AFWL IMPLEMENTATION OF ALTRAN

Clifford E. Rhoades, Jr.

February 1979

Final Report

Approved for public release; distribution unlimited.

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117
This final report was prepared by the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico under Job Order 88091822. Dr. Clifford E. Rhoades, Jr. (DYP) was the Laboratory Project Officer-in-Charge.

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report has been authored by an employee of the United States Government. Accordingly, the United States Government retains a nonexclusive, royalty-free license to publish or reproduce the material contained herein, or allow others to do so, for the United States Government purposes.

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

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

CLIFFORD E. RHoades, JR.
Project Officer

FOR THE COMMANDER

NORMAN F. RODERICK
Lt Colonel, USAF
Chief, Advanced Concepts Branch

THOMAS W. CIAMBRONE
Colonel, USAF
Chief, Applied Physics Division
# AFWL IMPLEMENTATION OF ALTRAN

## Abstract

AlTRAN is a system for processing algebra. This report provides a short introduction to the use of ALTRAN and to its implementation at the Air Force Weapons Laboratory. A number of examples are included for reference. A complete description of ALTRAN is contained in the Fourth Edition of the ALTRAN User's Manual (see ref. 1).
The ALTRAN algebraic processing system of Bell Laboratories, Inc., is available at the Air Force Weapons Laboratory under a SOFTWARE AGREEMENT and a PATENT LICENSE AGREEMENT between Western Electric Company, Inc., and the United States of America as represented by the Department of Defense.

These agreements grant a personal, nontransferable, and nonexclusive right to use ALTRAN solely for internal business purposes and solely on the worker computers located at the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico. These computers are CDC Cyber 176, Serial Numbers 102 and 104, and CDC 6600, Serial Numbers 6 and 1043. In addition, these agreements provide that ALTRAN shall be held in confidence, that it will not be used except as authorized, and that no copies shall be made except those copies which are necessary for use or for safekeeping.

It is a pleasure to acknowledge the assistance of Dr. Wayne Fullerton of Los Alamos Scientific Laboratory (LASL/C-3) in the installation of ALTRAN and in the preparation of this report.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>7</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
</tr>
</tbody>
</table>

- I INTRODUCTION
- II LOCAL CONSIDERATIONS
- III EXAMPLES
SECTION I
INTRODUCTION

The ALTRAN algebraic processor has been implemented at the Air Force Weapons Laboratory (AFWL). This makes possible the solution and checking of research involving much algebraic computation. The ALTRAN language is fully described in reference 1. The reader should use this technical report in conjunction with reference 1; comparable sections from reference 1 are cited in parenthesis throughout the report.

ALTRAN is available at a number of computing installations, but few as large as the AFWL. We have a minimum of 10K 60 bit words of workspace, and the CDC Cyber 176 is generally 10 to 30 times faster than the computers on which ALTRAN is usually implemented. These facts coupled with the efficiency of ALTRAN permit truly large algebraic problems to be done.

ALTRAN is about 15 times faster than FORMAC in a PL/I environment, and it is at least 12 times faster than REDUCE. Moreover, ALTRAN uses very little core compared with FORMAC and REDUCE. ALTRAN has already solved in 15 seconds problems which could not be solved with FORMAC or REDUCE because more than a half-million words of storage were required and a prohibitive amount of execution time would have been required.

The ALTRAN system is still under development—a substantial advantage because bugs can be fixed as they are discovered. One feature of ALTRAN has not yet been implemented: interlanguage communication still is not (easily) possible.

The best way to learn ALTRAN is to read the manual carefully, especially sections B, H, and L. Run several simple problems at the same time—a good one to try can be found in the examples section of this report. Turn on all the options (LISTOUT, LISTF) just this once to get an idea of what is going on. After you have run several programs, you will probably find a rereading of section B very helpful.

