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PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLA--ETC(U)
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Aerodynamics Technical Memorandum 329

PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLATION. PART 9. PRESSURE MEASUREMENTS UPDATED.

J.B. WILLIS

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SUMMARY

It is now ten years since the original pressure measurement program[1] for the transonic wind tunnel PDP 8/I data processing installation was written. During this period considerable changes have been made, and this memorandum describes the current program.

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16. ABSTRACT:

It is now ten years since the original pressure measurement program[1] for the transonic wind tunnel PDP 8/I data processing installation was written. During this period considerable changes have been made, and this memorandum describes the current program.

CONTENTS

1. INTRODUCTION

The only description of the program used for pressure measurements in the transonic wind tunnel PDP 8/I data processing installation is now ten years old (Ref. 1) and totally out of date. In the meantime, the hardware used to control the scanivalves and measure the transducer outputs has been replaced, and the program modified at various times. This memorandum describes the current program.

Essentially the program is required to read in the tunnel main instrumentation, start the pressure scanning hardware, respond to interrupts from this hardware and so read in scanivalve number, port number and pressure transducer output and when the scan is complete, stop the scan and send the scanivalves "HOME". It is required to compute pressure coefficients and the ratio of local static pressure (P) to total pressure (H), and plot and display these, plus the critical values. Raw and computed data are printed and stored on DEC tape. Throughout these activities, the program is also required to compute and display tunnel Mach number.

A readback program is also provided which retrieves the raw and computed data from DEC tape, permits recomputation with the same or different tables, and plots and displays the computed (or recomputed) data.

This memorandum is intended mainly for the use of the staff of the transonic tunnel, and a section on operating instructions is therefore included.

2. TABLES

Before the program can be run, essential tables must be prepared. The current program will accept tables only from the disc, and they must be stored on the disc as an ASCII file "TABS". It is good practice to store them on DEC tape also, so that they can be retrieved if accidentally lost from the disc. The format of the tables has been changed and must be as specified below, and entered in the sequence specified.

Carriage returns, tabs etc. may be used as desired to make print out clear and easy to read. No signs or decimal points are permitted throughout. In each section, enter only the constants needed and terminate with a colon.

(a) Start with transducer calibration constants. A maximum of 5 is permitted, but enter only the ones required in the sequence scanivalve 1, scanivalve 2, etc. End with a colon. Each constant must be 4 digits. The actual value is in the form X(.)XXX volt/in. of Hg.

(b) Reference length for Reynolds number. Here, five digits must be entered, followed by a colon. The decimal point is assumed after the first 2 digits. This should be a real number, not zeros, in inches.

(c) Pressure tapping locations are entered as 1 NNN, 2NNN, 3 NNN ---- i.e. one digit, space, three digits, comma and so on. Here, the first digit is the group number, used to specify, say, the upper surface of an aerofoil, and the three digit number specifies a length which may be a distance along a test section wall, or X/C with the decimal point ignored. (C = aerofoil chord, X = distance from leading edge).

Four groups are allowed, so the single digit should be 1, 2, 3 or 4, and storage has been provided for 144 entries, but only values needed should be entered, followed by a colon.

Pressure lines from one group may be connected to several scanivalves with differing transducer sensitivities, and the number of connections to each scanivalve need not be the same. It is entered later in the tables. However, the sequence in which these constants are entered must be the sequence in which they will be scanned by the scanivalves. The scanivalves stagger scan to give maximum settling time and their sequence is fixed, with the "HOME" position being reference static pressure, or zero. Thus, for three scanivalves, the scanning sequence is:

Step	Scanivalve No.	Port No.	
0	0	01	
1	1	01	HOME POSITION
2	2	01	(REFERENCE PRESSURE)
3	0	02	
4	1	02	
5	2	02	
6	0	03	

and so on.

Although this sounds complicated, it is easier to do than describe and performance is not restricted in any way. The alternative would require an input table cross referencing every position with a scanivalve number and a port number, which would be more difficult and still requires knowing which pressure tube is connected to which scanivalve and which port on that scanivalve.

