160-A Reference Manual

by

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8 February 1963

Approved

G. L. Myers

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Although this document contains no classified information it has not been cleared for open publication by the Department of Defense. Open publication, wholly or in part, is prohibited without the prior approval of the System Development Corporation.
This publication lists and describes all 160-A computer routines available in the Computer Program Development Center (CPDC), and consists of the following six sections:

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<td>This section is an alphabetical index for all available 160-A routines. It lists identification codes and either locates descriptions appearing in this document, or as in a few instances, references descriptions available in other documents.</td>
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<td>2.0 Subject Classification Code Index</td>
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<td>3.0 Abstracts</td>
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<td>4.0 Group I Routines</td>
<td>This section contains descriptions of routines found to be more efficient for CPDC use; accordingly these routines are modified and up-dated more often.</td>
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<td>5.0 Group II Routines</td>
<td>This section contains descriptions of routines that have not been employed in the CPDC. Some of these Group II routines are similar to those found in Group I, and other 160-A users may find some of these routines better suited for their applications.</td>
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<td>6.0 Appendix</td>
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This document provides a complete and current reference manual for all 160-A programming routines available in the CPDC. Use of this document will effect better dissemination of checked-out routines and will reduce redundant programming efforts by 160-A users. It also serves as training aid for new CPDC personnel. In an effort to maintain a realistic and current document, change pages will be published periodically to reflect modifications, additions and/or deletions.
NOTE: Paper tapes are available in the CPDC for each routine listed in this document.

Although source data evolved from SWAP and the CPDC, the majority of the routines are described per SWAP standards. In a few instances, the responsible corporation and/or programmer is not listed, as the information was not available. If upon using this document, you find that you know the answer to any of these voids, please transmit this information to the CPDC.
**ALPHABETICAL INDEX**

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SUBJECT CLASSIFICATION CODE INDEX

A. Assembly and Related Routines
   A1 Assembly Programs
   A2 Symbolic Code Editors
   A3 Peripheral Conversion Routines
   A4 Loaders

B. Interpretive Systems
   B1 Scientific Computations
   B2 Data Processing

C. Compilers
   C1 Scientific Computations
   C2 Data Processing

D. Service Routine Convenience Packages
   D1 Resident Service Packages
   D2 Special Purpose Packages

E. Input-Output Control Routines
   E1 Magnetic Tape
   E2 Card Equipment
   E3 Printers
   E4 Typewriters
   E5 Plotters

F. Service Routines
   F1 Duplicators and Related Routines
   F2 Memory Loaders
   F3 Memory Dumps
   F4 Data Transfer - Printer Output
   F5 Data Transfer - Card Output
   F6 Data Transfer - Magnetic Tape Output
   F7 Data Transfer - Paper Tape Output
   F8 Data Transfer - Plotter Output
G. Program Testing Aids
   G1 Trace Routines
   G2 Dynamic Analysis Routines

H. Information Processing Routines
   H1 Conversions
   H2 Sorts and Merges

I. Arithmetic and Elementary Function Routines
   I1 Fixed Point
   I2 Floating Point

J. Linear Programming

K. Civil Engineering
   K1 Surveying
   K2 Highway Engineering
   K3 Hydraulics Engineering
   K4 Structural Engineering
   K5 Photogrammetry
   K6 Soils

L. Statistical Analysis and Probability

Z. Demonstration Routines
   Z1 Mathematical
   Z2 Games
   Z3 Miscellaneous
AA1.01C  SYMBOLIC ASSEMBLY SYSTEM (OSAS-A)
ACCEPTS 160-A INSTRUCTIONS IN SYMBOLIC FORM, ASSIGNS ABSOLUTE
LOCATIONS TO THE SYMBOLIC ADDRESSES, PERFORMS THE NECESSARY
WORK OF RELATIVE ADDRESSING TO PROVIDE AN ABSOLUTE MACHINE
CODE FOR INPUT TO THE 160-A COMPUTER. INPUTS CAN BE PAPER
TAPE, MAGNETIC TAPE, OR CARDS. OUTPUT IS PAPER TAPE, MAG-
NETIC TAPE, CARDS, OR PRINTER.

AA1.02A  INTERFOR ASSEMBLY PROGRAM (FLAP)
ASSEMBLES A PROGRAM STATED IN SYMBOLIC LANGUAGE, INTO A
FORM EXECUTABLE BY INTERFOR. OUTPUT IS AN ASSEMBLY LISTING
TAPE AND A BINARY OBJECT PROGRAM TAPE LOADED BY A4.11.
CONFIGURATION - MINIMUM SWAP 160-A, 166 AND 167 INPUT/OUTPUT
OPTIONAL.

A2.01A  PAPER TAPE EDIT
CHANGES SYMBOLIC PAPER TAPES PREPARED FOR ASSEMBLY BY FLAP
OR OSAS. CHANGES MAY BE IN THE FORM OF REPLACEMENTS, INSERTIONS,
OR DELETIONS OF COMPLETE LINES.

AA2.02  OSAS-A MASTER PAPER TAPE EDIT
CHANGES AN OSAS-A MASTER PAPER TAPE BY ADDING TO, DELETING
AND/OR REPLACING EXISTING ROUTINES IN THE SECOND RECORD.

A3.02  MAGNETIC TAPE TO FLEX TAPE
CONVERT 80 CHARACTER BCD CODED INFORMATION ON MAGNETIC
TAPE IN FORMAT OF OSAP CARD INPUT.

A3.03  OSAS SYMBOLIC FLEX TAPE TO CARDS
CONVERTS OSAS SYMBOLIC FLEX TAPES TO HOLLERITH CARDS.
ALLOWS OPTIONAL CARD SEQUENCING UP TO FOUR DIGITS.

AA4.01  OSAS-A BINARY LOADER - PAPER TAPE
READS BINARY PROGRAMS ON PAPER TAPE PREPARED BY OSAS-A
INTO MEMORY. PROGRAMS ARE RELOCATABLE.

AA4.02  OSAS-A BINARY LOADER - CARD
READS BINARY PROGRAM CARDS PREPARED BY OSAS-A INTO MEMORY.
PROGRAMS ARE RELOCATABLE. USES 088 READER.
OSAS-A BINARY LOADER - ASSEMBLY MODE MAGNETIC TAPE
READS BINARY PROGRAM IMAGES PREPARED BY OSAS-A INTO MEMORY.
PROGRAMS ARE RELOCATABLE. USES 163 OR 164 TAPE UNITS.

OSAS-A BINARY LOADER - CHARACTER MODE MAGNETIC TAPE
READS BINARY PROGRAM IMAGES PREPARED BY OSAS-A INTO MEMORY.
PROGRAMS ARE RELOCATABLE. USES 163 OR 164 TAPE UNITS.

INTERFOR BINARY LOADER (FLOADER)
LOADS BINARY OBJECT PROGRAMS PREPARED BY FLAP. THE OBJECT
PROGRAM IS RELOCATABLE.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A

MULTIPLE PRECISION PACKAGE
PERFORMS ARITHMETIC WITH OPERANDS EXPRESSED TO 6, 12, 18, 24,
...6N BINARY DIGIT PRECISION.
CONFIGURATION - MINIMUM 160 COMPUTER

INTERFOR AN INTERPRETIVE SYSTEM PROVIDING SYMBOLIC AND NUMERIC
PROGRAMMING, 6 INDEX REGISTERS AND 33-BIT FLOATING POINT
ARITHMETIC. THE COMMANDS ARE A SUBSET OF THE CONTROL DATA
1604 COMMANDS. PROGRAMS MAY BE WRITTEN FOR INTERFOR WHICH
ALSO RUN ON THE 1604.
CONFIGURATION - MINIMUM 160-A COMPUTER

INTERFOR SINE COSINE SUBROUTINE.
GIVEN X, COMPUTES THE SINE X OR COS X (WHERE X IS IN
RADIANS).

INTERFOR ARCSINE, ARCCOSINE SUBROUTINE
GIVEN X, FINDS THE ARCCOS OF X OR ARCSINE OF X.

INTERFOR EXPONENTIAL SUBROUTINE
CALCULATES 2 TO THE X POWER, E TO THE X POWER OR 10 TO THE
X POWER.

INTERFOR SQUARE ROOT SUBROUTINE
GIVEN A NUMBER X IN THE ACCUMULATOR, FINDS THE SQUARE ROOT
OF THE NUMBER BY THE USE OF THE NEWTON ITERATION METHOD
AND LEAVES THE SQUARE ROOT IN THE ACCUMULATOR.
AB1.03-7 INTERFOR LOG TO THE BASE 2 SUBROUTINE
 GIVEN A FLOATING POINT NUMBER IN A, CALCULATE THE LOG TO
 THE BASE 2 OF THIS NUMBER.

AB1.03-8 INTERFOR SUBROUTINE, TRIG ROUTINES
 COMBINES THE FOLLOWING SUBROUTINES – SINE COSINE, ARCTAN
 X AND SERIES EXPANSION. SINE COSINE COMPUTES THE SIN X
 OR COS X WHERE X IS IN RADIANS. ARCTANGENT FINDS THE
 ARCTANGENT OF X USING THE MACLAURIN SERIES AS GIVEN IN
 HASTINGS, PAGE 137. X IS IN RADIANS.

AB1.03-9 INTERFOR SUBROUTINE, PLOT
 PLOTS RESULTS ON THE ON-LINE MODEL 165 PLOTTER IN EITHER
 OF TWO WAYS – 1. MOVING FROM PREVIOUS PLOT POINT TO
 PRESENT PLOT POINT IN A STRAIGHT LINE WITH PEN DOWN, AND
 2. MOVING FROM PREVIOUS PLOT POINT TO PRESENT PLOT POINT
 WITH PEN UP, PLOT A SYMBOL TO REPRESENT DESIRED POINT.
 CONFIGURATION – MINIMUM 160-A COMPUTER AND MODEL 165 PLOTTER.

AB1.04A SICOM
 A GENERAL PURPOSE INTERPRETIVE SYSTEM USING FLOATING POINT
 ARITHMETIC. APPLICABLE TO SCIENTIFIC, ENGINEERING AND
 COMMERCIAL COMPUTATIONS. CONVERTS THE 160-A INTO A DECIMAL,
 FLOATING POINT MACHINE WITH 10 DECIMAL DIGITS, PLUS EXPONENT
 WORD LENGTH.
 CONFIGURATION – CAN RUN WITH A MINIMUM 160-A.

AB1.04-2 SICOM STANDARD MATHEMATICAL SUBROUTINES
 THE FOLLOWING SUBROUTINES ARE INCLUDED – SQUARE ROOT,
 SIN-COS, LOG X TO BASE 10, 10 TO THE X POWER AND ARC TAN.

B1.05 160 FORTRAN FLOATING POINT ARITHMETIC PACKAGE
 PROVIDES A SEPARATE ASSEMBLY OF THE ARITHMETIC PACKAGE
 USED IN 160 FORTRAN FOR INCORPORATION AS A SUBROUTINE IN
 PROGRAMS WHICH REQUIRE SUCH FLOATING ARITHMETIC.
 CONFIGURATION – MINIMUM SWAP 160 OR 160-A COMPUTER.
AB1.06A  SICOM SINGLE PRECISION TRANSLATOR
THE SINGLE PRECISION INTERCOM TRANSLATOR IS A PROGRAM BY
WHICH A BENDIX G-15 INTERCOM 1000 SINGLE PRECISION OR
INTERCOM 500X SOURCE PROGRAM PREPARED ON THE FLEXOWRITER
MAY BE TRANSLATED INTO A CONTROL DATA 160-A SICOM SOURCE
PROGRAM TAPE.

AB1.07A  SICOM SINGLE PRECISION TRANSLATOR SUBROUTINES
INCLUDED WITH THE TRANSLATOR ARE SICOM SUBROUTINES WHICH
ARE SUBSTITUTED FOR THEIR G-15 COUNTERPARTS (i.e., SQUARE
ROOT, SIN-COS, ARCTAN, LOG, EXPONENTIAL AND MAGNETIC TAPE).
THE INTERCOM FRACTION SELECTOR AND FLEXOWRITER SUBROUTINES
ARE REPLACED BY SICOM COMMANDS. THE G-15 INDEX REGISTER
UTILIZATION SUBROUTINE IS UNNECESSARY IN SICOM.

AB1.08A  SICOM DOUBLE PRECISION TRANSLATOR
THE DOUBLE PRECISION INTERCOM TRANSLATOR IS A PROGRAM
BY WHICH A BENDIX G-15 INTERCOM 1000 DOUBLE PRECISION
SOURCE PROGRAM PREPARED ON THE FLEXOWRITER MAY BE TRANS-
LATED INTO A CONTROL DATA 160-A SICOM SOURCE TAPE. THE
TRANSLATION WILL, IN MOST CASES, BE READY FOR A PRODUCTION
RUN ON THE 160-A UNDER SICOM CONTROL. THE TRANSLATOR IS
DESIGNED TO MAKE THE CONVERSION OF ANY WELL-DOCUMENTED
INTERCOM DOUBLE PRECISION PROGRAM AS SIMPLE AS POSSIBLE
FOR A PROGRAMMER FAMILIAR WITH BOTH SYSTEMS.

AB1.09A  SICOM DOUBLE PRECISION TRANSLATOR SUBROUTINES
INCLUDED WITH THE TRANSLATOR ARE SICOM SUBROUTINES WHICH
ARE SUBSTITUTED FOR THEIR G-15 COUNTERPARTS. THE INTER-
COM FRACTION SELECTOR AND THE G-15 INTERCOM INDEX REGISTER
UTILIZATION SUBROUTINES IS UNNECESSARY IN SICOM.

AB1.10A  167 DATA INPUT FOR SICOM
FIXED POINT INTEGERS AND ALPHANUMERIC DATA MAY BE PUNCHED
ON CARDS AND LOADED VIA THE 167 READER. THE SUBROUTINE
MUST BE ENTERED EACH TIME A CARD IS READ.
CONFIGURATION - MINIMUM SWAP 160-A, 167 READER.

AB1.11A  SICOM GRAPH PLOTTER SUBROUTINE
RELOCATABLE GENERAL PURPOSE PLOTTER SUBROUTINE.

AB1.12  SICOM STRAIGHT LINE PLOT ROUTINE
PLOTS STRAIGHT LINES IN AN X, Y OR 45 DEGREE DIRECTION.
AC1.00 160 FORTRAN-A SYSTEM
Provides a simple and efficient method for scientific problem solving. Employs a language resembling that of ordinary mathematics and common language to describe the mathematical and logical procedure to be followed to calculate the desired results. This language (source program) is the input to FORTRAN which produces machine instructions (object program) that perform the desired calculations.
Configuration - Minimum swap 160-A, optional 088 or 167.
The system consists of physical tapes listed below.
160 FORTRAN-A COMPILER I (088 source input)
160 FORTRAN-A COMPILER I (167 source input)
160 FORTRAN-A COMPILER II
160 FORTRAN-A INTERPRETER

AD1.01 RESIDENT SERVICE PACKAGE 1.
Each of the following functions is operated by entering the resident library at a specified point - bi-octal punch, bi-octal verify, flex tape load, flex tape punch, flex tape verify, type load, and type dump.
Configuration - Minimum 160-A computer, typewriter optional.

AD1.02 MAGNETIC TAPE BOOTSTRAP
Keeps itself and programs or data on magnetic tape to eliminate paper tape handling. May be loaded and blocks written or read by console entry of data.

AD2.02 SIMULTANEOUS CARD-TO-TAPE, TAPE-TO-PRINT PROGRAM
Runs a card-to-tape operation simultaneously with a tape-to-printer operation. About 90 per cent of maximum speed is obtained.

AD2.03 PERIPHERAL INTEGRATED UTILITY SYSTEM (PIUS)
To provide a program to correlate and control a library of 160-A routines in an executive utility system.

AE2.01 167 CARD READ ROUTINE
Reads a hollerith or binary card and stores the information packed (12 bits per word), or unpacked, six bits in the lower half of each word.
MATION PACKED, (12 BITS PFR WORD), OR UNPACKED, SIX BITS
IN THE LOWER HALF OF EACH WORD.
CONFIGURATION - MINIMUM SWAP 160-A, 167 READER.

F1.00 PAPER TAPE DUPLICATOR (TAPDUP)
PRODUCES AND VERIFIES MULTIPLE COPIES OF A GIVEN PUNCHED PAPER
TAPE. COPIES UP TO 6395 FRAMES OF TAPE AND PRODUCES THE NUMBER
OF COPIES SPECIFIED IN THE A REGISTER.
PUNCHES AN 18 INCH LEADER BETWEEN COPIES.
CONFIGURATION - MINIMUM 160 COMPUTER.

F1.01 PAPER TAPE DUPLICATOR, LONG TAPES (TAPDPL)
REPRODUCES AND VERIFIES PAPER TAPES OF MORE THAN 6395 FRAMES BY
PLACING THE IMAGE ON MAGNETIC TAPE. REQUIRES 212 LOCATIONS
BEGINNING AT LOCATION 0050.
CONFIGURATION - MINIMUM 160 COMPUTER AND 163 OR 164 TAPE UNITS.

F1.02 TAPE LEADER PREPARATION (TAPIDT)
PRODUCES READABLE CHARACTERS ON PAPER TAPE LEADERS FOR
IDENTIFYING PROGRAM TAPES.
CONFIGURATION - MINIMUM 160 COMPUTER.

F1.03 PAPER TAPE VERIFY (FLXLOD)
VERIFIES PAPER TAPES BY COMPARING THEM AGAINST CHECK SUMS
FORMED BY THE ORIGINAL TAPE. ANY LENGTH TAPE BE VERIFIED.
CONFIGURATION - MINIMUM 160 COMPUTER.

F1.05 TAPE COPY - COMPARE
PROVIDES THE FOLLOWING OPTIONS - COPY OR COMPARE MAGNETIC
TAPE FILES, BCD OR BINARY MODE, REWIND LOAD AT START,
REWIND UNLOAD AT FINISH.
CONFIGURATION-MINIMUM 160-A COMPUTER.

AF1.06 TAPE COMPARE (TACO)
TO COMPARE TWO BCD TAPES TO INSURE SIMILARITY
CONFIGURATION-MINIMUM 160 A, 161 TYPEWRITER,
1612PRINTER (OPTIONAL)

AF2.00 FLEX LOAD AND FLEX VERIFY
READS PAPER TAPES INTO MEMORY THAT WERE PREPARED ON A
FLEXWRITER OR BY THE FLEX DUMP PROGRAM. FLEX VERIFY
CHECKS FOR DISCREPANCIES BETWEEN TAPE AND MEMORY.
CONFIGURATION-MINIMUM 160-A COMPUTER.
AF3.00  BI-OCTAL PUNCH AND VERIFY (BIOPUN)
PUNCHES PAPER TAPE AND COMPARES PORTIONS OF MEMORY IN BI-OCTAL
FORMAT.
CONFIGURATION—MINIMUM 160 COMPUTER.

AF3.01  MEMORY DUMP TO MAGNETIC TAPE (MEMTPE)
REQUIRES 181 LOCATIONS
CONFIGURATION—MINIMUM 160 COMPUTER AND 163 OR 164 TAPE UNITS.

AF3.02  LISTABLE OCTAL DUMP (MEMFLX)
PRODUCES IN FLEXOWRITER CODE A LISTABLE OCTAL DUMP OF A
SPECIFIED AREA OF CORE.
CONFIGURATION—MINIMUM 160 COMPUTER.

AF3.03  LISTABLE SYMBOLIC DUMP, 4 WORDS TO A LINE (MEMSY4)
PRODUCES IN FLEXOWRITER CODE A LISTABLE SYMBOLIC DUMP OF A
SPECIFIED AREA OF CORE, FOUR WORDS PER FLEX LINE.
CONFIGURATION—MINIMUM 160 COMPUTER.

AF3.04A LISTABLE SYMBOLIC DUMP, 1 WORD TO A LINE (MEMSYL)
PRODUCES IN FLEXOWRITER CODE A LISTABLE SYMBOLIC DUMP OF A
SPECIFIED AREA OF CORE, ONE WORD PER FLEX LINE.
CONFIGURATION—MINIMUM 160 COMPUTER.

AF3.06  BI-OCTAL DUMP (MEMTAP)
DUMPS MEMORY ONTO PAPER TAPE IN BI-OCTAL FORMAT FROM SELECTED
ADDRESSES.
CONFIGURATION—MINIMUM 160 OR 160A COMPUTER.

AF3.07  SYMBOLIC PRINTER DUMP
DUMPS MEMORY IN SYMBOLIC FORM ONTO THE 1612 PRINTER.
CONFIGURATION-MINIMUM 160-A COMPUTER, 1612 PRINTER.

AF3.08  SYMBOLIC FLEXOWRITER DUMP
DUMPS MEMORY IN SYMBOLIC FORM ONTO PUNCHED PAPER TAPE
FOR LISTING ON FLEXOWRITER.
CONFIGURATION-MINIMUM 160-A.

AF3.09  OCTAL DUMP
PROVIDES AN OCTAL DUMP OF ONE BANK OF 160-A MEMORY FROM A
GIVEN STARTING ADDRESS TO THE END OF THAT BANK ONTO THE
1612 PRINTER. THE PROGRAM IS RELOCATABLE.
CONFIGURATION-MINIMUM 160-A COMPUTER, 1612 PRINTER.

AF3.10
SYMBOLIC TYPEWRITER DUMP
PROVIDES A SYMBOLIC DUMP ONTO THE 161 TYPEWRITER.
CONFIGURATION-MINIMUM SWAP 160-A, 161 TYPEWRITER.*

AF3.11
160-A CORE DUMP TO 1612 (1612 DUMP)
TO ALLOW A LISTABLE DUMP OF THE MACHINE CODES AND
CONSTANTS STORED IN 160A AND 169 ONTO THE 1612
PRINTER.
CONFIGURATION-MINIMUM 160 A, 161 TYPEWRITER, 1612 PRINTER.

AF3.12
BIOCTAL DUMP (BIDU)
PUNCHES A GIVEN AREA OF A SELECTED BANK IN BIOCTAL
FORMAT FOR MACHINE LOADING.
CONFIGURATION-MINIMUM 160 A.

F4.06
1607 TO 1612 PRINT ROUTINE
READS BLOCKED OR UNBLOCKED MAGNETIC TAPES AND LISTS THEM
ON THE CONTROL DATA 1612 PRINTER AT 1000 LINES A MINUTE.
LIST CAN BE UNDER PROGRAM CONTROL OR UNDER CONTROL OF
1612 MONITOR CHANNEL 1-6.
CONFIGURATION-MINIMUM 160 OR 160-A COMPUTER, 1607, AND 1612.

F4.07
FLEX TAPE TO 1612
READS FLEX-CODED PAPER TAPE, CONVERTS THE FLEX CODES INTO
BCD, PRINTS THE RESULTS ON THE 1612.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A AND 1612.

F5.02
163/164 TAPE TO CARDS
READS MAGNETIC TAPE IN BCD OR BINARLY MODE AND PUNCHES
CORRESPONDING HOLLERITH OR BINARY CARDS. WRITTEN PRIMARILY
TO PUNCH OUTPUT FROM THE 1604 CO-OP MONITOR.
CONFIGURATION-MINIMUM SWAP 160 OR 160-A, 163 OR 164 TAPE
UNIT, 1610-523 CARD PUNCH SYSTEM.

