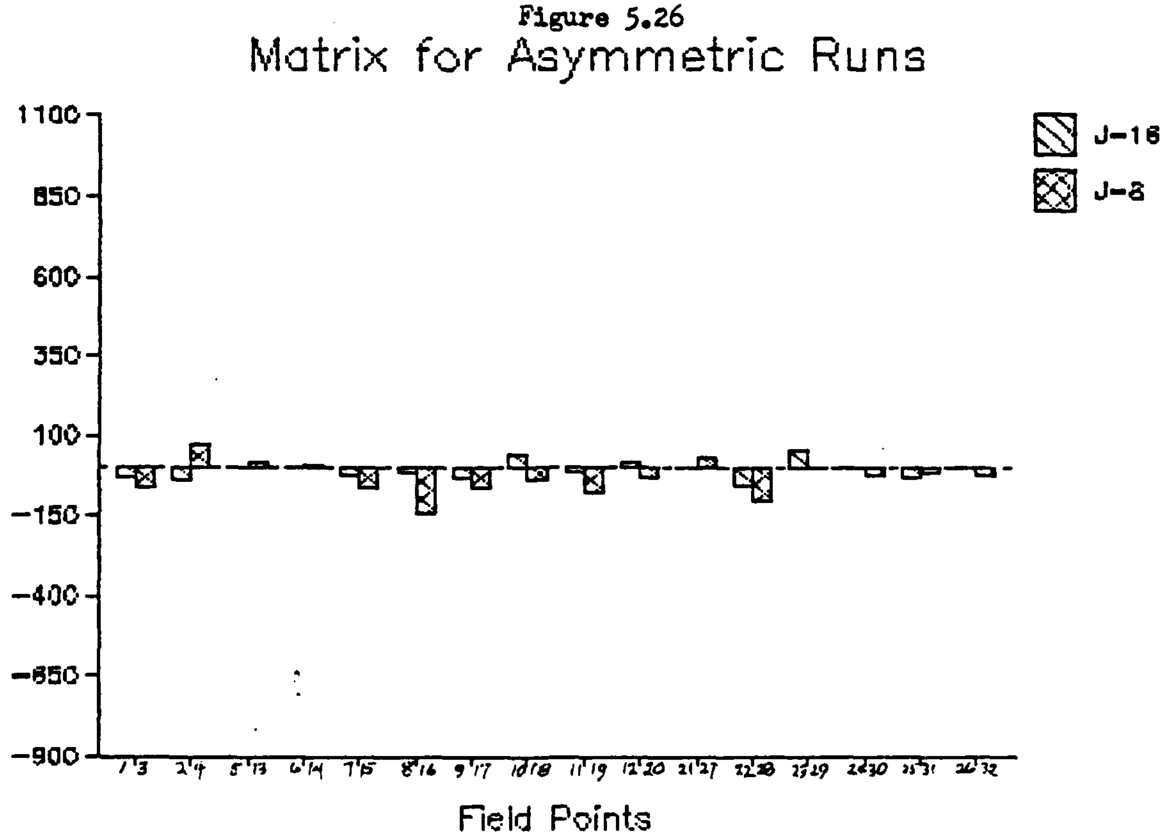


Figure 5.27

Matrix for Asymmetric Runs

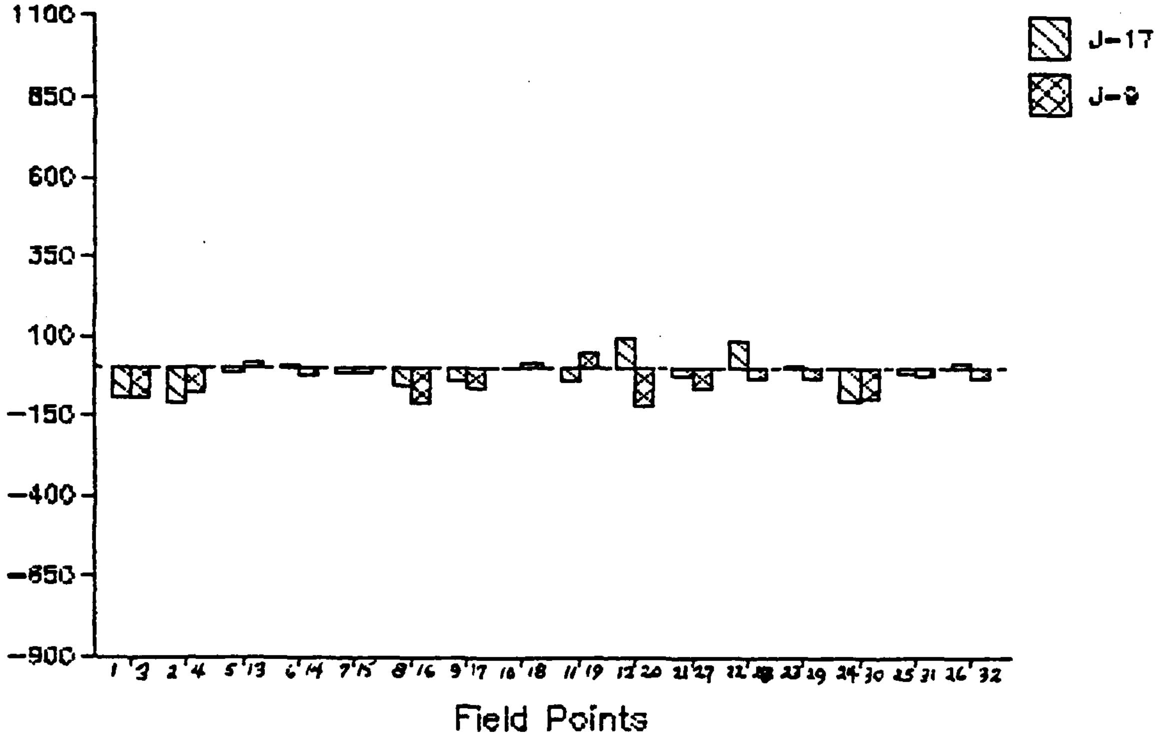


Figure 5.28

Matrix for Asymmetric Runs

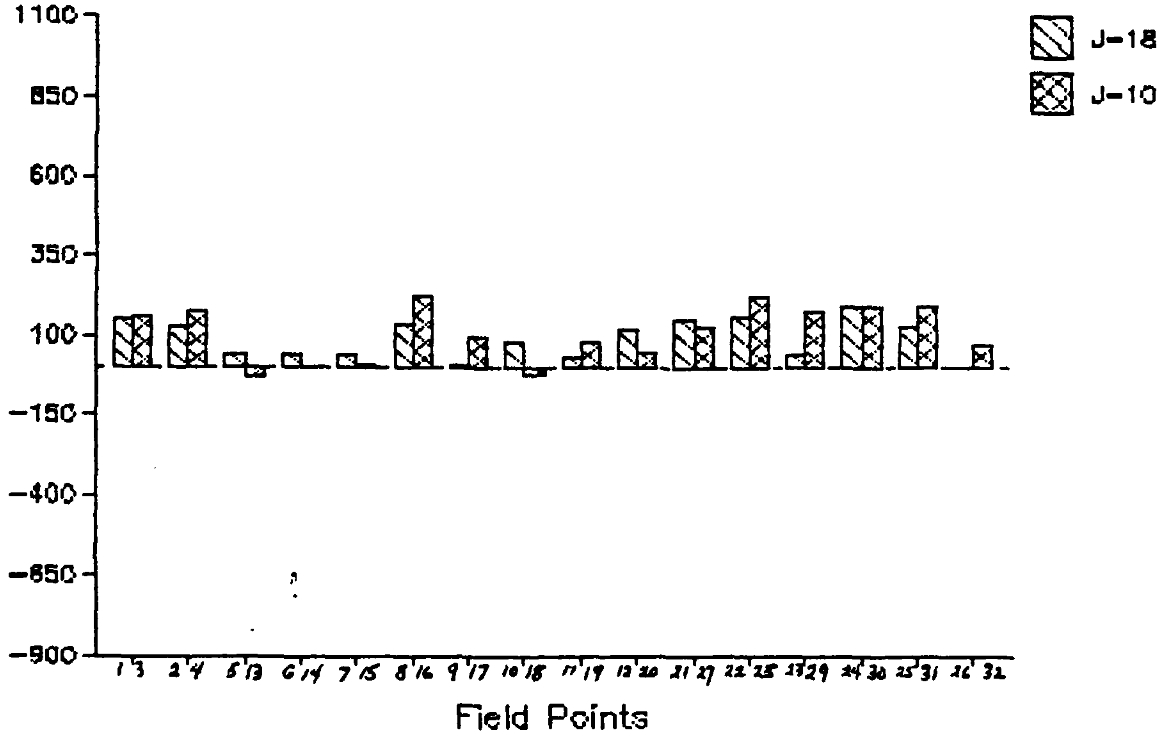
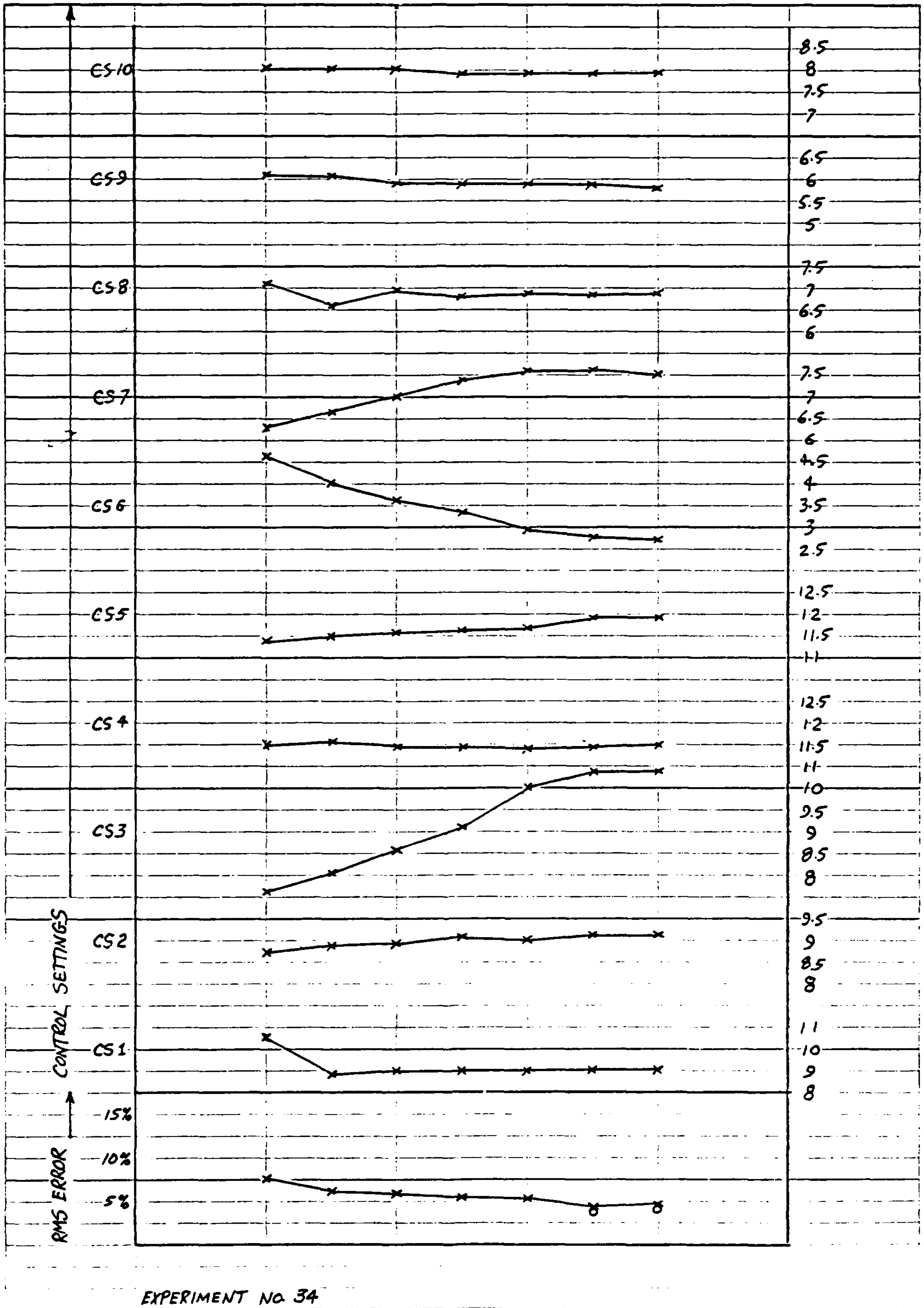


Figure 6.1


CS10
CS9
CS8
CS7
CS6
CS5
CS4
CS3
CS2
CS1
CONTROL SETTINGS
RMS ERROR
15%
10%
5%
8.5
8
7.5
7
6.5
6
5.5
5
7.5
7
6.5
6
7.5
7
6.5
6
4.5
4
3.5
3
2.5
12.5
12
11.5
11
12.5
12
11.5
11
10
9.5
9
8.5
8
9.5
9
8.5
8
11
10
9
8
EXPERIMENT NO 34

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795   at 32.0718   degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No.   34

RUN No.   1   DATE   220285

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10.6	1	-1.0735
2	8.73	2	.107226
3	7.65	3	.417379
4	11.51	4	.436232
5	11.39	5	-.111687
6	4.6	6	-.919112
7	6.36	7	-.434061
8	7.11	8	-.465648
9	6.21	9	-.387998
10	8.07	10	.0572258
11	34	11	-.133002
12	1	12	-.0610143
13	220285	13	.266227
14	4.82	14	.157678
15	3.02	15	.0446806
16	0	16	.0462749

RMS = .437749
RMS percent = 7.69608

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795 at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 2 DATE 220285 Iteration from Exp.34 Run 1 k = .15