Note that the restriction of the language to rational functions still includes a very large class of problems and that this restriction does not prohibit the use of special functions (e.g., SIN and COS) if one is willing to treat each function as an independent variable and define special simplification rules via AMOD. Also note that the prohibition of floating point numbers in algebraics can be circumvented by declaring the algebraics to have another independent variable, call it TEN. Then 1.8603E12 could be represented by 18603 * TEN ** 8, and 0.054 as 54/TEN**3. Do not use too many significant figures, or integer overflow may result.

In writing efficient programs there are two good general rules which you can follow. First, try to formulate your problem in a way which minimizes the number of terms in intermediate expressions. Second, try to formulate your problem so that it is easy for ALTRAN to do. The order of preference, with most preferable formulations first, is

1. Polynomials
2. Polynomials with side conditions
3. Rational polynomials
4. Rational polynomials with side conditions

If you publish any research which required ALTRAN as a step, a reprint would be appreciated by ALTRAN authors A. D. Hall (ref. 2) and Dr. W. D. Brown of Bell Laboratories (ref. 1). We hope that your application of ALTRAN along with any difficulties you may have encountered will influence the future development of ALTRAN and other algebraic languages.

SECTION II
LOCAL CONSIDERATIONS

1. INTRODUCTION (Q.6.1)

The ALTRAN system has been designed and implemented in a way that allows it to be installed on a variety of computers. One of the advantages of this flexibility is that certain characteristics of the implementation can easily be varied to fit particular computers and operating systems. The purpose of this section is to provide a quick reference guide to those features which are peculiar to the ALTRAN installation on the CDC Cyber 176 computers at the AFWL.

2. COMPILATION AND EXECUTION (Q.6.2)

The control cards needed to compile and execute an ALTRAN program are similar to those used to execute a small FORTRAN program—the biggest difference is that two extra control cards are needed in order to set up the ALTRAN run-time library. Another difference is that there are a few extra options for the ALTRAN user. If the ALTRAN program uses default input/output units (Q.6.4), default long precision (Q.6.3 and Q.6.13), and other default parameters, then the deck setup for executing an ALTRAN program is as follows:

```
EDR,T77. (sample job card)
ACCOUNT(NAME,JOBORDER-DCD,ORG,PHONE) (sample account card)
ATTACH(OLD,ALTRANLIB,ID=DYSXCR)
LIBRARY(OLD)
MAP(OFF)
COPYCR(INPUT,SYNIN)
ALTRAN(SYIN)
FTN(A,I=FORTIN,R=0)
RFL,160000. (optional see below)
LOAD(LGO)
XEQ.
```

7/8/9 card

```
{ ALTRAN source procedures
```

7/8/9 card

```
{ ALTRAN input data, if any
```

6/7/8/9 card
Many ALTRAN jobs will execute in less than 1 minute and print fewer than 50 pages. Output from WRITE and WRITE(6) statements is sent to OUTPUT, the printer. Diagnostic output, including symbolic snaps (E.4) and run statistics (B.5.13), is also sent to OUTPUT. If the program reads input via READ or READ (5) statements, the input will be taken from INPUT, the card reader.

The remainder of this section is devoted to a detailed explanation of the control cards.

The ATTACH and LIBRARY cards are used to make available the ALTRAN library from which both ALTRAN and the main program, XEQ, for the user's job step execution are loaded. ALTRAN is a FORTRAN program which translates ALTRAN source code to legal FORTRAN subroutines. These subroutines are written on the file FORTIN and the files TAPE10 and TAPE11 are used for intermediate storage. FORTIN is rewound both before and after it is used. The file INPUT is rewound prior to use. The ALTRAN program card is

\[
\text{PROGRAM ALTRAN(INPUT,OUTPUT,FORTIN,TAPE10,TAPE11,TAPE5=INPUT,TAPE6=OUTPUT,TAPE20=FORTIN)}
\]

If ALTRAN translation time errors are detected, ALTRAN issues a job step abort after the last procedure in the input stream.