F6.01
FLEX TAPE TO MAGNETIC TAPE CONVERTER (FLXTPE)
REPRODUCES A COPY OF A FLEXOWRITER TAPE ON MAGNETIC TAPE IN A
FORM SUITABLE FOR LISTING.
CONFIGURATION- MINIMUM 160 COMPUTER AND 163 OR 164 TAPE UNITS.

F6.02
1609 CARD TO MAGNETIC TAPE
READS BCD CARDS, CHECKS VALIDITY AND WRITES BCD CARD IMAGES
ONTO MAGNETIC TAPE. REQUIRES LOCATIONS 6600 THROUGH 0000 AND LOCATIONS 0070 THROUGH 0076.
CONFIGURATION - MINIMUM 160 OR 160-A, 1609 ADAPTER, 164 TAPE AND A 521 CARD READ PUNCH.

F6.03 167 CARD TO TAPE
CONVERTS DATA FROM CARDS TO MAGNETIC TAPE RECORDS, ONE CARD PER RECORD. HANDLES BINARY OR BCD CARDS. PRODUCES BINARY OR BCD RECORDS. CARDS MAY BE MIXED.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A, 167 READER AND A 163 OR 164 TAPE UNIT.

F6.04 CHANGE MAGNETIC TAPE RECORD LENGTH BINARY TAPES
WRITES MAGNETIC TAPES OF A DESIGNATED RECORD LENGTH FROM TAPES OF THE SAME OR DIFFERENT RECORD LENGTHS FOR BINARY TAPES ONLY (ODD PARITY).
CONFIGURATION - MINIMUM SWAP 160 OR 160-A, 163-2 OR 164-2 TAPE UNIT.

F6.05 160-A CARD TO MAGNETIC TAPE ROUTINE
ROUTINE ACCEPTS STANDARD 80 COLUMN BCD OR COLUMN BINARY CARDS AND WRITES THEIR CARD IMAGES WITH 'LOOK-AHEAD' BITS ONTO MAGNETIC TAPE.

AF6.06 160-A BINARY CARD BINARY TAPE VERIFY ROUTINE
ROUTINE COMPARES 80 COLUMN BINARY CARDS WITH THEIR IMAGE ON MAGNETIC TAPE. WRITTEN FOR IBM 533 CARD READ PUNCH.
CONFIGURATION - 160-A WITH 163 AND 1610 ADAPTOR FOR IBM CARD READ PUNCH.

AF7.00 FORTRAN CARDS TO FLEX TAPE
READS FORTRAN SOURCE CARDS AND PUNCHES PAPER TAPE ACCEPTABLE TO THE FORTRAN COMPILER.
CONFIGURATION - MINIMUM SWAP 160-A, 167 READER.

AF8.01 PLOT FROM MAGNETIC TAPE 163/164 TO 165 PLOTTER
PLOTS CONSECUTIVE POINTS ON THE 165 PLOTTER AND CONNECTS THEM WITH THE BEST STRAIGHT LINE. POINTS ARE OBTAINED FROM MAGNETIC TAPE, ONE POINT PER TWO-WORD ASSEMBLY-MODE RECORD.
CONFIGURATION - MINIMUM SWAP 160-A COMPUTER, TAPE UNIT 163 OR 164 AND 165 PLOTTER.

F8.02 165 ALPHANUMERIC AND SPECIAL CHARACTER DEMONSTRATION PLOT
BASICALLY A DEMONSTRATION ROUTINE, BUT IT MAY BE USED TO PRODUCE A NEAT LABELLING OF PLOTS ON THE 165 PLOTTER.

CONFIGURATION - MINIMUM 160 OR 160-A SWAP COMPUTER, 165 PLOTTER.

G1.00 TRACK (TRACE1)
Traces a program, providing flex-coded paper tape as output.
The beginning and ending addresses of consecutive instruction strings appear as output, allowing faster execution than is possible using a full trace.
CONFIGURATION - MINIMUM UNMODIFIED 160 COMPUTER.

H1.00 BINARY TO 4 BIT DECIMAL CONVERSION (BINDEC)
Converts a 24 bit binary integer into a decimal integer with each digit in successive cells.
CONFIGURATION - MINIMUM 160 COMPUTER.

H1.01 BCD TO BINARY CONVERSION (BCDBIN)
Converts a binary coded decimal number of up to six digits to the equivalent binary number in 22 bit arithmetic format. The BCD number is stored one digit per word with the digit as the low order four bits of the word.
CONFIGURATION - MINIMUM 160 COMPUTER AND 163 OR 164 TAPE UNITS.

AH1.02 OUTPUT IMAGE
Sets up a 120 character line image for on-line printing or writing on a BCD output tape. The format is specified in the calling sequence.

AH1.03 CONFLEx
Converts the Flexewriter Model 35-4 (standard with G-15) in the 6 level mode to equivalent control data Flexewriter characters.
CONFIGURATION - MINIMUM SWAP 160-A.

AH1.04 GENERAL BINARY TO BCD/BCD TO BINARY CONVERSION
A closed subroutine entered by a return jump with the A-register specifying the type of conversion.
CONFIGURATION - MINIMUM SWAP 160-A.

H2.01 SORT 3X
SORT 3X accepts input from one reel of magnetic tape where the information is recorded with one item per block of magnetic tape.
CONFIGURATION-MINIMUM SWAP 160 OR 160-A COMPUTER AND FOUR 606, 1607, 163, OR 164 TAPE HANDLERS.

11.00 PERCENTAGE CALCULATION, PROPER FRACTION (PERCAL)
DIVISION OF X OVER Y*, WHERE X IS ASSUMED TO BE LESS THAN Y. THE ANSWER WILL BE IN THE FORM XXXX, ADJUSTED BY ROUNDING IN TRUE BINARY.
REQUIRES 196 LOCATIONS, INCLUDING 70-77. RELOCATABLE.
CONFIGURATION—MINIMUM 160 COMPUTER.

11.01 SINGLE PRECISION DIVIDE (DIVFRC)
DIVIDES A POSITIVE 23 BIT FRACTION BY A POSITIVE 11 BIT FRACTION, GIVING A ROUNDED 11 BIT FRACTIONAL QUOTIENT.
CONFIGURATION—MINIMUM 160 COMPUTER.

11.02 QUICK MULTIPLY, 9 BIT (MULT9B)
MULTIPLIES TWO SIGNED 11 BIT NUMBERS TOGETHER. SIGNED ANSWER IS ACCURATE TO 10 BITS.
CONFIGURATION—MINIMUM 160 COMPUTER.

11.03 INTEGER DIVIDE (DIVINT)
DIVIDES A POSITIVE 23 BIT INTEGER BY A POSITIVE 11 BIT INTEGER,
GIVING A 12 BIT QUOTIENT WITH AN 11 BIT REMAINDER.
REPEATED SUBTRACTIONS ARE USED.
CONFIGURATION—MINIMUM 160 COMPUTER.

11.04 FRACTIONAL ARITHMETIC - 22 BIT
ADDS, SUBTRACTS, MULTIPLIES OR DIVIDES POSITIVE OR NEGATIVE BINARY FRACTIONS.
CONFIGURATION-MINIMUM SWAP 160 OR 160-A.

11.05 NINE BIT QUICK SINE
OBTAINS THE SINE OF ANY ANGLE LESS THAN 90 DEGREES.
ACCURATE TO 9 BITS. USES 11.02.
CONFIGURATION-MINIMUM 160 OR 160-A COMPUTER.

11.06 MATRIX INVERSION
SUBROUTINE IS WRITTEN IN 160 FORTRAN (160 FORTRAN-A) FOR FINDING THE INVERSE OF A SQUARE MATRIX.

11.07 PROGRAM STRUCTURE
DETERMINES ALL THOSE PERMUTATIONS WHICH LEAVE A STRUCTURE (S>R) INVARIANT, AND ALL THOSE PERMUTATIONS
RHO WHICH LEAVE (S,R) SELF-DUAL.
CONFIGURATION-MINIMUM SWAP 160-A.

J1.00
LINEAR PROGRAM I
FORTRAN. USES THE SIMPLEX METHOD. THE INPUT DATA MUST
IMPLY A FIRST FEASIBLE SOLUTION.
CONFIGURATION-MINIMUM SWAP 160 OR 160-A.

AJ1.01
EQUATION SOLVER
FORTRAN. SOLVES 30 LINEAR EQUATIONS WITH 30 UNKNOWNS.
A MODIFIED GAUSSIAN ELIMINATION METHOD IS USED.
CONFIGURATION-MINIMUM SWAP 160 OR 160-A.

AK1.01
SPIRALLED WAY ALIGNMENT
COMPUTES THE ALIGNMENT AND CURVE DATA FOR A HORIZONTAL
ALIGNMENT CONTAINING SPIRALS AND CIRCULAR CURVES IN
ANY COMBINATION.
CONFIGURATION-MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK1.02
TRAVERSE ADJUSTMENT
FOR THIS PROGRAM, A TRAVERSE IS DEFINED AS A SERIES OF
MEASURED DISTANCES AND DIRECTIONS, STARTING FROM A POINT
OF KNOWN COORDINATES, AND TERMINATING AT A POINT OF KNOWN
COORDINATES. THE PROGRAM PROVIDES FOR THE OUTPUT OF EITHER
THE ADJUSTED OR UNADJUSTED TRAVERSE (ACCORDING TO COMPASS
RULE).
CONFIGURATION-MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK1.03
LINES AND CIRCLE
THIS PROGRAM CONSISTS OF THE FOLLOWING FIVE INDEPENDENT
PARTS. THE KNOWN DATA MAY BE LOCATED IN ANY ONE OF FOUR
QUADRANTS.
PART 1 - INTERSECTIONS OF TWO LINES
PART 2 - INTERSECTION OF LINE AND CIRCLE
PART 3 - DISTANCE AND BEARING
PART 4 - HEIGHT OF TRIANGLE
PART 5 - TANGENT, ARC, AND SEGMENT
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK1.04
TRANSFORMATION OF COORDINATES
THIS PROGRAM WILL ROTATE AND TRANSLATE THE COORDINATES OF
SERIES OF POINTS WHICH DEFINE AN ENCLOSED AREA OR TRAVERSE,
COMPUTE THE BEARINGS AND DISTANCES BETWEEN THESE POINTS, AND
FIND THE AREA ENCLOSED.
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.
AK2.01 SINGLE PROFILE
GIVEN BASIC DATA TO DEFINE THE VERTICAL ALIGNMENT OF A HIGHWAY THE PROGRAM WILL COMPUTE ALL THE REQUIRED DATA AND ELEVATIONS AT EVEN INCREMENTED STATIONS.
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK4.01 COMPOSITE BEAMS
DESIGNS INTERIOR OR EXTERIOR STEEL BEAMS FOR SIMPLE SPAN HIGHWAY BRIDGES. THE FIRST PART COMPUTES A SOLUTION FOR INTERIOR BEAMS, THE SECOND PART COMPUTES A SOLUTION FOR FASCIA OR EXTERIOR BEAMS. EACH PART MAY BE RUN INDEPENDENTLY.
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK5.01 HORIZONTAL ADJUSTMENT
IT IS DESIRED TO OBTAIN MAP OR GRID COORDINATES OF PHOTOGRAMMETRIC POINTS, NAMELY THE HORIZONTAL PASS POINTS, AS THE RESULTS OF STEREOTRIANGULATION. THE MAP COORDINATES OF HORIZONTAL CONTROL POINTS ARE GIVEN. THE INSTRUMENT COORDINATES OF THE CONTROL POINTS AND THE PASS POINTS ARE OBSERVED FOR A TRIANGULATED STRIP OF CONTROLLED PHOTOGRAPHY.
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.

AK6.01 SOIL CONSOLIDATION
COMPUTES THE SETTLEMENT OF N LAYERS OF SOIL WITH A MAXIMUM OF FOUR LAYERS AND A SURCHARGE LOAD PLACED IN N NUMBER OF LIFTS WHICH COULD BE TOTALLY OR PARTIALLY REMOVED.
CONFIGURATION - MINIMUM SWAP 160-A, 161 TYPEWRITER.

L1.01 STATISTICAL PROGRAM 1
PRODUCES THE MEANS AND STANDARD DEVIATIONS FOR TWO SETS OF VARIABLES AND THE CORRELATION BETWEEN CORRESPONDING ENTRIES IN THE TWO LISTS. FORTRAN.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A COMPUTER.

L1.02 STATISTICAL PROGRAM 2
LINEAR REGRESSION ROUTINE WHICH PRODUCES QUANTITIES FOR TWO SETS OF VARIABLES.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A COMPUTER.

L1.03 STATISTICAL PROGRAM 3
TEST OF NORMALITY IN A FREQUENCY DISTRIBUTION OF LARGE SIZE.
CONFIGURATION - MINIMUM SWAP 160-A OR 160 COMPUTER.

L1.04 STATISTICAL PROGRAM 4
PRODUCES THE MEAN AND STANDARD DEVIATION FOR A SINGLE VARIABLE. FORTRAN.
CONFIGURATION - MINIMUM SWAP 160 OR 160-A COMPUTER.

L1.05 STATISTICAL PROGRAM 5
PRODUCES THE BASIC STATISTICAL BUILDING BLOCKS FOR A THREE-DIMENSIONAL SAMPLE-SPACE, I.E., SUMS, SUMS OF SQUARES AND SUMS OF CROSS PRODUCTS. FORTRAN.
CONFIGURATION - MINIMUM SWAP 160 OR 160A COMPUTER.

L1.06 STATISTICAL PROGRAM 6
PRODUCES THE PERCENTILES AT 5 PERCENT INTERVALS AFTER SORTING THE ORIGINAL DATA INTERNALLY. FORTRAN.
CONFIGURATION - MINIMUM SWAP 160 OR 160A COMPUTER.

L1.07 STATISTICAL PROGRAM 7
PRODUCES AND OUTPUTS EITHER THE T-TEST VALUE FOR EQUAL-SIZED SETS OR THE T-TEST VALUE FOR UNEQUAL-SIZED SETS, DEPENDING ON WHETHER THE SETS ARE EQUAL OR UNEQUAL IN LENGTH.
CONFIGURATION - MINIMUM SWAP 160-A OR 160 COMPUTER.

Z1.00 SINGLE PRECISION FRACTIONAL SQUARE ROOT (DEMSQR)
FINDS THE SQUARE ROOT OF A PROPER FRACTION WITH MAXIMUM ERROR OF 2 TO THE MINUS 11.
CONFIGURATION - MINIMUM 160 COMPUTER.

Z1.02 RANDOM NUMBER GENERATOR (12 BIT) (DERRGN)
PRODUCES 12 BIT RANDOM NUMBERS. WILL GENERATE 2,560,000 NUMBERS WITHOUT REPEATING. OUTPUT IS DISPLAYED IN REGISTER A.
CONFIGURATION - MINIMUM 160 COMPUTER.

23.00 ALNUP
ROUTINE PUNCHES CHARACTER MESSAGES IN PAPER TAPE THAT ARE LEGIBLE TO AN UNSKILLED OBSERVER.
CONFIGURATION-160 CODED FLEXOWRITER. 160 COMPUTER WITH PAPER TAPE INPUT AND OUTPUT.
TRAJECTORY CALCULATION
GIVEN THE TARGET RANGE, THE VELOCITY OF THE PROJECTILE,
AND ITS ANGLE OF INCLINATION, THE PROGRAM WILL PLOT THE
PATH OF THE PROJECTILE ON THE TYPEWRITER.
CONFIGURATION-MINIMUM 160-A AND TYPEWRITER.

MORTGAGE AMORTIZATION
THE PROGRAM HAS TWO OPTIONS - 1. COMPUTES THE MONTHLY
PAYMENT NECESSARY TO AMORTIZE A GIVEN PRINCIPAL AMOUNT
AT A GIVEN INTEREST RATE FOR GIVEN DURATION, AND
2. COMPUTES THE DURATION NECESSARY TO AMORTIZE A GIVEN
INTEREST RATE WITH A GIVEN MONTHLY PAYMENT.
CONFIGURATION-MINIMUM SWAP 160-A, 161 TYPEWRITER.
A2.

IDENTIFICATION

Title: Paper Tape Edit - Ident. A2.01A
Programmer: Harold C. Schnackel, February 1961

PURPOSE

This program permits changes to be made to symbolic paper tapes prepared for assembly via FLAP, or OSAS. Changes may be in the form of replacements, insertions, or deletions of complete lines relative to the tape to be corrected.

USAGE

1. Operational Procedure

   a. Machine load biocital program tape at location 0000.

   b. Position correction tape in reader, master clear, and run.

   c. When correction tape has stopped, position the tape to be corrected in the reader, and run. The original tape will read in and the corrected tape will be punched out.

   d. NORMAL STOPS (OCTAL)

      0657: Correction tape has been read in correctly, RUN from here to read tape to be corrected.

      1067: WAI pseudo-op on the original tape has been encountered. If more input is to be processed, RUN. If no more input is to be processed, make the A-Reg. non-zero and RUN. This will complete output punching and indicate if all corrections have been processed.

      1106: END pseudo-op has been encountered or WAI has been previously encountered. The input tape has been edited completely. This is the final normal stop.

3. Space required

   a. Program plus transient storage occupies locations 0000 through 1232.

   b. Input from the correction tape occupies locations 1467 through 7776 as needed.

   c. Locations 1267 through 1466 are reserved for output characters.
7. ERROR STOPS (OCTAL)

0512: There was an error in the edit tape; a line was referenced incorrectly. Continuation will cause the current correction code to be bypassed and the next to be processed.

0572: Computer capacity for holding the corrections has been exceeded. Corrections must be reorganized into two or more passes.

0755: A non-digit character, with the exception of blank, space, and delete code, is present in the additive field of a correction code line. Correction tape must be corrected.

1032: No correction code found - machine error.

1057: An illegal edit code (outside the set d, i, r, z) has been encountered. Restart after correcting correction tape.

1107: Corrections not completed. RUN to punch out correction code not processed.

1207: Final error stop after 1107 has been reached.

10. Input and Output Formats

FLAP and OSAS formats may be used on the tape to be corrected. The format of a correction specification line on the correction tape is as follows:

a. Tab

b. A letter of the set d, i, r, z where
   d = delete. The delete code followed by two minus signs (--) in the address field and n in the additive field will cause n lines of information to be deleted from the symbolic paper tapes.
   i = insert
   r = replace
   z = end of correction tape

c. Tab

d. Location symbol on original tape

e. Tab

f. Pure decimal digit address relative to the location symbol. The
absence of a location symbol means that this numerical quantity is an absolute line count.

g. Carriage Return

The following example illustrates formats of input and output tapes. Symbolic tape to be corrected:

```
abcd  ldf  qxr
  adn  22
  sbf  qxr
  sti  cntr
  ldf  02
  jfi  02
      next
      subr
next  aod  cntr
  zjf  01
  jpi  xyz
  hlt  00
  end
```

Corrections to be applied:

```
  r  abcd  1
add  XYZ
  d  --  3
  i  abcd  7
aod  stu
  zjf  05
  d  --  2
d  next  1
d  --  1
z
```

Corrected Symbolic Tape:

```
abcd  ldf  qxr
  add  xyz
  jfi  02
      next
aod  stu
  zjf  05
  hlt  00
  end
```

12. Cautions to user:
   a. Tape to be corrected must begin with a carriage return.
   b. Tape containing the corrections must begin with a carriage return.
   c. Any character in the additive field of the correction specification line that is not of the set (null, space, digit, delete code) will cause an error stop.
   d. The additive field of the correction specification line may be terminated only by a carriage return.
   e. The correction specification line identification, i.e., the symbol and additive fields, is always relative to the original program listing.
   f. When the block delete code immediately follows a d or r code, the n lines following the line referenced by the d or r code will be deleted.
   g. When the block delete code immediately follows an i code, n lines including the line referenced by the i code will be deleted.
   h. There may be any number (within the capacity of the Edit Program) of consecutive insertions or replacements following a single insertion or replacement code.
   i. A replacement of line n with m new lines is equivalent to deleting line n and inserting the m new lines at n + 1.
   j. An insertion results in a line or lines inserted AHEAD of the line specified in the correction code.
   k. The order of corrections (correction line identification) must be according to the original list.
   l. The symbolic identification of a line of the original listing must be made either by the location symbol of the line itself or by relative reference to the last symbol preceding the line.
   m. The same line in the original listing may not be referenced by more than one correction code.
   n. To facilitate editing symbolic tapes to be assembled by FLAP, a plus or comma symbol in the location Field of the original tape will be ignored as a tag.

14. Equipment configuration: Minimum SWAP 160 Computer
IDENTIFICATION

Title: Magnetic Tape to Flex Tape - Ident. A3.02
Programmer: J. A. Pederson, April 1961

PURPOSE

Convert 60 character BCD coded information on magnetic tape in format of
OSAP card input. This tape is suitable for listing on a Flexowriter and
as input to the paper tape version of OSAP.

USAGE

1. Operational Procedure
   a. Load program tape
      1. Turn on reader and insert S 028
      2. Master Clear
      3. Set Load-Clear switch to LOAD
      4. Run (P=0000)
   b. Load magnetic tape
      1. Place tape to be converted on tape unit
      2. Select tape unit 1
      3. Select CODED mode
      4. Set to Load Point
   c. Turn on punch
   d. Set P = 0000
   e. Run
   f. Routine stops when end-of-file is read

3. Space Required: 3308 = 21610 locations

7. Error Stops: Parity errors cause the routine to re-read tape three times
   before stopping.

13. Cautions to User: Inspect first frame on Flex tape output for carriage
    return (45).
A3.
IDENTIFICATION

Title: OSAP Symbolic Flex Tape to Cards - Ident. A3.03 (SYMCORD)
Programmer: J. Emmet Murphy, January 1962

PURPOSE:
To convert OSAP Symbolic Flex tapes to Hollerith cards.

USAGE:
1. Operational Procedure
   a. Machine load biptal program tape at zero.
   b. Clear console and set any of the desired suppression codes in the A-register:
      4000 - suppress card sequencing
      2000 - suppress reading and converting flex tape
      (sequence cards only)
      If no suppression codes are used, the program will convert the Flex tape to sequenced, Hollerith cards.
   c. Load Symbolic Flex Tape to be converted and run.
   d. After final halt, load the next tape to be processed and continue as follows:
      1) For continuous sequencing, run from final halt (loc. 1708).
      2) To re-initialize, clear, set parameters in A-register and run.

7. Error Stops:
   41k8 - too many suppression codes: suppress everything.
   4638 - card punch not ready.

10. Timing:
    Maximum Punch speed.

13. Configuration:
    Minimum 160 or 160-A computer, 1610 and 523 Card Punch.
Title: Binary Loader for FPP-33 Input - Ident. A4.11A

PURPOSE

This routine loads binary object program tapes prepared by FLAP (A1.02). Programs loaded by this routine are stored into memory and are ready for execution by FPP-33 (B1.00).

The binary object program tapes prepared by FLAP are relocatable. This means that if the programmer follows certain rules, then the FLAP binary object program can be loaded and executed from 160 memory locations other than those specified in the symbolic input.