CONTROL SETTINGS

Control Number	setting
1	8.95
2	8.85
3	8.11
4	11.53
5	11.52
6	4.03
7	6.68
8	6.98
9	6.07
10	8.04
11	34
12	2
13	220285
14	4.82
15	3.02
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.807276
2	-.190745
3	.427777
4	.500862
5	.126891
6	-.3681
7	-.324096
8	-.441587
9	-.613425
10	-.0880244
11	-.118548
12	-.0139762
13	.20721
14	.172059
15	.0427341
16	.0790849

RMS = .358162
RMS percent = 6.29685

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795   at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 3   DATE 220285   Iteration from Exp.34 Run 2   k = .15

CONTROL SETTINGS / MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	9	1	-.865358
2	8.93	2	-.211643
3	8.62	3	.362402
4	11.47	4	.432963
5	11.57	5	.0485407
6	3.66	6	-.270934
7	7.02	7	-.3958
8	6.92	8	-.375062
9	5.96	9	-.486957
10	8.02	10	.0140088
11	34	11	-.121978
12	3	12	-.0465122
13	220285	13	.32857
14	4.82	14	.179963
15	3.02	15	.0700258
16	0	16	.0586127

RMS = .343563
RMS percent = 6.04019

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795 at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 4 DATE 220285 Iteration from Exp.34 Run 3 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9	1	-.70725
2	9.04	2	-.357156
3	9.28	3	.260909
4	11.42	4	.256662
5	11.65	5	.0271247
6	3.31	6	-.223441
7	7.33	7	-.437844
8	6.83	8	-.368502
9	5.87	9	-.523365
10	7.98	10	-.0567086
11	34	11	-.144662
12	4	12	-.13596
13	220285	13	.262382
14	4.82	14	.152289
15	3.02	15	.0873919
16	0	16	.117057

RMS = .313228
RMS percent = 5.50687

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795 at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 5 DATE 10385 Iteration from Exp.34 Run 4 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9	1	-.919696
2	8.99	2	.0182368
3	10	3	.217487
4	11.37	4	.172068
5	11.63	5	-.0710959
6	2.93	6	.0921686
7	7.62	7	-.264858
8	6.8	8	-.175738
9	5.82	9	-.368971
10	7.93	10	.0776987
11	34	11	-.143279
12	5	12	-.121887
13	10385	13	.263451
14	4.82	14	.13062
15	3.02	15	.0722919
16	0	16	.078866

RMS = .286481
RMS percent = 5.03662

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795 at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 6 DATE 10385 Iteration from Exp.34 Run 5 k = .15

CONTROL SETTINGS

Control Number	setting
1	9
2	9.13
3	10.35
4	11.42
5	11.75
6	2.79
7	7.65
8	6.79
9	5.78
10	7.9
11	34
12	6
13	10385
14	4.82
15	3.02
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.637391
2	.19635
3	-.0137343
4	-.0974589
5	-.256909
6	.0442748
7	-.216988
8	-.172237
9	-.260444
10	.26443
11	-.124024
12	-.126574
13	.284325
14	.0654967
15	.10503
16	.10085

RMS = .233815
RMS percent = 4.1107

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.85 W = 3

RESULTANT = 5.70285 at 31.7415 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 6 DATE 10385 Results of Search for best RMS %

CONTROL SETTINGS

Control Number	setting
1	9
2	9.13
3	10.35
4	11.42
5	11.75
6	2.79
7	7.65
8	6.79
9	5.78
10	7.9
11	34
12	6
13	10385
14	4.85
15	3.00
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.558286
2	.134801
3	-.0326639
4	-.107459
5	-.257705
6	.0474156
7	-.270763
8	-.245989
9	-.346432
10	.17929
11	-.117779
12	-.123709
13	.290881
14	.0746809
15	.107499
16	.107334

RMS = .229068
RMS percent = 4.01673

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 3.02

RESULTANT = 5.68795 at 32.0718 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 7 DATE 10385 Iteration from Exp.34 Run 6 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9	1	-.800144
2	9.12	2	.271667
3	10.38	3	.0699083
4	11.5	4	.023155
5	11.78	5	-.107645
6	2.72	6	-5.47033E-03
7	7.51	7	-.200889
8	6.81	8	-.104799
9	5.74	9	-.236942
10	7.84	10	.198871
11	34	11	-.136843
12	7	12	-.118768
13	10385	13	.210932
14	4.82	14	.125597
15	3.02	15	.0471922
16	0	16	.132847

RMS = .248882
RMS percent = 4.3756

RESULTS OF ITERATION
****

STREAM VECTOR: U = 4.82 W = 2.96

RESULTANT = 5.65632 at 31.5567 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 34

RUN No. 7 DATE 10385 Results of Search for best RMS %

CONTROL SETTINGS

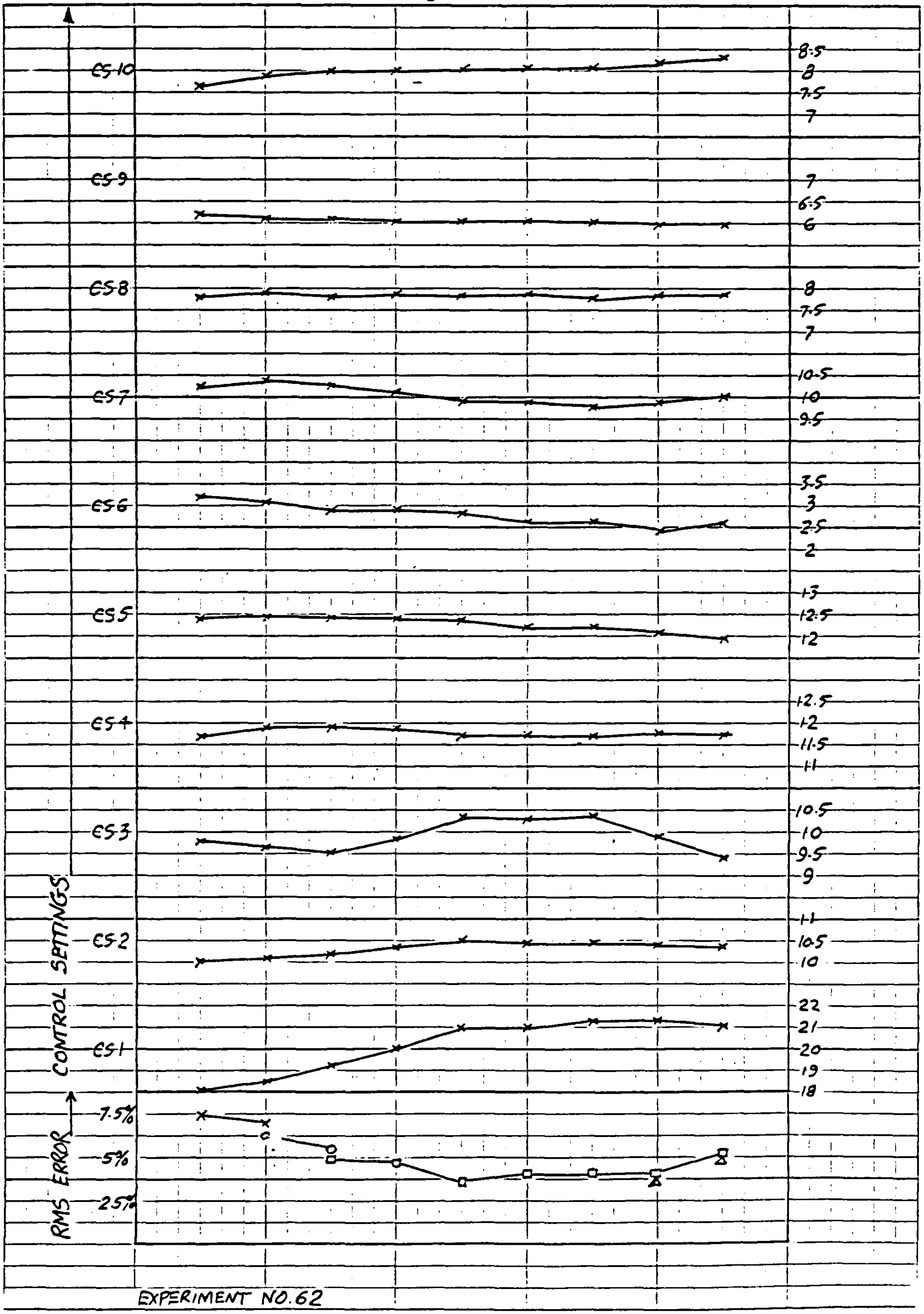
Control Number	setting
1	9
2	9.12
3	10.38
4	11.5
5	11.78
6	2.72
7	7.51
8	6.81
9	5.74
10	7.84
11	34
12	7
13	10385
14	4.82
15	2.96
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.589163
2	.0606863
3	-.0391496
4	-.102472
5	-.237822
6	-.128468
7	-.309947
8	-.230426
9	-.367119
10	.0758724
11	-.141251
12	-.118173
13	.21104
14	.130005
15	.0465975
16	.132739

RMS = .229229
RMS percent = 4.05261

Figure 6.2



ES 10
ES 9
ES 8
ES 7
ES 6
ES 5
ES 4
ES 3
ES 2
ES 1
CONTROL SETTINGS
RMS ERROR
7.5%
5%
2.5%
8.5
8
7.5
7
7
6.5
6
8
7.5
7
10.5
10
9.5
3.5
3
2.5
2
13
12.5
12
12.5
12
11.5
11
10.5
10
9.5
9
11
10.5
10
22
21
20
19
18
EXPERIMENT NO. 62

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.4 W = 4.33

RESULTANT = 6.92163 at 38.7273 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 1 DATE 80785

CONTROL SETTINGS

Control Number	setting
1	18
2	9.99
3	9.73
4	11.67
5	12.43
6	3.28
7	10.29
8	7.73
9	6.69
10	7.71
11	62
12	1
13	80785
14	5.4
15	4.33
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.846241
2	.299997
3	.246764
4	.489093
5	-.405422
6	-.971464
7	.0179687
8	-1.13102
9	-.690904
10	-.147961
11	-.270863
12	-.133211
13	.0040642
14	-.0153173
15	.0629309
16	-.127118

RMS = .506494
RMS percent = 7.31756

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.4 W = 4.33

RESULTANT = 6.92163 at 38.7273 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 2 DATE290785 Iteration from Exp.62 Run 1 k = .15

CONTROL SETTINGS

Control Number	setting
1	18.5
2	10.17
3	9.62
4	11.79
5	12.46
6	3.08
7	10.34
8	7.75
9	6.63
10	7.88
11	62
12	2
13	290785
14	5.4
15	4.33
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.194106
2	-.252291
3	-.0489209
4	.174577
5	-.607667
6	-1.07875
7	-.0461287
8	-1.18553
9	-.700273
10	-.236071
11	-.311262
12	-.155531
13	.137144
14	.0296507
15	.0425143
16	-.0853491

RMS = .48546
RMS percent = 7.01366

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.6 W = 4.49

RESULTANT = 7.17775 at 38.725 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 2 DATE 290785 Results of Search for best RMS %

CONTROL SETTINGS MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	18.5	1	-.699503
2	10.17	2	.370143
3	9.62	3	.358727
4	11.79	4	.722863
5	12.46	5	.0242482
6	3.08	6	-.455729
7	10.34	7	.12921
8	7.75	8	-1.06226
9	6.63	9	-.636305
10	7.88	10	-.201586
11	62	11	-.248048
12	2	12	-.139338
13	290785	13	.180322
14	5.6	14	.0693018
15	4.49	15	.0618856
16	0	16	-.0415922

RMS = .44723
RMS percent = 6.23078

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.6 W = 4.49

RESULTANT = 7.17775 at 38.725 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 3 DATE 310785 Iteration from Exp.62 Run 2 k = .15

CONTROL SETTINGS

Control Number	setting
1	19.25
2	10.24
3	9.5
4	11.82
5	12.38
6	2.96
7	10.29
8	7.78
9	6.59
10	8.02
11	62
12	3
13	310785
14	5.6
15	4.49
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	.21428
2	-.0509019
3	.0256528
4	.348692
5	-.385988
6	-.717946
7	.0746186
8	-1.03706
9	-.603746
10	-.206904
11	-.253868
12	-.0177063
13	.157974
14	-.0996144
15	.0607711
16	-.153824

RMS = .391357
RMS percent = 5.45236

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 3 DATE 310785 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	19.25	1	-.0377684
2	10.24	2	.259664
3	9.5	3	.229141
4	11.82	4	.622447
5	12.38	5	-.0704317
6	2.96	6	-.406814
7	10.29	7	.161951
8	7.78	8	-.975814
9	6.59	9	-.572163
10	8.02	10	-.190041
11	62	11	-.222274
12	3	12	-9.60817E-03
13	310785	13	.179563
14	5.7	14	-.0797752
15	4.57	15	.0704551
16	0	16	-.131946

RMS = .365005
RMS percent = 4.9961

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 4 DATE 310785 Iteration from Exp.62 Run 3 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	20	1	.433659
2	10.38	2	.25014
3	9.87	3	.053035
4	11.8	4	.476066
5	12.38	5	-.194941
6	2.85	6	-.187924
7	10.16	7	.264955
8	7.8	8	-.929725
9	6.56	9	-.69516
10	8.05	10	-.249723
11	62	11	-.204999
12	4	12	.0421891
13	310785	13	.159813
14	5.7	14	.0144481
15	4.57	15	.0692455
16	0	16	-.0785838

RMS = .363501
RMS percent = 4.9755

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 5 DATE 20885 Iteration from Exp.62 Run 4 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	20.9	1	-.306789
2	10.54	2	.343683
3	10.43	3	.096802
4	11.75	4	.352709
5	12.4	5	-.291663
6	2.8	6	-.590209
7	9.91	7	.247234
8	7.81	8	-.404249
9	6.52	9	-.129743
10	8.04	10	.122896
11	62	11	-.20693
12	5	12	-.037821
13	20885	13	.156659
14	5.7	14	.0322912
15	4.57	15	.0542122
16	0	16	-.0561554