Otherwise, the FORTRAN compiler, FTN, is invoked to process the legal FORTRAN subroutines. A listing of the FORTRAN subroutine corresponding to an ALTRAN procedure is produced by FTN if the ALTRAN option LISTF is selected for that ALTRAN procedure. Otherwise, no FORTRAN source listing is made. Only the most enthusiastic paper recyclers could want a FORTRAN source listing. The DECK, NODECK options for producing a punched object deck are not implemented. There is little advantage in attempting to punch such decks. The time required to translate and compile ALTRAN codes is usually trivial, and the source decks usually have fewer cards than the resulting object decks.

Now the ALTRAN object code produced by FTN by default on LGO is ready to be executed. Because the load map produced with the default PART map option requires 10 pages, it is suggested that the map continue to be suppressed. Execute-time error reference the ALTRAN source code, and this is usually entirely sufficient. Of course, if a disastrous error occurs, both the FORTRAN source listing and the load map may have to be obtained.

If input for READ or READ (5) statements is to be obtained from a file other than INPUT, then INPUT should be assigned to that file on the XEQ card. Likewise,
if output from WRITE or WRITE (6) statements is to go to the file other than OUTPUT, then OUTPUT should be assigned to that file. The XEQ program card is

```
PROGRAM XEQ(INPUT,OUTPUT,TAPE25,TAPE27,
             TAPE5=INPUT,TAPE6=OUTPUT,TAPE26=OUTPUT)
```

Hence, only three files may be used.

In the current implementation of ALTRAN, there is only one run-time parameter which may be set. This is the number of words of work space to be used. The minimum value is 10,000 words. An RFL card can be used to specify any value of central memory allowed by NOS/BE, in which case the work space value is the memory remaining after all routines are loaded. With RFL, 160000., normally about 20,000 decimal words are available.

There are two restrictions in the current implementation. First, the number of words to be used for long precision integers is fixed at 2. Two words allow integers as large as $10^{28}$ which should be large enough for virtually all algebraic problems. Second, all hardware and software interrupts are automatically recovered. They are intercepted to permit ALTRAN to give a snap dump of the work space. Normally, this is the most useful information, since the work space is a dynamic stack.

3. LIMITS (Q.6.3)

The maximum and minimum precision for long integers is 2 words, and the maximum work space size is approximately 80,000 decimal words on our current NOS/BE. If a logical unit other than 5 or 6 is used, it must be 25.

4. RUN-TIME INPUT AND OUTPUT (Q.6.4)

At run-time, all ALTRAN input and output is carried out by FORTRAN READ and WRITE statements. Because the FORTRAN main program used to drive ALTRAN procedures is in the ALTRAN run-time library and not accessible to the user, all nondefault unit assignments must be made on the XEQ card (and then be processed by the main program). The units with a preassigned function in the run-time system are given below:

- Logical unit 5 is used for READ statements with no specified unit or with a null unit number. By default, unit 6 is assigned to OUTPUT.

- Logical unit 25 may be used for punched output, because it has a linelength of 80 columns. (Other units have a default linelength of 80 at AFRL.) See section Q.6.14 for another use of unit 25. (Note: For section Q.6.14 use, the
5. REAL UNDERFLOW AND OVERFLOW (Q.6.5)

When a real underflow occurs, zero is assumed and execution continues.

When a real overflow occurs, the run is terminated (Q.6.6).

6. ABNORMAL TERMINATIONS (Q.6.6)

If the execution of an ALTRAN program is terminated because of an error
detected by the FORTRAN run-time system or by the operating system, a SNAP and
run statistics are automatically given. The first procedure in the SNAP will be
the one in control at the time the error was detected. The reason for termina-
tion can be found in the dayfile.

7. END OF FILES (Q.6.7 also see B.3.6)

.EOF is not required at the end of translator input.

.EOF is not required at the end of run-time input.

8. LINE LENGTHS (Q.6.8)

The translator reads the first 80 characters from an input line, and prints
them in the source listing (D.2). Sequence numbers may be used by preceding
them with # in Column 72.

At run-time, only the first 80 characters of each input line are considered
meaningful. When output is to be punched or used for later input, be sure that
the value of the output line length option (D.4) is no more than 80 characters
(the default at AFWL is 80):

The maximum value of the output line option is 136.

