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COMPUTATIONAL UPGRADING

J. H. Van Velkinburgh

DEVELOPMENT DIVISION

January - March 1971

For

Systems Division, Dept. 112

MASTER

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COMPUTATIONAL UPGRADING

ABSTRACT

Additions to our data acquisition and reduction facilities and other non-programming endeavors are discussed.

Computer codes designed to aid in the analysis and interpretation of quantitative data which were written or modified this period are discussed.

DISCUSSION

The acquisition proposal (per AECM Chapter 1801) for the DEC PDP 12/30 Advanced LINC System was completed. The PDP 12/30 will provide data acquisition and computational support for the development and research activities pertaining to the thermal properties of high explosives and related materials. The acquisition proposal was started on the required channels for approval and purchase.

The justification for the purchase of the IBM Model 029 keypunch to be used in conjunction with the Grant optical comparator was rewritten in the AECM 1801 format to comply with the requirements for the procurement of ADP equipment. The acquisition proposal was submitted for approval.

The Wang Model 702 plotting output writer was delivered this period. A number of plotting and data output routines have been written. These include, among others, polynomial regression codes with plots and output, non-linear regression codes with plots and output, plotting routines and data tabulation routines. Many of the plots and output routines are in a finished format suitable for inclusion in reports. Figs. 1 and 2 are typical output from the Wang 702 output writer.

A paper tape reader was requisitioned this period for the Wang 700 system.

Final preparations were completed for the installation of the CDC 3600. The building modifications were completed and environmental control systems installed. The wiring of the various component modules was tentatively completed pending final checkout by Control Data personnel. The entire system should be ready to operate the first week of the next period. The COSMIC program library, operated by the University of Georgia, was searched for applications programs which may be of interest or use. Table I is a list of the programs and documentation initially requested. The COSMIC library will be reviewed periodically for other possible applications programs.

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This project concerns the upgrading of computer technology to a level commensurate with other technologies at hand, to provide a meaningful link between Development and the Data Center, and to assist personnel in their computational needs.

January, February, March 1971

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Section BB

STANDARD ERROR OF ESTIMATE .046358302
 SUM OF SQUARED RESIDUALS .032236383
 CORRELATION COEFFICIENT .999996709

$$Y = A1 + A2*X + A3*\exp(A4*X)$$

A1 = 3.905464377
 A2 = 6.784636296
 A3 = -3.972125109
 A4 = .156028492

X ARRAY	Y ARRAY	Y CALCULATED	RESIDUAL	Y PRIME
.000000000	.000000000	-.066660732	-.066660732	6.364871602
.431800000	2.714400000	2.672469906	-.041930093	6.321677405
.881000000	5.428900000	5.501483105	.072583105	6.273544889
1.315800000	8.143300000	8.218491525	.075191525	6.223629588
1.742600000	10.857700000	10.863677905	.005977905	6.171226422
2.181600000	13.572200000	13.560332624	-.011967375	6.113558195
2.633000000	16.286600000	16.305814951	.012214951	6.049794918
3.087900000	19.001100000	19.042595565	.041405565	5.981245575
3.535500000	21.715500000	21.703656713	-.011843286	5.908665480
4.044000000	24.701400000	24.688250694	-.013149305	5.819746789
4.505800000	27.415800000	27.353662912	-.062137987	5.732792144
4.987500000	30.130300000	30.091908513	-.038391481	5.635078864
5.474800000	32.844700000	32.812235545	-.032464454	5.528466741
5.975400000	35.559200000	35.550561389	-.008638611	5.410168577
6.537900000	38.545000000	38.553754360	.008754360	5.265738470
7.065200000	41.259500000	41.292048872	.032548872	5.118337607
7.603500000	43.973900000	44.003854220	.020054220	4.954816034
8.158800000	46.688300000	46.704992212	.016692212	4.771103320
8.744400000	49.402800000	49.437885596	.035035596	4.559324344
9.336000000	52.117200000	52.066875102	-.050324898	4.324794588