RMS = .263609
RMS percent = 3.6082

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 6 DATE 20885 Iteration from Exp.62 Run 5 k = .15

CONTROL SETTINGS

Control Number	setting
1	20.9
2	10.49
3	10.33
4	11.73
5	12.27
6	2.64
7	9.86
8	7.82
9	6.52
10	8.09
11	62
12	6
13	20885
14	5.7
15	4.57
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	.142659
2	.55993
3	-.149465
4	.0348871
5	-.569635
6	-.335201
7	.366732
8	-.519915
9	-.154074
10	.131184
11	-.307006
12	.0433078
13	.183093
14	.1762
15	.103248
16	-.116921

RMS = .298439
RMS percent = 4.08495

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 7 DATE 90885 Iteration from Exp.62 Run 6 k = .15

CONTROL SETTINGS

Control Number	setting
1	21.4
2	10.48
3	10.43
4	11.71
5	12.23
6	2.6
7	9.64
8	7.78
9	6.49
10	8.09
11	62
12	7
13	90885
14	5.7
15	4.57
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.745102
2	.067868
3	.213917
4	.315629
5	-.17989
6	.0415799
7	-.0938723
8	-.589855
9	-.275637
10	-.0333666
11	-.275905
12	3.21409E-03
13	.215843
14	.1334
15	.1482
16	-.0734878

RMS = .2895
RMS percent = 3.9626

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 8 DATE 90885 Iteration from Exp.62 Run 7 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	21.3646	1	-.650964
2	10.4154	2	-.038782
3	9.93014	3	.218081
4	11.7372	4	.414383
5	12.1124	5	-.198584
6	2.55138	6	.216497
7	9.79566	7	-.0936011
8	7.80316	8	-.546989
9	6.48743	9	-.194427
10	8.24247	10	.0518292
11	62	11	-.28317
12	8	12	6.06763E-03
13	90885	13	.208772
14	5.7	14	.11335
15	4.57	15	.0529896
16	0	16	-.138106

RMS = .278144
RMS percent = 3.80715

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.6 W = 4.55

RESULTANT = 7.21544 at 39.0967 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 8 DATE 90885 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	21.3646	1	-.609897
2	10.4154	2	-.138367
3	9.93014	3	.123651
4	11.7372	4	.266254
5	12.1124	5	-.383963
6	2.55138	6	.0283628
7	9.79566	7	-.0718762
8	7.80316	8	-.482612
9	6.48743	9	-.0958326
10	8.24247	10	.157964
11	62	11	-.310355
12	8	12	-2.62515E-03
13	90885	13	.187074
14	5.6	14	.0891032
15	4.55	15	.0439004
16	0	16	-.159876

RMS = .257937
RMS percent = 3.57479

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 4.57

RESULTANT = 7.30581 at 38.7239 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 62

RUN No. 9 DATE 260885 Iteration from Exp.62 Run 8 k = .15

CONTROL SETTINGS

Control Number	setting
1	20.9
2	10.34
3	9.44
4	11.75
5	11.98
6	2.48
7	10.03
8	7.84
9	6.48
10	8.36
11	62
12	9
13	260885
14	5.7
15	4.57
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.269358
2	-.534495
3	-.143168
4	-.0739921
5	-.679997
6	.358658
7	-.323569
8	-.400527
9	7.98999E-03
10	.811223
11	-.345491
12	-.0806786
13	.224805
14	-.265732
15	-.147428
16	-.163165

RMS = .370295
RMS percent = 5.06849

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.85 W = 4.6

RESULTANT = 7.44194 at 38.1817 degrees

FLAPS: Position 4, 50 p.s.i.

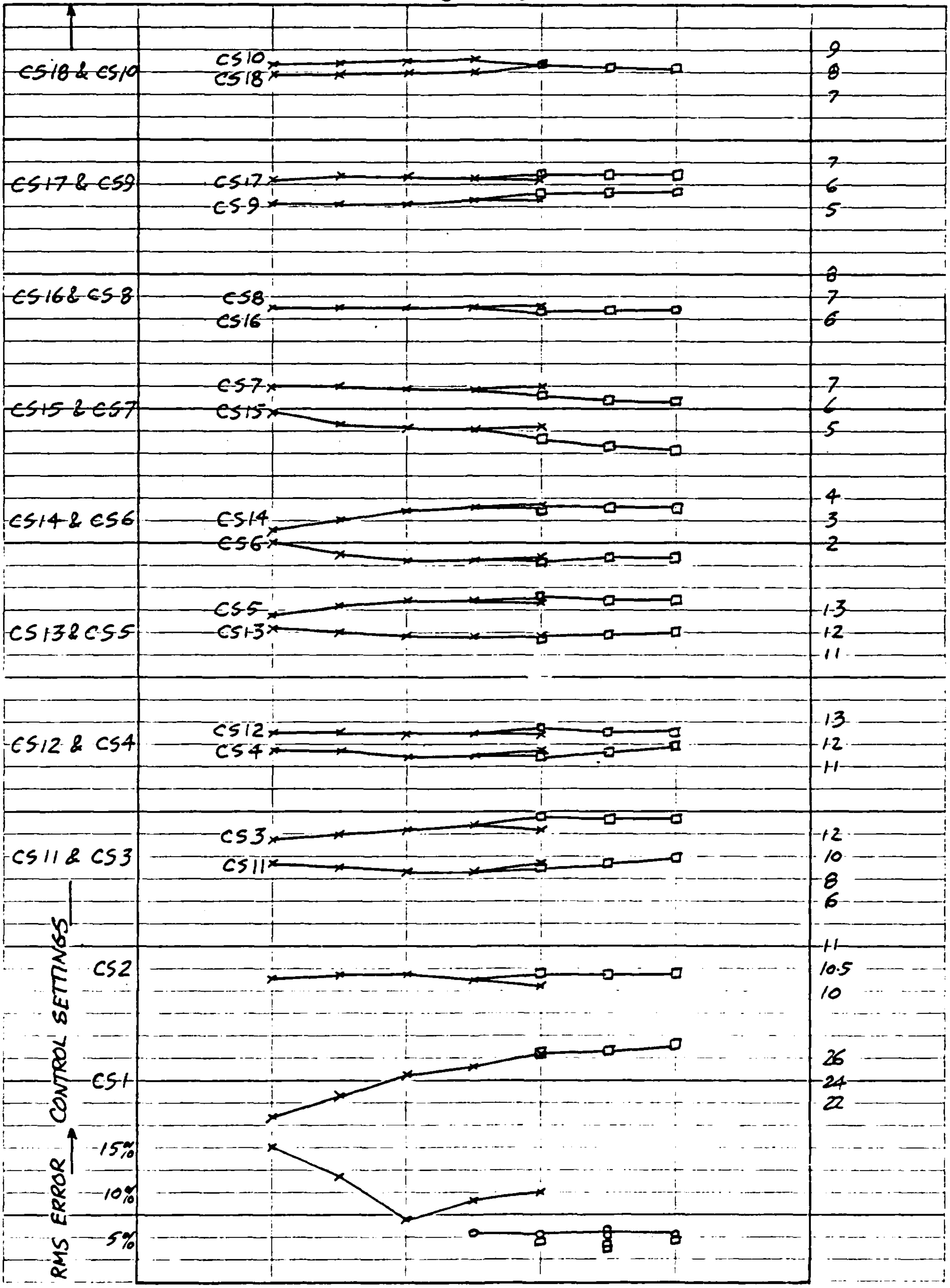
EXPERIMENT No. 62

RUN No. 9 DATE 260885 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	20.9	1	-.330958
2	10.34	2	-.385118
3	9.44	3	-1.52362E-03
4	11.75	4	.148201
5	11.98	5	-.401928
6	2.48	6	.640859
7	10.03	7	-.356157
8	7.84	8	-.497094
9	6.48	9	-.139903
10	8.36	10	.65202
11	62	11	-.304713
12	9	12	-.0676394
13	260885	13	.257351
14	5.85	14	-.229361
15	4.6	15	-.133794
16	0	16	-.130511

RMS = .346582
RMS percent = 4.65715

Figure 6.3



EXPERIMENT NO. 76

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 1 DATE 60186

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	20.6	1	1.93196
2	10.24	2	-2.81352
3	11.6	3	-3.1665
4	11.74	4	.41151
5	12.85	5	-.926918
6	2.06	6	-.520968
7	7.08	7	-.711694
8	6.65	8	-.670019
9	5.29	9	-.96893
10	8.27	10	-.912625
11	9.01	11	-.772983
12	12.4	12	-1.03816
13	12.19	13	1.10604
14	2.49	14	1.54951
15	5.93	15	1.46971
16	6.55	16	1.53936
17	6.17	17	.256473
18	7.95	18	.410514
19	76	19	.341187
20	1	20	.0094422
21	60186	21	-.273545
22	6	22	-.0404702
23	4	23	1.10328
24	0	24	-.0112939
25	0	25	.0483099
26	0	26	-.0853547
27	0	27	-.180003
28	0	28	-.0182608
29	0	29	.0578872
30	0	30	.104713
31	0	31	.123459
32	0	32	-.0573147

RMS = 1.07893

RMS percent = 14.9623

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 2 DATE 60186 Iteration from Exp.76 Run 1 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	22.6	1	1.87304
2	10.29	2	-2.19969
3	12.22	3	-2.49464
4	11.6	4	-.505959
5	13.29	5	-.790615
6	1.64	6	-.349789
7	6.98	7	-.554302
8	6.62	8	-.304679
9	5.13	9	-.783578
10	8.38	10	-.60555
11	8.17	11	-.255966
12	12.47	12	-.642662
13	11.97	13	.901547
14	2.99	14	1.32611
15	5.43	15	1.15437
16	6.47	16	.7446
17	6.48	17	.0755932
18	7.91	18	-.101481
19	76	19	-.302102
20	2	20	-.528102
21	60186	21	-.327858
22	6	22	-.175263
23	4	23	.715771
24	0	24	-.0452944
25	0	25	.0918714
26	0	26	-.139337
27	0	27	-.163005
28	0	28	.136013
29	0	29	.324128
30	0	30	.0693051
31	0	31	.157549
32	0	32	-.101026

RMS = .850511
RMS percent = 11.7945

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 3 DATE 70186 Iteration from Exp.76 Run 2 k = .15

CONTROL SETTINGS | MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	24.5	1	.914148
2	10.26	2	-1.10769
3	12.59	3	-1.67753
4	11.49	4	-.702318
5	13.55	5	-.573965
6	1.31	6	.0668495
7	6.97	7	-.0184752
8	6.55	8	.100844
9	5.14	9	-.395746
10	8.39	10	-.0466141
11	7.37	11	.262995
12	12.48	12	-.217792
13	11.84	13	.500967
14	3.46	14	.655602
15	5.28	15	.0357181
16	6.49	16	-.265804
17	6.51	17	.154772
18	7.93	18	-.0639054
19	76	19	-.350879
20	3	20	-.63788
21	80186	21	-.262463
22	6	22	-.0394212
23	4	23	.355884
24	0	24	-.0901826
25	0	25	.0740584
26	0	26	-.223045
27	0	27	-.196313
28	0	28	.174619
29	0	29	.156418
30	0	30	.0491077
31	0	31	.213751
32	0	32	-.074993

RMS = .490798
RMS percent = 6.80614

RESULTS OF ITERATION

****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 4 DATE 80186 Iteration from Exp.76 Run 3 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	25.6	1	-.116143
2	10.25	2	-1.53448
3	12.79	3	-1.70159
4	11.56	4	-1.28354
5	13.53	5	-.0632382
6	1.23	6	.693812
7	6.84	7	.596102
8	6.48	8	.748137
9	5.3	9	-.490838
10	8.34	10	-.208208
11	7.8	11	.0649803
12	12.47	12	-.164201
13	11.86	13	.734603
14	3.62	14	.903849
15	5.12	15	.257761
16	6.5	16	-.433388
17	6.45	17	-.266788
18	7.99	18	-.622334
19	76	19	-.756774
20	4	20	-1.19644
21	80186	21	-.167287
22	6	22	-.154001
23	4	23	.226355
24	0	24	-.0389358
25	0	25	.0254461
26	0	26	-.125643
27	0	27	-.127765
28	0	28	.27181
29	0	29	.362588
30	0	30	.0913814
31	0	31	.216355
32	0	32	-.100583

RMS = .640025
RMS percent = 8.87554

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.03

RESULTANT = 7.32771 at 33.3672 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 4 DATE 80186 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	25.6	1	.699647
2	10.25	2	-.504814
3	12.79	3	-.885841
4	11.56	4	-.253876
5	13.53	5	-.582857
6	1.23	6	.128292
7	6.84	7	.0759266
8	6.48	8	.680393
9	5.3	9	.14006
10	8.34	10	.488357
11	7.8	11	.719259
12	12.47	12	.0356555
13	11.86	13	.214993
14	3.62	14	.338338
15	5.12	15	-.262403
16	6.5	16	-.501118
17	6.45	17	.364122
18	7.99	18	.0742512
19	76	19	-.102472
20	4	20	-.99656
21	80186	21	-.342978
22	6.12	22	-.161933
23	4.03	23	.117049
24	0	24	-.219238
25	0	25	.0181102
26	0	26	-.234883
27	0	27	-.303452
28	0	28	.263881
29	0	29	.253281
30	0	30	-.0889087
31	0	31	.209017
32	0	32	-.209822

RMS = .410796

RMS percent = 5.60607

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 5 DATE 100186 Iteration from Exp.76 Run 4 k = .15