USAGE

1. Operating Procedure:
   This routine is in 7400-7743 of FPP-33.
   a. Turn on reader.
   b. Position FLAP binary object program tape in paper tape reader.
   c. Set (A) = b, where b is the relocation constant.
   d. Set P = 7400
   e. Run
   f. Normal Stop:
      \[ P = 7541 \quad Z = 7700 \]
      At the normal stop (A) = S where S is the 1604 address specified in the M-term of the END pseudo-instruction in the assembled program. If no address is specified, then S is zero. Normally S will be the starting address of the program to be simulated.
      If S is in the A register, then running from normal loader stop (7541) will enter the simulator and begin execution of the program just loaded.


7. Error Stops:
   \[ P \quad Z \quad \text{Reason} \]
   a. 7404 7701 Bias quantity (b) is greater than 10008.
   b. 7416 7702 Incorrect binary tape label, i.e. the first non-blank frame encountered does not contain punches in levels 1 thru 6.
8 February 1963

<table>
<thead>
<tr>
<th>P</th>
<th>Z</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. 7507</td>
<td>7703</td>
<td>Current load address out of range. NOTE: FLAP is capable of assembling programs that cannot be run under control of FPP-33.</td>
</tr>
<tr>
<td>d. 7522</td>
<td>7704</td>
<td>Checksum error, bit run to ignore checksum error and go to normal stop.</td>
</tr>
<tr>
<td>e. 7766</td>
<td>7713</td>
<td>Illegal decimal number. Run to get error print-out as in simulator.</td>
</tr>
</tbody>
</table>

10. Timing:
The tape will be loaded at full tape speed unless DEC pseudo-ops were included in the assembly. When a decimal number is encountered, the loader must convert it to FPP-33 floating point format before storing.


METHOD

The loader examines two frames of the FLAP binary output tape at a time. The seventh level bits are used to signify whether the information is a new load address, FPP-33 instructions to be stored, checksum, or a DEC number carried along by FLAP.

When a load address is encountered, the previous load address is replaced by that one. When 1604 instructions are encountered as binary information, they are stored sequentially starting at the last load address specified. If a DEC number is encountered, FPP-33 conversion routines are used to prepare it into FPP-33 floating point format and the result stored. The checksum consists of the last two frames on the binary tape.
AD1.01

IDENTIFICATION

Title: Floating Resident Service Library - Ident AD1.01
Programmer: A. Perro, December 1961

PURPOSE

Load memory from punched paper tape or the on-line electric typewriter; or
dump the contents of the memory on punched paper tape or the on-line typewriter.
The accuracy of the punched paper tape may be verified. Selection of input
or output option is made at the console.

The following subroutines are callable from the resident service library:

- Bi-Octal Punch
- Bi-Octal Verify
- Flex Tape Load
- Flex Tape Punch
- Flex Tape Verify
- Type Load
- Type Dump

USAGE

1. Operational Procedure

a. Load the program tape for RESERV as follows:

1) Turn on the reader and insert the program tape anywhere on the
blank leader.

2) Lift load - clear switch in LOAD position and set P = to any
desired location, X.

3) Press run switch.

4) Computer stops
   
   \[ P = X + 572 \]
   \[ A = 4210 \]

b. Type load - used to store data received from the on-line electric
typewriter.

1) Turn on electric typewriter.

2) Put operation mode switch into CLEAR position.

3) Press operation mode switch into COMPUTER position. The ready
light should be on and the input request light off.
4) Check to ensure input disconnect switch is in center position.

5) Set $P = \text{initial address of RESERV (X)}$.

6) Press run switch. The status indicator will immediately show an input (IN) condition. The input request light and the ready light on the typewriter cabinet will also be on.

7) Type in instructions and data using the format described in the Flex Tape Load program.

8) Discrepancy - computer stops

$$P = X + 3638$$
$$A = \text{address of discrepancy}$$
$$Z = 0000$$

To continue the program press the run switch after returning it to the center position.

9) End of file code - a period typed after the last carriage return causes the program to stop.

$$P = X + 3048$$
$$Z = 7700$$

10) To repeat the program press the run switch after returning it to the center position.

c. Type Dump - produces listings of programs directly on the on-line electric typewriter.

1) Turn on typewriter.

2) Put operation mode switch in the CLEAR position.

3) Put operation mode switch in the COMPUTER position.

4) Check to ensure input disconnect switch is in the center position.

5) Set $P = \text{initial address + 3 of RESERVE (X + 3)}$.

6) Press run switch.

7) After first stop set bank selection in right most 3 bits of A. Run.

8) After second stop set $A = \text{initial address to be dumped}$. Run.
9) After third stop set A = last address to be listed. Run.

10) Type dump will produce the specified listing allowing up to 48 individual listings on each page, with a double space preceding each listing group whose initial address is divisible by eight. Each listing contains a tab followed by (4 digits) which is the information. Address locations appear only at the beginning of each 10\textbf{0} group of listings. Computer stops to allow the operator to change paper.

11) End of Page

\begin{align*}
P &= X + 5468 \\
A &= 0000 \\
Z &= 7700
\end{align*}

Continue by pressing the run switch after returning it to the center position.

12) Program stop - typewriter shows listing is completed by an end of file code (carriage return followed by a period).

\begin{align*}
P &= X + 5678 \\
A &= 7677 \\
Z &= 7700
\end{align*}

d. Floating Flex Load - load previously prepared Flex coded paper tape in specified memory locations.

1) Turn on reader and insert tape to be loaded somewhere on the blank leader.

2) Set \( P = \text{initial address} + 6 \) of RESERV \((X + 6)\).

3) Press run switch - program will store and check the information following the first carriage return character on the tape.

4) Computer stops on finding a discrepancy

\begin{align*}
P &= X + 363 \\
A &= \text{address at which discrepancy occurred} \\
Z &= 0000
\end{align*}

5) Program stop

\begin{align*}
P &= X + 3048
\end{align*}
Characters 0-7, carriage return, tab, and period are recognized by the program. All other non-printing characters are ignored by the program. A carriage return defines the beginning of a line.

Tape may be prepared in a nine digit format giving the bank designator followed by the four digits of the address followed by the four digits of the instruction or constant. A space or tab may or may not be inserted between the address and the data in this format. An eight digit format may be used but a TAB MUST SEPARATE THE ADDRESS FROM THE DATA and the program will store the information in the INDIRECT BANK which the operator manually sets. The program always takes the last four characters and stores them at the address specified by the first four characters.

Tape may also be prepared in a four digit format in which a carriage return followed by a tab followed by four characters of data make up a line. The program will take the four characters and store them at the next consecutive memory location following that at which information was last stored. If an insufficient number of digits in either format is present on a line, the data on that line will be ignored. A period appearing after a carriage return or a tab is interpreted as an end of file code and will cause the program to stop.

The following is an example of format supplied to Flex Tape Load:

<table>
<thead>
<tr>
<th>Address</th>
<th>Instruction</th>
<th>Comments on Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>1463</td>
<td>3051</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4163</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5410</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>6550</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4310</td>
<td></td>
</tr>
<tr>
<td>4306</td>
<td>0112</td>
<td></td>
</tr>
<tr>
<td>5060</td>
<td>0277</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1793</td>
<td>* (period causes program to stop)</td>
</tr>
</tbody>
</table>

The Flex Tape Load program would cause the following information to be stored in memory:

<table>
<thead>
<tr>
<th>Location</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1463</td>
<td>3051</td>
</tr>
<tr>
<td>1464</td>
<td>4163</td>
</tr>
<tr>
<td>1465</td>
<td>5410</td>
</tr>
<tr>
<td>1500</td>
<td>6550</td>
</tr>
<tr>
<td>1501</td>
<td>4310</td>
</tr>
<tr>
<td>4306</td>
<td>0112</td>
</tr>
<tr>
<td>5060</td>
<td>0277</td>
</tr>
</tbody>
</table>
The last entry is missing because the program ignored the 9 and rejected the data because only three recognizable characters were left on the line.

e. Flex Tape Punch - produce paper tape listings of a program suitable for off-line printing on a Flexowriter or re-entry into the computer via the Flex Load option.

1) Turn on punch.
2) Set P = initial address + 14 of RESERV (X + 14)
3) Press run switch
4) After first stop (X + 413) set bank selection in A. Run.
5) After second stop (X + 421) set A = initial address to be listed. Run.
6) After third stop (X + 424) set A = last address to be listed. Run.
7) Program stop

\[ P = X + 567 \]

Flex tape punch will produce the specified listings allowing up to 48 listings on each page, with a double space preceding each listing with an address divisible by eight. Each listing contains a tab followed by (4 digits) which is the information. Address locations appear only at the beginning of each 10 group of listings.

f. Flex Tape Verify - verify the accuracy of a tape prepared by Flex Tape Punch.

1) Turn on reader
2) Insert Flexowriter tape into reader someplace on the blank leader.
3) Set P = initial address + 11 of RESERV (X + 11)
4) Press the run switch. On encountering a carriage return the program will begin assembling information according to the format rules given under Flex Tape Load. It will check this information against the current contents of the specified area memory. To verify a previously prepared tape proper indirect bank selection may be made.
5) Discrepancy - computer stops

\[ P = X + 3638 \]
\[ A = \text{address of discrepancy} \]
\[ Z = 0000 \]

Press run switch after returning it to center position. Program will continue to check the rest of the tape.

6) Program stop

\[ P = X + 3048 \]
\[ Z = 7700 \]

g. Floating Bi-Octal Punch - punch out portions of the 160-A memory bi-octal format.

1) Start punch motor

2) Master Clear

3) Manually set the last octal digit of A to the memory bank from which you wish to punch data

4) Set \( P = \text{initial address } + 17 \) of RESERV \((X + 17)\)

5) Press Run switch

6) Computer stops

\[ P = X + 44 \]
\[ Z = 7700 \]

7) Set \( A = \text{initial address of the region to be punched} \)

8) Press run switch after returning it to the center position

9) Computer stops

\[ P = X + 47 \]
\[ Z = 7700 \]

10) Set \( A = \text{last address to be punched} \)

11) Press run switch after returning it to the center position

12) Program stop

\[ A = X + 36 \]
\[ Z = 7700 \]
h. Floating Bi-Octal Verify - verify accuracy of a tape prepared by Bi-Octal Punch.

1) Set \( P = \text{initial address} + 21 \) of RESERV \((X + 21)\)

2) Set \( A = \) first data word location on the tape; set indirect bank to the bank where data is to be verified

3) Turn on reader and insert tape

4) Press run switch

5) Discrepancy stop

\[
P = X + 143
A = \text{address of discrepancy}
Z = 0000
\]

6) Format error on the tape

\[
P = X + 141
Z = 0
\]

The tape must be removed because the computer will not accept the remainder.

7) Program stop

\[
P = X + 104
Z = 7700
\]

2. Space Required: \(572_8 = 378_{10}\) locations

3. Timing

Output, approximately 110 frames per second
Input, approximately 350 frames per second

4. Cautions to User: Off line prepared Flexowriter tapes must start with a carriage return, code 45; input from typewriter must also start with a carriage return.

IDENTIFICATION

Title: Magnetic Tape Bootstrap 160-A - Ident. AD1.02
Programmer: David W. McIlhenny, May 1962, Fleet Numerical Weather Facility

PURPOSE

The bootstrap program is used to keep itself and programs or data on magnetic tape (163-2 units) in order to eliminate paper tape handling. The bootstrap may be loaded and blocks written or read by simple console entry of pertinent data.

USAGE

1. Operational Procedure

   a. To load bootstrap from magnetic tape:

      (1) Magnetic tape with bootstrap rewound on unit 4

      (2) Set tapes to binary

      (3) Enter the following sequence beginning at location 0000:

         7500
         2134
         7203
         7400
         7700
         7100

      (4) Clear, start at 0000

   b. To load bootstrap from paper tape:

      (1) Clear, load paper tape at location 7100 using binary loader.

   c. To write a record on tape:

      (1) Clear, P = 7100 set A = bank number, start

      (2) P = 7110 set A = first address of block, start

      (3) P = 7113 set A = last address + 1 of block, start

      (4) P = 7117 set A = record number, start

   d. To read a record from tape:

      (1) Clear, P = 7220 set A = record number, start
3. **Space Requirements**

277 words octal
191 words decimal
program is assembled in bank 0  7100-7377

7. **Stops**

a. 7332 - Final stop both read and write

b. 7307 - Read end of file

   **On Read:** This block is not on the tape.
   **On Write:** There are not enough records to make this the one desired.

c. If tape rocks continually, the program is having difficulty in reading or writing the record desired. Put stop switch 4 up to stop rocking. The program will stop at P = 7271 with the type of error in the A register:

   A = 0004 parity  
   A = 0020 read end of file; record is not there  
   A = any other; check sum is bad on read

9. **Tape Mounting**

The bootstrap uses tape unit 4 in binary.

12. **Cautions to User**

a. The bootstrap cannot be used to load information into locations 7100-7377 of bank 0. It may be reassembled to do so, but must be in bank 0.

b. Do not try to insert a block in the middle of a series. For example do not rewrite block 3 of a tape containing 5 blocks; the ones subsequent to 3 would be destroyed.

c. Do not step through program.

14. **Equipment Configuration:** Minimum SWAP 160-A and 163 Tape

**METHOD**

1. A maximum of safeguards, such as extra waits, are incorporated for dependability. Records are checked for both lateral parity and longitudinal checksum.
2. The bootstrap writes itself on the tape as a "flag" record when writing block 0. It searches for itself in order to synchronize when reading. Blocks are written with a 5 word identification record preceding each one. An end of file is written after a block when the write operation is performed.
Title: Simultaneous Card-to-Tape, Tape-to-Print Program (SDX0)

Purpose

Provides a peripheral processing system which fully utilizes the capabilities of the 160-A Computer by running a card-to-tape operation simultaneously with a tape-to-printer operation. About 90% of maximum speed is obtained.

Usage

1. Operational Procedures
   Load the bi-octal tape into bank 0 starting at 0000. Master Clear, start at 0000 with OMXY in the A-register as in 2 below.

2. Parameters
   OMXY as follows:
   
   \[ \begin{array}{c|c}
   \text{W} & \text{Card-to-tape} \\
   \text{X} & \text{Tape-to-print} \\
   \text{Y} & \text{Use carriage control for tape-to-print} \\
   \end{array} \]

   \[ \begin{array}{c|c}
   =1 & \text{no card-to-tape} \\
   =1 & \text{no tape-to-print} \\
   =1 & \text{single space tape-to-print} \\
   =1 & \text{double space tape-to-print} \\
   =1 & \text{triple space tape-to-print} \\
   \end{array} \]

   The Y parameter may be entered even though tape-to-print is not selected (i.e., \( X = 0 \)). This allows subsequent starting of the tape-to-print operation by means of jump switch control (See 10.c.2.).

   At each program stop A = 0000. A new OMXY parameter may be inserted in A at that time, or A may be left 0000 to continue using the previous parameter. See Appendix 4 for full discussion of program stops.

3. Space Required
   \[ 4125_8 = 2133_{10} \text{ locations in bank 0} \]
   \[ 1464_8 = 820_{10} \text{ locations in bank 1} \]

5. Bank Allocation
   Upon entry to the routines the direct, indirect, and buffer bank settings have been set to 1, and the relative bank is 0. Do not change these bank settings.
7. Program stops

Ten program stops are provided to indicate various error conditions, jump switch settings, and end-of-operation conditions. See Appendix 4 for discussion of stops.

9. Tape Mountings

a. Output tape, for card-to-tape operations, selection 1.
b. Input tape, for tape-to-print operations, selection 2.

10. Formats

a. Input, card-to-tape

1. BCD cards. Standard 80-column card with punching as per standard Hollerith set.

2. Binary cards. Standard column binary card, 7-9 punch in column 1.

3. End-of-File Card

Column 1 and 2 7-8 punches
Column 3 and 4 12-1-4-7 punches
Columns 5 through 5 blank

The end-of-file card terminates the card-to-tape operation, after causing an end-of-file mark to be written on tape 1. (During simultaneous operations the tape-to-print portion will continue.) See Appendix 1 to change the end-of-file card configurations. Cards are read from primary read station only.

b. Output, card-to-tape

1. BCD card images

80 character BCD image in even parity plus 8 look-ahead characters as follows:

20 20 20 20 20 20 20 20 if the next image on tape is a BCD image in even parity.

11 11 07 07 20 20 20 20 if the next image on tape is binary image in odd parity.

2. Binary card images

160 character binary image in odd parity plus 8 look-ahead characters as follows:

00 04 00 00 00 01 00 00 if the next image on tape is a BCD image in even parity

00 05 00 01 00 05 00 04 if the next image on tape is a binary image in odd parity
See Appendix 2 for discussion of changing the character size of the images, and of changing or eliminating the look-ahead characters.

3. Input format, tape-to-print

Maximum 120 character records in even parity. An end-of-file mark or end of tape reflective marker will stop the tape-to-print operation (during simultaneous operations the card-to-tape portion will continue.) If the carriage control feature of the program is used, the first character of the record is the control character.

4. Output format, tape-to-print

Maximum 120 character line (same length as input record) printed. The first tape character in print position 1, the second in print position 2, etc. The first character is printed as blank if carriage control mode is selected.

5. Carriage control character.

The program recognized the following carriage control characters.

018 Skip to Format Channel 8 (page eject)
028 Skip to Format Channel 7
128 Double space
208 Single space
408 Triple space

All spacing and channel skipping is interpreted as spacing before printing.

Provision has been made to allow Monitor channel skipping and other interpretations of carriage control characters. See Appendix 3 for full discussion.

c. Selective Stop and Selective Jump Switches

1. Selective Stop Switches: Not used.
2. Selective Jump Switches:

# 1 = in the Up position program will start simultaneous operations if a card-to-tape only or a tape-to-print only operation is in progress. For this option to be available, Jump switch #1 must be at least momentarily in the neutral position.

#2 - Not used
#4 - in the UP position, program will stop. See Appendix 4.
11. Timing
   a. Card-to-tape operations: 650 cards per minute.
   b. Tape-to-print operations: 1000 lines per minute, maximum.
   c. Simultaneous operations proceed with an overall speed of
      approximately 90-95% of maximum.

13. Cautions to User
   Do not step through this routine. Do not take computer out of RUN.
   To stop the program use jump switch #4 as in 10.c.2.

14. Equipment Configuration
   160-A - Minimum SWAP Configuration
   163-2 - on normal channel
   1612 - on normal channel
   1610 - (with 088 card reader) - buffer channel

   Tapes are written and read in character (6-bit) mode only.

A Note on the Programming Appendices

Provision has been made for this program to be easily adapted to meet the
requirements of any installation. Changes may be made to the routines for
1) the end-of-file card, (2) the look-ahead characters and tape record length,
and (3) tape-to-print carriage control interpretations. Each of these has
been placed near the end of the program so that they may be found easily
by the programmer.

Upon entry to the routines the direct, indirect, and buffer bank settings
have been set to 1, and the relative bank is 0. Do not change these bank
settings. Except where noted, contents of the A-register upon entry or
leaving these routines need not be guaranteed.

Temporary storage for the routines may be made available by reserving
locations in the relative bank 0, and referencing them with relative forward
and relative backward mode instructions. Direct storage locations 00 and 77
are also available, as these are not used by the main program. In addition,
at least two other direct storage locations may be changed by the programmer,
as noted in the appendices. Unless otherwise allowed, changing of other
locations is not permitted.
APPENDIX I

Programming for the End-of-File Card

The End-of-File card must appear as an illegal BCD card, that is, not both rows 7 and 9 in column 1 may be punched at least one non-Hollerith punch combination must appear on some card column.

When the illegal punch combination is recognized, the program transfers to location CDCK9 to determine if this is an End-of-File card or an illegal BCD card. The check is to be made on the actual card image in memory. Direct storage locations TIOC contains the address of the first 12-bit word (9 row left) of the card image. The card image is located in 84 consecutive addresses and is to be examined to determine if it is that of an End-of-File card.

If the card image is that of an End-of-File card, return to the main program at location EOFORD; otherwise return to location ERRORD.

Direct storage locations available for changing: CSRR and TEMP2.
APPENDIX 2

Programming for look-ahead characters and tape record length.

The length of the tape record written by the card-to-tape portion of the program is composed of two parts: (1) the number of characters in the tape-image - 80 for BCD records and 160₁₀ for binary records, plus (2) the number of look-ahead characters. The tape record character length is kept in direct storage locations BCDING for BCD records and BINLING for binary records. These direct storage locations are set during normal start at 0000 procedures, at locations (0)0010 and (0)0013. The record length may be changed by the programmer, but records longer than 176₁₀ characters are forbidden.

The main program determines the card type (BCD or binary) of the current and next card image and following the conversion to a tape image transfers to one of the four following routines for insertion of look-ahead characters:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCDBCD</td>
<td>if a BCD card image will follow current BCD card image</td>
</tr>
<tr>
<td>BCDBIN</td>
<td>if a binary card image will follow current BCD card image</td>
</tr>
<tr>
<td>BINBIN</td>
<td>if a binary card image will follow current binary card image</td>
</tr>
<tr>
<td>BINBCD</td>
<td>if a BCD card image will follow current binary card image</td>
</tr>
</tbody>
</table>

The look-ahead characters are to be stored in consecutive locations, 1 character to a computer word, placed in the low-order 6 bits of the word. (Tapes are written in the character mode only.) Direct storage location STORE, upon entry to the above routines, contains the location to store the first character.

It is not necessary to have any look-ahead characters; the tape record length may be set to 80 characters for BCD cards or 160₁₀ characters for binary cards. After setting the look-ahead characters, the routine must return to program location CDCl.

Direct storage locations available for changing: STORE and TEMP2.
APPENDIX 3

Programming for control of the 1612 printer carriage control tape.

If carriage control of the tape-to-print portion of the program is selected (parameter Y = 0 as in C.2 above), the program transfers to location TCKENT for each tape record read with the control code in both the A-register and direct storage location TCKSVK.

The TCKENT routine is to interpret the control character and return to the main program at location TCKHK5 with a parameter in the A-register as follows:

A = 0000   - single space
A = 4000   - skip to format Channel 8 (new page)
A = 2000   - skip to Format Channel 7
A = 1000   - skip one line (double spacing)
A = 0400   - skip two lines (triple spacing)
A = 0000   - skip to Monitor Channel P

All codes are interpreted as spacing before printing. Normal single spacing always follows every line printed. Skipping to Monitor Channels 1-6 is for the current tape record only; the selection is removed for subsequent records.

If carriage control mode is not selected (i.e., if parameter Y=1, 2 or 3 in C.2 above) the TCKENT routine is not entered. Instead the program maintains an internal count of the number of lines per page and page ejects when necessary. The number of lines used per page is stored in direct storage location LINES and is set during normal start at 0000 procedures at location (0) 0005. This parameter may be changed if required.
APPENDIX 3 (Cont.)