FIG. 1. SAMPLE OUTPUT FROM WANG PLOTTER

Fig. 2. Sample Output from Wang Plotter

Table I. Computer Programs Requested from COSMIC

<u>Program Name</u>	<u>Description</u>
TOODY II	A computer program for calculating problems of motion in two dimensions
WONDY	A computer program for calculating problems of motion in one dimension
WONDY III	An enlarged and more generalized version of WONDY
TRUMP	A computer program for transient and steady-state temperature distributions in multi-dimensional systems
TRUMP/XB2	Materials constants library and data compilation program for TRUMP
SWAP-9	A computer program for analyzing stress or shock waves in multi-dimensional systems
MFS-14285	Techniques for polynomial curve fits where the degree of the polynomial is equal to or greater than the number of data points
GSC-10362	A computer program for calculating surface area and pore size of materials from data obtained from the BET gas adsorption apparatus
ALO-00223	A computer program for performing calculations on data obtained from an isoperibol calorimeter
NPO 11473	A computer program for the reduction of mass spectrometer data
NASAP	A computer program to aid in the analysis of electrical network systems
BROOT	A computer program to find roots or solutions of equations
VERGE	A computer program to accelerate the convergence of iterative processes

A series of Wang 700 programs was written to aid in the analysis of streak camera data generated by C. E. Canada and L. D. Hanes in their study of a Sandia-developed pressure gage. Programs written included data normalization routines, non-linear equation solvers to find particle velocities and the angles of shock wave emergence, Hugoniot equation solvers and modifications to plotting routines for data presentation.

A major portion of the data analysis and FORTRAN programming effort this period was directed toward the Aquarium Sphere Tests. As mentioned last period, it was thought that useful information about spherical detonation could be obtained by performing calculations on the radial expansion-time data numerically. This would alleviate limitations imposed upon calculated results which might be due to analytical curve fitting.

Toward this end, then, a computer code was written to evaluate first and second derivatives (velocities and accelerations) numerically. The normal numerical derivative formulas demand that when approximating dY/dX , the Y values be evenly spaced. The technique employed in the present programs used numerical derivative algorithm with linear interpolation to handle data unequally spaced with respect to distance. Computer runs were made and plots generated for several explosives. Photographic reproductions of some of the results are given in Figs. 3 through 6. Results were not as illuminating as had been hoped for. Differences in velocity histories and acceleration histories between different explosive compositions were of such magnitude so as to make any distinction between them difficult.

Besides trying to observe differences in performance among a series of explosives, a major purpose of this computer code was to observe bumps or a ringing effect in the velocity history. These perturbations and their physical causes were discussed at length last period. If these perturbations were present in the velocity history, but were of an amplitude that they might be overlooked, they would be magnified to such an extent in the acceleration history so as to be unmistakable. This magnification, due to the differentiation process, has been discussed in previous periods. No perturbations were observed in the acceleration histories studied. This was interpreted to mean that the change in pressure as the reflected rarefaction passes the main shock is so weak that no observable event occurs or that this second shock has not yet reached the main shock in the interval of time recorded on the streak camera record. The latter interpretation is probably correct. The theoretical aspects of this second wave phenomenon, discussed last period, state that the first bump will occur at approximately seven spherical charge radii. This is about 1-1/4 to 1-1/3 the maximum radial expansion observed on any record. Results from this study therefore were somewhat inconclusive.

A different approach to the problem of separating explosives on the basis of performance as measured in the Aquarium Sphere Test* was taken. This involved calculating the rate at which work was being done on the water by the expanding spherical shock wave. Neglecting energy losses such as those due to production of heat in the water by the passing of the shock wave, etc., the rate of

**Under study by I. B. Akst and J. K. Rigdon*

energy within the spherical volume enclosed by the expanding shock front at any one time is the negative of the rate at which work is being done by the shock wave on the water. The computer code was written to calculate this rate of work. Results of these calculations are shown as plots of the dE/dt history for several explosives in Fig. 7. These plots show these explosives as distinctly different in their ability to perform work. This is the first time in this endeavor that differences in performance have been readily observable. The plots show, for instance, that PBX 9404 very quickly gives up its work-producing energy while TNT loses its energy at a much slower rate.

FUTURE WORK; COMMENTS; CONCLUSIONS

Future work on this project will be directed toward the Aquarium Sphere Tests especially in the area of dE/dt histories in relation to explosives performance.

Fig. 3. Numerical First and Second Derivatives
for 3-cm Radius RX-04-DS Sphere

Fig. 4. Numerical First and Second Derivatives
for 3-cm Radius PBX 9404 Sphere

Fig. 5. Numerical First and Second Derivatives
for 3-cm Radius LX-07-0 Spheres

Fig. 6. Numerical First and Second Derivatives
for 3-cm Radius LX-04-1 Sphere

Fig. 7. dE/dt Curves for Five Explosives in 3-cm Radius Geometry