CONTROL SETTINGS

Control Number	setting
1	26.4
2	10.15
3	12.14
4	11.77
5	13.29
6	1.42
7	6.95
8	6.61
9	5.44
10	8.27
11	7.32
12	12.31
13	11.88
14	3.79
15	5.34
16	6.51
17	6.22
18	8.13
19	76
20	5
21	100186
22	6
23	4
24	0
25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0

MATCHING DISCREPANCY

Field Point	DVe
1	1.24042
2	-1.78095
3	-2.58105
4	-1.19607
5	-.526091
6	.0679979
7	-.0840388
8	-.0303798
9	-.609038
10	-.403283
11	-.222102
12	-.337194
13	.968516
14	1.23392
15	.595147
16	-.0963131
17	-.0674332
18	-.230224
19	-.362096
20	-.719651
21	-.214692
22	-.141538
23	.351733
24	-.0405744
25	.0275096
26	-.154647
27	-.0753618
28	.233966
29	.529115
30	.13101
31	.143975
32	-.0808527

RMS = .74834
RMS percent = 10.3776

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.03

RESULTANT = 7.32771 at 33.3672 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 6 DATE 100186 Iteration from Exp.76 Run 4 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	26.5	1	-.370616
2	10.37	2	-.57602
3	13.48	3	-.769646
4	11.66	4	-.70944
5	13.53	5	-.228761
6	1.16	6	.366531
7	6.62	7	.196559
8	6.39	8	.575802
9	5.58	9	-.0608375
10	8.27	10	.102511
11	7.3	11	.169874
12	12.54	12	-.212846
13	11.9	13	.0750564
14	3.68	14	.13083
15	4.64	15	-.529618
16	6.46	16	-.787823
17	6.52	17	.336413
18	8.1	18	-.0313194
19	76	19	-.234776
20	6	20	-.707018
21	100186	21	-.266289
22	6.12	22	-.0162528
23	4.03	23	.174903
24	0	24	-.0823276
25	0	25	.0402406
26	0	26	-.228064
27	0	27	-.285685
28	0	28	.217149
29	0	29	.234485
30	0	30	-.0400586
31	0	31	.222953
32	0	32	-.119611

RMS = .362916

RMS percent = 4.95265

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.15 W = 4.05

RESULTANT = 7.36376 at 33.3688 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 6 DATE 100186 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	26.5	1	-.211227
2	10.37	2	-.274041
3	13.48	3	-.610268
4	11.66	4	-.407462
5	13.53	5	-.335481
6	1.16	6	.252456
7	6.62	7	.0944578
8	6.39	8	.586395
9	5.58	9	.120074
10	8.27	10	.303959
11	7.3	11	.361389
12	12.54	12	-.135353
13	11.9	13	-.0316613
14	3.68	14	.0167572
15	4.64	15	-.631716
16	6.46	16	-.777227
17	6.52	17	.517328
18	8.1	18	.170135
19	76	19	-.0432557
20	6	20	-.629518
21	100186	21	-.309253
22	6.15	22	-.01836
23	4.05	23	.147562
24	0	24	-.128363
25	0	25	.0385306
26	0	26	-.25536
27	0	27	-.328648
28	0	28	.215043
29	0	29	.207144
30	0	30	-.0860908
31	0	31	.221242
32	0	32	-.146907

RMS = .336255

RMS percent = 4.56634

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.03

RESULTANT = 7.32771 at 33.3672 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 7 DATE 130186 Iteration from Exp.76 Run 6 k = .15

CONTROL SETTINGS

Control Number	setting
1	26.8
2	10.38
3	13.32
4	11.86
5	13.4
6	1.27
7	6.51
8	6.43
9	5.7
10	8.23
11	6.98
12	12.54
13	11.97
14	3.62
15	4.41
16	6.49
17	6.46
18	8.18
19	76
20	7
21	130186
22	6.12
23	4.03
24	0
25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0

MATCHING DISCREPANCY

Field Point	DVe
1	.348866
2	-.914142
3	-1.29477
4	-.753692
5	-.444226
6	.0901634
7	1.10274E-04
8	.10621
9	-.191545
10	-.0494778
11	.0128038
12	-.0927146
13	.326044
14	.359368
15	-.217405
16	-.827755
17	.253118
18	-.178262
19	-.403909
20	-.701338
21	-.245163
22	-.0720376
23	.302214
24	-.0153799
25	.0309835
26	-.153599
27	-.158814
28	.383758
29	.182627
30	-.0110581
31	.143041
32	4.03623E-03

RMS = .418072
RMS percent = 5.70536

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.16 W = 4.09

RESULTANT = 7.39417 at 33.5851 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 7 DATE 130186 Results of Search for best RMS %

CONTROL SETTINGS / MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	26.8	1	.44256
2	10.38	2	-.392686
3	13.32	3	-1.20109
4	11.86	4	-.232235
5	13.4	5	-.524692
6	1.27	6	.0108778
7	6.51	7	-.06151
8	6.43	8	.193742
9	5.7	9	.111495
10	8.23	10	.291931
11	6.98	11	.342668
12	12.54	12	.0840168
13	11.97	13	.245582
14	3.62	14	.280087
15	4.41	15	-.27902
16	6.49	16	-.740216
17	6.46	17	.556162
18	8.18	18	.163155
19	76	19	-.0740362
20	7	20	-.524597
21	130186	21	-.299889
22	6.16	22	-.075178
23	4.09	23	.265722
24	0	24	-.0793182
25	0	25	.0290346
26	0	26	-.189955
27	0	27	-.213539
28	0	28	.380619
29	0	29	.146134
30	0	30	-.0749917
31	0	31	.141091
32	0	32	-.0323191

RMS = .362907
RMS percent = 4.90801

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.03

RESULTANT = 7.32771 at 33.3672 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 8 DATE 130186 Repeat of Exp. 76 Run 7

CONTROL SETTINGS		MATCHING DISCREPANCY	
ontrol umber	setting	Field Point	DVe
1	26.8	1	.343417
2	10.38	2	-.720718
3	13.32	3	-1.15019
4	11.86	4	-.693664
5	13.4	5	-.465668
6	1.27	6	.062929
7	6.51	7	-.0373104
8	6.43	8	.296885
9	5.7	9	-.134171
10	8.23	10	.024671
11	6.98	11	.0885149
12	12.54	12	-.0567751
13	11.97	13	.236645
14	3.62	14	.239661
15	4.41	15	-.365276
16	6.49	16	-.727437
17	6.46	17	.305904
18	8.18	18	-.114867
19	76	19	-.339279
20	8	20	-.673779
21	130186	21	-.263767
22	6.12	22	-.0747336
23	4.03	23	.288156
24	0	24	-.0366095
25	0	25	.0288844
26	0	26	-.166727
27	0	27	-.183299
28	0	28	.3777
29	0	29	.169858
30	0	30	-.0326707
31	0	31	.140021
32	0	32	-9.63061E-03

RMS = .381093

RMS percent = 5.20071

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.15 W = 4.08

RESULTANT = 7.38031 at 33.5634 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 8 DATE 130186 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	26.8	1	.395866
2	10.38	2	-.311801
3	13.32	3	-1.09775
4	11.86	4	-.284746
5	13.4	5	-.516745
6	1.27	6	.0143855
7	6.51	7	-.07235
8	6.43	8	.373544
9	5.7	9	.102384
10	8.23	10	.291651
11	6.98	11	.347091
12	12.54	12	.0867847
13	11.97	13	.185571
14	3.62	14	.191121
15	4.41	15	-.400312
16	6.49	16	-.650772
17	6.46	17	.542462
18	8.18	18	.152119
19	76	19	-.0806962
20	8	20	-.530211
21	130186	21	-.304429
22	6.15	22	-.0771385
23	4.08	23	.260781
24	0	24	-.0849473
25	0	25	.0274723
26	0	26	-.193988
27	0	27	-.223959
28	0	28	.375297
29	0	29	.142483
30	0	30	-.081005
31	0	31	.138608
32	0	32	-.0368916

RMS = .348481
RMS percent = 4.72177

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.03

RESULTANT = 7.32771 at 33.3672 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

RUN No. 9 DATE 150186 Iteration from Exp.76 Run 8 k = .15

CONTROL SETTINGS | MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	27.3	1	.265616
2	10.39	2	-.271852
3	13.42	3	-.83825
4	12.01	4	-.877068
5	13.36	5	-.378671
6	1.21	6	.097098
7	6.4	7	-.0972522
8	6.42	8	.438776
9	5.8	9	.144892
10	8.15	10	.317891
11	6.58	11	.414971
12	12.54	12	-1.29689E-03
13	12.05	13	.0419285
14	3.67	14	8.16059E-03
15	4.18	15	-.625233
16	6.5	16	-.74894
17	6.4	17	.495114
18	8.25	18	.0256223
19	76	19	-.199397
20	9	20	-.640831
21	150186	21	-.290732
22	6.12	22	-.229881
23	4.03	23	.15158
24	0	24	-.117303
25	0	25	.0425142
26	0	26	-.311502
27	0	27	-.35134
28	0	28	.397899
29	0	29	.177099
30	0	30	-.0887928
31	0	31	.217527
32	0	32	-.171004

RMS = .378559

RMS percent = 5.16613

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6.12 W = 4.06

RESULTANT = 7.34425 at 33.5627 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 76

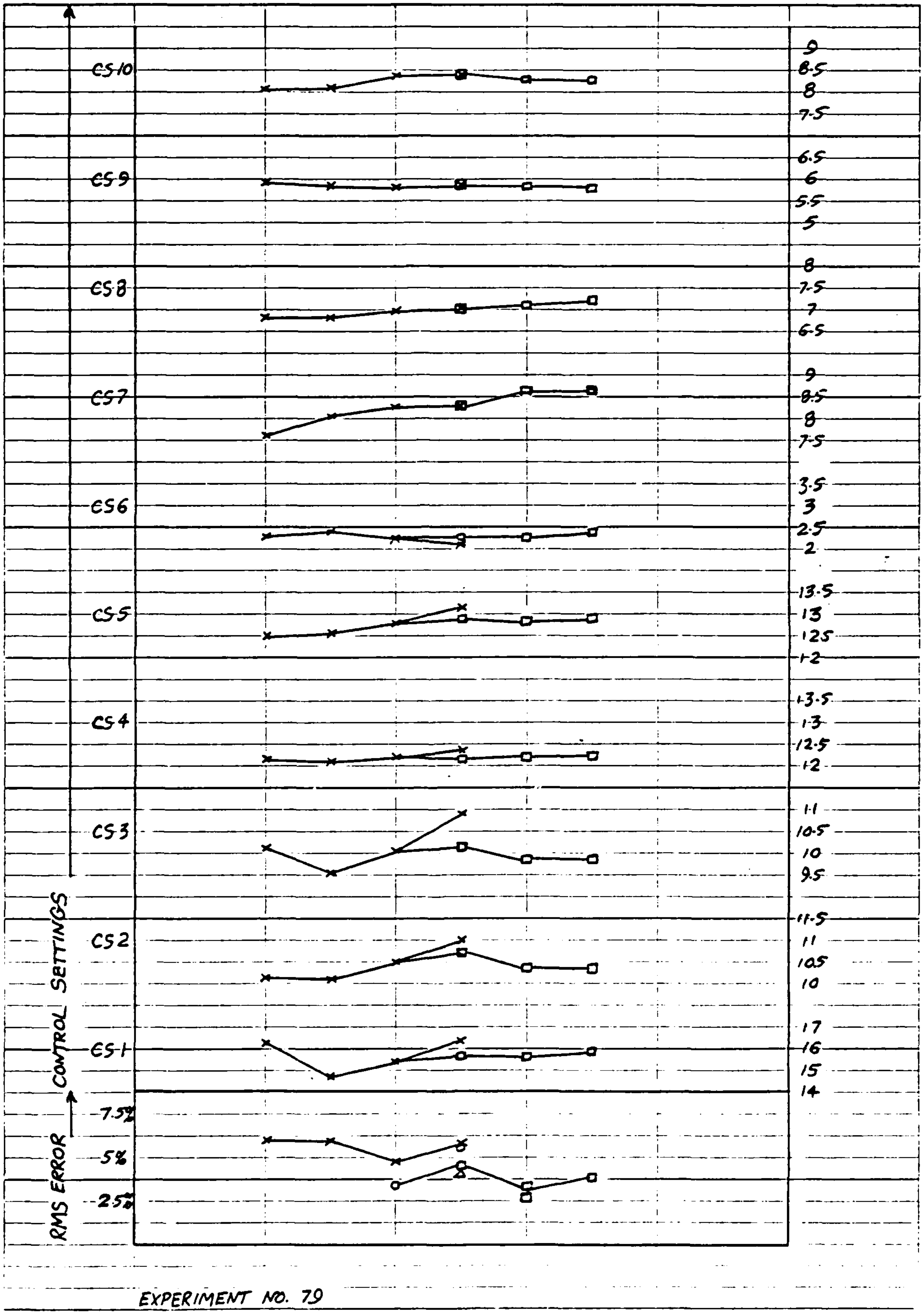
RUN No. 9 DATE 150186 Results of Search for best RMS %

CONTROL SETTINGS / MATCHING DISCREPANCY

Control Number	setting	Field Point	DVe
1	27.3	1	.158675
2	10.39	2	-.164911
3	13.42	3	-.945191
4	12.01	4	-.770127
5	13.36	5	-.323027
6	1.21	6	.16263
7	6.4	7	-.0301897
8	6.42	8	.504843
9	5.8	9	.200537
10	8.15	10	.383423
11	6.58	11	.482033
12	12.54	12	.0647706
13	12.05	13	.0975729
14	3.67	14	.0736939
15	4.18	15	-.558169
16	6.5	16	-.68287
17	6.4	17	.550758
18	8.25	18	.0911554
19	76	19	-.132334
20	9	20	-.574763
21	150186	21	-.28843
22	6.12	22	-.230179
23	4.06	23	.151545
24	0	24	-.119606
25	0	25	.042812
26	0	26	-.311468
27	0	27	-.349038
28	0	28	.397602
29	0	29	.177064
30	0	30	-.091095
31	0	31	.217825
32	0	32	-.170969