(d) The next input needed is the number of pressure tubes connected to each scanivalve, excluding zeros - i.e. the model and/ or walls have so many tubes connected, and the total number of these tubes must be the sum of the numbers entered here. Two digits must be entered for each scanivalve used, and they must be entered in the sequence scanivalve 0, scanivalve 1, scanivalve 2 ------. End with a colon, as usual.

(e) Because experience has shown that a tube may become faulty, or a pressure hole become defective during a test, provision has been made for deletions. A maximum of 10 deletions is permitted, which should be more than adequate, and the same format as (c) above is used. Of course, the entry to be deleted must be identical with the entry previously included in (c). End with colon. Points so deleted are now not plotted, printed, stored or displayed.

The program searches for the colon in each section of the tables. Therefore, it must be typed as soon as the values have been entered - e.g. if only one scanivalve is used, enter four digits for its calibration constant, followed by carriage return and line feed, then the colon. Do not fill in the other constants with zeros. Similarly, for no deletions, type a colon and enter no digits at all.

3. OPERATION

The program is saved as three system programs P1, P2 and P3, and loaded in the normal way. Starting address is *200 for the whole program, and it recycles automatically for successive scans. If the program is stopped for some reason, it may be restarted at *600 for the next scan.

Since the program uses the PDP8/I switch register, as described later in this section, the proper sequence for starting is to set *200 (or *600) press "Load Address", then set the switch register to 0, 1, 2 --- and press "START".

The standard identification program is used, and the storage provided for "Details" should always be used. Tables have already been discussed. As usual, DEC tape may be used, or not, for each section of the program.

The query "Number of Pressure Points between Records" appears on the first pass, and requires 3 digits to be entered. Because tunnel pressure and Mach number may drift slightly during a scan, the program reads in static pressure and total pressure bounding the number of pressure points specified. It then uses the *mean* values of these pressures, and of Mach number squared, to compute C_p and P/H. Therefore, if the plumbing requires a very slow scan, this number could be 005; normally 010 is satisfactory with, say, 014 where rapid scanning is possible.

On the first pass, the query "PLOT?" requires Y or N, if N, no further action is needed; if Y, "PLOT AXES?" appears and the answer is self evident. "MOVE" requires 3 digits and shifts successive graphs by the amount specified - e.g. 050 corresponds to 0.50 inches, since the plotter increments are 0.01 inch.

The program now waits for the operator to press the Record pushbutton. Before doing so, he should check that the scanivalves are "HOME", all devices powered up, control desk switches for incidence, JOB, IDENT. etc. all set, DEC tape loaded on a transport set to 2, and so on. When the pushbutton is pressed, the program reads in the main tunnel instrumentation and then starts the pressure scan. It responds to the interrupts from the pressure measuring equipment, and reads in the values, reads in the tunnel instrumentation after the number of pressure points specified, and so on and finally stop the scan and takes a last read in of the tunnel instrumentation. During this procedure, the printer is printing out the raw data, and it is being stored on DEC tape, and the plotter draws axes.

At the end of the scan, the display will draw P/H versus X/C; type Cp for pressure coefficients, and PH to revert back, and so on. It is permissible to cycle from one to the other, but whichever is selected will remain for ensuing scans unless instructed otherwise. The plotter does both pressure ratios and pressure coefficients automatically. In all cases, the dotted lines produced are the critical values.

To complete the print out of the computed data, a colon must be typed. The display now does not listen to the teletype, and at the end of the print out, the program cycles and is ready for the next scan. The computed data print out has been completely changed, and a typical example is shown in Fig. 1.

Unlike the force measuring program, the display program does not provide for scaling or shifting. It may, of course, be photographed, and typical results are shown in Fig. 2.