9. THE DECK AND LISTF OPTIONS (Q.6.9)

The punched object deck option (D.2) is not effective, and is permanently set
to NODECK.

The FORTRAN listing option (D.2) is effective and defaults to NOLISTF for
each ALTRAN procedure.

10. The translator reads input from files INPUT (by default) and writes program
listings, symbol tables, etc., on file OUTPUT. Diagnostics are also written on
file OUTPUT.
File OUTPUT is used for the listing of compiled FORTRAN translations, and the file LGO is used for object decks.

11. CHARACTER SET (Q.6.11)

The local representations of the ALTRAN special characters are the same as the standard representations (B.3.2), except as follows:

<table>
<thead>
<tr>
<th>ALTRAN character</th>
<th>Local representation</th>
<th>Data 100s (key punch)</th>
<th>All others</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot; quote</td>
<td>&quot;</td>
<td>(8-4)</td>
<td>#</td>
</tr>
<tr>
<td>: colon</td>
<td>:</td>
<td>(8-2)</td>
<td>:</td>
</tr>
<tr>
<td>; semicolon</td>
<td>;</td>
<td>(12-8-7)</td>
<td>;</td>
</tr>
<tr>
<td>- hyphen</td>
<td>-</td>
<td>(0-8-5)</td>
<td>[</td>
</tr>
<tr>
<td># sharp</td>
<td>#</td>
<td>(0-8-6)</td>
<td>=</td>
</tr>
<tr>
<td>** exponentiation operator</td>
<td>**</td>
<td>(11-8-4,11-8-4)</td>
<td>**</td>
</tr>
</tbody>
</table>

12. TOKEN LENGTHS (Q.6.12)

In the interests of compatibility and uniformity, the maximum length of an identifier is 6 characters. For procedure names with external scope the maximum is 6 characters.

The maximum length of a character string is 135 characters.

All other tokens are limited to 145 characters in length.

13. PRECISION AND RANGE OF NUMBERS (Q.6.13)

The magnitude of a short integer cannot exceed \(10^{14} - 1\). The magnitude of a long integer cannot exceed \(10^{28} - 1\).

There are approximately 14 significant digits in a short real, but only 13 digits occur in output. Similarly, there are 28 significant digits in a long real, but only 27 occur in output.

The largest value that may be represented by short and long reals is approximately \(10^{321}\).

For further information about the precision and range of numbers see Section B.5.4 of reference 1.
14. GENERATING FORTRAN STATEMENTS IN ALTRAN (Q.6.14)

One nonstandard feature and one nonstandard convention have been implemented in ALTRAN in order to facilitate the generation of legal FORTRAN statements from ALTRAN programs. The convention requires one to WRITE 72-column output on unit number 25 by changing the line length via the procedure OPTS. That is, the line length of unit 25 must be set to 72 columns for use by FTNOUT (see below). Output written on 25 is otherwise normal ALTRAN output which could later be read from another ALTRAN procedure. There will be blank lines between output lines, no FORTRAN continuation characters, and multiple-precision integers will contain hyphens.

In order to obtain legal FORTRAN statements from output on unit 25, it is necessary to invoke the ALTRAN procedure FTNOUT, a nonstandard feature in ALTRAN. FTNOUT rewinds unit 25, then reads it and puts variable names on the left-hand side of equations. FTNOUT also deletes blank lines, inserts FORTRAN continuation numbers in column 6, and converts multiple precision integers to single precision floating point numbers. Output from FTNOUT is written on unit 27. Most likely it will be DISPOSED to PUNCH.

A very simple example of the use of these features follows this section. The example includes the intermediate output from TAPE25 as well as the output from FTNOUT. Note that a complete FORTRAN routine was written. In many cases, you will probably want to obtain only an equation or two as legal FORTRAN statements. Later you can insert the appropriate FORTRAN statements to make a complete routine. You may also wish to change some of the names of the variables on the left-hand side of the equation.