RMS = .373751
RMS percent = 5.08903

Figure 6.4


CS 10
CS 9
CS 8
CS 7
CS 6
CS 5
CS 4
CS 3
CS 2
CS 1
CONTROL SETTINGS
RMS ERROR
7.5%
5%
2.5%
9
8.5
8
7.5
6.5
6
5.5
5
8
7.5
7
6.5
9
8.5
8
7.5
3.5
3
2.5
2
13.5
13
12.5
12
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12
11
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10
9.5
11.5
11
10.5
10
17
16
15
14
EXPERIMENT NO. 79

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 1 DATE 50286

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	16.3	1	-1.27901
2	10.18	2	.440601
3	10.1	3	.558702
4	12.15	4	.723035
5	12.52	5	.245504
6	2.25	6	-.0582475
7	7.66	7	-.213245
8	6.81	8	-.185383
9	5.94	9	-.143333
10	8.13	10	-.103974
11	79	11	-.249632
12	1	12	-.0795374
13	50286	13	.162493
14	6	14	.168597
15	4	15	.110476
16	0	16	7.28551E-03

RMS = .431241
RMS percent = 5.98024

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 2 DATE 70286 Iteration from Exp.79 Run 1 k = .15

CONTROL SETTINGS

Control Number	setting
1	14.74
2	10.09
3	9.56
4	12.1
5	12.54
6	2.41
7	8.05
8	6.91
9	5.86
10	8.17
11	79
12	2
13	70286
14	6
15	4
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.800182
2	-.544487
3	.366994
4	.620643
5	.0430775
6	-.0582329
7	-.513139
8	-.6156
9	-.517861
10	-.521491
11	-.133342
12	-.0703102
13	.102645
14	.160989
15	.115465
16	-.0140474

RMS = .412083
RMS percent = 5.71457

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 3 DATE 70286 Iteration from Exp.79 Run 2 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.5	1	-.195676
2	10.51	2	-.530984
3	10.07	3	.136334
4	12.25	4	.469373
5	12.84	5	-.202079
6	2.29	6	-1.18665E-03
7	8.37	7	-.463691
8	7.01	8	-.659859
9	5.81	9	-.529316
10	8.28	10	-.516517
11	79	11	-.151159
12	3	12	-.0470836
13	70286	13	.146009
14	6	14	.121091
15	4	15	.135255
16	0	16	-.0397562

RMS = .342626
RMS percent = 4.75137

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 3 DATE 70286 Results of Search for best RMS %

CONTROL SETTINGS

Control Number	setting
1	15.5
2	10.51
3	10.07
4	12.25
5	12.84
6	2.29
7	8.37
8	7.01
9	5.81
10	8.28
11	79
12	3
13	70286
14	5.8
15	4.085
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.554154
2	-.29179
3	.175305
4	.435654
5	-.292571
6	-.15499
7	-.193712
8	-.269948
9	-.0802561
10	-.0121288
11	-.196139
12	-.0660992
13	.103865
14	.0636177
15	.117956
16	-.081616

RMS = .23948
RMS percent = 3.37573

RESULTS OF ITERATION
****

STREAM VECTOR: U = 6 W = 4

RESULTANT = 7.2111 at 33.6926 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 4 DATE 70286 Iteration from Exp.79 Run 3 k = .15

CONTROL SETTINGS

Control Number	setting
1	16.5
2	11.03
3	10.93
4	12.41
5	13.16
6	2.05
7	8.38
8	7.03
9	5.79
10	8.39
11	79
12	4
13	70286
14	6
15	4
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.978442
2	-.445638
3	.365099
4	.66099
5	.0843117
6	.21119
7	-.406503
8	-.595732
9	-.508798
10	-.444517
11	-.143645
12	-.0848543
13	.155099
14	.162533
15	.0870834
16	-.0988959

RMS = .422059
RMS percent = 5.8529

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 4 DATE 70286 Results of Search for best RMS %

CONTROL SETTINGS

Control Number	setting
1	16.5
2	11.03
3	10.93
4	12.41
5	13.16
6	2.05
7	8.38
8	7.03
9	5.79
10	8.39
11	79
12	4
13	70286
14	5.8
15	4.085
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-1.33692
2	-.206444
3	.40407
4	.62727
5	-6.17526E-03
6	.0573889
7	-.136523
8	-.20582
9	-.0597374
10	.0598714
11	-.188621
12	-.10387
13	.112956
14	.105059
15	.0697844
16	-.140757

RMS = .399456
RMS percent = 5.63077

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 5 DATE 70286 Iteration from Exp.79 Run 3 k = .15

CONTROL SETTINGS

Control Number	setting
1	15.75
2	10.58
3	10.16
4	12.26
5	12.91
6	2.22
7	8.39
8	7.04
9	5.79
10	8.28
11	79
12	5
13	100286
14	5.8
15	4.085
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.947109
2	-.273098
3	.375127
4	.695357
5	.0856213
6	.149337
7	-.0927312
8	-.0443029
9	.0674641
10	.197754
11	-.180847
12	-.15422
13	.119786
14	.0929612
15	.0416573
16	-.135764

RMS = .33348
RMS percent = 4.70076

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.7 W = 3.99

RESULTANT = 6.95774 at 34.9946 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 5 DATE 100286 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.75	1	-.645738
2	10.58	2	-.634112
3	10.16	3	.146173
4	12.26	4	.39207
5	12.91	5	-.247964
6	2.22	6	-.209483
7	8.39	7	-.206181
8	7.04	8	-.135774
9	5.79	9	3.65514E-03
10	8.28	10	.168032
11	79	11	-.213385
12	5	12	-.162347
13	100286	13	.0989419
14	5.7	14	.0742737
15	3.99	15	.0316274
16	0	16	-.156922

RMS = .285213
RMS percent = 4.09922

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 6 DATE 100286 Iteration from Exp.79 Run 5 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.6	1	-.345092
2	10.48	2	-.297454
3	9.86	3	.105489
4	12.21	4	.468233
5	12.88	5	-.0824498
6	2.33	6	.0860336
7	8.61	7	8.74807E-03
8	7.19	8	-.0444072
9	5.75	9	-3.22543E-03
10	8.24	10	.0112419
11	79	11	-.234525
12	6	12	-.102781
13	100286	13	.183556
14	5.8	14	.0959734
15	4.085	15	.0403286
16	0	16	-.106463

RMS = .189696
RMS percent = 2.67397

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 79

RUN No. 7 DATE 170286 Iteration from Exp.79 Run 6 k = .15

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.75	1	-.589862
2	10.46	2	-.372618
3	9.79	3	.252179
4	12.2	4	.617525
5	12.85	5	6.57074E-03
6	2.32	6	.150168
7	8.57	7	-.119603
8	7.27	8	-.258021
9	5.74	9	-.0435012
10	8.24	10	.0231954
11	79	11	-.236806
12	7	12	-.16452
13	170286	13	.152135
14	5.8	14	.0838523
15	4.085	15	.0162397
16	0	16	-.129659

RMS = .270186
RMS percent = 3.80857

RESULTS OF ITERATION
****

STREAM VECTOR: U = 5.8 W = 4.085

RESULTANT = 7.09417 at 35.16 degrees

FLAPS: Position 4, 50 p.s.i.

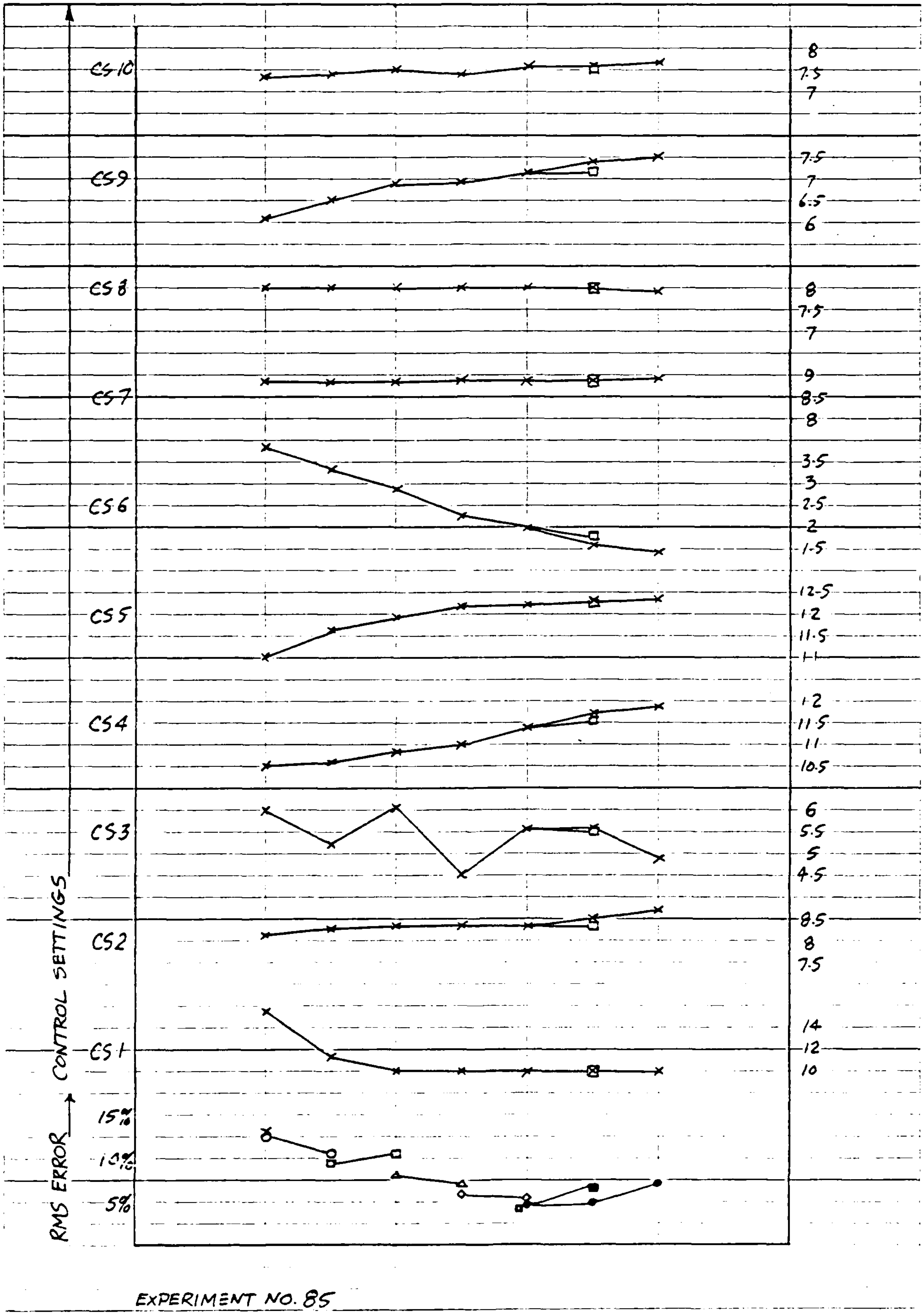
EXPERIMENT No. 79

RUN No. 8 DATE 210286 Repeat of Exp.79 Run 6

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.6	1	-.391283
2	10.48	2	-.580943
3	9.86	3	.137755
4	12.21	4	.483906
5	12.88	5	-.126402
6	2.33	6	-.0553834
7	8.61	7	-.0575841
8	7.19	8	-.196711
9	5.75	9	-.0397111
10	8.24	10	.0566793
11	79	11	-.20895
12	8	12	-.128327
13	210286	13	.151052
14	5.8	14	.0890202
15	4.085	15	.014661
16	0	16	-.08536

RMS = .238217
RMS percent = 3.35792

Figure 6.5



CS10
CS9
CS8
CS7
CS6
CS5
CS4
CS3
CS2
CS1
RMS ERROR → CONTROL SETTINGS
15%
10%
5%
8
7.5
7
7.5
7
6.5
6
8
7.5
7
9
8.5
8
3.5
3
2.5
2
1.5
12.5
12
11.5
11
12
11.5
11
10.5
6
5.5
5
4.5
8.5
8
7.5
14
12
10
EXPERIMENT NO. 85

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.8 W = 1.568

RESULTANT = 2.38718 at 41.0625 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 1 DATE 280486

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.5	1	-.116501
2	8.17188	2	.544412
3	6.00858	3	-.12777
4	10.5035	4	-.231908
5	11.028	5	-.474919
6	3.86468	6	-.241853
7	8.79956	7	.251761
8	7.9893	8	.497649
9	6.19908	9	.502178
10	7.31773	10	.323547
11	85	11	-.207143
12	1	12	-.0957222
13	280486	13	.0886521
14	1.8	14	.0107302
15	1.568	15	.0304997
16	0	16	.34282

RMS = .307257
RMS percent = 12.8711

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.82 W = 1.585

RESULTANT = 2.41343 at 41.055 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 1 DATE 280486 Results of Search for best RMS %

CONTROL SETTINGS

Control Number	setting
1	15.5
2	8.17188
3	6.00858
4	10.5035
5	11.028
6	3.86468
7	8.79956
8	7.9893
9	6.19908
10	7.31773
11	85
12	1
13	280486
14	1.82
15	1.585
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.170165
2	.610006
3	-.0853957
4	-.175189
5	-.412167
6	-.173966
7	.271034
8	.512004
9	.510974
10	.325614
11	-.200773
12	-.0940777
13	.092824
14	.0146059
15	.0324867
16	.347049

RMS = .308363
RMS percent = 12.777

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.82 W = 1.585

RESULTANT = 2.41343 at 41.055 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 2 DATE *300*486 Iteration from Exp.85 Run 1 k = .20