Both display and plotting programs are OR'd with the PDP8/I switch register. Setting 0, 1, 2 --- will change the symbols used in each case, but to date, only 14 symbols are provided for plotting, and 12 for the display. If 4 groups are used, 4 symbols will be used, and at present, the program is unprotected if too many symbols are requested and may self destruct. However, the intention of this feature is to permit pressure distributions which are very similar to be plotted on top of one another and so show small differences. Normally, the MOVE feature would be used. For the display, changing symbols may assist in identifying display photographs.

As written, the plot program automatically plots both P/H and Cp. Since the plotter is a slow device, it may be convenient to delete one of these. To do this, toggle 7000 (NOP) into the locations given in Table I, all in *field 1*. *The program may then* be "saved" in the usual way, if so desired.

TABLE I

Deletion	Location
P/H Axes	6601
P/H Points	5611
Cp Axes	6602
Cp Points	5620

4. PROGRAM DETAILS

As stated previously, the program is saved as P1, P2 and P3. P3 is the field Ø program, and contains the main program, interrupt service subroutines, and the usual subroutines (Ref. 2). P2 is the field 1 program which is the plotting program, while P1 is field 2 and contains the display programming and the program used to compute the results.

No listings are included here because of their size. However, the program is reasonably straightforward and with the aid of Ref. 1 and the listings available in the Transonic Wind Tunnel, should not be too difficult to follow. The program is a multiple interrupt one, and therefore reads rather strangely. Interrupts arrive from the Record pushbutton, the pressure measuring equipment, the printer, plotter, teletype, DEC tape, display and Mach number clock. The last causes Mach number to be computed and displayed about twice per second. Thus, in operation, scanning, printing, plotting, Mach number computation etc. all appear to be proceeding simultaneously. Unfortunately, at the end of the scan, the program goes into a teletype loop to control the display, and this causes the printer to cease printing. This requires typing a colon to get out of this loop and permit completing print out.

It should also be noted that the computation of each batch of raw data bounded by two tunnel inputs is computed "on the run". Thus, if scanning at say 10 per second, the machine has 1/10th of a second to read in the last pressure data, read in the tunnel data, compute this batch of data, and be ready for the next input. This procedure was adopted in the early days when print out used an ASR33 teletype, and was designed to permit plotting of computed data to proceed as soon as the first batch is computed, and to minimize teletype delays. Using scanivalves, the maximum scanning rate is limited by plumbing, transducer ringing etc., and no problems have arisen from the program at considerably higher scanning rates. In the future, if discrete transducers are used within a model, vastly accelerated scanning would be possible, and program changes would probably be needed.

Another point not immediately obvious is that certain data are recorded on DEC tape to facilitate readback, and without these data, readback would not be possible. Data stored in *100-104 on field Ø are transferred to *200-204 on field 1, and are then stored on DEC tape at the beginning of the data storage. Thus, the DEC tape program should not be altered without care, and future programs should preserve these locations so that earlier DEC tapes can still be readback.

Except for the tables, formats remain unchanged from those given in Ref. 1. Four DEC tape blocks are used for the identification section, now located at *6000 onwards, field Ø, and 5 blocks for the tables, now located at *2500 onwards, field 1 (see Fig. 3). Raw and computed data uses 31 blocks from *200 onwards on field 1.

5. READBACK PROGRAM

A program to readback all the data from DEC tape is available, and this program will also display and plot the computed data. Thus, a test may be run without being delayed by plotting, and selective plotting carried out at a later date. If requested, the program will recompute the raw data, so that if there is doubt about the results, they may be recomputed and checked, and written back on DEC tape. It is also possible to change the tables and then recompute the raw data. This is intended to cope with changes in pressure transducer calibrations, errors in specifying pressure tapping positions etc. Deletions may also be included, for the case where a tapping has developed a fault in the course of a test. If recomputing is required, the program expects the tables to be on the disc as "TABS", and in the format given in section 2.

The actual program is saved as L1, L2 and L3, being fields 2, 1 and Ø respectively, and is essentially the same program as the operating program, the only real difference being that all the raw data come from DEC tape.