<table>
<thead>
<tr>
<th>Stop Location</th>
<th>If A=0000 upon restart will continue with</th>
<th>Reason for start</th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM CARD-TO-TAPE ONLY OPERATIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0063</td>
<td>Card-to-tape</td>
<td>Tape write EOT or bad spot on tape</td>
</tr>
<tr>
<td>0066</td>
<td>Card-to-tape</td>
<td>E-0-F card or illegal BCD card read</td>
</tr>
<tr>
<td>0071 *</td>
<td>Card-to-tape</td>
<td>Jump switch 4 set</td>
</tr>
<tr>
<td>FROM TAPE-TO-PRINT ONLY OPERATIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0074</td>
<td>Tape-to-print</td>
<td>Read tape EOT or EOT</td>
</tr>
<tr>
<td>0077</td>
<td>Tape-to-print</td>
<td>Jump switch 4 set</td>
</tr>
<tr>
<td>MISCELLANEOUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0102</td>
<td>Executes a start at 0000 operation</td>
<td>Illegal parameter (W=X=0)</td>
</tr>
</tbody>
</table>

* For the two stops at 0060 and 0071 a card has been read and its image is in memory. If A is non-zero upon restart and if parameter W=O, the card image will not be processed. A start at 0000 sequence will always cause loss of any information in core memory.
APPENDIX 4

Program Stops

Any tape-to-print operation started by the program has been completed at the
time of all program stops. All non-end-of-file tape records read have been
printed and the read tape is in position to continue reading with the next
record. If an end-of-tape reflective marker has been encountered, the tape
is in a rewind unload status.

A card has been read and its image is in core, but has not been processed at
the time of the jump switch 4 stops (0060 and 0071). At all other stops no
useable card image is in memory.

Following the processing of an end-of-file card, the write tape is positioned
immediately after the end-of-file mark written. After the error conditions
have been noted, the loss of information is inevitable and the position of
the write tape or of cards in the card reader cannot be predicted. If an end-
of-tape reflective marker has been encountered, the tape is in a rewind unload
status, but at least one record has been written beyond the end-of-tape marker.

At each stop the A-register is 0000. If the A-register is 0000 upon restart
the program will continue as per the chart below. If the A-register is non-
zero, the value will be interpreted as a new GWXY parameter (see 10.c.2.
above).

Stop Locations

<table>
<thead>
<tr>
<th>Stop Location</th>
<th>If A=0000 upon restart will continue with</th>
<th>Reason for stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0047</td>
<td>Simultaneous</td>
<td>Tape-to-print over and either tape write EOT or bad spot on tape.</td>
</tr>
<tr>
<td>0052</td>
<td>Tape-to-print</td>
<td>Tape write EOT or bad spot on tape.</td>
</tr>
<tr>
<td>0055</td>
<td>Simultaneous</td>
<td>Tape-to-print over and either E-0-F card or illegal BCD card read.</td>
</tr>
<tr>
<td>0060 *</td>
<td>Simultaneous</td>
<td>Jump switch 4 set</td>
</tr>
</tbody>
</table>
IDENTIFICATION

Title: Peripheral Integrated Utility System (PIUS) - Ident. AD2.03
Programmer: E. J. Rosenberg, July 1962, System Development Corporation

PURPOSE

To provide a program to correlate and control a library of 160A routines in an executive utility system.

USAGE

1. Operating Procedures

   A. General (applies to any of the following control methods)
      1. Load P.T. Bootstrap at 7750 in Bank 0.
      2. Mount PIUS Master Tape on logical tape drive 2.

   B. Typewriter Control
      1. Set selective jump 1.
      2. Clear and run.
      3. Type in 4 character name of desired routine. If less than 4, terminate with a period.

   C. Card Control
      1. Place control card in card reader
      2. Make card reader ready
      3. Clear and run.

   D. Program Control
      1. Either the subroutine "CALL" (see appendix 1) or one of similar nature must be assembled with the controlling program.
      2. The following locations in bank 1 must be respected:
         70 = Any parameters necessary in "A" upon entrance to requested routine.
         71 = 0 - to preclude card read selection
         72 = BCD code for 1st 2 characters of requested routine (assembly mode)
         73 = BCD code for 2nd 2 characters of requested routine (where name is of less than 4 characters substitute 0's in lieu of BCD 20 code)
         74 = 1 - flag to PIUS to indicate program control
         75 = Relocation address of requested program (where applicable).
3. Program utilizing this calling sequence must consider bank
selection (as listed in the directory) of desired routine
when jumping to it. The relative bank of the called routine
must be the same as that of the controlling program.

4. In the case of OSAS store the I/O configuration selections in
72 and 73, i.e., they become the routine name.

MESSAGES

A. Typewriter

1. NOT A CONTROL CARD. No asterisks in column 1.
   Make corrections and run.
2. PROGRAM REFERENCE ERROR. The program requested is not in
   directory. Try again.
3. READY THE I/O EQUIPMENT AND RUN. I/O routine has been selected.
   Stop and wait for magnetic tape, etc. Run to continue.
4. ENTER PARAMETERS. While under typewriter control, you must
   key into "A" desired parameters and run.
5. RELOCATE AT. Type in relocation address and run. If none, run.
6. TYPE IN YOUR I/O SELECTION AND RUN. OSAS has been requested.
   Type in your I/O configuration and run.

B. Printer

1. Control card image.

ERROR STOPS

3511 - A card other than a control card has been read. Clear the
   card reader, correct the control card, return to reader, and run.

NORMAL STOPS

3706 - Stop to allow I/O selection to be made. Run to continue.

3745 - Stop to allow input of Parameters. Run to continue.

TAPE ASSIGNMENTS

The PIUS MASTER will be assigned to logical tape drive #2. Consists
of 1 file with X + 2 records. (X = # of separate routines and programs
included.) The first record is PIUS Control, the second record is the
directory.
### CONTROL CARD

<table>
<thead>
<tr>
<th>Format:</th>
<th>Columns</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Asterisks</td>
<td></td>
</tr>
<tr>
<td>3-6</td>
<td>Routine name as designated in directory</td>
<td></td>
</tr>
<tr>
<td>9-12</td>
<td>Entrance parameters</td>
<td></td>
</tr>
<tr>
<td>25-28</td>
<td>Relocation address</td>
<td></td>
</tr>
</tbody>
</table>

### JUMP AND STOP KEY SELECTIONS

- **SLJ 1** - Typewriter control
- **SLJ 4** - Suppresses control card printing on 1612

### METHOD

The system consists of 2 control records on a magnetic tape and 1 paper tape bootstrap of 528 locations. The bootstrap is loaded in high core of Bank 1 and operated.

This bootstrap loads the PIUS control program into Bank 1 and operates it. PIUS calls in the 2nd record, the directory, which contains seven words for each record on the master tape in the following format:

<table>
<thead>
<tr>
<th>Word</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First 2 BCD characters of the program name.</td>
</tr>
<tr>
<td>2</td>
<td>Second 2 BCD characters of the program name.</td>
</tr>
<tr>
<td>3</td>
<td>Loading address</td>
</tr>
<tr>
<td>4</td>
<td>Last word address + 1</td>
</tr>
<tr>
<td>5</td>
<td>Complement of the record number</td>
</tr>
<tr>
<td>6</td>
<td>Beginning address</td>
</tr>
<tr>
<td>7</td>
<td>Routine Qualifications Viz:</td>
</tr>
</tbody>
</table>

- **Set if this routine is relocatable.** (bit 11)
- **Set to Bank in which this routine is to be loaded.** (bits 3, 4 & 5)
- **Set if Entrance Parameters are required.** (bit 0)

It searches this directory for the routine name requested and reads that routine into the computer as prescribed by the remaining five words of the directory.
RESTRICTIONS

A. Requires a minimum 160-A with 163 tape cabinet and 161 typewriter.

B. Any routines written to be subject to PIUS control must not use the following locations:

- 0 - 1  Bank 0
- 70 - 77  Bank 1
- 7750 - 7776  Bank 0

C. Must not be programmed so as to be loaded above location 5700 of Bank 1.

STORAGE REQUIREMENTS

A. Program 427 locations of bank 1 (PIUS).

B. Storage 200 locations of bank 1 (Directory).

C. Storage 27 locations of bank 1 (Direct Cells-PIUS).

REFERENCES

A. PIUS Master Magnetic Tape-AF/CPL #

B. Symbolic Deck  AF/CPL #  Working ID

C. Assembly Listing  AF/CPL #
APPENDIX I

MAIN PROGRAM

JPR CALL 
LDI 2 
STF 2 
JPR XXXX 

CONTINUE

JFI 1 
0 

CALL

CTA 
LPN 7 
ADN 10 
STF REL

CTA 
LS6 
LPN 7 
STF BUFF 
CTA 
LS6 
LPN 7 
ADN 40 
STF DIR 
CTA 
LPN 70 
ADN 20 
STF IND

LDD METERS 
STD 70 
LDN 0 
STD 71 
LDC 4724 
STD 72 
LDC 4400 
STD 73 
LDN 1 
STD 74 
LDC 3000 
STD 75

BOOT EQU 7751
PTA 
ADN 3

ACJO 

RETURN JUMP TO CALLING SEQUENCE SUBROUTINE SPECIFIC WILL CONTAIN THE BEGINNING ADDRESS OF THE REQUESTED ROUTINE RETURN JUMP TO ROUTINE JUST LOADED INTO STGE.

RETURN TO MAIN PROGRAM RETURN JUMP ADDRESS CONTROLS TO "A" BANK CONTROL INTERROGATION

IF OBJECT PROGRAM REQUIRES PARAMETERS STORE THEM IN LOCATION 70 OF BANK 1.

BCD CODE FOR CHARACTERS PU

BCD CODE FOR CHARACTERS M ONLY

(0 SUBSTITUTED FOR BLANKS)

SET FLAG FOR PIUS TO RECOGNIZE PROGRAM CONT.

STORE THE RELOCATION ADDRESS (WHERE APPL.)

THE 2ND LOCATION OF THE BOOTSTRAP

SET ALL BANKS TO 0 TO OPERATE PIUS BOOTSTRAP

*If bank selections are previously known this area may be dispensed with.
APPENDIX I (continued)

JPR   BOOT
IND   0
DIR   0
BUFF  0
LDC CALL 1
       0

RESET INDIRECT BANK
THE SUBROUTINE HAS STORED AN SRJ INSTRUCTION HERE
IDENTIFICATION

Title: 167 Card Read Routine - Ident AE2.01
Programmer: A. R. Perro, October 1962, Control Data Corporation

PURPOSE

Reads a Hollerith or binary card with the 167 Card Reader and stores the information either packed (12 bits per word) or unpacked (6 bits per word) in the lower half of each word. The routine allows 1-80 columns to be read from a card.

USAGE

1. Calling Sequence:

   L-1 LDN PARAM
   L  JPL CARDIN +1
   L+2 Starting location of input
   L+3 Terminating location of input
   L+4 Return

2. Parameters:

   PARAM = 000X
   X = 0 BCD
   = 00Y0
   Y = 0 Packed
   = 1 Binary
   = 1 Unpacked


11. Timing: 1.5 milliseconds times number of columns per card plus 70 milliseconds latch up.

12. Caution to User:

   No provision for bank settings is made in the routine.

IDENTIFICATION

Title: Punched Paper Tape Duplicator - Ident. F1.00
Programmer: J. Pederson, December 1960

PURPOSE

This program produces multiple copies of a given seven level punched paper tape.

USAGE

1. Operation Procedure

   a. Enter Tape

      1. Turn on reader, insert F1.00 tape and load starting P = 0000
      2. Place tape to be duplicated on the reader and enter with P = 0000. Tape will be read in until succeeding blank frames indicate the end of the tape.
      3. Program Stop
         P = 0214
         A = 0000
         Z = 7701
      4. If more information remains to be duplicated press switch after returning it to center position.
      5. Error Stop - More than 6395 frames have been entered.
         P = 0206
         A = 7777

   b. Verify

      1. Place tape on reader and run with P = 0001
      2. Program Stop
         P = 0034
         Z = 7707
      3. Error Stop
         P = 0361
         A = 0000
         Z = 7705

   c. Punch

      1. Turn on Punch
      2. Set P = 0002 A = number of copies desired (in octal)
      3. Press Run switch
4. Program Stop.
P = 0320
Z = 7707
The program will punch an 18 inch leader between copies.

d. To Verify multiple copies

1. Place tape in the reader
2. Set P = 0001; A = number of copies to be verified
3. Error Stop
P = 0361
Z = 7705
Tear out bad copy. Master Clear. Place tape on the reader and
set P = 0030. Press Run switch. Alternative method: Set
P = 0001, A = remainder of the tape to be verified and press Run
switch. Program Stop with
P = 0034
Z = 7707
The program will copy up to 6395 frames of seven level tape and
produce the number of copies specified by the A Register. It
also produces an 18 inch leader between copies. Use F1.01
for tapes greater than 6395 frames.

3. Storage Requirements: Program 0000 - 0377
   Tape Image 00400 - 7775

8 February 1963

IDENTIFICATION
Title: Duplicate Paper Tape - Ident. AF1.00
Programmer: J. A. Pederson, August 1960

PURPOSE
This routine duplicates information on paper tape from the photoelectric reader to the high speed punch.

USAGE
1. Operational Procedure - The routine floats and may be loaded anywhere in memory.
   a. Load, set P = any arbitrary address.
      - 7507 select reader
      - 7210 read 2 frames
      - 0072
      - 7505 select punch
      - 7305 punch 2 frames
      - 0072
      - 6506 go back
      - 4102 reader code
      - 4104 punch code
      - 0070 start of I/O
   b. Master Clear
   c. Set P = starting address selected
   d. Turn on reader and punch
   e. Place tape to be duplicated in the reader
   f. Press Run switch
   g. To stop duplication return switch to center. The duplication process stops automatically after the tape in the reader has been read.

3. Space required - \( 128 = 10_{10} \) locations

IDENTIFICATION

Title: Punched Paper Tape Duplicator - Ident. F1.01
Programmer: R. M. Olson, February 1961

PURPOSE

This routine is designed to reproduce paper tapes of more than 6395 frames by placing the paper tape image on magnetic tape.

USAGE

1. Operational Procedure

   a. Load Program Tape S 025

      1) Place S 025 tape in the reader and set P = 0050.
      2) Set load switch and press run.
      3) Program stop

         P = 0406
         A = 2161
         Z = 0000

   b. Enter Tape to be Duplicated

      1) Place tape to be duplicated in the reader.
      2) Load a reel of magnetic tape onto tape unit. Check the following items:

         a) Magnetic tape unit 1 selected.
         b) BINARY parity selected.
         c) The tape is run forward past load-point, or is set to load point and the CLEAR button has been pushed.
         d) The magnetic tape unit has a green ready light on.

      The magnetic tape units need not be touched during the rest of the operations.
3) Set $P = 0050$

4) Press Run switch

5) Temporary program stop

$P = 0167$
$A = 0000$
$Z = 7700$

At this stop there are two options:

a) If more tape is to be duplicated; press the Run switch after returning it to the center position.

b) If at the end of the tape: Master Clear, set $P = 0166$, and press the Run switch. This will transfer the last partial block of data onto magnetic tape.

6) Final program stop.

$P = 0204$
$A = 2161$
$A = 7700$

7) Error Halt (parity error)

$P = 0207$
$A = 2161$
$Z = 7750$

c. Verify Master Tape and Copies

1) Place tape in reader.

2) Set $P = 0052$

3) Press the Run switch

4) Proper verify stop

$P = 0320$
$A = 2161$
$Z = 7700$

5) Improper verify stop
6) Error Halt (parity error)

P = 0306
A = 2161
Z = 7752

d. Punch New Copies

1) Turn on punch
2) Set P = 0054
3) Press the Run switch
4) Program stop

P = 0400
A = 2161
Z = 7700

5) Error Halt (parity error)

P = 0376
A = 2161
Z = 7754

3. Space Required - $324_8 = 212_{10}$ locations.

4. Temporary Storage Requirements - locations 0070 through 0076.

12. Caution to user - Make certain that the magnetic tape unit is set to
   BINARY mode and the Tape Unit 1 is selected.

IDENTIFICATION

Title: Tape Leader Preparation - Ident. F1.02
Programmer: J. A. Pederson, August 1960

PURPOSE

Used to prepare tape leaders which identify program tapes. The characters 0 to 9, as S,T,P,R, -, , can be punched on a tape leader.

USAGE

1. Operational Procedure

a. Load program starting at location zero.

b. Master Clear, turn on the punch and start. The program will punch two frames of leader.

c. Place in A the desired character to be punched from the following table.

d. Push Run switch. The program will punch the character and stop.

e. After preparing the leader on the punch, run out about two inches and then the desired program may be copied.

If the program is internal the resident service routine may be used to punch out the information from core storage. By clearing and starting at location 0050, the information on the photoelectric paper tape reader may be repunched on the high speed punch.

Character Code in A Register:

<table>
<thead>
<tr>
<th>Character</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>S</td>
<td>13</td>
</tr>
<tr>
<td>T</td>
<td>14</td>
</tr>
</tbody>
</table>
Character Code in A Register (Cont.)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>15</td>
</tr>
<tr>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>R</td>
<td>17</td>
</tr>
</tbody>
</table>

3. Space required $311_8 = 201_{10}$ locations

4. Temporary Storage Requirements - 7 locations

10. Timing - Output approximately 60 frames per second

14. Equipment Configuration - Minimum 160 computer
IDENTIFICATION

Title: Tape Copy/Compare - Ident. Fl.05
Programmer: John Steffani, August 1962, Control Data Corporation

PURPOSE

This routine utilizes the Control Data 160 or 160-A computer to copy or compare magnetic tape files on 163 or 164 tape units. The operator has the following options:

1. Copy or compare operation.
2. BCD or binary mode.
3. Rewind load at start.
4. Rewind unload at finish.
5. Up to \((77)_8\) files can be copied or compared per run.

NOTE: For operations involving more than \((77)_8\) files, the following procedure may be followed:

1. Enter control word in Direct Storage location 0067, (lower 6-bits zero).
2. Enter number of files to check indirect storage location 0064.
3. Set P to 0103.
4. Press RUN.

USAGE

1. Operational Procedure
   a. Clear core, set all banks to zero.
   b. Set P-register to 0100.
   c. Load bi-octal program paper tape.
   d. Mount magnetic source tape, remove file protection ring, set unit selection switch to \#1.
   e. Mount output or copy tape, set unit selection switch to \#2.
   f. Set both tapes to desired starting location (tapes must not be in a rewind unload state).
   g. Enter control word into A-register.
   h. Set P to 0100.
   i. Set RUN-STEP switch to RUN.

2. Parameters
   a. Control word bit structure.
Bits 0 thru 5 = set equal to number (octal) of files to be copied or compared.
Bits 6 and 7 = set to zero.
Bit 8 = set to 1 for rewind with lockout both tapes when number of files specified is completed.
= set to 0 for no rewind.
Bit 9 = set to 1 for rewind load both tapes at start of operation.
= set to 0 for no rewind at start.
Bit 10 = set to 1 for compare operation. Compare tape 2 against tape 1.
= set to 0 for copy operation. Copy tape 1 onto tape 2.
Bit 11 = set to 1 for binary coded input/output
= set to 0 for BCD coded input/output.

Example control word to compare 3 BCD files with rewind unload upon completion, rewind load at start:

1) Bit representation

```
11 10 9 8 7 6 5 4 3 2 1 0
0 1 1 1 0 0 0 0 0 0 1 1
```

2) Octal representation

3403

3. Space Required: \((7776)_{8}, (4094)_{10}\) locations.

7. Error Stops

<table>
<thead>
<tr>
<th>P-register</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0214</td>
<td>Record length too long for this routine. Discontinue operation.</td>
</tr>
</tbody>
</table>
| 0234      | Parity error on Read Tape #1. To re-read, press RUN switch. To continue (with parity error present),
|           | a) Master clear. |
|           | b) P-register to 0243. |
|           | c) Press RUN switch. |
| 0261      | Compare operation, record length tape #2 too long for this routine. Discontinue operation. |
| 0270      | Compare operation: EOF TAPE 2, NO EOF TAPE 1. The above condition is the result of either of two causes:
|           | a) Tapes are not compatible, i.e., there are more records per file on tape 1 than tape 2; |
for this case, operation should be discontinued.
b) The remainder of the file for the output tape is on a continuation tape. For this case a visual inspection of tape unit #2 will show the reel to be nearly empty. For this case, continue as follows:

1) Rewind unload tape unit #2.
2) Mount next output tape and place in a rewind load position.
3) Set P-register to 0220.
4) Press RUN.

0301 Compare Operation: Record length tape #1 not equal (#) to record length tape #2. Tapes not compatible, discontinue operation.

0307 Compare Operation: Parity error on read tape #2. To re-read, press RUN switch. To continue (with parity error present):

a) Master clear.
b) Set P to 0317.
c) Press RUN.

0333 Compare Operation: compare error.

a) To backspace, re-read and compare again. Press RUN.
b) Word on tape #2 causing error displayed in A-register. Address of corresponding word on tape #1, located at 0040.
c) To by-pass compare error, set P to 0326.

1) Master clear.
2) Set P to 0326.
3) Press RUN.

0374 Copy operation: End of tape encountered on tape #2. Record has not been written on tape #2. EOF has been written.
a) Rewind unload output tape.
b) Mount next output tape and place in rewind-load position.
c) Press RUN.
0402 Parity error on attempt to write tape #2. To backspace and rewrite, press RUN.

0417 Copy operation: End of tape encountered on tape #2. Record has been written on tape #2, EOF has been written.
   a) Mount next output tape and place in rewind load position.
   b) Press RUN.

0443 Compare operation: End of file tape #1, no EOF tape #2. Discontinue operation.

0462 Operation completed.

10. Input and Output Formats

   Input record length should not exceed the following:
   a. Copy operation (16,624)\textsuperscript{8} characters.
   b. Compare operation (7,310)\textsuperscript{8} characters.

14. Equipment Configuration

   Minimum SWAP 160 or 160-A computer, 163-2 or 164-2 magnetic tape handler.
Fl.
IDENTIFICATION

Title: Tape Compare (STACO) - Ident. AF1.06
Programmer: E. J. Rosenberg, August 1962, System Development Corporation

PURPOSE

To compare two BCD magnetic tapes to insure similarity.

USAGE

Operating Procedures:

1. Machine load biocatal paper tape at 0.
2. Select logical tape drives to 1 and 2.
3. Clear and run from 0.

Normal Stops

P = 213 A = 7701
One file has been compared without error. Clear and run to process additional files.

P = 220 A = 7700
All files on this tape have been compared, and tapes rewound to unload.

Error Stops

P = 141 End of tape on drive #1 has been sensed.
P = 221 There is a read parity on drive #2. After 5 attempts it has been unsuccessful.
P = 343 Halt on miscompared records.
P = 355 There is a read parity on TD #2. After 5 attempts it has been unsuccessful.

MESSAGES

Typewriter: MISCOMPARE
Indicates the latest read records were not the same.

1612 Printer: The 1st of 2 lines printed is what was in the card image of the miscompared record of TD #1. The 2nd line is from TD #2.

JUMP & STOP KEYS

SIS 1 - will preclude rewind of tapes after 1 file has been compared.
SLJ 1 - will suppress printing of card images in cases where a 1612 is not available.
RESTRICTIONS

Tapes must be written in BCD card (6 bit hollerith) format.