CONTROL SETTINGS

Control Number	setting
1	11.4
2	8.27
3	5.25
4	10.61
5	11.68
6	3.24
7	8.83
8	7.96
9	6.54
10	7.45
11	85
12	2
13	300486
14	1.82
15	1.585
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.435637
2	.510571
3	.0235796
4	.0968493
5	-.0259511
6	.0981959
7	.250926
8	.394471
9	.384797
10	.280164
11	-.15901
12	-.131575
13	.0776174
14	5.92517E-03
15	-.0125584
16	.290259

RMS = .256041
RMS percent = 10.609

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.75 W = 1.524

RESULTANT = 2.32058 at 41.0542 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 2 DATE 300486 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	11.4	1	-.242045
2	8.27	2	.275229
3	5.25	3	-.12771
4	10.61	4	-.105101
5	11.68	5	-.249041
6	3.24	6	-.14279
7	8.83	7	.180489
8	7.96	8	.340792
9	6.54	9	.35055
10	7.45	10	.269546
11	85	11	-.181424
12	2	12	-.137314
13	300486	13	.0630184
14	1.75	14	-.0075192
15	1.524	15	-.0195295
16	0	16	.275457

RMS = .212193
RMS percent = 9.14398

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.75 W = 1.524

RESULTANT = 2.32058   at 41.0542   degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No.   85

RUN No.   3   DATE 300486   Iteration from Exp.85 Run 2   k = .20

CONTROL SETTINGS

Control Number	setting
1	10
2	8.26944
3	6.07842
4	10.8797
5	11.9547
6	2.83911
7	8.85002
8	7.95207
9	6.92137
10	7.57455
11	85
12	3
13	300486
14	1.75
15	1.524
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.2823
2	.592106
3	.0647479
4	.22101
5	.137909
6	.206503
7	.255825
8	.328259
9	.319278
10	.322066
11	-.181326
12	-.0917266
13	.0611748
14	.0183705
15	.0602798
16	.180844

RMS = .250694
RMS percent = 10.8031

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.65 W = 1.437

RESULTANT = 2.18803 at 41.0559 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 3 DATE 300486 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	-5.92552E-03
2	8.26944	2	.256089
3	6.07842	3	-.151284
4	10.8797	4	-.0673797
5	11.9547	5	-.180679
6	2.83911	6	-.137654
7	8.85002	7	.155297
8	7.95207	8	.251685
9	6.92137	9	.270466
10	7.57455	10	.307006
11	85	11	-.213341
12	3	12	-.0999259
13	300486	13	.040319
14	1.65	14	-8.39626E-04
15	1.437	15	.0503218
16	0	16	.159698

RMS = .174045
RMS percent = 7.95441

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.65 W = 1.44

RESULTANT = 2.19 at 41.1151 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 4 DATE 20586 Iteration from Exp.85 Run 3 k = .20

CONTROL SETTINGS

Control Number	setting
1	10
2	8.33
3	4.54
4	11.06
5	12.26
6	2.29
7	8.82
8	7.98
9	6.91
10	7.44
11	85
12	4
13	20586
14	1.65
15	1.44
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.0497232
2	6.30045E-03
3	-.232234
4	-.128973
5	-.171625
6	-.244519
7	.0681197
8	.19496
9	.182288
10	.209005
11	-.176553
12	-.102482
13	.0265805
14	-.0293676
15	6.90059E-03
16	.26868

RMS = .157592
RMS percent = 7.19599

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.69 W = 1.475

RESULTANT = 2.24315 at 41.1169 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 4 DATE 20586 Results of Search for best RMS %

CONTROL SETTINGS

Control Number	setting
1	10
2	8.33
3	4.54
4	11.06
5	12.26
6	2.29
7	8.82
8	7.98
9	6.91
10	7.44
11	85
12	4
13	20586
14	1.69
15	1.475
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.16085
2	.141284
3	-.145523
4	-.013274
5	-.0438435
6	-.106519
7	.108629
8	.225933
9	.202159
10	.215368
11	-.163735
12	-.0992041
13	.0349225
14	-.0216956
15	.0108855
16	.277139

RMS = .147016
RMS percent = 6.55399

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.69 W = 1.475

RESULTANT = 2.24315 at 41.1169 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 5 DATE 20586 Iteration from Exp.85 Run 4 k = .20

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	-.124086
2	8.38186	2	.0882299
3	5.57215	3	-.0755432
4	11.4224	4	.0444258
5	12.2534	5	.0403712
6	1.96293	6	4.43399E-03
7	8.88627	7	.0872111
8	7.96552	8	.128843
9	7.22249	9	.189288
10	7.58023	10	.131057
11	85	11	-.186712
12	5	12	-.0791567
13	20586	13	.0450741
14	1.69	14	-1.64498E-04
15	1.475	15	.0237484
16	0	16	.252978

RMS = .116577
RMS percent = 5.19704

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.67 W = 1.4575

RESULTANT = 2.21658 at 41.116 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 5 DATE 20586 Results of Search for best RMS %

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	-.0688394
2	8.38186	2	.0210545
3	5.57215	3	-.118735
4	11.4224	4	-.0132353
5	12.2534	5	-.0233293
6	1.96293	6	-.0643806
7	8.88627	7	.0671198
8	7.96552	8	.113544
9	7.22249	9	.179543
10	7.58023	10	.128061
11	85	11	-.193114
12	5	12	-.0807967
13	20586	13	.0409029
14	1.67	14	-4.00707E-03
15	1.4575	15	.0217569
16	0	16	.248748

RMS = .111253
RMS percent = 5.01915

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.74 W = 1.44

RESULTANT = 2.25858 at 39.6136 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 5 DATE 20586 , Results of Search for best RMS %
(continued) Note Stream Angle.

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	.0135629
2	8.38186	2	-.019598
3	5.57215	3	-.110114
4	11.4224	4	.0242319
5	12.2534	5	.0341787
6	1.96293	6	.0147121
7	8.88627	7	-5.11166E-03
8	7.96552	8	2.74072E-03
9	7.22249	9	.0482082
10	7.58023	10	-.0232134
11	85	11	-.176472
12	5	12	-.0742648
13	20586	13	.0556326
14	1.74	14	.0152082
15	1.44	15	.0279352
16	0	16	.26342

RMS = .0893433
RMS percent = 3.95572

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.67 W = 1.46

RESULTANT = 2.21822 at 41.1647 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 6 DATE 50586 Iteration from Exp.85 Run 5 k = .20

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	.0793736
2	8.53	2	-.0457516
3	5.57	3	-.101274
4	11.74	4	.0422947
5	12.35	5	.11598
6	1.56	6	.0732114
7	8.85	7	-3.32529E-03
8	7.93	8	.0867657
9	7.46	9	.0792918
10	7.69	10	.0430581
11	85	11	-.21767
12	6	12	-.0737648
13	50586	13	.0361148
14	1.67	14	.018466
15	1.46	15	.032166
16	0	16	.387397

RMS = .1276
RMS percent = 5.75236

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.67 W = 1.46

RESULTANT = 2.21822 at 41.1647 degrees

FLAPS: Position 4, 50 p.s.i.

EXPERIMENT No. 85

RUN No. 8 DATE 70586 Iteration from Exp.85 Run 5 k = .10

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	-.0506968
2	8.45	2	-.0760766
3	5.56	3	-.0411339
4	11.56	4	.130697
5	12.3	5	.168979
6	1.76	6	-7.73967E-03
7	8.87	7	.13605
8	7.95	8	.0609092
9	7.34	9	.0716079
10	7.64	10	.046942
11	85	11	-.172297
12	8	12	-.14297
13	70586	13	7.81066E-03
14	1.67	14	.0385913
15	1.46	15	.0680191
16	0	16	.509341

RMS = .158317
RMS percent = 7.13712

RESULTS OF ITERATION
****

STREAM VECTOR: U = 1.67 W = 1.46

RESULTANT = 2.21822 at 41.1647 degrees

FLAPS: Position 4, 50 p.s.i.

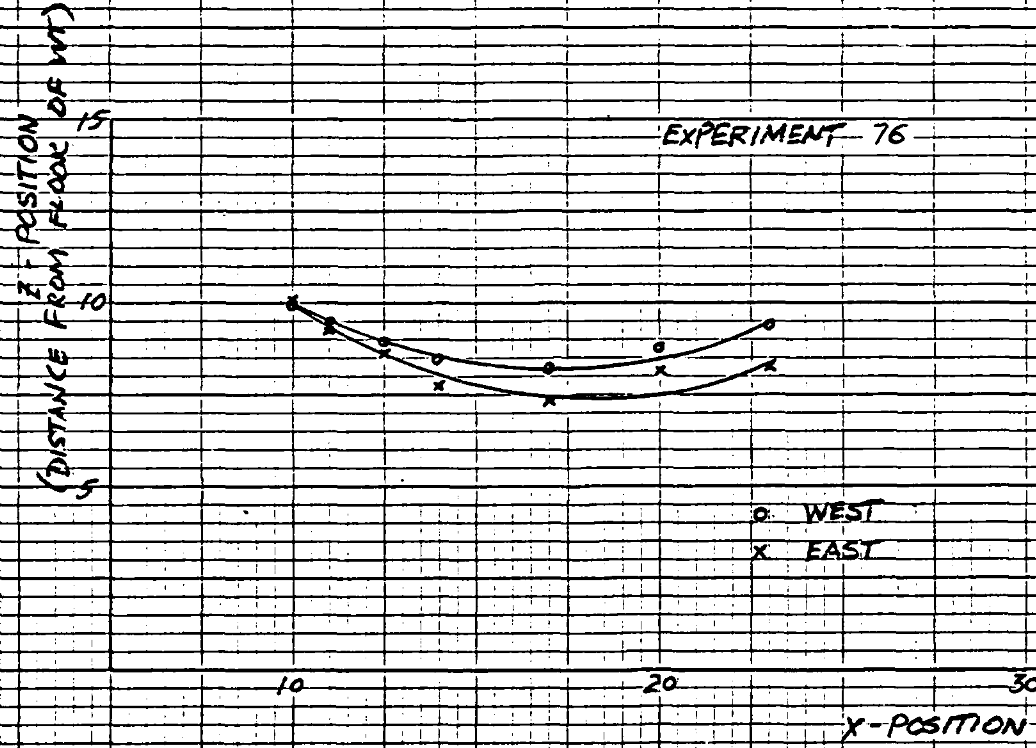
EXPERIMENT No. 85

RUN No. 7 DATE 50586 Iteration from Exp.85 Run 6 k = .10

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	10	1	-.010317
2	8.75	2	-.0897504
3	4.86	3	-.0716949
4	11.94	4	.0631453
5	12.46	5	.133764
6	1.33	6	-.0186475
7	8.84	7	.163413
8	7.91	8	-.0296856
9	7.55	9	.0277688
10	7.79	10	-.0609595
11	85	11	-.140828
12	7	12	-.14654
13	50586	13	.0101033
14	1.67	14	.0499648
15	1.46	15	.0731428
16	0	16	.541955