To cope with earlier DEC tapes recorded with earlier programs, this program has two starting addresses. These are *200 for the present tables and *400 for the original tables. Obviously, deletions are not possible for DEC tapes with the old tables. Print out is in the current format in both cases. As for the operating program, this program waits in the display-teletype loop for a colon. When this is typed, print out proceeds, and if the display is not used, the program runs straight through without needing the colon.

In the readback program, the critical value of Cp is only computed when the raw data are recomputed, and the dotted line appears at Cp = 0 when data are displayed or plotted without recomputing. If this is important, the program should be told to recompute which takes no detectable time.

For readback purposes, it may well be desirable to suppress various activities. While plotting may be totally deleted via the normal program, it may be desired to plot only F/H or Cp and not both. Table II lists deletions possible by toggling 7000 (NOP) into the locations specified. The program may then be "saved" in the usual way.

TABLE II

	Deletion	Location	Field
TOF	for Raw Data Print Out	300	Ø
	Raw Data Print Out	302	Ø
TOF	for Computed Data Print Out	1202	Ø
	Computed Data Print Out	312	Ø
Plot	F/H (Axes)	6601	1
Plot	F/H (Points)	5611	1
Plot	Cp (Axes)	6602	1
Plot	Cp (Points)	5620	1
Display		TURN OFF	

6. CONCLUSION

The current program for use in measuring pressure distribution in the transonic wind tunnel has been described, together with the program for readingback from DEC tape. The aim of these descriptions has been primarily to assist tunnel operators and provide a basis for future program development.