Hardware
Minimum 160-A
161 Typewriter
1612 Printer (optional)

STORAGE REQUIREMENTS

4238 Storage locations of bank 0.
6 Constants in direct bank.
IDENTIFICATION

Title: Flex Load and Flex Verify - Ident. AF2.00
Programmer: L. Kuller, September 1960

PURPOSE

Flex Load is designed to read 160 program tapes prepared on a Flexowriter or by the Flex Dump program and store them in memory at addresses specified by the tape.

Flex Verify is designed to check 160 program tapes prepared on a Flexowriter or by the Flex Dump program against the current contents of the 160 storage locations as specified by the tape. The program indicates any discrepancies that are found.

USAGE

1. Operational Procedure
   a. Turn on reader
   b. Insert tape someplace on blank leader
   c. Flex Load set P = 0400
      Flex Verify set P = 0401
   d. Press Run switch
   e. Discrepancy stop (Flex Verify)
      P = 0434
      A = address of the discrepancy
      Z = 0001
   f. Program Stop
      P = 0414
      Z = 7707

3. Space Required - 177 = 127 locations

4. Temporary Storage Required - Locations 0072 through 0077

12. Caution to User - Location 7777 can not be loaded or verified by these programs unless it is referenced in the eight digit format. If 7777 is referenced in the four digit format the data will be stored at location 0000.

F3.

IDENTIFICATION

Title: Floating Bi-octal Punch and Floating Bi-octal Verify - Ident. AF3.00
Programmer: J. Oden, June 1961

PURPOSE

Floating Bi-octal Punch is used to punch out portions of the 160-A memory in bi-octal format. Floating Bi-octal Verify compares bi-octal date on punched paper tape with the current contents of the 160-A memory.

USAGE

1. Operational Procedure

   Master clear and turn on the reader. Load the tape beginning at any location with the load-clear switch in LOAD position.

   a. Floating Bi-octal Punch

      1. Start punch motor
      2. Master clear
      3. Manually set the last octal digit of A to the memory bank from which you wish to punch data.
      4. Set P = initial address of the floating bi-octal routine, "X"
      5. Press Run switch
      6. Computer stops
         
         P = X + 12
         Z = 7700
      7. Set A = initial address of the region to be punched.
      8. Press Run switch after returning it to the center position
      9. Computer stops
         
         P = X + 15
         Z = 7700
10. Set A = last address to be punched.

11. Press Run switch after returning to the center position

12. Program stop

\[ A = X + 4 \]

\[ Z = 7700 \]

b. Floating Bi-octal Verify

1. Set P to the third location of the region containing the floating bi-octal routines: \( X + 2 \)

2. Set A = first data word location on the tape

3. Turn on reader and insert tape

4. Press run switch

5. Discrepancy Stop

\[ P = X + 111 \]

\[ A = \text{address of discrepancy} \]

\[ Z = 0000 \]

6. Format error on the tape

\[ P = X + 107 \]

\[ Z = 0000 \]

The tape must be removed because the computer will not accept the remainder.

7. Program stop

\[ P = X + 52 \]

\[ Z = 7700 \]

3. Space Required: 75 to 113 locations. Temporary storage requirements: None. This routine does not use addresses 0-77.

THEORY OF OPERATION

The instruction 002X = SIC, sets indirect storage bank control (i) to x. All subsequent indirect storage references address storage bank x. This value x is manually set in the last octal digit of A; then the program builds instruction SIC.

By using instructions LCN 77 and LPN 77 the 12 bit words are separated into upper and lower six bits. One is added to the word after the lower six bits have been masked and SHA 11 instruction given to get seventh level format. These are output immediately via OTA = 7677 to avert the problem of storage and establishing initial and terminal addresses in this floating routine.

In the Floating Bi-octal Verify, the seventh level format is checked, and also each word on the tape is compared with its counterpart in memory. Stops are provided in the program where format and word discrepancies occur.
IDENTIFICATION

Title: Memory Dump - Ident. F3.01
Programmer: G. M. Bronstein, August 1961

PURPOSE

Dump most of memory on magnetic tape.

USAGE

1. Operations; Procedure
   a. Load program tape
      1. Turn on reader and insert S 030 tape
      2. Master Clear
      3. Set P = 7511
      4. Set Load-Clear switch to LOAD
      5. Run
      6. Stop - P = 7776
   b. Load magnetic tape
      1. Place magnetic tape on tape unit
      2. Select tape unit 1
      4. Select BINARY mode
      5. Set tape to Load Point
   c. Set P = 7511
   d. Run
   3. Space Required - \(265_8 = 181_{10}\) locations

13. Cautions to User: The routine dumps memory locations 0000-7757. There are no parity checks made in writing on tape.
IDENTIFICATION

Title: Listable Symbolic Dump - Ident. F3.03
Programmer: Don T. Miller, July 1961

PURPOSE

To produce a listable symbolic dump of a specified area of core with 4 words per Flex line.

USAGE

1. Operational Procedure

   The program may be loaded anywhere greater than address 1. The P register should be set to the starting load address, the starting address of the area to be dumped put in the A register, and the Run switch put in the RUN position. The program will stop at the load address +7, and the final address of the dump placed in A. Put the Run switch in RUN and the program will punch the required area of core (in Flexowriter code), punch a stop code and stop at the load address +478.

3. Space Used: \(436_8 = 281_{10}\) locations

9. Output Format: Each line will contain one octal address, the octal contents, the mnemonic instruction code and the last two octal digits of four words.

10. Timing: The program operates at punch speed.

12. Caution to User: The contents of 7777 will not be dumped. The program will operate if the final address is less than the start address.

13. Equipment Configuration: Minimum
IDENTIFICATION

Title: Listable Symbolic Dump - F3.04A
Programmer: Don T. Miller, July 1961

PURPOSE

To produce a listable symbolic dump of a specified area of core with 1 word per Flex line.

USAGE

1. Operational Procedure

The program may be loaded anywhere greater than address 1. The P register should be set to the starting load address, the starting address of the area to be dumped put in the A register and the Run switch put in the RUN position. The program will stop at the load address +6, and the final address of the dump should be placed in A. Put the Run switch in RUN and the program will punch the required area of core (in Flexowriter code) punch a stop code and stop at the load address +41.

3. Space Used: 421\textsubscript{8} = 273\textsubscript{10} locations

9. Output Format: Each line will contain: a carriage return, octal address, octal contents of that address, mnemonic instruction code for the first two digits and the last two octal digits, e.g., (0100 4201 STF 01).

10. Timing: The program operates at punch speed.

12. Caution to User: The contents of 7777 will not be dumped. The program will operate if the final address is less than the start address.

13. Equipment Configuration: Minimum
IDENTIFICATION

Title: 160-A Symbolic Printer Dump - AF3.07
Programmer: L. Brown, S. Palais, January 1962

PURPOSE

To provide a dynamic symbolic dump for the 160-A onto the 1612 printer.

USAGE

1. a. As a closed subroutine

   L JPR
   L+1 DMPPRT
   L+2 NORMAL
   L+3 RETURN
   L+4 000X (X = Bank to be dumped)
   L+5 FWA of dump
   L+6 LWA of dump

   The calling sequence must be in the same bank as the subroutine. The A-register and bank settings will be restored by the program.

b. Independent Routine Procedure

   (1) To locate the program at location (P), load the OSAP-A binary output with the OSAP-A relocatable binary loader, using (P) as the relocation increment. (P) must be £ 67708. The program may be loaded into any bank.

   (2) Master clear.

   (3) Ready the 1612 printer.

   (4) Put (P) in the P-register and 000X (where X is the bank to be dumped) in the A-register.

   (5) RUN. Upon halting at (P+2), enter FWA in the A-register.

   (6) RUN. Upon halting at (P+5), enter LWA in the A-register.

   (7) RUN. The program will stop at (P+10).

   (8) RUN with 000X in the A-register to restart.
3. Space Required

$1005_{8} = 517_{10}$ as an independent routine.

$765_{8} = 501_{10}$ as a closed subroutine.

9. Output Format

First Line

\begin{verbatim}
DUMP(n)XXXX TO (n)XXXX LOC(n)7777 = XXXX
BANKS XXXX AREG XXXX JUMP ADDRESS XXXX
\end{verbatim}

where (n) is the number of the bank being dumped.

BANKS XXXX is the display of the bank settings, bdir, upon entry to the dump program.

AREG XXXX is the contents of the A-register upon entry to the dump subroutine.

JUMP ADDRESS XXXX is the address L in the calling sequence. (L is $P+10_8$ when program is used independently.)

Normal Lines:

The normal line output consists of an address followed by 10 words of the form: 3 digit op code and 4 digit octal word. The first address dumped will be the nearest address less than FWA and divisible by $10_8$. The number of words per line may be made less than $10_8$ by replacing location ($P+26_8$) by LCN N, where N is the word count.

The last line dumped will include, but not necessarily end with, the word in IWA.

Zero Lines:

1st - normal line format
2nd - ...... subsequent lines of zeros are suppressed.

Last Line:

\begin{verbatim}
END DUMP (n)XXXX TO (n)XXXX
\end{verbatim}

NOTE: Location (n) 7777 is included only in the first line printed. If 777 is given as the FWA, 0000 will be the FWA used by the routine; if 7777 is given as the LWA, 7776 will be the LWA used.

No symbolic op codes are printed for 00 and 01 F-terms.
13. Equipment

160-A, 1612
IDENTIFICATION

Title: 160-A Symbolic Flexowriter Dump - Ident. AF3.08
Programmer: L. Brown, S. Palais, January 1962

PURPOSE

To provide a symbolic dump for the 160-A onto punched paper tape, to be listed on the flexowriter.

USAGE

1. a. As a closed subroutine

L JPR
L+1 DMPFLX
L+2 NORMAL
L+3 RETURN
L+4 OOOX (X = Bank to be dumped)
L+5 FWA of dump
L+6 LWA of dump

The calling sequence must be in the same bank as the subroutine. The A-register and bank settings will be restored by the program.

b. Independent Routine Procedure

(1) To locate the program at location (P), load the OSAP-A binary output with the OSAP-A relocatable binary loader, using (P) as the relocation increment. (P) must be 6740. The program may be loaded into any bank.

(2) Master Clear.

(3) Turn the paper tape punch on.

(4) Put (P) in the P-register and OOOX (where X is the bank to be dumped) in the A-register.

(5) RUN. Upon halting at (P+2), enter FWA in the A-register.

(6) RUN. Upon halting at (P+5), enter LWA in the A-register.

(7) RUN. The program will stop at (P+10) after punching paper tape.

(8) RUN with OOOX in the A-register to restart.
3. Space Required

\[ 1036_8 = 542_{10} \] as an independent routine.
\[ 1016_8 = 526_{10} \] as a closed subroutine.

9. Output Format

First line:

\[
\text{DUMP(n)XXXX TO (n)XXXX LOC(n)7777 = XXXX} \\
\text{BANKS XXXX AREG XXXX JUMP ADDRESS XXXX}
\]

where \( n \) is the number of the bank being dumped.

- BANKS XXXX is the display of the bank settings, bdir, upon entry to the dump program.
- AREG XXXX is the contents of the A-register upon entry to the dump subroutine.
- JUMP ADDRESS XXXX is the address \( L \) in the calling sequence. \( L \) is \( P+10_8 \) when program is used independently.

Normal Lines:

The normal line output consists of an address followed by 10\(_8\) words of the form: 3 digit op code and 4 digit octal words. The first address dumped will be the nearest address less than FWA and divisible by \( 10_8 \). The number of words per line may be made less than 10\(_8\) by replacing location \( (P+26_8) \) by LCN N, where N is the word count.

Zero Lines:

1st - normal line format
2nd - .......
subsequent lines of zeros are suppressed.

Last Line:

\[
\text{END DUMP (n)XXXX TO (n)XXXX}
\]

NOTE: Location (n) 7777 is included only in the first line punched. If 7777 is given as the FWA, 0000 will be the FWA used by the routine; if 7777 is given as the LWA, 7776 will be the LWA used.

13. Equipment

160-A, Paper Tape Punch
IDENTIFICATION

Title: Octal Dump - Ident AF3.09
Programmer: D. T. Miller and S. Palais, November 1961

PURPOSE

Provides an octal dump of one bank of 160-A memory from a given starting address to the end of that bank onto the 1612 printer. The program is relocatable.

USAGE

1. Operational Procedure
   a. The program may be loaded anywhere.
   b. Set the P-register to the starting load address and the A-register to the starting dump address.
   c. Set the indirect bank setting to the number of the bank to be dumped.
   d. RUN.
   e. Program Stop
      Load address + 40_8.

3. Space Required: 132_8 = 90_10 in the relative bank.

4. Temporary Storage: Location 77 in the direct bank, which is not restored.

9. Output Format

   The line format consists of an address and 20 words. An asterisk indicates the omission of one or more lines of zeros. Duplicate lines will be printed, and the contents of the A-register will not be printed.

10. Timing

    For consecutive non-zero lines, the program operates at printer speed.

IDENTIFICATION

Title: 160-A Symbolic Typewriter Dump - Ident AF3.10
Programmers: L. Brown, B. Palais, T. Easley, June 1962, Control Data and Philco

PURPOSE

Provides a symbolic dump for the 160-A onto the 161 typewriter.

USAGE

1. a. As a closed subroutine

   L JPR
   L+1 DMPTYP
   L+2 NORMAL
   L+3 RETURN
   L+4 O00X (X-Bank to be dumped)
   L+5 WMA of dump
   L+6 LMA of dump

   The calling sequence must be in the same bank as the subroutine. The A-register
   and bank settings will be restored by the program.

b. Independent Routine Procedure

   (1) To locate the program at location (P), load the OSAS-A binary output
       with the OSAS-A relocatable binary loader, using (P) as the relocation
       increment. (P) must be ± 6548. The program may be loaded into any bank.

   (2) Master Clear.

   (3) Turn the typewriter on.

   (4) Put (P) in the P-register and O00X (where X is the bank to
       be dumped) in the A-register.

   (5) RUN. Upon halting at (P+2), enter FWA in the A-register.

   (6) RUN. Upon halting at (P+5), enter LMA in the A-register.

   (7) RUN. The program will stop at (P+10) after typing out the
       last line.

   (8) RUN with O00X in the A-register to restart.
3. Space Required

\[ 1232_8 = 542_{10} \] as an independent routine.

\[ 1212_8 = 526_{10} \] as a closed subroutine.

10. Output Format

First Line:

\[
\text{DUMP}(n)\text{XXXX TO (n)XXXX LOC (n)7777 = XXXX}
\]

\[
\text{BANKS XXXX AREG XXXX JUMP ADDRESS XXXX}
\]

where \( n \) is the number of the bank being dumped.

\[
\text{BANKS XXXX} \text{ is the display of the bank settings, bdir, upon entry to the dump program.}
\]

\[
\text{AREG XXXX} \text{ is the contents of the A-register upon entry to the dump subroutine.}
\]

\[
\text{JUMP ADDRESS XXXX} \text{ is the address L in the calling sequence. (L is } P+10^8 \text{ when program is used independently.)}
\]

Normal Lines:

The normal line output consists of an address followed by 4 words of the form: 3 digit op code and 4 digit octal word.

The first address dumped will be the nearest address less than \( PVA \) and divisible by \( 10^8 \). The number of words per line may be made more or less than \( 4^8 \) by replacing location \( P+26_8 \) by \( \text{LOC N} \), where \( N \) is the word count.

The last line dumped will include, but not necessarily end with, the word in \( LWA \).

Zero Lines:

1st - normal line format

2nd - .......

subsequent lines of zeros are suppressed.

Last Line:

\[
\text{END DUMP (n)XXXX TO (n)XXXX}
\]
NOTE: Location (n) 7777 is included only in the first line punched. If 7777 is given as the FWA, 0000 will be the FWA used by the routine; if 7777 is given as the LMA, 7776 will be the LMA used.

F3.
IDENTIFICATION

Title: 160-A Core Dump to 1612 (1612 DUMP) - Ident AF3.11
Programmer: Richard Mihm, January 1962, Control Data Corporation
(Documented by E. J. Rosenberg, July 1962, System Development Corporation)

PURPOSE

To allow a listable dump of the machine codes and constants stored in 160-A and 169 onto the 1612 printer. Completely Relocatable.

USAGE

A. Operating Procedures:

1. Call DUMP from PIUS Master or load biocatal paper tape anywhere.
2. Run from load address.
3. Answer typewriter queries as to area and bank to be listed.
   Terminate area specifications with periods.
4. Run.

B. Stops:

1. Will stop at beginning of this program. Clear and run to return to PIUS control.

RESTRICTIONS

A. Hardware

1. Minimum 160-A
2. 161 typewriter
3. 1612 printer

STORAGE REQUIREMENTS

4556 locations in bank 0.
IDENTIFICATION

Title: BiOctal Dump (BIDU) - Ident. AFJ.12
Programmer: E. J. Rosenberg, August 1962, System Development Corporation

PURPOSE

Punches a given area of a selected bank in bioctal format for machine loading.

USAGE

1. Under PIUS Control:
   a. Call BIDU.
   b. At stop L*, set indirect bank equal to the bank in which your output is contained. Set "A" equal to the first word address of the output area and run.
   c. At stop L+3, set your LWA + 1 in "A" and run.
   d. Normal stop is at location L.
   e. To return to PIUS control, clear and run.

2. Paper tape version:
   a. Machine load anywhere in bank 0. Run from loading address.
   b. Follow steps 1b, and following, above.

RESTRICTIONS

1. Must be 7 level paper tape.
2. Requires 378 storage cells in bank 0.
3. Minimum 160-A.

* L = Loading address.
IDENTIFICATION

Title: 1607 to 160 to 1612 Routine - Ident. F4.06
Programmer: Sanford Elkin, February 1962

PURPOSE

Accepts blocked or unblocked magnetic tapes, and lists them on the Control Data 1612 printer at 1000 times per minute. The listing may be done either under program control (using standard IBM carriage control characters) or under the control of the 1612 Monitor Channels 1-6.

USAGE

1. Operational Procedure
   a. Load the program at location 100. Put the tape to be listed on logical tape handler N.
   b. Put OONP in the A register, where P = 0 for program control, P = 1 - 6 for Monitor Channel 1 - 6.
   c. Run. The first file will be listed, and the program will stop at location 215. If there are more files to be listed, repeat (c). A page eject will occur after each file.

   If it is desired to print several files, and the end of useful information is denoted by 2 successive EOF marks, the only changes needed are to change location CONTIN + 3 (octal 261) to be LDN 0 (0400), and REWIND (octal 215) to be NXF 3 (6103). Then the program will rewind the tape to the unload point and stop at REWIND 5 (octal 222).

3. Space Required

   \[ 412_{8} = 266_{10} \]

4. Temporary Storage

   \[ 202_{8} = 130_{10} \] locations, plus the storage needed for the longest tape the longest tape record.

5. Error Print-outs

   If a line has a parity error in it, the words PARITY ERROR will be printed before the line.

8. Input Tape Mounting

   On logical tape N, when the A register contains OONP.
9. Input Format

A record may have any number of characters up to $7266_{10}$. The character $32_8$ in an even position is interpreted as an end-of-record mark. This will terminate the line, and the $32_8$ will not be printed. If program control is desired, the first character of every line will be interpreted as a carriage control character, and will not be printed. Legal CC characters are $1$ (page eject), $128_8$ (double space), and $40_8$ (triple space). All others are interpreted as single space.

10. Timing

1000 lines per minute, if the blocked records do not exceed approximately $1250_{10}$ characters.

12. Cautions to User

If blocked records are used, each line image must be ended by a $32_8$ in an even character position. If program control is also used, the $32_8$ must be followed by a CC character.

13. Equipment Configuration

160 or 160-A, 1612, and 1607.

METHOD

The first record is read into core in assembly mode, starting at INAD(0713). The program then unpacks the information, storing 1 character per word starting at BFINAD (0523). When $32_8$ occurs in the right half of an input word, or the end of the input record is reached, the program prints the unpacked characters on the 1612.
IDENTIFICATION

Title: Flexowriter Tape to ANelex - Ident. F4.07 (Flexlex)
Programmer: Bud Vitoff, February 1961

PURPOSE

1. Flexlex was designed primarily for printing OSAP listing tapes. It can be used efficiently whenever the ANelex is available for use immediately after assembly.

2. The routine can be used for printing any paper tape prepared by or for a Flexowriter.

USAGE

1. Operational Procedure
   a. Load program into 0000 through 0650.
   b. Turn on reader. Insert tape to be printed anywhere on its blank leader.
   c. Master clear and start. A page eject is executed before printing starts.
   d. When ten consecutive blank frames are detected, a page eject is executed and printing stops. Starting at this point enters a closed "page eject and stop" loop.
   e. A master clear restarts the program.
   f. A closed "page eject and stop" loop can be entered by setting P = 0001.

7. Programmed Stops

   Z = 7700: Page eject loop entered at 0001
   Z = 7702: Page eject loop entered after ten consecutive blank frames.
   Z = 0004: Program check sum failure. Reload program.

9. Output format

   a. Lines per page: 56
   b. Flexowriter code interpretation (7th level is ignored):
      1. carriage return and tabulator codes cause appropriate printing action, with tab stops after every 12 columns (i.e., in cols. 13, 25, 37, etc.).*
      2. delete codes and illegal codes are ignored.
3. all other non-printing codes are represented by the indicated substitutes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>Substitute</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>color shift</td>
<td>( )</td>
</tr>
<tr>
<td>43</td>
<td>stop</td>
<td>*</td>
</tr>
<tr>
<td>47</td>
<td>upper case</td>
<td>:</td>
</tr>
<tr>
<td>57</td>
<td>lower case</td>
<td>?</td>
</tr>
<tr>
<td>61</td>
<td>backspace</td>
<td>(</td>
</tr>
</tbody>
</table>

c. An automatic carriage return is executed after 120 columns have been "set" for a line of print.

10. Timing

Printing speed varies with the amount to be printed on each line, but GBAF listings run about 325 lines per minute.

11. Equipment configuration

Basic 160 computer and ANlex.

*Tab stops must be equally spaced across the page; however, the routine may be easily changed to provide one of the following options:

1. tab interval fixed at a value other than 12, or
2. tab interval fixed, with provision for changing it at the beginning of each run (by manually changing the contents of register A at a programmed stop).

The tab interval is set at the beginning of a run by the instructions in location 0107 and 0110:

<table>
<thead>
<tr>
<th>Location</th>
<th>Current</th>
<th>Change 1</th>
<th>Change 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0107</td>
<td>LDN 14</td>
<td></td>
<td>LDN xx</td>
</tr>
<tr>
<td>0110</td>
<td>LDN 14</td>
<td>LDNxx</td>
<td>HIN 01</td>
</tr>
</tbody>
</table>

Load the program, and make the change in core. Master clear and start. Error stop 0004 will display the calculated new check sum in register A.

Permanent change:

Enter the new check sum into location 0650 and punch a new bi-octal tape.
Temporary change:

Start. Program stop 7704 will display the programmed check sum in register A. (Of course, the check sum difference should be accounted for by your changes.) Start to enter the program.
IDENTIFICATION

Title: Tape-to-Card Punching Routine - Ident. F5.02
Programmers: E. Campbell, R. Mills, October 1962, Control Data Corp.

PURPOSE

To read magnetic tape in BCD or binary mode and punch corresponding Hollerith or binary cards.