Several notes are in order now.

a. Only 19 continuation cards are permitted by FORTRAN, but FTNOUT will write as many as are needed. If more than 19 are written, you will have to edit the output by hand and perhaps use a temporary variable in order to ensure that all equations have fewer than 19 continuation cards. In order to minimize the probability of such long equations, use 1 or 2 character independent variable names, use the factored option whenever possible, and try to formulate your problem to minimize the number of terms. Sometimes a simple substitution such as $X = Y - 1$ can greatly reduce the number of terms.

b. Because multiple precision integers are truncated to single precision floating point numbers, you must be certain that the attendant loss of precision
will not adversely affect the answers you need. Ordinarily, you can ensure this simply by examining the equation. In complicated cases, however, you may wish to substitute several numbers for the variables in ALTRAN and compare the (exact or double precision) ALTRAN numerical results with the (approximate) FORTRAN results.

c. FTNOUT obtains the name of the left-hand variable from the comment automatically written by ALTRAN immediately preceding the variable's value. Arrays, however, are written as lists; they contain only one name and subexpressions may appear as an equals sign followed by a number. Thus, arrays must be written to unit 25, one element at a time.
SECTION III

EXAMPLES

The following three examples are provided for instruction purposes.
ALTRAN VERSION 1 LEVEL 9

PROCEDURE MAIN # SIMPLE EXAMPLE OF USE OF FTNOUT

       1       2       3
       4       5       6
       7       8       9
       10      11      12
       13      14

LONG ALGEBRAIC (X=10,Y=10) F

ALTRAN FTNOUT

OPTS(201,72) # FTNOUT REQUIRES A LINE LENGTH OF 72

F = EXPAND( (X+2*Y+1000000)**3 )

WRITE F # PRINT F

WRITE (25) " FUNCTION F(X,Y)" ,
"C EXAMPLE PROG WRITTEN WITH FTNOUT." ,
F,
" RETURN", " END"

& WE HAVE WRITTEN A SIMPLE PROGRAM ON UNIT 25, NOW WE INVOK FTNOUT TO
& THIS ALTRAN OUTPUT TO LEGAL FORTRAN.

FTNOUT END

NAME/EXTNAME USE TYPE STRUC PREC CLASS SCOPE DB LAY ADDR

F VAR ALG L L=001
X IND ALG L L=001
Y IND ALG L L=001
EXPAND/99XPNB PROC ALG L S X
FTNOUT PROC L S X
MAIN PROC L S X
OPTS/99OPTS PROC INT S X
L=001 LAY
C EXAMPLE PROG WRITT CONS CHAR S
1000000 CONS INT S
10 CONS INT S
201 CONS INT S
25 CONS INT S
2 CONS INT S
3 CONS INT S
72 CONS INT S
  END CONS CHAR S
FUNCTION F(X,Y CONS CHAR S
RETURN CONS CHAR S

# F

X**3 + 6*X**2*Y + 3000000*X**2 + 12*X*Y**2 + 12000000*X*Y +
3000000000000*X + 8*Y**3 + 12000000*Y**2 + 6000000000000*Y +
10000_00000000000000
*** NORMAL RETURN FROM MAIN PROCEDURE

*** RUN STATISTICS

0.046 SECONDS ELAPSED
14 DIGITS IN SHORT INTEGERS
28 DIGITS IN LONG INTEGERS
10017 WORDS IN WORKSPACE
388 MAXIMUM WORDS USED
149 CURRENT WORDS USED
0 GARBAGE COLLECTIONS

FUNCTION F(X,Y)
C EXAMPLE PROG WRITTEN WITH FTNOUT.