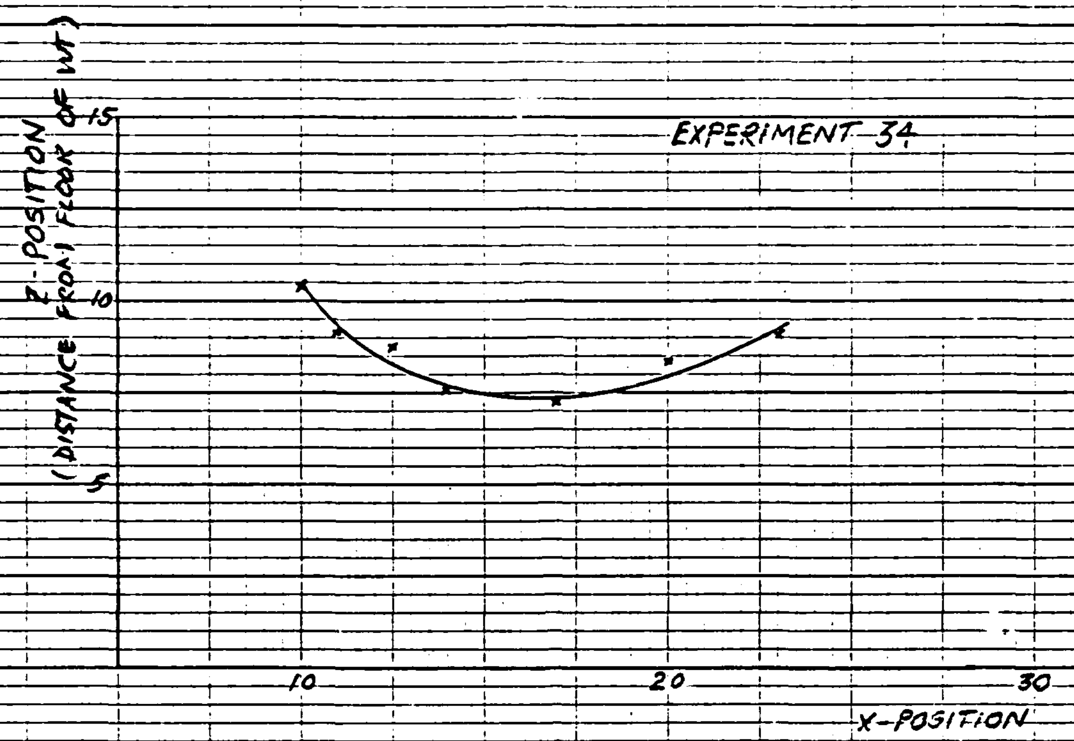
RMS = .16019
RMS percent = 7.22155

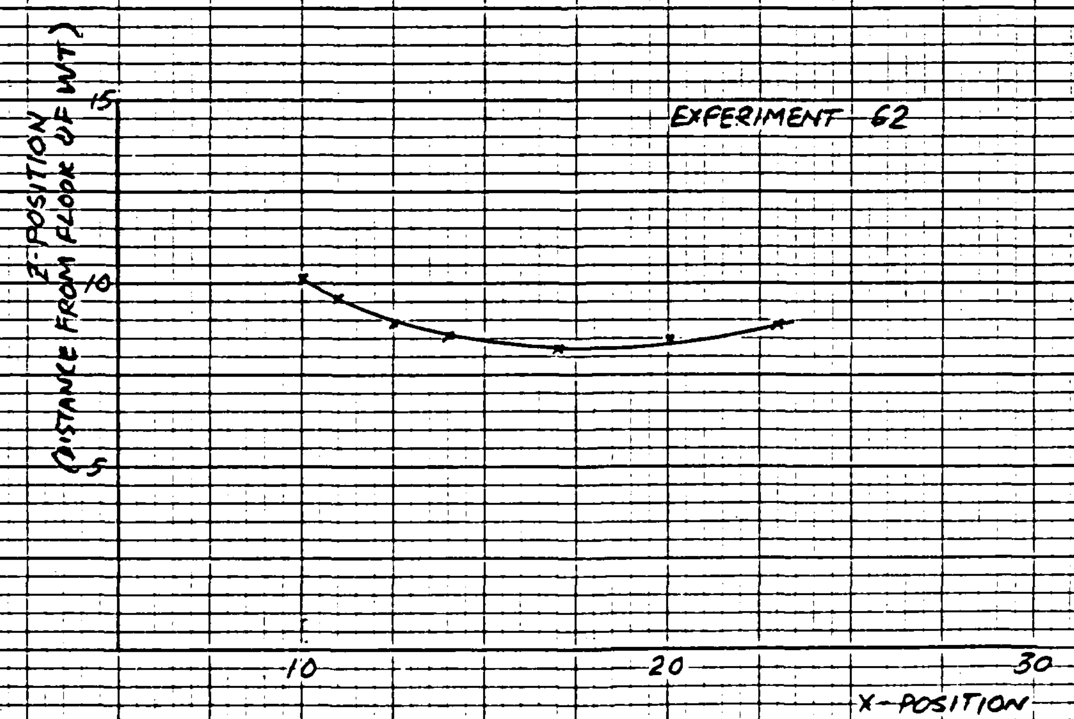
Figure 7 continued



10 Squares to the Inch

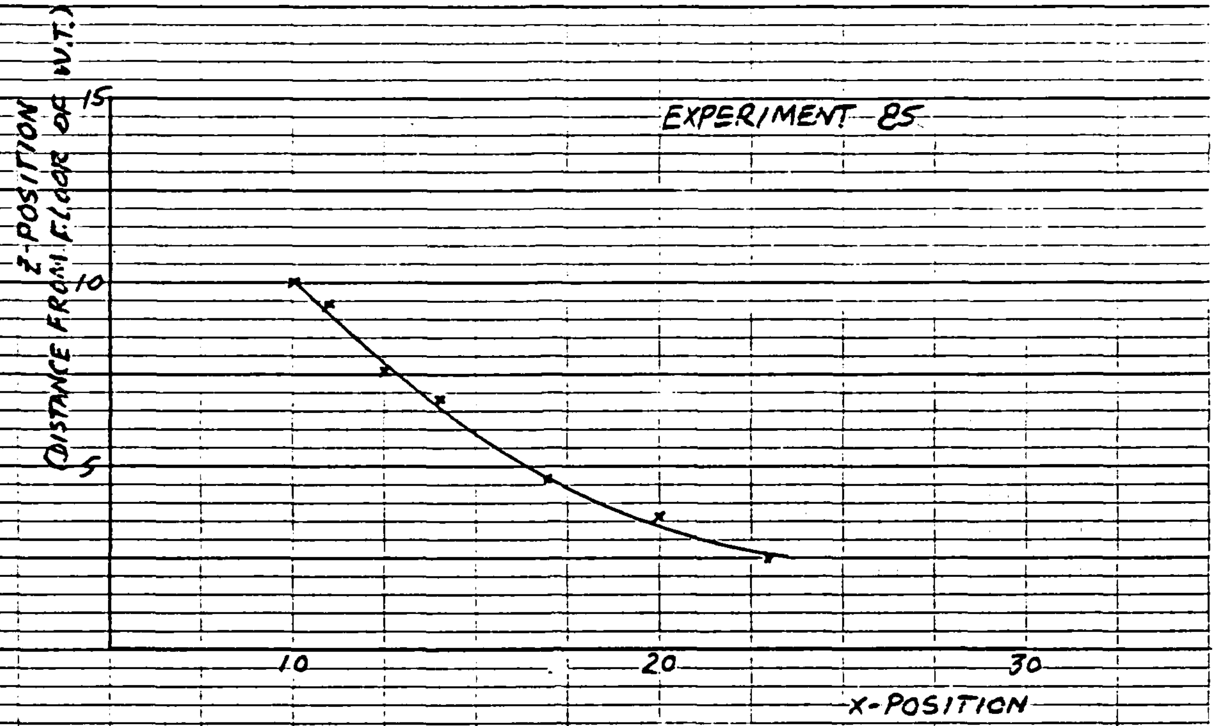
Figure 7





10 Squares to the Inch

Figure 7 continued



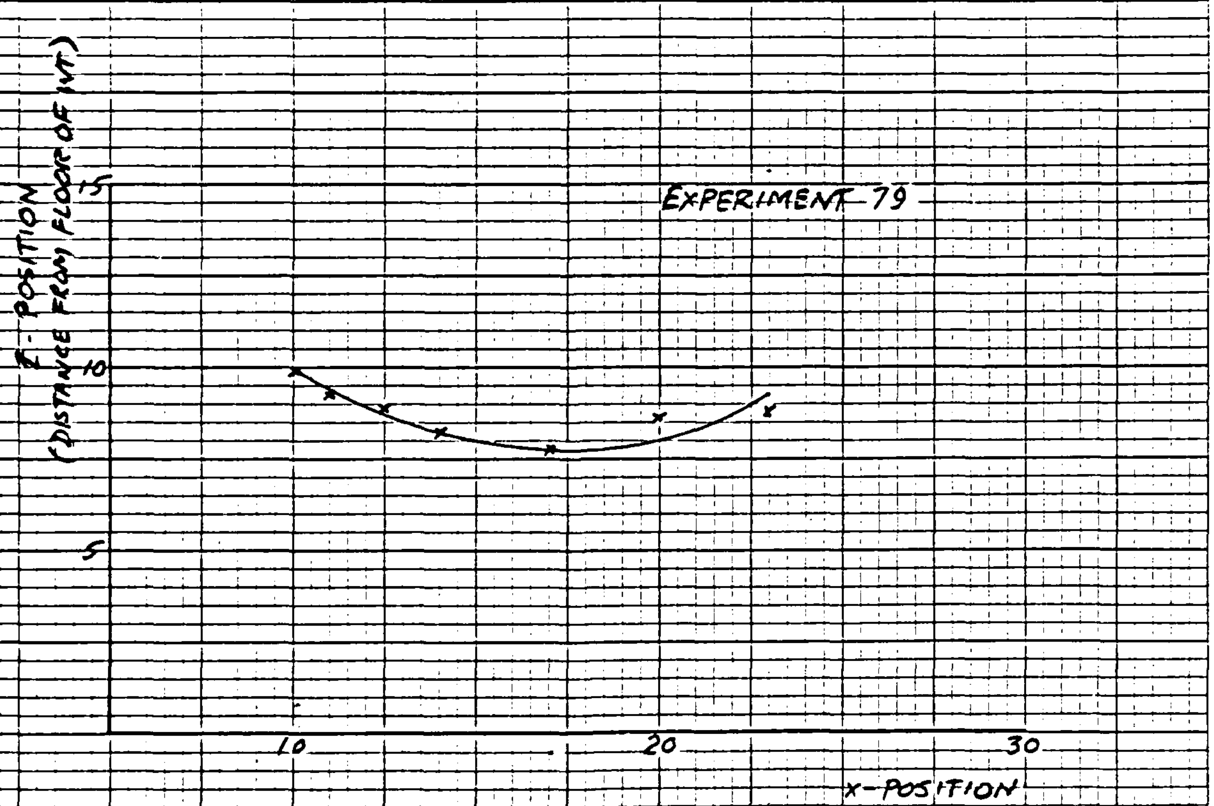
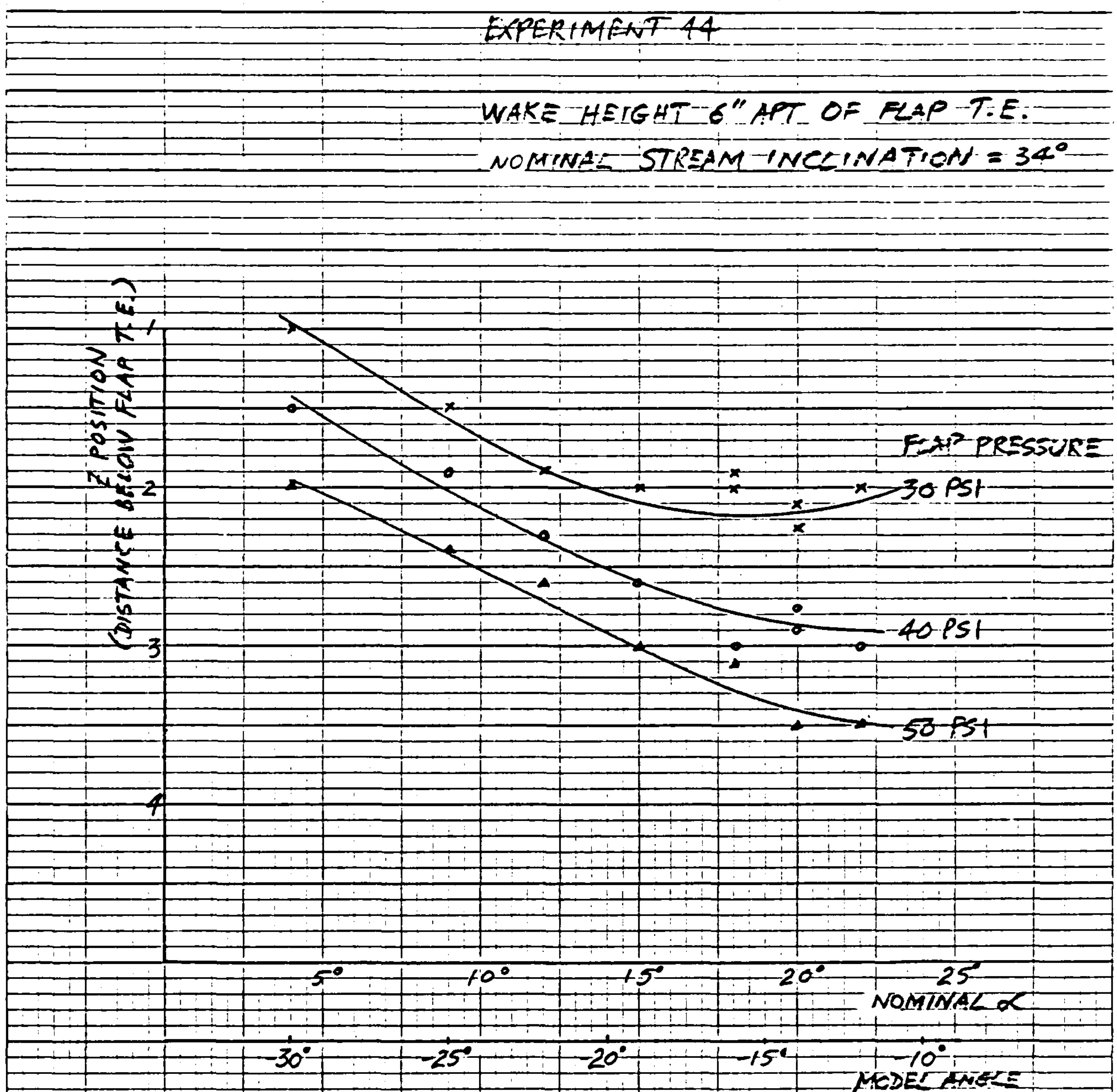


Figure 8



EXPERIMENT 44
WAKE HEIGHT 6" AFT OF FLAP T.E.
NOMINAL STREAM INCLINATION = 34°
Z POSITION (DISTANCE BELOW FLAP T.E.)
1
2
3
4
FLAP PRESSURE
30 PSI
40 PSI
50 PSI
5°
10°
15°
20°
25°
NOMINAL α
-30°
-25°
-20°
-15°
-10°
MODEL ANGLE

REPEATABILITY OF DATA : RESULTS OF REPEATED RUNS
****

EXPERIMENT No. 68

MODEL ANGLE -13 deg. FLAPS: Position 4, 50 p.s.i.

CONTROL SETTINGS

Control Number	Setting
1	16.9
2	10.78
3	11.05
4	12.24
5	12.87
6	2.4
7	7.81
8	7.18
9	6
10	8.12
11	68
12	5
13	141085
14	6
15	4

COMPARISON OF MEASURED VELOCITY COMPONENTS

First Run No. 5 , Date 141085 Second Run No. 8 , Date 161085

Total Vt		I	Total Ve	
1st Run	2nd Run		1st Run	2nd Run
4.23919	4.21201	1	6.44238	6.42154
4.01946	3.94985	2	5.80013	5.60667
6.45808	6.48029	3	4.12322	4.05132
7.09294	7.08124	4	3.26854	3.15614
7.04003	7.12825	5	2.87443	2.82268
6.22331	6.27334	6	3.33719	3.3313
5.434	5.45318	7	4.00201	4.00532
5.96974	5.97476	8	3.6578	3.66596
5.84734	5.84811	9	3.39676	3.29016
6.41814	6.5486	10	3.67782	3.55034
7.00129	6.99625	11	6.85492	6.86298
6.20825	6.38871	12	6.20107	6.2938
5.40469	5.18764	13	5.0409	5.07738
5.85429	5.80224	14	5.72838	5.69822
5.70306	5.67647	15	5.73208	5.67806
6.25031	6.25839	16	6.25176	6.20425

Average Absolute Vt Difference = .0571029

Average Absolute Ve Difference = .0606714

REPEATABILITY OF DATA : RESULTS OF REPEATED RUNS

****

EXPERIMENT No. 71 & 79

MODEL ANGLE -13 deg. FLAPS: Position 4, 50 p.s.i.