USAGE

1. Operational Procedure
   Mount input tape on a 163 or 164 tape handler. Set the 523 punch unit to ready. Load the biocula program tape at zero, set the A register to one of the input parameters, set the P register to one of the entry points, and run.

2. Parameters
   a. Input - A Register
      Load the A with OXYZ where:
      X = 1  halt at each end-of-file mark
      X = 0  process to end-of-tape
      Y = 1  tape unit 163 or 164 - only legal tape unit at present
      Z = 1  tape handler number 1
      Z = 2  tape handler number 2
   b. Entry Points - P Register
      Normal entry - P = 100
      Read to next end of file and halt - P = 1077

3. Space Required
   947 decimal or 1663 octal locations

5. Bank Allocations
   When operating this program on the 160-A, be sure all bank settings are the same, e.g., R=O, I=O, D=O, B=O, or R=1, I = 1, D=1, B=1.

6. Alarms or Printouts
   This routine was written to process punch output from the 1604 CO-OP Monitor System, consequently the program looks for a job number. No job number is required to use the program, but if there is one it will be displayed in the A register at halt location 324 octal if non-recoverable parity error occurs. This number will be in 4-bit BCD code allowing a maximum job number of 999.

   A second halt at location 326 occurs with parity errors. A contains the octal punched card count. If processing is continued from this halt, an X card is punched and the parity error record follows. Normal processing will then continue.
7. **Error Stops**

<table>
<thead>
<tr>
<th>Location</th>
<th>Cause</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0101</td>
<td>Illegal input parameter</td>
<td>Set A and run</td>
</tr>
<tr>
<td>0324</td>
<td>Solid tape parity error</td>
<td>(A) is job number in 4-bit BCD</td>
</tr>
<tr>
<td>0326</td>
<td>Solid tape parity error</td>
<td>(A) is nth punched card in octal</td>
</tr>
<tr>
<td>0713</td>
<td>Halt at each end-of-file</td>
<td>(A) is job number in 4-bit BCD</td>
</tr>
<tr>
<td>1074</td>
<td>Normal halt at end-of-tape</td>
<td>Tape will have been rewound to unload.</td>
</tr>
<tr>
<td>1104</td>
<td>Illegal unit number when EOF entry was used</td>
<td>Set A and Run</td>
</tr>
<tr>
<td>1135</td>
<td>Halt after skipping one file</td>
<td>Run if processing is desired, reset P and A if next EOF is desired</td>
</tr>
</tbody>
</table>

10. **Input/Output Formats**

a. **Input**

Tape records may be 84 characters or less in BCD, binary or a mixture of both modes. Two consecutive end-of-file marks or an END MONITOR OUTPUT card will terminate processing.

b. **Output**

Hollerith or binary punched cards.

11. **Timing**

The program operates at punch speed (100 rpm).

14. **Equipment Configuration**

163 or 164 tape unit
Minimum SWAP 160 or 160-A computer
1610-523 card punch system

**METHOD**

The program reads magnetic tape in 12-bit word mode (2 frames/word) for binary records and 6-bit word mode (1 frame/word) for BCD records. If a parity error occurs, a reread in the binary mode is tried 3 times, then 3 tries are made in BCD mode. If the parity condition persists, it is classified as a solid parity error. If no parity error occurs the mode continues used until the next parity error.
F6.
IDENTIFICATION

Title: Flex Tape to Magnetic Tape Converter – Ident. F6.01
Programmer: L. Kuller, August 1960

PURPOSE

Produce a copy of a Flexewriter tape on magnetic tape in a form suitable for listing.

USAGE

1. Operational Procedure

   a. Load program tape F6.01

      1. Turn on reader, insert tape and set P = 0000.
      2. Set Load switch and press Run.
      3. First stop
         \[ P = 0004 \]
         \[ A = 1111 \]
         \[ Z = 0000 \]
      4. Set \( P = 1000 \), press Run switch
      5. Program Step
         \[ P = 1177 \]
         \[ A = 0000 \]
         \[ Z = 0000 \]

   b. Convert Flexewriter tape to magnetic tape

      1. Turn on reader and insert Flexewriter tape.
      2. Set CODED parity selection on magnetic tape unit.
      3. Set \( P = 1000 \)
      4. Press Run switch
      5. Program Step (16 consecutive blank frames read)
         \[ P = 1021 \]
         \[ A = 0000 \]
         \[ Z = 7707 \]
      7. To convert more Flexewriter tape, return Run switch to center
         and then to RUN.

3. Space required - \( 2048 \) - \( 132 \) locations

7. Error - parity, routine attempts to write output block on tape until the error disappears.

METHOD

Punched paper tape characters are translated into equivalent line printer codes. If there is no equivalence, the punched paper tape character is ignored. When a CR is read, blank codes to fill the 120 character line printer line are inverted on the magnetic tape. The output from the 160 is copies on magnetic tape with parity checking.
IDENTIFICATION

Title: 1609 Card to Magnetic Tape (1609-164) - Ident. F6.02
Programmer: C. Frankenfield, October 1961

PURPOSE

This routine will read BCD cards, check validity, and write BCD card images on magnetic tape.

USAGE

1. Operational Procedure
   a. Load the program binary tape using the OSAP Binary Loader Program (A4.00).
   b. Place cards in card reader hopper 9-edge first, face-down. Cycle one card. Select tape unit 1.
   c. Set P-register to 6600 and RUN.
   d. Normal Stops

   6635 - Card stacker full. Remove cards from stacker; RUN from this location to continue program.
   6661 - Card hopper empty.
      a. To continue program reload card hopper and RUN from this location.
      b. To read last two cards in reader and write end of file, enter 1 in A-register and RUN from this location.
   7351 - Last two cards have been read and written on magnetic tape. End of file has been written.
      a. To write more card images on same tape, reload card hopper, feed one card, and RUN from this location.
      b. To rewind magnetic tape, enter 1 in A-register and RUN.
   7356 - Tape has been rewound. Depress RUN to perform next job.
   7402 - End of magnetic tape has been reached. End of File has been written and tape has been rewound. After changing magnetic tapes, RUN from this location without removing cards from hopper to continue program.

3. Space Required

Program occupies locations 6600 through 0000 and low core locations 70 through 76.
7. Error Stops

6642 - Card feed failure. Impossible to recover at this point. Repeat Step b under Operational Procedure and RUN from this location to restart program.

6653 - Card reader not ready. Correct status fault; RUN.

6657 - No cards initially in hopper. Correct fault; RUN.

7174 - Illegal BCD character read.
   a. RUN, and card with illegal BCD character will be ignored.
   b. Enter 1 in A-register and RUN to write card with illegal character on tape.

7466 - After 3 attempts at three successive locations unable to write a record due to parity errors or illegal BCD code.
   a. RUN from here to try to write on magnetic tape again.
   b. Enter 1 in A-register, and RUN to start over again with new tape.

10. Timing

The program reads at reader speed (100 cards per minute).

13. Equipment Configuration

Minimum 160 with 164 and 1609 adaptor for the IBM 521 Card Read Punch Unit.
IDENTIFICATION

Title: CARD TO MAGNETIC TAPE (167 to 163/164) - Ident. F6.03.
Programmer: Anthony Taylor Smith, October 1962, Control Data Corporation

PURPOSE
This program is written in OSAS language for either the 160 or 160-A computer. It converts data from cards into magnetic tape records, one card per record. Either binary or BCD cards will be handled, producing binary or BCD records, respectively. (A binary card is identified by a 7-9 punch in column 1). These cards may be mixed.

USAGE
1. Operational Procedures
The program is distributed as a binary tape and should be loaded with a starting address L between 0100-7410 inclusive; the program will then be run with the starting address, L, in the P register.

Use tape unit 1 for the output tape.

The program will process cards until the card hopper becomes empty, at which time the 'card hopper empty' status response produces a halt at Location L + 61 (L+61 0000 7700). If more cards are to be loaded in the same magnetic tape file, NON-ZERO must be put in the A register before running from this point. To produce an end-of-file mark after the hopper-empty condition, leave ZERO in A and run.

Note: Cards with the same leading corner cut must be used throughout.

3. Space Requirements
The program 2472 cells which can be loaded anywhere within core locations 0100-7656 and location 702 in low core. Locations 7657-7776, inclusive, are used for the 80-column read-in-area, one column per word.

7. Error Stops
L+112 10XX 0000 - XX is the 167 status response code. Clear 167 error condition. Note value of P register, clear, enter noted P plus 1, in P; 0 in A, and run.

L+241 0XXX 0000 - XXX is the card column (in octal) where an illegal code exists. Correct the card, replace in reader, and run.

14. Equipment Configuration
Minimum SWAP 160 or 160-A, 167 reader and a 163 or 164 tape unit.
F6.
IDENTIFICATION

Title: Change Magnetic Tape Record Length Binary Tapes - Ident. F6.04
Programmer: (Control Data Corporation/Applications), October 1962

PURPOSE

Writes magnetic tapes of a designated record length from tapes of the same
or different record lengths for binary tapes only (odd parity).

USAGE

1. Operational Procedure:

   Load and run at 0, TU1 input, TU2 output.

   At the halt 0000 0000 7700 enter required output record size in the A
   register and run.

   Halt 0123 0000 7700 allows two or more input tapes to be output with no
   "zero fill in" gap between them. At the halt enter either zero or posi-
   tive non-zero into the A register. In the latter case, a new tape must
   be readied on TU1-run. To terminate the process make no entry in the
   A register-run. The program will fill up the last record with 0's
   to the required size, output it and a tape mark on the output tape.

   Final Halt, 0157 2112 7700: After this halt the program reinitializes
   itself, so that another process can be handled without reloading the
   program.

   Clear and run from 0.

   Note: Since the program was originally written for the 160 computer
   and is at this time designed to be compatible with either
   the 160 or the 160-A the sum of the output and input block
   lengths must not exceed 75008. Further, in operation on the
   160-A all banks should be zero.

3. Space Requirements:

   Program uses locations 0000-0163. From location 200 on is made available
   as the input/output area.

5. Bank Allocation: Set all banks on the 160-A to zero.
7. Error Stop:

0031 0000 0000: Delinquent record.
The tape has been read three times without success, enter non-zero in A to bypass delinquent record, or 0 to keep trying to read the same record.

14. Equipment Configuration:

Two 163/164 Magnetic Tape Units, 160 or 160-A SWAP Computer.
IDENTIFICATION
Title: 160-A Binary Card Binary Tape Verify Routine - Ident. AF6.06
Programmer: Larry Brown, Control Data Corporation

PURPOSE
This routine compares 80 column binary cards with their image on magnetic tape. If the card and tape image do not match, a card is punched representing the tape image. The routine has been written for the IBM 533 Card Read Punch.

USAGE
1. Calling Sequence and Operational Procedures
   a. As a closed subroutine, entry is made with the following calling sequence:

```
L   JPR
L+1 VERIFY
L+2 NORMAL
L+3 RETURN
L+4 OWOU
```

   b. As an independent program, load the bi-octal tape at location 0060 in either bank and start at location (r) 0060 with OWOU in the A-register.

c. 533 Card Read Operation

Place the cards to be verified in the read hopper to feed 9-edge first, face down. Push the START button twice to feed two cards and turn off the NOT READY light. At least two cards must follow the deck to be read; these cards may be blank or the first two cards of the next deck to be verified if more than one file is on tape.

d. Card Read Feed Failure

   In case of a card read feed failure, follow these procedures:

   I) Put the read stacker switch in the ON position (toggle it toward you).

   II) Remove the cards from the read hopper. Reproduce the damaged cards from the bottom of the stack and discard the damaged cards. Put the reproduced cards at the bottom of the stack.
III) Push the START button until all cards have been fed out of the machine.

IV) Put the last card fed out in front of the reproduced cards from the read hopper.

V) Place the corrected card stack in the read hopper and push the start button twice to feed two cards.

VI) Put the read stacker switch in the OFF position (toggle it away from you). The NOT READY light will go out and the computer will continue reading cards.

e. 533 Card Punch Operation

Place blank cards to feed 9-edge first, face down, in the card punch hopper. Push the START button once to feed a card and turn off the NOT READY light.

f. Card Punch Feed Failure

In case of a card punch feed failure, remove the blank cards from the hopper and examine the cards on the bottom of the stack. Discard all damaged cards and replace the stack in the hopper. Push the START button once to turn off the NOT READY light and place a card in position for punching.

g. Procedures for NOT-COMPARE Stop

If the binary card read in does not match with the binary tape image, the computer punches a card and stops.

I) Remove the blank cards from the card punch hopper and feed all cards out. There will be 2 cards, the last one of which is blank and should be placed with the other blank cards. The first card out is the card punched from the tape image.

II) Remove the cards from the card read hopper and feed all cards out of the machine. The last two cards fed out are to be placed in front of the cards from the read hopper. The third last card fed out is the one which did not compare with the tape image; discard that card.

III) Put the card punched in front of the stack from the read hopper (in front of the last two cards fed out in the last step).

IV) Place the corrected deck in the card read hopper and push the START button twice to feed two cards and turn off the NOT READY
light. Place the blank cards in the card punch hopper and push the START button once to feed one card and turn off the NOT READY light.

V) Place the computer's RUN-STEP switch into the STEP position and then into the RUN position. Computer operations will then continue.

2. Entrance Parameter

OWOU as follows:

W = tape control unit number (usually 1)
U = logical tape number selection

3. Space Requirements

3258 locations in the relative bank
58 locations in the direct bank
3748 locations in the indirect bank

Locations in the indirect bank are assigned by EQU cards, $12^{4_8} - 8_{10}$ non-overlapping locations must be reserved for the symbols BLKB and BLRC. Location (i) 0000 must not be included in this storage assignment. If it is desired to re-arrange the direct storage assignments, only the symbol SETS may be assigned location (d) 0000. All other direct storage locations may be assigned at will.

7. Program Stops

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CKPAR+7</td>
<td>Three attempts have been made to read a tape record and all have failed because of parity errors. A card has not been read for this tape image. Continuing from this point tries three more times to read the record. This stop is at (r) 0223 when used as an independent program.</td>
</tr>
<tr>
<td>BBLKB+1</td>
<td>This stop is the NOT-COMPARE stop. A new card has been punched from the tape image. Follow procedures outlined in C.1.g. above. This stop is at location (r) 0346 when used as an independent program.</td>
</tr>
<tr>
<td>RWD+1</td>
<td>An End-Of-Tape reflective spot has been encountered. The program rewind-unloads the current tape. Mount the next tape and continue. This stop is at location (r) 0375 when used as an independent program.</td>
</tr>
</tbody>
</table>
If this routine is used as an independent program, one additional stop is provided: at location \((r)\) 0063 for the normal return.

8. Input Tape Mounting

The input tape is mounted on control unit \(W\) with logical selection \(U\) as in 2. above. The tape may be file protected.

9. Input and Output Formats

a. Card Input

Standard 80 column binary card.

b. Tape Input

160_{10} character column binary image in odd parity of card 9.a. above.

c. Card Output

Standard 80 column binary card of image 9.b. above.

10. Timing

Approximately 200 cards per minute compared. This routine operates as fast as the IBM 533 read feed.

12. Cautions

Do not step through the routine or take the computer out of RUN.

13. Equipment Configuration

Minimum 160-A with 163 and 1610 adaptor for the IBM card read punch. The program assumes a 2-bank 160-A. The 163 tape unit is selected in odd parity and assembly (12-bit) mode only. The buffer channel is used to read cards from the second read station. The normal channel is used to read tapes and punch cards.

15. Miscellaneous

a. Normal Return

Follows reading an End-of-File mark.

b. Interrupt

Not used.
c. Bank Settings

Upon normal return, the direct, indirect and buffer banks are restored to their values as the time of entry to the subroutine. The subroutine will work in either bank.

d. Machine Registers

The Buffer Entrance, Buffer Exit, and A-registers are not restored.

e. Selective Stop and Selective Jump switches are not used.
IDENTIFICATION

Title: FORTRAN cards to Flex Tape - Ident. AF 7.00
Programmer: N. D. Babic, August 1962, Control Data Corporation

PURPOSE

This routine reads FORTRAN source cards using the 167 Reader and punches paper tape acceptable to the FORTRAN compiler, eliminating blank columns and inserting Tab, Carriage Return, and Case Code characters as applicable.

RESTRICTIONS

1. Comments cards (C in column 1) are not punched on flex tape.
2. Only blank columns in a Hollerith field are punched as semicolon.
3. Card reader assumed to be on normal channel.
4. Both 11 and 8-4 punches are converted to minus sign.
5. In accordance with existing FORTRAN restrictions, format statements must be the first statement in a program.
6. Blank card terminates the run.

USAGE

1. Operational Procedure
   a. Machine load the program at P = 0000.
   b. Master clear.
   c. Ready FORTRAN deck followed by three blank cards in reader.
   d. Press RUN switch.
2. Programmed Halts
<table>
<thead>
<tr>
<th>P setting</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0216)8</td>
<td>End of run - for next run start at l(b) in Oper. Proc.</td>
</tr>
<tr>
<td>(0162)8</td>
<td>Err - number of characters in Hollerith field not specified</td>
</tr>
<tr>
<td>(0406)8</td>
<td>Card reader - program error, amplifier failure, or motor power off. Take appropriate action; to continue set P = 0375 and press RUN switch.</td>
</tr>
<tr>
<td>(0407)8</td>
<td>Feed failure; to continue set P = 0375 and press RUN switch.</td>
</tr>
<tr>
<td>(0410)8</td>
<td>Stacker full; empty stacker, set P = 0375 and press RUN switch.</td>
</tr>
<tr>
<td>(0411)8</td>
<td>Hopper empty; place additional cards in hopper, set P = 0375 and press RUN switch.</td>
</tr>
</tbody>
</table>
3. Space Required
   Program occupies locations 0000 through 1020.
10. Standard FORTRAN input and output formats.
11. Timing - None available.
IDENTIFICATION

Title: Plot from Magnetic Tape 163/164 to 165 Plotter via 160-A Computer - Ident AF8.01
Programmer: (Control Data Corporation/ Applications), August 1962

PURPOSE

This routine, written in OSAS-A, is designed to plot consecutive points on the 165 plotter and connect them with the best straight line. Points are obtained from magnetic tape, one point per two-word assembly-mode record, x then y. The first point obtained is used as a base reference point and the plot proceeds relative to this point. There are many switch options, including a library of graph identification marks (upright cross, diagonal cross, square, circle, diamond, eight triangles and two starts) under the control of Jump Switch 1. Tapes must be in binary mode only (odd parity).

USAGE

1. Operational Procedures:

The first record on the program paper tape is the OSAS-A paper tape loader. Load anywhere in any bank and run from the load address with the desired starting address for the routine in the A register. Run the routine from its starting address. There will be a halt (L+10 0000 7700) at which the tape unit being used should be put in the A register. At a second halt (L+32 0000 7777) selection may be made, by a suitable entry in the A register (0 through 17), from the library of graph marks to identify different plots.

Selective Jump Switch 1 Up Produces a graph with each point marked by the previously selected graph symbol. Without the switch Up the plot proceeds smoothly but the individual points comprising the plot will not necessarily be evident.

Stop Switch 1 is used to effect a pause (L+240 0000 7700); running will allow continuation of the same plot.

Jump Switch 2 is used to effect an absolute stop (L+153 1161 7700) i.e., to change tape reels or tape units. Running from here requires a new selection of a tape unit at the initial halt. This switch setting produces a rewind to load point of the selected tape unit. This switch setting also produces a resetting of all the bank controls to their initial values.
After a tape mark is read Jump Switch 4 is interrogated: Up, the pen stays where it is; Down, the pen is returned to the starting point for the plot, and then a program halt occurs, L+230 0000 7700. Zero in the A register allows a new plot to proceed from the original base reference point after selecting from the graph mark library at the next halt, L+32 0000 7700. Non-zero in the A register continues the previous plot.

3. Space Requirements

Total space requirements for the routine are 1264 locations anywhere in any bank. Approximately half of the routine (the latter 5268 locations) are involved with the tape identification marks and could be dispensed with if it is not required to mark the plots.

7. Error Stops:

L+111 4444 0000 Indicates a suspicious record on magnetic tape. Tape has been read three times and each time a parity error has occurred. Putting zero in the A register allows the bad record to be ignored; running without disturbing A allows reading the tape three more times. This may be repeated indefinitely.

14. Equipment Configuration:

160-A Swap Computer, Tape unit 163/164, and 165 Plotter.
IDENTIFICATION

Title: 165 Alphanumeric and Special Character Demonstration
Plot - Ident. F8.02
Programmer: (Control Data Corporation/Applications), July 1962

PURPOSE

This routine, written in OSAS for the Control Data 160 or 160-A computer, is basically a demonstration routine, but it may be used to produce a neat labeling of plots on the 165 plotter. The basic letter size is six-tenths of an inch and all letters or digits with curved portions are produced with smooth curves, utilizing the small internal up and down, sideways or diagonal steps of the plotter to the limit. The program works from either paper tape or the console typewriter.

USAGE

1. Operational Procedures:
   a. 160 - Load and run anywhere in core. At the halt (L+1 0000 7710) entering non-zero in A allows input from paper tape, otherwise input is via the console typewriter. (More than one character at a time can be typed, but care must be taken not to overload the typewriter buffer since this will result in characters being lost.)
   b. 160-A - Load and run anywhere in core with care that the indirect and relative banks are the same bank. Selective Jump Switch 1 UP allows input from paper tape, otherwise input is via the console typewriter.

3. Space Requirements: 45048 locations

7. Error Stop:

In either computer an error stop L+13 7777 0000 indicates that the 161 typewriter is not ready for the entering of characters. Correction of the condition before running will ensure success.

12. Caution to Users:

Since the routine is written for the 160-A, the selective jump instruction is a two-instruction set, which, on the 160, will be regarded as individual instructions.

The second instruction of the two-instruction set will be an error halt
if, and only if, the routine is loaded in 0; otherwise, garbage.

Therefore, for the 160:

a. The routine must be loaded at 0, and

b. A normal error halt will occur after the first normal halt.
   (Error halt will occur at L 2 after the normal halt L+1).

   Note: This error halt does not constitute an error fault.

G1.
IDENTIFICATION

Title: TRACK - Ident. - G1.00
Programmer: R. Beale, March 1961

PURPOSE

Trace a program, providing a flex-coded paper tape as output. Only the beginning and ending addresses of a consecutive instruction string appear as output, thus the object program is executed at higher speed than is possible using a full trace.

USAGE

1. Operational Procedure
   a. Clear memory
   b. Machine load the bioctal tape starting at 7000 - correct loading will end with P = 7577.
   c. Machine load the object program without altering locations 7000 - 7600. Position input data tape in paper tape reader if required.
   d. Set P = 7000, A = starting address of program to be traced. Run. Halt 7701 will immediately occur - P = 7002. Without otherwise altering console, set A = normal contents of A at start of object program. Turn on punch, run.

3. Space required
   7000 through 7534
   5358 = 3498

10. Timing

   Depending on the nature of the object program, its instructions are executed at 10-500 per second. The average is close to 75 per second.