        F = X*3 + 6*X**2*Y + 3000000*X**2 + 12*X*Y**2 + 120000000*X*Y +
             300000000000*X + B*Y**3 + 12000000*Y**2 + 60000000000000*Y +
             10000_00000000000000

RETURN
END

FUNCTION F(X,Y)
C EXAMPLE PROG WRITTEN WITH FTNOUT.
F = X*3 + 6*X**2*Y + 3000000*X**2 + 12*X*Y**2 + 120000000*X*Y +
1 300000000000*X + B*Y**3 + 12000000*Y**2 + 60000000000000*Y +
2 100000000000000E4
RETURN
END
20.52.14.EDR00K7 FROM NX2/IU
20.52.14.IP 00000256 WORDS - FILE INPUT, DC 04
20.52.14.EDR,777,P60.
20.52.15.ACCOUNT(RHOADES,************,BYP,1851)
20.52.15.SYSBULL(BATCH)
20.52.16.DISPOSE(OUTPUT)
20.52.16.HAP(OFF)

20.52.16.ATTACH(OLD,ALTRANLIB,ID=DYSXCR)
20.52.16.PF CYCLE NO. = 003
20.52.16.LIBRARY(OLD)
20.52.16.COPYCR(INPUT, SYSIN)
20.52.17.ALTRAN(SYSIN)
20.52.23. STOP
20.52.23.FTN(A,I=FORTRAN,R=0)
20.52.25. .047 CP SECONDS COMPILATION TIME
20.52.25.LOAD,LGO.
20.52.26.XEO.
20.52.35. EXIT
20.52.35. REWIN(TAPE25,TAPE27)
20.52.36.COPYSYM(TAPE25,OUTPUT)
20.52.37.COPYSYM(TAPE27,OUTPUT)
20.52.37.OP 00001024 WORDS - FILE OUTPUT, DC 40
20.52.37.HS 3584 WORDS (75264 MAX USED)
20.52.37.CPA 1.172 SEC. 1.172 ADJ.
20.52.37.IO 3.587 SEC. .896 ADJ.
20.52.37.CH 62.126 KUS. .118 ADJ.
20.52.37.SS 3.202
20.52.37.** PRIORITY JOB **
20.52.37.PP 11.050 SEC. DATE 05/01/78
20.52.37.COST ESTIMATE 4.55
20.52.37.EJ END OF JOB, IU
ALTRAN VERSION 1 LEVEL 9

1 PROCEDURE MAIN
2 ALGEBRAIC (X*20) TCHEBY,T
3 ALTRAN TCHEBY
4 INTEGER N
5 OPTS(101,1)
6 DO N = 0,3
7 T = TCHEBY(N,X)
8 WRITE T
9 END

NAME/EXTNANE USE TYPE STRUC PREC CLASS SCOPE DB LAY ADDR

TCHEBY PROC ALG L S X L=001
X VAR ALG L=001
MAIN PROC IND ALG L=001
N INT VAR INT
OPTS/S9OPTS PROC INT S X LAY
0 CONS INT S
101 CONS INT S
1 CONS INT S
20 CONS INT S
3 CONS INT S

ALTRAN VERSION 1 LEVEL 9

1 PROCEDURE TCHEBY(N,X)
2 ALGEBRAIC TCHEBY,X
3 STATIC X
4 INTEGER N
5 IF(N .EQ. 0) RETURN (1)
6 IF(N .EQ. 1) RETURN (X)
7 RETURN ( 2*X*TCHEBY(N-1) - TCHEBY(N-2) )
8 END

NAME/EXTNANE USE TYPE STRUC PREC CLASS SCOPE DB LAY ADDR

N VAR INT L S D
TCHEBY PROC ALG L S X
X VAR ALG S D
0 CONS INT S
1 CONS INT S
2 CONS INT S

19
**NORMAL RETURN FROM MAIN PROCEDURE**

**RUN STATISTICS**

- 0.050 SECONDS ELAPSED
- 14 DIGITS IN SHORT INTEGERS
- 28 DIGITS IN LONG INTEGERS
- 10062 WORDS IN WORKSPACE
- 395 MAXIMUM WORDS USED
- 194 CURRENT WORDS USED
- 0 GARBAGE COLLECTIONS
MFY NOS/BE 1.2 KAFB 009 MFY 03/27/78
FLCH=314000 MXCN=314000 FLEC=1720K MXEC=0750K