CONTROL SETTINGS

Control Number	Setting
1	16.3
2	10.18
3	10.1
4	12.15
5	12.52
6	2.25
7	7.66
8	6.81
9	5.94
10	8.13
11	71
12	7
13	41185
14	6
15	4

COMPARISON OF MEASURED VELOCITY COMPONENTS:

First Run No. 7 , Date 41185 (Experiment 71) Second Run No. 1 , Date 50286 (Experiment 79)

Total Vt		I	Total Ve	
1st Run	2nd Run		1st Run	2nd Run
4.28228	4.09406	1	6.4629	6.42253
3.99854	3.85721	2	5.97534	5.70471
6.53492	6.5314	3	3.84941	3.79966
7.17134	7.12269	4	3.09096	3.16774
6.93882	7.09076	5	2.71163	2.80407
5.98967	6.09619	6	2.98414	2.7574
5.72478	5.42862	7	3.99896	3.99021
5.84648	5.89751	8	3.49858	3.69706
5.9892	5.72944	9	3.45947	3.45324
6.57948	6.72709	10	3.68209	3.83411
6.93922	6.94898	11	6.86336	6.95904
6.4404	6.57778	12	6.41552	6.49035
4.90309	5.20067	13	5.00919	5.25744
5.88147	5.69875	14	5.81445	5.62685
5.64628	5.66514	15	5.71598	5.6703
6.18861	6.18011	16	6.11359	6.08999

Average absolute Vt difference = .128097

Average absolute Ve difference = .112365

REPEATABILITY OF DATA : RESULTS OF REPEATED RUNS
****

EXPERIMENT No. 79

MODEL ANGLE -13 deg. FLAPS: Position 4, 50 p.s.i.

CONTROL SETTINGS

Control Number	Setting
1	15.6
2	10.48
3	9.86
4	12.21
5	12.88
6	2.33
7	8.61
8	7.19
9	5.75
10	8.24
11	79
12	6
13	100286
14	5.8
15	4.085

COMPARISON OF MEASURED VELOCITY COMPONENTS:

First Run No. 6 , Date 100286 Second Run No. 8 , Date 210286

Total Vt		I	Total Ve	
1st Run	2nd Run		1st Run	2nd Run
4.31279	4.36856	1	6.28777	6.32178
4.18014	4.18853	2	5.81149	5.8611
6.2954	6.29914	3	4.01818	4.02078
6.94463	6.94917	4	3.1583	3.1465
6.94712	6.95626	5	2.80563	2.82171
5.77942	5.80797	6	2.37799	2.41674
5.28446	5.24913	7	3.828	3.78655
5.78452	5.81904	8	3.55441	3.61096
5.64362	5.65182	9	3.33741	3.32761
6.6468	6.59196	10	3.80663	3.71753
6.88781	6.78102	11	6.81279	6.70137
6.23427	6.07107	12	6.22176	6.11424
4.92517	4.79086	13	4.97767	4.90358
5.83399	5.72269	14	5.74627	5.67487
5.57275	5.54071	15	5.63728	5.6194
6.0517	5.95527	16	6.05365	5.95435

Average absolute Vt difference = .0554438

Average absolute Ve difference = .0519622

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 4.7 W = 2.94

RESULTANT = 5.54379 at 32 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 6 deg.

EXPERIMENT No. 53

RUN No. 1 DATE 30685

CONTROL SETTINGS

Control Number	setting
1	9.1
2	9.25
3	10.41
4	11.5
5	11.85
6	2.79
7	7.81
8	6.78
9	5.76
10	7.94
11	53
12	1
13	30685
14	4.7
15	2.94
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.301896
2	.0107004
3	-.111419
4	-.189839
5	-.356
6	.284407
7	-.154613
8	-.0463801
9	-.0963289
10	.0346619
11	-.176361
12	-.103039
13	.0946593
14	.104255
15	.0826186
16	.0586202

RMS = .16876
RMS percent = 3.04413

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 4.65 W = 2.9

RESULTANT = 5.48019 at 32 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 11 deg.

EXPERIMENT No. 52

RUN No. 1 DATE 30685

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9.1	1	-.568961
2	9.25	2	.0377719
3	10.41	3	6.76854E-03
4	11.5	4	-.0755723
5	11.85	5	-.259827
6	2.79	6	.295727
7	7.81	7	-.226295
8	6.78	8	-.133467
9	5.76	9	-.174384
10	7.94	10	-1.03166E-03
11	52	11	-.153294
12	1	12	-.0765105
13	30685	13	.180485
14	4.65	14	.0904809
15	2.9	15	.0800023
16	0	16	.0237688

RMS = .203467
RMS percent = 3.71276

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 4.7 W = 2.94

RESULTANT = 5.54379 at 32 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 16 deg.

EXPERIMENT No. 51

RUN No. 1 DATE 310585

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9.1	1	-.353755
2	9.25	2	.12608
3	10.41	3	-.079341
4	11.5	4	-.141969
5	11.85	5	-.291962
6	2.79	6	.314784
7	7.81	7	-.185051
8	6.78	8	-.135731
9	5.76	9	-.246977
10	7.94	10	.0675498
11	51	11	-.157955
12	1	12	-.0761504
13	310585	13	.246903
14	5	14	.101027
15	2.98	15	.0743992
16	0	16	.0858678

RMS = .191192
RMS percent = 3.44877

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 4.67 W = 2.918

RESULTANT = 5.50669 at 32 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 21 deg.

EXPERIMENT No. 50

RUN No. 2 DATE 310585

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	9	1	-.443813
2	9.25	2	-.0728233
3	10.41	3	-.044828
4	11.5	4	-.127905
5	11.85	5	-.265883
6	2.79	6	.189212
7	7.81	7	-.237221
8	6.78	8	-.21007
9	5.76	9	-.357874
10	7.94	10	-.0560596
11	50	11	-.15325
12	2	12	-.142676
13	310585	13	.245655
14	4.67	14	.121542
15	2.918	15	.126694
16	0	16	.159922

RMS = .212035
RMS percent = 3.85051

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 6.28 W = 4.42

RESULTANT = 7.67951 at 35.14 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 4.14 deg.

EXPERIMENT No. 91

RUN No. 4 DATE 140786

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.6	1	-.301606
2	10.48	2	-9.27832E-03
3	9.86	3	.316667
4	12.21	4	.74759
5	12.88	5	.326153
6	2.33	6	-1.11889
7	8.61	7	.132387
8	7.19	8	-.415298
9	5.75	9	-.018726
10	8.24	10	-.205758
11	91	11	-.0876777
12	4	12	-.0438776
13	140786	13	.102822
14	6	14	.14044
15	4.42	15	.0386385
16	0	16	-.110281

RMS = .386875
RMS percent = 5.03776

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 6.28 W = 4.47

RESULTANT = 7.70839 at 35.45 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 10.45 deg.

EXPERIMENT No. 91

RUN No. 3 DATE 140786

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.6	1	-.362643
2	10.48	2	-.0339967
3	9.86	3	.328435
4	12.21	4	.766749
5	12.88	5	.154448
6	2.33	6	-1.09042
7	8.61	7	.182402
8	7.19	8	-.315458
9	5.75	9	-.193219
10	8.24	10	-.288987
11	91	11	-.0935399
12	3	12	.0170164
13	140786	13	.182854
14	6.28	14	.137133
15	4.4	15	.0621131
16	0	16	-.116777

RMS = .385171
RMS percent = 4.99677

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 6.16 W = 4.39

RESULTANT = 7.56424 at 35.5 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 16.5 deg.

EXPERIMENT No. 91

RUN No. 2 DATE 110786

CONTROL SETTINGS		MATCHING DISCREPANCY	
Control Number	setting	Field Point	DVe
1	15.6	1	-.564145
2	10.48	2	-.171625
3	9.86	3	.171623
4	12.21	4	.532479
5	12.88	5	-.0304471
6	2.33	6	-.678878
7	8.61	7	.0884154
8	7.19	8	-.315222
9	5.75	9	-.142459
10	8.24	10	-.262817
11	91	11	-.165648
12	2	12	-.047596
13	110786	13	.325178
14	6.16	14	.113085
15	4.39	15	.114835
16	0	16	-.172657

RMS = .307234
RMS percent = 4.06167

RESULTS OF RUNS AT CONSTANT CONTROL SETTINGS
******* ** **** ** ******** ******* ********

& VARYING ANGLE OF ATTACK
* ******* ***** ** ******

STREAM VECTOR: U = 6 W = 4.42

RESULTANT = 7.45227 at 36.38 degrees

FLAPS: Position 4, 50 p.s.i. ANGLE OF ATTACK = 23.38 deg.

EXPERIMENT No. 91

RUN No. 1 DATE 110786

CONTROL SETTINGS

Control Number	setting
1	15.6
2	10.48
3	9.86
4	12.21
5	12.88
6	2.33
7	8.61
8	7.19
9	5.75
10	8.24
11	91
12	1
13	110786
14	6
15	4.42
16	0

MATCHING DISCREPANCY

Field Point	DVe
1	-.250883
2	-.336079
3	.166341
4	.5817
5	-5.98491E-03
6	-.475758
7	.256896
8	-.20276
9	-.0634727
10	-.278764
11	-.20282
12	.0542531
13	.294798
14	.113819
15	.0827493
16	-.111046

RMS = .264608
RMS percent = 3.5507

EFFECTS OF MATCHING ERROR
******* ** ******** *****

Experiment No. 34	Run No. 6	Speed 5.7	Model Angle -11
	RMS Error = 4.02%		

DVe's (input)

-.558	-.258	-.346	.291
.135	.047	.179	.075
-.033	-.271	-.118	.107
-.107	-.246	-.124	.107

P	Vx	Vz	P
1	-.0557379	-.020418	1
2	-.0537508	-.020287	2
3	-.0471657	-.0212467	3
4	-.0819244	.155086	4
5	-.0405932	-.0644855	5
6	-.0520729	-.0814909	6
7	-.0335878	-.0971938	7

EFFECTS OF MATCHING ERROR
******* ** ******** *****

Experiment No. 62	Run No. 8 RMS Error = 3.57%	Speed 7.22	Model Angle -.18

DVe's (input)

-.61	-.384	-.096	.187
-.138	.028	.158	.089
.124	-.072	-.31	.044
.266	-.483	-.003	-.16

P	Vx	Vz	P
1	-.0946182	3.66817E-03	1
2	-.0916128	2.04809E-03	2
3	-.0820689	-5.68907E-03	3
4	-.140832	.126375	4
5	-.0875125	-.0404226	5
6	-.138242	-.0399161	6
7	-.105478	-.078033	7

EFFECTS OF MATCHING ERROR
******* ** ******** *****

Experiment No. 76 | Run No. 6 RMS Error = 4.57% | Speed 7.36 | Model Angle -13

DVe's (input)

-.211	.12	.517	.039
-.274	.304	.17	-.255
-.61	.361	-.043	-.329
-.407	-.135	-.63	.215
-.335	-.032	-.309	.207
.252	.017	-.018	-.086
.094	-.632	.148	.221
.586	-.777	-.128	-.147

P	Vx	Vz	P
1	-.0595572	.0186814	1
2	-.0727993	.0258054	2
3	-.0892194	.0290155	3
4	-.100622	.0278918	4
5	-.0991806	.0186742	5
6	-.179233	.0392906	6
7	-.0183678	8.43228E-04	7
8	-.0659455	-.0287526	8
9	.0254231	.0544307	9

EFFECTS OF MATCHING ERROR
******* ** ******** *****

Experiment No. 79	Run No. 6	Speed 7.21	Model Angle -13
	RMS Error = 2.67%		

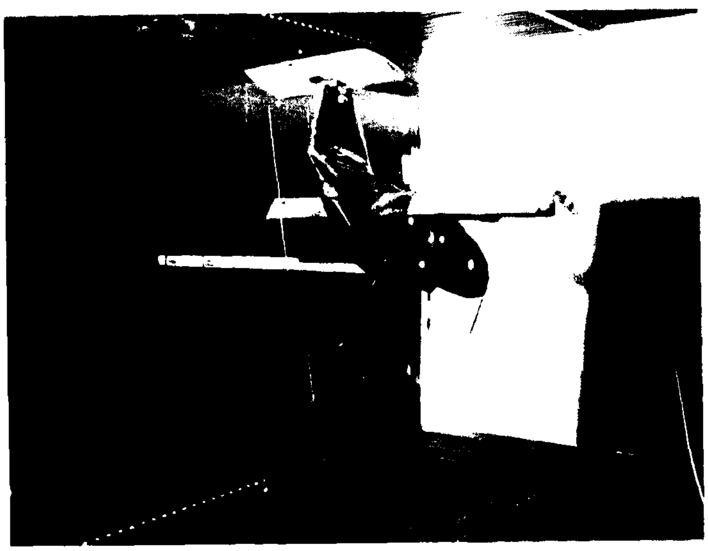
DVe's (input)

-.345	-.082	-.003	.184
-.297	.086	.011	.096
.105	.009	-.235	.04
.468	-.044	-.103	-.106

P	Vx	Vz	P
1	-.0695064	.0395217	1
2	-.067178	.0366136	2
3	-.0594161	.0255524	3
4	-.117406	.0385572	4
5	-.0539953	.0282769	5
6	-.0993245	.0562356	6
7	-.0430545	.0203902	7

View of working section with model installed and laser traverse system

View of blower, diffuser, and settling chamber



View of model installed inside the working section

END

1-87

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