12. Cautions to User

   Because each instruction must be interpreted before execution, the timing relationships within a program are altered - it is not possible to trace most card to tape programs for this reason. The track program attempts to faithfully execute a sequence of instructions regardless of its correctness. If proper selection of peripheral equipment does not precede the activation of the equipment, the computer hangs on a "sel" error indication. Punching by the track program does not alter the object program external function selections or senses. Each instruction is executed from upper cord, rather than from its normal position memory; therefore programmed error stops or halts in the object program show P = 7146.
IDENTIFICATION

Title: Binary to 4-bit Decimal Conversion - Ident. H1.00
Programmer: Sandord Elkin, March 1961

PURPOSE

This subroutine will convert a 24 bit binary integer into a decimal integer with each digit in successive cells.

USAGE

1. Operational Procedure

The 24 bit integer must be placed in locations BINDEC + 1008 and BINDEC + 1018, and the return address in cell 6. The 8-digit answer will be put in cells 708-778, with the units digit in 778.

3. Space Required: 6710 = 1038 locations.

4. Temporary Storage: Octal locations 6 and 70-77.

11. Timing = Approximately 4.3 milliseconds per decimal digit.


MATHEMATICAL METHOD

The binary integer is divided by 128. The remainder is stored in the appropriate location and the quotient used as a new binary integer.
Hello.

IDENTIFICATION

Title: Convert Binary Coded Decimal to Binary - Ident HI.01
Programmer: J. Pedersen, August 1960

PURPOSE

This subroutine will convert a binary coded decimal number of up to six digits to the equivalent binary number in 22 bit arithmetic format. The binary coded decimal number is stored one digit per word with the digit as the low order four bits of the word.

USAGE

1. Operational Procedure

   The address of the high order digits of the decimal number is specified by the contents of storage location 0010. The number of digits in the decimal number is specified by the contents of storage location 0011. The resulting binary number will be stored in location 0012 and 0013 with the high order portion of the word in 0012.

   The 22 bit arithmetic format uses the high order bit of the low order word as a buffer to catch overflows, thus this bit must be a zero and is not considered as an information bit. The low order bit of the high order word will be considered as the $2^{11}$ bit.

   On completion, the contents of location 10 will point one location beyond the low order digit of the decimal number. Contents of 0011 will be unchanged. The routine uses the high order four bits of location 0013 to catch the overflow from the multiply process. This overflow is added to the low order four bits of 0012. On completion of the routines, the program reassembles words 0012 and 0013 to the 22 bit arithmetic format. The assumption in the conversion routine is that the numbers are positive. Any sign indication will have to be added later.

2. Argument or Parameters - None

3. Space Required - 37 locations

4. Temporary Storage Requirements

   0010 - Contains address of high order digit of decimal number
   0011 - Contains count of number of digits in decimal number
   0012 - High order binary result
   0013 - Low order binary result
10. Timing - The routine takes $230.4 + 198.4$ N microseconds where $N$ is the number of decimal digits to be converted. The routine will take approximately 1.2 milliseconds to convert a five decimal digit number. The time to convert binary coded decimal information to the corresponding binary information is given in the table below. These times are derived on the assumption that the binary coded decimal information is stored one digit per word with the high order digit of the number given first.

The break in the time sequence between 3 and 4 digits, 6 and 7 digits, 9 and 10 digits is based on changing from a single to double to triple to quadruple precision binary representation.

<table>
<thead>
<tr>
<th>Number of decimal digits</th>
<th>Conversion time in milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.11</td>
</tr>
<tr>
<td>3</td>
<td>0.18</td>
</tr>
<tr>
<td>4</td>
<td>1.03</td>
</tr>
<tr>
<td>5</td>
<td>1.23</td>
</tr>
<tr>
<td>6</td>
<td>1.43</td>
</tr>
<tr>
<td>7</td>
<td>2.6</td>
</tr>
<tr>
<td>8</td>
<td>2.9</td>
</tr>
<tr>
<td>9</td>
<td>3.4</td>
</tr>
<tr>
<td>10</td>
<td>5.0</td>
</tr>
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</table>

11. Accuracy - The routine is good for up to six decimal digit numbers.

IDENTIFICATION

Title: 160-A Output - Ident. AH1.02
Programmer: D. T. Miller, January 1962

PURPOSE

To set up a 120 character line image for on-line printing or writing on a BCD output tape. The format will be specified in the calling sequence.

USAGE

1. Calling Sequence

The routine is entered by a return jump. The calling sequence will be of the following form:

L   JPR
L+1 OUTPUT
L+2 NORMAL
L+3 RETURN
L+4 ERROR
L+5 RETURN
L+6 ADDRESS OF ERROR
L+7 XXXX
L+8 XXXX } Format Specification Slot - as many as desired
L+9 XXXX
.
.
L+N XXXX
L+N+1 XXXX } Output Mode Specification Slot - as many as desired
L+N+2 0000

The calling sequence must be in the same bank as the output program. Three full words in an output specification specify a field in the line image or a mode of output. The format specification may refer to data in any bank. Although ordering within the format specifications is immaterial, the entire group of format specifications must precede the first output mode specification word. At least one output mode specification must be given.
2. Options and Parameters for Format Specifications

a. Binary-to-Octal

L  OPPP
L+1  DATA
L+2  NOOB

PPP: The rightmost print position to be used for this field.
DATA: The base address of the data word.
B: Bank number of the bank the data word is in.
N: The number of octal digits for output; if less than four octal digits, the octal digits should be right justified. The maximum is four digits.

b. Hollerith-to-Hollerith

L  OPPP
L+1  DATA
L+2  NOOB

PPP: The rightmost print position to be used for this field.
DATA: The base address of the data word.
B: Bank number of the bank the data word is in.
NN: Number of words in the BCD field.

The BCD information is transferred in whole words, any blanks in a BCD field must be provided by the programmer. The maximum number of words is 60 (120 characters).

c. Integer-to-Integer

L  OPPP
L+1  DATA
L+2  000B

PPP: The rightmost print position to be used for this field.
DATA: The base address of the data word.
B: Bank number of the bank the data word is in.

The output is 5 characters, sign plus 4 decimal digits. The integer is converted by successive subtraction of powers of ten.
3. Options and Parameters for Output Mode Specifications

a. Print On-Line

L  4000
L+1 00CC
L+2 0000

CC: Carriage control character, any of those applicable to the CDC 1612 printer. The paper motion will be pre-skip except for selection of one of the six monitor channels, then it will be post-skip.

b. Write on BCD Tape

L  3UOT
L+1 KOCC
L+2 0000

U: Tape control unit number used.
T: Tape number in proper unit.
CC: Carriage control character, any of those applicable to the CDC 1612 printer. The paper motion will be pre-skip except for selection of one of the six monitor channels, then it will be post-skip.
K: K = 4 provides for blocked output. The line image is stored in blocked form until a normal write tape sequence is encountered, and then outputs the accumulated lines in one record. A maximum of 5 lines may be blocked, then they will be put out in one record and blocking will continue.

The routine is coded for the CDC 163 tape unit.

6. Error Returns

In the event of error, error indications are placed in the A-register and the calling sequence. The address of the erroneous calling sequence word is stored in the calling sequence to the output routine. One of the following numeric codes is placed in the A-register:

1 = Print position not in the range 0-120,
2 = Illegal output specification number,
3 = No output mode specification given.

)
8. Tape Mounting

Controlled by programmer.

9. Format of Input and Output Data

a. Numeric data is assumed to occupy one full word in memory. Hollerith data is assumed to occupy one or more consecutive full words in memory for any one calling sequence reference.

b. Output: Controlled by programmer.

10. Selective Jump and Stop Settings

None.

11. Accuracy

Conversions are designed for full significance obtainable.

12. Cautions to the User

a. No check is made for overlapping fields. Any entry to the image supercedes any previous entries in the same position (the image is initially filled with BCD blanks).

b. The routine does not interfere with any buffering in operation at the time of entry.

c. No tape checking is done within the routine.

13. Total Space Required

\[ 618_{10} \text{ Program. } 305_{10} \text{ temporary storage for blocked records. } \]
IDENTIFICATION

Title: Conflex - Ident. AHI 03

PURPOSE

This routine allows you to use the #Flexowriter Model 35-4 in the 6 level mode to prepare programs and data for the 160A. All 35-4 Flexowriter characters produce equivalent 160A Flexowriter characters except ", $, A, P, #, ^, *, _, f, and uppercase period.

OPERATING PROCEDURE

1) Master clear.
2) Set all banks equal to 1
3) Mount conflex
4) Machine load at P = 0000
5) Set P = 0140
6) Mount tape prepared on 35-4 Flexowriter
7) Turn on punch
8) Run
9) Operation is terminated by moving run switch to off.

*(Standard Flexowriter used with G-15)

Note: If jump switch #1 - ON computer will stop on illegal character.
If jump switch #1 - OFF computer will not stop on illegal character.
### Character Table

<table>
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<th>LC</th>
<th>UC</th>
<th>G-15 6 Level Flex</th>
<th>160A Flex</th>
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Stop 2

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tab  tab  130  51  tab  tab
CR  CR  110  45  CR  CR

,  o  126  56  o  See Note
.  .  114  42  ----
/  ?  124  44  ---- /
---- UC  122  47  UC  ----

*Punches 44 which is*
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Punches 47, 46, 57 which is +
IDENTIFICATION

Title: General Binary to BCD, BCD to Binary Conversion

Programmer: A. R. Ferro, October 1962

PURPOSE

Uses a format statement, similar to Fortran statements, to specify the type of conversion to be made in the input or output field. The input and output fields are always internal information and are not in any way associated with external equipment. All input and output information is handled internally and is operated on specifically by the requirements made in the format statement. The format statements are conversion specifications which control the conversion of data from internal machine representation to packed external representation.

FNCNV is a closed subroutine entered by a return jump (JPR) with the contents of the A-register specifying the type of conversion.

USAGE

1. Calling Sequence:

   L-1  LDN   0 or 1   0 = BCD to Binary
       L   JPR    GENBCD
       L + 2 Location of format statement
       L + 3 Starting Location of Input
       L + 4 Terminating location in input
       L + 5 Starting location of output
       L + 6 Terminating location of output
       L + 7 Error indicator
       L + 10 Return

2. Space required: 2063\text{j} = 1075\text{j} locations

3. Temporary Storage: Direct cells 70-74

5. Bank Allocation: Relative and direct must be the same, indirect must be the same as the main program, and input, output, and format fields must be in the same bank as the indirect bank setting.

Error Returns:

An error sets an error indicator at L+7; will also be in the A-register at the time control transfers to the main program.
The error codes are:

A = 1  The first left parenthesis is missing
= 2  Illegal character where a number should appear
  = 3  Illegal code for parenthesis
        = 4  Illegal imbedded parenthesis
  = 5  Digit count exceeds 99 or output exceeds the range
  = 6  Comma following a repeat digit or illegal alpha character
  = 7  Output exceeded during alphanumeric format
  = 10 Integer exceeds range of ± 204710.

10. Input-Output Formats:

a. Format Statement

   The format statement must always be packed BCD information with a left parenthesis beginning the statement and terminating with a right parenthesis. Between the left and right parentheses repeat parens may be used such as:

   (2(16,3HABC,4A6),120,2X,4(o5,02)).

b. Conversion Types

   There are two numerical conversion type codes: I, for integer, and O for octal; and three alphanumeric conversion type codes: A, X, and H.

I Conversion

In: Where n is an unsigned integer specifying the number of characters in the field.

Input: Causes conversion between external BCD to internal binary representation. Spaces are entered as zeros and the integer variable may take on values from -2047 to 2047 inclusive. A minus sign will count as a character read. Maximum integer would be 14 for positive values and 15 for negative values. If n is greater than 4 (or 5 for negative) during input, the leading characters of the input field will be ignored and only one work will be stored in the output field. If the integer exceeds the range of ± 2047, the routine will exit to an error indicator.

Example: Input field contains 3 words 0305, 0212, 0407. The result in the output field would be one word 3777, and conversion would continue from the character following the 07.
Output: Causes conversion between internal fixed point representation and external BCD representation. The external representation is of the form, (-) DDDD, where D is a decimal digit and the minus sign or blank may appear. The field width must be large enough to include the sign; it may be larger to include leading blanks in the field. Leading zeros are replaced by blanks except for a zero value. Figure 1 shows the effect of various width fields.

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<tr>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
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</table>

Figure 1.

O Conversion

On: Where n is an unsigned integer specifying the number of characters in the field.

Input: During input is is expected to find only spaces, digits from 0-7 and possible a minus sign. All other characters are illegal. If n is greater than 4 will cause n-4 leading characters to be ignored.

Output: O specification causes output of the octal equivalent of the 12-bit representation of the integer value. Leading zeros are not suppressed. If n is less than 4, n leading digits will be placed into the output field. If n is greater than 4, n-4 leading spaces will precede the 4 digits in the output field.
The three alphanumeric conversion specifications provide for transmission of alphanumeric field, spacing by skipping character positions, and Hollerith information from the input list. These are converted by A, X, and H specifications.

A Conversion

An: Where n is an unsigned integer specifying the number of characters in the field.
Input: Transfers n characters to the output field. If n is less than 2, n characters are transferred. If n is greater than 2, n-2 leading characters are ignored.
Output: Transfers n characters to the output field. If n is less than 2, n characters plus the necessary leading blanks are transferred to the output field. If n is greater than 2, n-2 blanks precede the alphanumeric characters.

X Conversion

nX Where x is an unsigned integer specifying the number of characters in the field.
Input: n characters are skipped in the input field.
Output: n spaces are placed into the output field.

H Conversion

nH Where n is an unsigned integer specifying the number of characters in the field.
Input: n characters are skipped in the input field.
Output: Causes n alphanumeric characters immediately to the right of the H to be transferred to the output field.

Repeated Groups

A repeat factor may precede any of the K, O and A specification codes. Limits of the repeat are n = 99. Groups may be repeated in a similar manner. The group to be repeated is enclosed in parentheses and a repeat factor given preceding the left parenthesis.

Example: 2(16,3X,4A2)

12. Caution to User: A repeated group may not contain a repeated group.
Example, illegal: 2(16,3X,2(4A2))

H2.

IDENTIFICATION

Title: Sort 3X - Ident. H2.01
Programmer: (Control Data Corporation Sales), November 1962

PURPOSE

Sort 3X is a revised version of Sort 34 which is replaced. Sort 3X accepts input of a file from one reel of magnetic tape where the information is recorded as one item per physical tape block. This information is sorted on up to ten sort key fields using any standard Control Data tape transport. Four tape units are required. The sorted file is written out on tape with one item per block of magnetic tape. Either a minimum Control Data 160 or 160-A computer is used.

USAGE

1. Operational Procedure

a. Load Program Tape
   1. Turn on paper tape reader.
   2. For 160-A set all bank controls to bank 0.
   3. Depress the load-clear switch to clear and then place in load position.
   4. Run. Tape will load and stop with P = 3700 A = 2361. This loads the program version for the 163, 164, or 162 tape systems.
   5. For 1607 or 1615 tape systems, Clear. Place the load-clear switch in the load position.
   6. Set P = 3360, Run. Tape will load the 1607/1615 tape driver routines and stop with P = 3722 A = 7012.

b. Define Sort Fields
   1. Place enter-sweep switch at ENTER. Press load-clear switch.
   2. Set P = 0100
   3. Enter octal equivalent of location of left-most character of sort field in Z.
   4. Press step switch.
   5. Enter octal equivalent of location of right-most character of sort field in Z.
   6. Press step switch.
   7. Repeat steps 3 to 6 for each succeeding minor sort field.
   8. Press step switch 2 times to place zeros after last field definition if 9 or fewer fields are used.
   9. Return all switches to center position and press load-clear.
EXAMPLE: Sort a card record on columns 10 to 19 as major field and columns 1 to 5 as a minor field. The 6 numbers entered in the program are in order: 0012, 0023, 0001, 0005, 0000, 0000.

c. Define Sort Order for Magnetic Tape Character Code

Sort 3X includes a sort order table for standard BCD magnetic tape codes. If a different code is to be used, place the sort order table in locations 0200 to 0277 either manually from the console, or by machine loading a previously created binary input paper tape sort order table.

The present sort order from low to high is as follows:
Blank, 0 1 2 3 4 5 6 7 8 9
a b c d e f g h i j k l m n o p q r s t
u v w x y z + - / % $ * # @
other special codes

To define a new sort order, for instance, blank A-Z, 0-9, it is necessary to place a sort order number, starting with octal 00 in the location corresponding to the magnetic tape input coding of the required character. Thus, blank comes in as octal 20, a is 61, B is 62, etc. This new sort order would require that location 0220 contain a zero, 0261 contain 0001, 0262 contain 0002, etc.

d. Mount Magnetic Tapes

1. Mount input tape on tape unit number 1.
2. Mount scratch tapes of sufficient length on tape units 2, 3, 4.
3. Manually position all 4 tapes at load point.

e. Running the Sort Program

1. Specify parity of input tape by placing in location 0002 the number 0000 for even parity 0001 for odd parity.
2. Press the load-clear switch on console.
4. Input pass will take place. On completion, all tapes will rewind. Tape number 1 will rewind to unload position and computer will stop with P = 0643, A = 0643, Z = 7700. For other stops and corrective action, see Halt Table (Appdx I).
5. Replace input tape on tape unit 1 with a scratch tape.
6. Move run-step switch to the center position and return it to run position.
7. The sort will continue to completion and computer will stop either with P = 0701, A = 0001 or P = 0711. A = 0003. The contents of A will indicate which tape contains the output sorted file. This tape will be in the unload condition.
8. Return run-step switch to center position.

9a. For 162, 163, or 164 tape systems: If the output is on tape unit 1, press load-clear and return it to center. Set $P = 0130$ and run to rewind the error tape number 2. If the output is on tape unit 3, press load-clear and return to center position. Set $P=0135$ and run to rewind error tape unit 4.

9b. For 1607 or 1615 tape system: If output is on tape unit 1, press load-clear and return to center. Set $P = 3711$ and run to rewind error tape unit 2. If output is on tape unit 3, press load-clear and return to center; set $P = 3714$ and run to rewind error tape unit 4.

f. List Error Tape

The error tape contains records involved in an unrecoverable read situation. These records are also on the sorted output tape. The operator should check and correct such errors.

g. To Perform Another Sort

The sort program is self-restoring and may be used without reloading. If the same set of sort fields is to be used, mount the new input and run the sort program starting with Step e.

h. Rerun Points or Sort Termination

1. To terminate sort (160-A) set optional stop one ON. Program will stop after completion rewind of tapes at end of current merge pass with $A = abcd$. Octal digits a and b are the tapes which were input to the merge, c, and d, are the tapes with which the output of the merge pass.

2. For a rerun point, remove tapes a and b and save. Replace them with the new scratch tapes. Run from the point of the stop.

3. To terminate sort for further running at a later date, remove tapes 3 and d and save them.

i. Resuming Terminated Sort or Rerun

1. Load sort 3X program, or if already in machine go to step 2.

2. Place intermediate tapes obtained from "h" advice on tape units 1 and 2.

3. Master clear. Place 1234 in A register. Set $P = 0764$. Step 3 times; this places the correct tape numbers in the read control.


5. Stops may occur with $P = : 1036\ 1067\ 1077\ 1104$, in all cases run to continue.
5. Bank Allocation: Set all 160-A bank controls to Bank 0.

7. Error Stops

Appendix I, HAM TABLE, gives each stop and corrective action.

Sort 3X provides error checking at several levels. The main source of possible errors is the magnetic tape system; Sort 3X provides checks and corrective action. The checks are as follows:

a. Checks for short records from input tape: Sort 3X places a lower limit of 16 characters for an acceptable input record. If a smaller record is introduced a 0426 stop occurs. If the short record is not expected, it should be discarded from the sort as a probable noise record generated by bad tape.

b. Intermediate tape records must have a given format. Sort 3X checks each intermediate tape record for the correct format before releasing it to the merge operation. Stop 3316 provides the option to try to read the record again or to eliminate it from the merging operation. On elimination, a copy of the record is produced on punched paper tape for further analysis by maintenance personnel.

9. Input and Output Tape Mountings

See l.d. page 2

11. Timing

To estimate the time required by Sort 3X to process a file of records, it is necessary to know the duration of phase 1, the duration of each merge pass of phase 2 and the duration of phase 3 as well as the tape rewind time required for each pass.