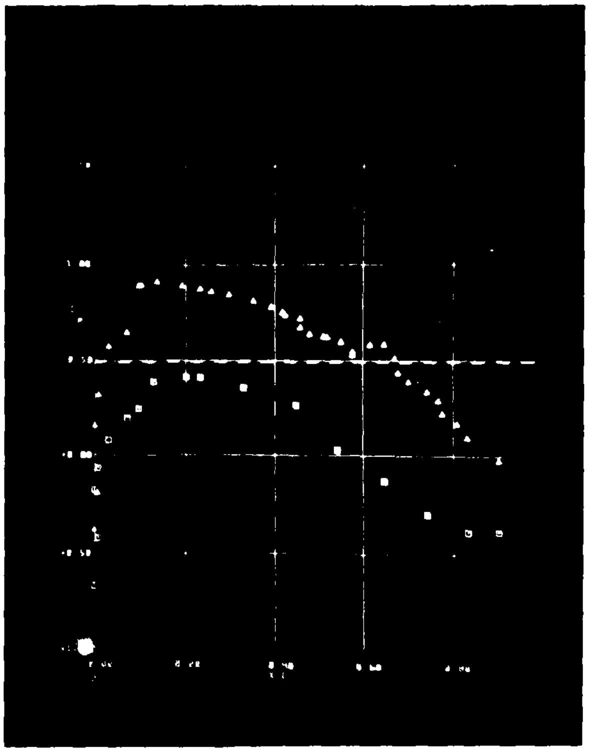
REFERENCES

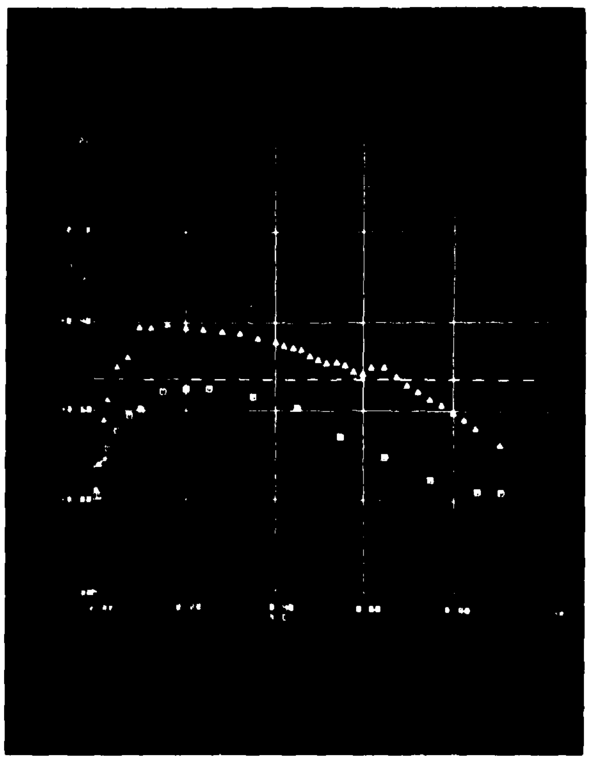
1.	Willis, J.B. and Roberts, L.J.	Programmes for the Transonic Wind Tunnel Data Processing Installation. Part 2. Pressure Measurements. ARL Tech. Memo. Aero. 262, January 1971.
2.	Willis, J.B. and Roberts, L.J.	Programmes for the Transonic Wind Tunnel Data Processing Installation. Part 1. Minor Programmes and Subroutines. ARL Tech. Memo. Aero. 259, October 1970.

POS.		P/H	Cp.	POS.		P/H	Cp.
1	004	0.773	0.357	2	001	1.000	1.158
1	008	0.720	0.167	2	005	0.857	0.656
1	020	0.620	-0.165	2	010	0.789	0.414
1	029	0.576	-0.339	2	020	0.722	0.178
1	050	0.502	-0.602	2	030	0.680	0.056
1	074	0.483	-0.671	2	050	0.646	-0.087
1	099	0.409	-0.931	2	075	0.612	-0.206
1	124	0.415	-0.909	2	100	0.600	-0.249
1	159	0.409	-0.931	2	150	0.558	-0.396
1	199	0.418	-0.901	2	200	0.551	-0.421
1	238	0.422	-0.885	2	250	0.551	-0.419
1	279	0.435	-0.841	2	350	0.571	-0.351
1	319	0.447	-0.796	2	450	0.593	-0.272
1	359	0.463	-0.741	2	549	0.655	-0.053
1	399	0.473	-0.703	2	649	0.705	0.121
1	419	0.486	-0.660	2	750	0.754	0.295
1	440	0.494	-0.629	2	850	0.775	0.368
1	459	0.508	-0.581	2	900	0.777	0.375
1	479	0.513	-0.561				
1	498	0.525	-0.521				
1	518	0.524	-0.524				
1	540	0.521	-0.530				
1	559	0.509	-0.575				
1	579	0.504	-0.596				
1	599	0.490	-0.644				
1	618	0.481	-0.677				
1	648	0.484	-0.661				
1	675	0.522	-0.526				
1	699	0.545	-0.446				
1	724	0.562	-0.388				
1	749	0.575	-0.339				
1	774	0.591	-0.286				
1	799	0.608	-0.226				
1	824	0.626	-0.162				
1	849	0.642	-0.103				
1	899	0.678	0.025				

LAST BLOCK NO. = 1067

FIG. 1. COMPUTED DATA OUTPUT





2501	2502	2503	2504	2505	2506	2507	2510	2511	2512
CØ		C1		C2		C3		C4	
SCANIVALVE TRANSDUCER CALIBRATION CONSTANTS									

2513	2514	2515	2516	2517	...	2731	2732	2733	2734
REF. LENGTH FOR REYNOLDS NUMBER		GROUP NO & X/C	MAXIMUM OF 144. EACH 1 WORD *GROUP NO. IS AC0 & AC1; X/C IS AC2-AC11*						GROUP NO & X/C

2735	2736	2737	2740	2741	2742	2743	...	2752	2753
SVØ	SV1	SV2	SV3	SV4	GROUP NO & X/C				GROUP NO & X/C
NO. OF CONNECTIONS TO EACH SCANIVALVE					DELETIONS - MAXIMUM OF 10				

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FIG. 3. LOCATION OF TABLES ON FIELD 1.

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