20.49.41.EDROOKS FROM MX2/IU
20.49.41.IP 00000320 WORDS - FILE INPUT, DC 04
20.49.41.EDR,T77,P60.
20.49.42.ACCOUNT(RHODES,********-***,DYP,1851)
20.49.42.SYSBULL(BATCH)
20.49.43.DISPOSE(OUTPUT)
20.49.43.ATTACH(OLD,ALTRANLIB,ID=DYSXER)
20.49.43.PF CYCLE NO. = 003
20.49.43.LIBRARY(OLD)
20.49.51.MAP(OFF)
20.49.51.COPYCR(INPUT,SYSin)
20.49.52.ALTRAN(SYSin)
20.49.58. STOP
20.49.58.FTN(A,I=FORTIN,R=0)
20.50.01. .071 CP SECONDS COMPIILATION TIME
20.50.01.LOAD(LGO)
20.50.10.EXIT
20.50.10.EXIT(S)
20.50.10.OP 00000640 WORDS - FILE OUTPUT, DC 40
20.50.10.MS 3584 WORDS ( 75264 MAX USED)
20.50.10.CPA 1.243 SEC. 1.243 ADJ.
20.50.10.IO 3.758 SEC. .939 ADJ.
20.50.10.CH 67.549 KUS. .128 ADJ.
20.50.10.SS
20.50.10.PP 11.239 SEC. DATE 05/01/78
20.50.10.COST ESTIMATE 4.58
20.50.10.EJ END OF JOB, IU
ALTRAN VERSION 1 LEVEL 9

1 PROCEDURE MAIN # SIMPLE EXAMPLE OF USE OF FTNOUT
2 LONG ALGEBRAIC (X=10, Y=10) F
3 ALTRAN FTNOUT
4 OPTS(201,72) # FTNOUT REQUIRES A LINE LENGTH OF 72
5 F = EXPAND( (X+2*Y+1000000)**3 )
6 WRITE F # PRINT F
7 WRITE (25) "FUNCTION F(X,Y)",
8 "EXAMPLE PROG WRITTEN WITH FTNOUT."
9 F,
10 "RETURN", "END"
11 # WE HAVE WRITTEN A SIMPLE PROGRAM ON UNIT 25, NOW WE INVOKE FTNOUT TO
12 # THIS ALTRAN OUTPUT TO LEGAL FORTRAN.
13 FTNOUT
14 END

<table>
<thead>
<tr>
<th>NAME/EXTNAME</th>
<th>USE</th>
<th>TYPE</th>
<th>STRUC</th>
<th>PREC</th>
<th>CLASS</th>
<th>SCOPE</th>
<th>DB</th>
<th>LAY</th>
<th>ADDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>VAR</td>
<td>ALG</td>
<td>L</td>
<td></td>
<td>L=001</td>
<td></td>
<td></td>
<td></td>
<td>L=001</td>
</tr>
<tr>
<td>X</td>
<td>IND</td>
<td>ALG</td>
<td>L</td>
<td></td>
<td>L=001</td>
<td></td>
<td></td>
<td></td>
<td>L=001</td>
</tr>
<tr>
<td>Y</td>
<td>IND</td>
<td>ALG</td>
<td>L</td>
<td></td>
<td>L=001</td>
<td></td>
<td></td>
<td></td>
<td>L=001</td>
</tr>
<tr>
<td>EXPAND/S9XPND</td>
<td>PROC</td>
<td>ALG</td>
<td>L</td>
<td>S</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTNOUT</td>
<td>PROC</td>
<td>ALG</td>
<td>L</td>
<td>S</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAIN</td>
<td>PROC</td>
<td>INT</td>
<td>S</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTS/S9OPTS</td>
<td>PROC</td>
<td>INT</td>
<td>S</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L=001</td>
<td></td>
<td>LAY</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C EXAMPLE PROG WRITT</td>
<td>CONS</td>
<td>CHAR</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000000</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>CONS</td>
<td>INT</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END</td>
<td>CONS</td>
<td>CHAR</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FUNCTION F(X,Y)</td>
<td>CONS</td>
<td>CHAR</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RETURN</td>
<td>CONS</td>
<td>CHAR</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F

X**3 + 6*X**2*Y + 3000000*X**2 + 12*X*Y**2 + 12000000*X*Y +
3000000000000*X + 8*Y**3 + 12000000*Y**2 + 6000000000000*Y +
10000000000000000000
*** NORMAL RETURN FROM MAIN PROCEDURE

*** RUN STATISTICS

.046 SECONDS ELAPSED
14 DIGITS IN SHORT INTEGERS
20 DIGITS IN LONG INTEGERS
10017 WORDS IN WORKSPACE
388 MAXIMUM WORDS USED
149 CURRENT WORDS USED
0 GARBAGE COLLECTIONS

# FUNCTION F(X,Y)
# C EXAMPLE PROG WRITTEN WITH FTNOUT.
# F
# X**3 + 6*X**2*Y + 3000000*X**2 + 12*X*Y**2 + 12000000*X*Y +
# 3000000000000*X + 8*Y**3 + 12000000*Y**2 + 6000000000000*Y +
# 10000_00000000000000
# RETURN
# END
ALTRAN VERSION 1 LEVEL 9

PROCEDURE MAIN
ALGEBRAIC (X*20) TCHEBY,T
ALTRAN TCHEBY
INTEGER N
OPTS(101,1)
DO N = 0,3
T = TCHEBY(N,X)
WRITE T
DOEND
END

NAME/EXTNAME USE TYPE STRUC PREC CLASS SCOPE DB LAY ADDR

TCHEBY PROC ALG L S X L=0001
T VAR ALG L=0001
X IND ALG L=0001
MAIN PROC L S X L=001
N VAR INT
OPTS/S9OPTS PROC INT S X L=001
L=001 CONS INT S
101 CONS INT S
1 CONS INT S
20 CONS INT S
3 CONS INT S

ALTRAN VERSION 1 LEVEL 9

PROCEDURE TCHEBY(N,X)
ALGEBRAIC TCHEBY,X
STATIC X
INTEGER N
IF(N .EQ. 0) RETURN (1)
IF(N .EQ. 1) RETURN (X)
RETURN ( 2*X*TCHEBY(N-1) - TCHEBY(N-2) )
END

NAME/EXTNAME USE TYPE STRUC PREC CLASS SCOPE DB LAY ADDR

N VAR INT D
TCHEBY PROC ALG L S X
X VAR ALG S D
0 CONS INT S
1 CONS INT S
2 CONS INT S
\[ \begin{align*}
N & = 1 \\
T & = X \\
T & = 2X^{\ast 2} - 1 \\
T & = X \cdot (4X^{\ast 2} - 3)
\end{align*} \]

### NORMAL RETURN FROM MAIN PROCEDURE

### RUN STATISTICS

- .048 SECONDS ELAPSED
- 14 DIGITS IN SHORT INTEGERS
- 20 DIGITS IN LONG INTEGERS
- 17614 WORDS IN WORKSPACE
- 395 MAXIMUM WORDS USED
- 174 CURRENT WORDS USED
- 0 GARBAGE COLLECTIONS
FILE INPUT
DC 04

20.48.38. FTF(A, I=FORTIN, R=O)
20.48.41. .074 CP SECONDS COMPIILATION TIME
20.48.41. RFL, 140000. GETS ADDITIONAL WORKSPACE
20.48.41. E - NOT NEEDED FOR THIS EXAMPLE
20.48.41. LOAD(LBO)
20.48.41. XER.
20.48.52. EXIT
20.48.52. EXIT(S)

FILE OUTPUT
DC 40

20.48.52. DP 00000640 WORDS - FILE OUTPUT, DC 40
20.48.52. MS 3584 WORDS ( 75264 MAX USED)
20.48.52. CPA 1.190 SEC. 1.190 ADJ.
20.48.52. CP 3.693 SEC. .923 ADJ.
20.48.52. CM 88.634 KUS. .168 ADJ.
20.48.52. SS 3.424
20.48.52. ** PRIORITY JOB **
20.48.52. PP 10.571 SEC. DATE 05/01/78
20.48.52. COST ESTIMATE .57
20.48.52. EJ END OF JOB, IU