The following definitions and timing formula give the sort time using Sort 3X using various tape units.

\[ N \] Number of records to sort
\[ R \] Number of characters in record. If odd, take next even number.
\[ K \] Number of characters in key, if odd, take next even number.
\[ BF \] First pass blocking factor \( = \frac{2970}{\text{Integer portion of division } K+R+4} \)
\[ P \] Number of passes \( = \log_2 \frac{N}{BF} \)
\[ G \] Grouping in merge pass \( = \frac{986}{K+R+4} \)
\[ NB \] Number of data blocks in merge pass \( = \frac{N}{G} \)
\[ BS \] Block size for merge in characters \( = 6 + G(K+R+4) \)
\[ CPR \] Characters contained per full reel of tape
\[ IBS \] Number of characters used for interblock space
TR Transfer rate in thousands of characters per second
RS Read start stop time (milliseconds)
WS Write start stop time (milliseconds)
SD Stop delay (milliseconds dead time for continuous read or write)
RW Rewind time in minutes for a full reel of tape.
MG Internal processing time to merge one group of data to get
an output block. (milliseconds)
T Sort time in minutes

The sorting formula for Sort 3X is as follows.

\[ T = \frac{(N + \frac{2N}{BF})(RS + SD + \frac{R}{TR}) + (P)(NB)(RS + WS + MG + \frac{2BS}{TR}) + (N(WS + SD + \frac{R}{TR}))}{60,000} \]

\[ + \quad \frac{2N(R + IBS)}{CPR} \quad + \quad (P)(.75) \left( \frac{NB(RS + IBS)}{CPR} \right) \quad RW \]

Where \( MG = (g)(.15)(K + .3R + 12) \)

**EXAMPLE**

This example illustrates the use of the Sort 3X timing formula. Assume that a file of records to be sorted has the following specifications:

- Record length \((R) = 80\)
- Number of records \((N) = 20,000\)
- Length of key \((K) = 16\) in two fields
- 163 magnetic tapes with a 30 KC transfer rate are to be used.
- First determine the first pass blocking factor \( BF = \frac{2070}{K+R+4} = 29.7 \)
  Taking the integer portion we have \( BF = 29 \)
- We then determine the number of passes \((P)\) by finding \( N/BF = 689 \)
  And take the log to the base 2, or use table 2 to determine that \( P = 10 \)
- We next determine \( G = \frac{986}{100} = 9.86 \) so take \( G = 9 \)
- We then determine \( NB = \frac{N}{G} = \frac{20,000}{9} = 2,222 \)
- And determine \( BS = 6 + G(K+R+4) = 6 + 9(100) = 906 \)

Taking values of \( CPR, IBS, TR, RS, WS, SD, RW \) from the tape characteristics table and computing \( MG = (g)(.15)(K+.3R +12) = 70.2 \) milliseconds. We substitute in the formula to find the sort time is
\[ T = \frac{(20,000 + 40,000)(4 + 10 + \frac{80}{30}) + 10 \times 2,222(4 + 18 + 70.2 + \frac{1812}{30})}{60,000} \]
\[ + \frac{20,000(18 + 10 + \frac{80}{30}) + \frac{40,000(230) + (10)(.75) 2,222(1056)}}{5,520,000} \]
\[ = \frac{(20 + 40)(16.67) + 10 \times 2.222(152.6) + (20)(30.33) + \frac{4\times2.3}{60} + \frac{7.5\times2.2\times1.056}{5.52}}{3.33} \]
\[ T = 5.95 + 56.5 + 10.3 + 16 = 88.8 \text{ minutes} \]

Table 2  Number of merge passes

<table>
<thead>
<tr>
<th>N/BF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>1</td>
</tr>
<tr>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td>5-8</td>
<td>3</td>
</tr>
<tr>
<td>9-16</td>
<td>4</td>
</tr>
<tr>
<td>17-32</td>
<td>5</td>
</tr>
<tr>
<td>33-64</td>
<td>6</td>
</tr>
<tr>
<td>65-128</td>
<td>7</td>
</tr>
<tr>
<td>129-256</td>
<td>8</td>
</tr>
<tr>
<td>257-512</td>
<td>9</td>
</tr>
<tr>
<td>513-1024</td>
<td>10</td>
</tr>
<tr>
<td>1025-2048</td>
<td>11</td>
</tr>
<tr>
<td>2049-4096</td>
<td>12</td>
</tr>
<tr>
<td>4097-8192</td>
<td>13</td>
</tr>
</tbody>
</table>
Magnetic Tape Characteristics for Sort 3X Timing Purposes

<table>
<thead>
<tr>
<th>Description</th>
<th>Tape Unit</th>
<th>163</th>
<th>164</th>
<th>6031D</th>
<th>60311D</th>
<th>6061D</th>
<th>60611D</th>
<th>1607</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR Characters per reel</td>
<td>5.52M</td>
<td>5.52M</td>
<td>5.52H</td>
<td>15.3M</td>
<td>5.52M</td>
<td>15.3M</td>
<td>5.52M</td>
<td></td>
</tr>
<tr>
<td>IBS Characters for inter block space</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>417</td>
<td>150</td>
<td>417</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>TR Character transfer rate (KC)</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>41.5</td>
<td>30</td>
<td>83</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>RS Road Start (MS)</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>WS Write Start (MS)</td>
<td>18</td>
<td>27</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>SD Stop Delay (MS)</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>RW Rewind time for full reel (minutes)</td>
<td>3.33</td>
<td>2</td>
<td>1.33</td>
<td>1.33</td>
<td>1.33</td>
<td>1.33</td>
<td>3.33</td>
<td></td>
</tr>
</tbody>
</table>

Note: 5.52 M = 5,520,000
15.3 M = 15,300,000
14. Equipment Configuration

Minimum SWAP 160 or 160-A computer and four magnetic tape units.
(163, 164, 1607 or 606)

METHOD

The sort process used in Sort 3X is performed in three steps. The first called Phase 1 is an internal sort which reads individual records, determines the sort control fields, and sorts internally to form sorted groups of records. Phase 2 is a two way merge of the individual sorted groups which were formed in Phase 1. Phase 3 performs the final two way merge to form the sorted file and also writes out the individual records in their original form. It should be noted that although the input and output of the Sort 3X program are individual records, the intermediate tapes formed between the various phases of the program are blocked up to form records of 1,000 characters for maximum magnetic tape efficiency.

Sorting Technique

The sorting technique used in the Sort 3X program consists of reading input records from the input file until the total of records plus key is a total of 3,000 characters. These records are then arranged in sequence and written on alternate tapes in blocks of 1,000 characters of record plus key. After the input file has been read in, phase 2 of the sort program merges these sorted sequences into longer sequences. When there is one merge left, the sort 3X program automatically goes into phase 3 which produces one long sequence which is the sorted file.

One tape is used for input, and two units are used for output during the initial sorting process. In the merging process, the input units become output units, and vice versa.

Sort 3X accomplishes the sorting operation in three steps - Phase 1, phase 2, phase 3.

Phase 1

1. Phase 1 determines the total size of the sort key field and reserves space prior to the data for the key field.
2. Each record is read into the area immediately following its reserved key field, the size of the record is determined from the read in command.
3. The key is extracted from the record, recoded to a sort sequence code, and placed in front of the record in its key field. The key information is extracted from up to ten fields in the record.
4. Successive records are read in until the storage occupied exceed 3,000 characters for key and records.
5. The last record read in is backspaced to be accepted as the first record of the next block.
6. The information is sorted internally to form a sequence of not over 3,000 characters in final sort order.
7. The information is written on the output tape in blocks of not over 1,000 characters. The blocking factor is determined solely by the number of records plus key which can be contained in less than 1,000 characters.
8. Output is to the alternate output tape when there is a break in sort sequence between the last record output from the previous block and the first record output of the current block.
9. A sequence count is kept so there will be an automatic switch to phase 3 if the records were in sort on input, or were brought into sort by the internal sort process.

Phase 2
1. Phase 2 merges the sequences written during phase 1 using as many merge passes as are required to arrive at two sorted files, one on each or the two output tapes. The files are still blocked to a maximum of 1,000 characters per block. The blocking information is contained on the magnetic tape blocks.
2. On reaching two sorted files, phase two goes to phase three.

Phase 3
1. The two sorted files are merged to form one sorted output file.
2. At output, the key is stripped from the record, and the original record is written on the output tape.
3. If at any time during the sort process in phase 1, 2 or 3, a record was encountered which was not recoverable during the read process, the record is flagged as possibly being wrong. The bad records are written on an alternate output tape as well as being written on the final output tape. This allows for the operator to peruse the possible errors and take corrective action.

Allowable Input Record Configurations
Sort 3X accommodates variable length input records which must appear on tape singly as one record per block of tape. The maximum size of an input record must be such that the number of characters in the record plus the number of characters in the key do not exceed 984 characters.

Maximum File Length
The input file to be processed by Sort 3X must be no longer than the number of records that can be contained on a single tape reel when in the blocked form for the merge passes. This number depends on the record length, key length, and whether the processing is being performed on a high density or low density magnetic tape mode. The following table shows the maximum number of records which can be processed as one job.
8 February 1963

Table 1

<table>
<thead>
<tr>
<th>Key and record size in characters</th>
<th>Maximum number of records</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low density</td>
</tr>
<tr>
<td>10</td>
<td>430,000</td>
</tr>
<tr>
<td>20</td>
<td>225,000</td>
</tr>
<tr>
<td>30</td>
<td>150,000</td>
</tr>
<tr>
<td>40</td>
<td>111,000</td>
</tr>
<tr>
<td>50</td>
<td>90,000</td>
</tr>
<tr>
<td>60</td>
<td>75,000</td>
</tr>
<tr>
<td>70</td>
<td>64,200</td>
</tr>
<tr>
<td>80</td>
<td>56,500</td>
</tr>
<tr>
<td>90</td>
<td>50,000</td>
</tr>
<tr>
<td>100</td>
<td>45,000</td>
</tr>
<tr>
<td>120</td>
<td>37,500</td>
</tr>
<tr>
<td>140</td>
<td>32,100</td>
</tr>
<tr>
<td>160</td>
<td>28,000</td>
</tr>
<tr>
<td>180</td>
<td>25,000</td>
</tr>
<tr>
<td>200</td>
<td>22,500</td>
</tr>
<tr>
<td>300</td>
<td>15,000</td>
</tr>
<tr>
<td>400</td>
<td>11,100</td>
</tr>
<tr>
<td>500</td>
<td>9,000</td>
</tr>
<tr>
<td>600</td>
<td>7,500</td>
</tr>
<tr>
<td>700</td>
<td>6,400</td>
</tr>
<tr>
<td>800</td>
<td>5,600</td>
</tr>
<tr>
<td>900</td>
<td>5,000</td>
</tr>
</tbody>
</table>
EXAMPLE

Compute the maximum file size for records 50 characters long using a sort key of six characters. To total record plus key size is 56 characters. Assume high density mode of processing.

From the table we find that for 60 characters we have a file size of 166,700 records and for 50 characters we have a file size of 200,000 records thus we can use a file of approximately 180,000 records.

Sort Key Fields

From one to ten fields of each input record can be specified to control sequencing of the file. These fields can be located anywhere within the record, provided they are in the same place in each record. The fields can be of any length.

The locations of each control field is specified by the contents of locations 0100, 0101 for the first field, 0102, 0103 for the next lower field, etc. in the core storage of the 160 or 160-A computer. The values of these locations can be very conveniently set up by the operator by following the operating instructions.

There is no penalty for using any number of fields or the location of the fields in the record. The control fields can contain any character. The standard collating sequence is included in the program, but can be changed by changing the contents of the location 0200 to 0277 in the Sort 3X program.

Unreadable Input Records

Input tape blocks, during any phase, are flagged for special treatment on output. An unreadable record is one that causes redundancy error indications after eight attempts to re-read the input record. A read error does not cause the sort program to stop. In the phase 3 (output phase) the unreadable records are put out with the regular sorted file and they are also listed on the error tape.
INTERMEDIATE TAPE FORMATS

The intermediate tapes produced by sort 3X are written in binary and are provided with a header record and a trailer record. The tape records in between also are blocked records. All records are a multiple of two characters and will be shown in a two character representation as seen in memory. This is also the form of the punched paper tape output of an error from the 3316 stop.

The formats are as follows:

Header Record

7772    Header code identifying this record as a header
00xx    Tape account number. Starts at 1 and is increased by 1 for each tape written.
yyyy    Key size. Size of sort key in words for rerun of the program.

Information Record

7775    Beginning of information block code
xxxx    Number of records in block
7776    Beginning of record, may be 7774 if record came from parity error block
yyyy    Number of computer words to reach next record
kkkk    Key information, coded in sort order code

rrrr    Original record

7776    Beginning of next record
yyyy    kkkk

rrrr    End of block code (placed where next beginning of record code might be)
Trailer Record

7771  Beginning of trailer code
0000
7773 0000
bbbb  Count of number of information blocks on the tape
bbbb
rrrr  Count of number of information records on the tape
rrrr

The counts in the trailer record are carried in BCK notation.

SAMPLE TAPE

A sample intermediate tape containing the records 2abc, 3abc 1abc which are being sorted on column 4 and 1 would appear on an intermediate tape in the following form, assuming that the block size was two records.

Header

7772
00xx  Tape account number
0001  Sort key is one word or two characters

Information Block 1

7775
0002  Two records on this block
7776  Beginning of record flag
0005  This record is five words long, including key and flag
1503  Sort key "c2" in sort order code
0261  "2a" in magnetic tape code
6263  "bc" in magnetic tape code
7776  Beginning of second record flag
0005
1504
0361
6263
7773  End of block flag

Information Block 2

7775
0001
7776
0005
1502
0161
6263
7773  End of block flag
Trailer Record

7771
0000
7773
0000
0002  Low order  3 decimal digits of block count given in octal
0000  High order  3 decimal digits of block count given in octal
0003  Low order  3 decimal digits of record count given in octal
0000  Middle order 3 decimal digits of record count given in octal
0000  High order  3 decimal digits of record count given in octal

The beginning of information record code 7776 may be changed to 7774 by sort 3X if the record is in doubt. The value 7774 is used as a tape as well as the normal record tape.
# Appendix I

## Sort 3X Halt Table

<table>
<thead>
<tr>
<th>P</th>
<th>A</th>
<th>Reason and Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0134</td>
<td>1152</td>
<td>Error tape 2 rewound on 162, 163, or 164 tape system. List tape number 2 and take corrective action on sorted file.</td>
</tr>
<tr>
<td>0141</td>
<td>1154</td>
<td>Error tape 4 rewound on 162, 163, or 164 tape system. List tape number 4 and take corrective action on sorted file.</td>
</tr>
<tr>
<td>9426 n/2</td>
<td></td>
<td>Source input record is less than 16 characters. The contents of A gives one half of the number of characters read in the input record. If this record is legal, run to accept. To delete the record from the sort, set A to 4000 or greater and run. This check is included to catch possible noise records from the input change location 0423 to 070N where N is one half the size of the shortest expected record and start at P = 0430 to accept the record which caused the halt prior to correcting the program.</td>
</tr>
</tbody>
</table>

- 0701 0001: Sort 3X completed. Output on tape number 1. To rewind error listing tape, see step 1.3.9 of operating procedure.
- 0711 0003: Sort 3X completed. Output on tape number 3. To rewind error listing tape, see step 1.3.9 of operating procedure.
- 0762 abcd: This is optional stop 7701 which occurs between merge passes. For 160, to eliminate this stop change location 0762 to 0300. Start at P = 0761. The digits in the A register indicate the input tapes as a, b, and the output tape as c, d which were used in the last merge pass. This stop may be used as a rerun point in a long sort. Remove tapes a and b and replace with scratch tapes. To continue operation, do not change the contents of A, and run. For the 160-A, to eliminate this stop, return optional stop switch 1 to the neutral position.
- 1036 xxxx: Input tape A header halt. Checks on the header of the intermediate input tape header format failed for the following reasons: (1) Unrecovered parity error in reading the input header. (2) Account number on the header did not compare with the internal account number. (3) No header record on the tape. Replace tape A as indicated by octal digit Axxxx in location 0037. Manual rewind load ll tapes. Start with
P = 0761. Program will stop with P = 0762 if optional stop 1 is on. The program will stop with P = 1036. Run, program will stop with P = 1067. Run.

This recovery procedure assumes that the scratch tape was bad and performs the previous merge pass. The two stops at 1036 and 1067 will be caused by account number errors which should be ignored.

1067  xxxx  Input tape B header halt.
Checks on the header of the intermediate input tape header format failed for same reasons as 1036 halt.
Replace tape B as indicated by octal digit xxxxx in loca-0037. Follow rest of the recovery procedure given for the 1036 halt.

1077  xxxx  Key size specified on intermediate tape A and B do not agree.
If this stop occurs during a normal sort, manual rewind load all tapes and start with P = 0761. Program will stop with P = 0762 if optional stop 1 is on. The program will stop with P = 1036. Run, program will stop with P = 1067. Run.
If this stop occurs during the resumption of an interrupted sort, obtain the correct pair of input tapes and restart the resumption procedure. The tapes presently on drives 1 and 2 are not the correct pair.

1104  xxxx  Key size specified on intermediate tapes and in the memory of computer do not agree.
This stop should occur during the resumption of an interrupted sort. Run to get correct key size in memory from tape. This stop should not occur otherwise.

1611 1611  Intermediate output tape C at physical end of tape.
Place longer scratch tape on unit C indicated by octal digit xxxxx in location 0037. Manual rewind load all tapes. Start with P = 0777.

1621  xxxx  Attempt to write merge output on error tape during third phase, or output section of sort.
This error may occur as a result of a recovery procedure.
Manual rewind load all tapes. Start with P = 0777.

1700 1700  Intermediate output tape D at physical end of tape.
Place longer scratch tape on unit D indicated by octal digit xxxxx in location 0037. Manual rewind load all tapes. Start with P = 0777.

2004  xxxx  Intermediate tape A record count error.
Number of records moved from A input area does not compare with the number indicated on the input tape for this block. xxxx = number of records in the block minus the number of records moved out. This stop usually is an indication of machine trouble, however one attempt may be made to get around the error by manual rewind load all tapes and start with P = 0777.
Intermediate tape A file accounting error.
Number of records and blocks processed from intermediate tape A does not check with the Tape A trailer account records.
Manually rewind load all tapes and start with P = 0777.

Format error.
The intermediate record read in from tape A does not conform to the format required for sort 3X.
Manual rewind load all tapes. Start with P = 0777.

Intermediate tape B record count error.
See 2004 stop for cause and action.

Intermediate tape B file accounting error.
See 2103 stop for cause and action.

All above stops may occur only during the first or input pass and have to do with internal format checks.
Manually rewind load all tapes. Start with P = 0000.

Intermediate pass output tape is at physical end of tape during input pass.
If contents of 0031 = 0001, output is tape D. If contents of 0031 = 0000, output is tape C. Place a longer scratch tape on output tape c or d as indicated by the contents of location 0037 = XXCD. Manual rewind load all tapes. Start P = 0000.

Internal format error during output pass.
Manually rewind load all tapes. Start P = 0770.

Physical end of tape normal output tape C during output pass.
Place longer tape on output tape C as indicated by the contents of location 0037 = XXXC. Manual rewind load all tapes. Start P = 0770.

Physical end of tape, error output tape D during output pass.
Place longer tape on output tape D as indicated by contents of location 0037 = XXXD. Manual rewind load all tapes. Start P = 0770.

Halt before re-read of bad input record. A contains the address of the location in Sort 3X where re-read of the input record will start. This stop always follows a 3316 stop in which the decision is to re-read the input tape. Run to continue.
Format error on reading intermediate input tape. The block read in from the intermediate tape does not conform to the format required by sort 3X. This stop is caused by either a noise record left on the tape in passing a bad spot, or by a malfunction of the tape system.

Recommended recovery procedure is:
1) Re-read the bad record. Move run-step switch to neutral and then to run. Computer will arrive at 3312 stop. Run again to reread the bad tape. If the 3316 stop occurs again, it is probably a noise record, so take step 2.

2) Eliminate the record from the operation. Turn on paper tape punch. Clear A register and run. The bad record will be punched out on paper tape in the magnetic tape code. Feed out the paper tape and keep the bad record for possible diagnostics by the maintenance representative.

3) If this stop persists on alternate passes, it is possible that one of the scratch tapes has a bad area on it. Note the tape unit which is used during the tape re-read process, set optional stop 1 and replace the tape at the next between merge stop. Caution: Replace the bad tape at the between merge stop immediately following the 3316 stop and recovery procedure.

4) If a 2103 or 2262 stop occurs after the 3316 stop, the record removed from the sort is one of the records in the file. It is recommended that the sort be performed again.

Error tape rewound on 1607 or 1615 system.
List error tape and take corrective action on sorted file.
II. IDENTIFICATION

Title: Proper Fraction for Calculating Percentages - Ident. I1.00
Programmer: L. Goodreau, May 1961

PURPOSE

Division of $\frac{x}{y}$ where $x$ is assumed to be $< y$. The answer will be in the form $0.xxxxx$, adjusted by rounding, in true binary.

USAGE

1. Operational Procedure: Program tape can be loaded anywhere in memory.

2. Arguments
   a. Dividend in location 71
   b. Divisor in location 70
   c. Exit to main program in 77
   d. Result in location 73

      1) If the divisor $= 0$, result will be 0.
      2) If $x < y$, the result will be in the form $0.xxxx$, rounded.
      3) Space required: $196_{10}$ locations, including locations 70 - 77.

METHOD

$D = \text{dividend which is } \leq 4095_{10}$
$d = \text{divisor which is } \leq 4095_{10}$

$D \text{ BCK } x 10^{3}$

d BCK

d BCK $x 10^{1}$

d BCK $x 10^{2}$
II.

IDENTIFICATION

Title: Single Precision Divide - Ident. I1.01
Programmer: Sanford Elkin, February 1961

PURPOSE

This subroutine will divide a positive 23-bit fraction by a positive 11-bit fraction, giving a rounded 11-bit fractional quotient.

USAGE

1. Operational Procedure

   The dividend (a and b) must be placed in locations 60 and 61 respectively, and the divisor (x) in 62. The contents of a must be less than the contents of x, and both must be positive. b contains 12 low order magnitude bits, which may be all zeroes. The routine is entered at the symbolic address DVDSBR, and the return address must be in cell 7. The quotient (y) will be in cell 63.

3. Space Required: $27_{10} = 33_{8}$ locations 7 and 60-63.

11. Timing: 2.0 milliseconds

12. Cautions to User: The dividend is destroyed by the subroutine. If the true quotient equals or exceeds $1 - 2^{-12}$, the octal value 4000 will be in cell 63.

13. Accuracy: 1 bits, with answer being rounded.


MATHEMATICAL METHOD

Repeated subtractions are used.
II.
IDENTIFICATION

Title: 9-bit Quick Multiply - Ident. II.02
Programmer: Sandord Elkin, February 1961

PURPOSE

This subroutine will multiply two signed 11-bit numbers together in about 600 microseconds, giving a signed answer accurate to approximately 10 bits.

USAGE

1. Operational Procedure

The two numbers and their product are interpreted as signed fractions with magnitude less than unity. The multiplicand must be in cell 10 and the multiplier in cell 11. Cells 70-72 are used for temporary storage, and the product will be placed in the A register. The routine is entered at the symbolic address MPY9B, and cell 2 must contain the return address.

3. Space Required: 18110 or 26518 locations, plus locations 10, 11, and 70-72.

11. Timing: Average - 595 microseconds, maximum - 660 microseconds

13. Accuracy: Average - 1 \times 2^{-11}, worst case - 3 \times 2^{-11}

14. Equipment configuration: Minimum SWAP 160 Computer

MATHEMATICAL METHOD

$2^{-10}$ is added to the absolute value of each factor, and the two low-order bits of each are truncated. If either resulting number is 0 or 1, 0 or the other factor becomes the answer. Each of the three octal digits of the resultant multiplier is examined, and the partial product of each with the resultant multiplicand is obtained. The bits in each partial product which are less significant than $2^{-12}$ are truncated, and the sum of the partial products is truncated to $2^{-11}$. The sign of the product is then obtained, and the answer is placed in the A register.
II. IDENTIFICATION

Title: Integer Divide - Ident. II.03
Programmer: Sandord Elkin, March 1961

PURPOSE

This subroutine will divide a positive 23-bit integer by a positive 11-bit integer, giving a 12-bit quotient with a 11-bit remainder.

USAGE

1. Operational Procedure

   The 23 bit integer must be placed in a (70) and b (71), the divisor in x (72), and the return address in exit (7). x must be greater than a (a being the more significant half). The routine must be entered at DVDINT. The quotient will be in y (73) and the remainder in a (70).

3. Space Required: $22_{10} = 26_8$ locations.

4. Temporary Storage: Octal locations 7 and 70-74.


14. Equipment Configuration: Minimum SWAP 160 computer

MATHEMATICAL METHOD

Repeated subtraction are used.
Title: Fractional Arithmetic - 22 bit - Ident. II.04
Programmer: S. Palais and J. Seewerker, July 1961

PURPOSE

This is a relocatable package, designed to add, subtract, multiply or divide 22-bit binary fractions (positive or negative).

USAGE

1. Operational Procedure

a. Calling Sequence

The desired subroutine may be entered by either a JPI or a JFI 01 as in the example below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Subroutine Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD</td>
<td>0002</td>
</tr>
<tr>
<td>SUBTRACT</td>
<td>0003</td>
</tr>
<tr>
<td>MULTIPLY</td>
<td>0004</td>
</tr>
<tr>
<td>DIVIDE</td>
<td>0005</td>
</tr>
<tr>
<td>RETURN ADDRESS</td>
<td>0007</td>
</tr>
</tbody>
</table>

Examples:

LDF 03 LDF 04
STD 07 STD 07
JPI (02, 03, 04 or 05) JFI 01
(RETURN ADDRESS) (SUBROUTINE ADDRESS)
(RETURN ADDRESS)

The augend, multiplicand, minuend or dividend is placed in cells 70 and 71 and the addend, subtrahend, multiplier or divisor in cells 72 and 73. The result appears in 70 and 71, with the contents of 72 and 73 unchanged. Thus, a sequence of operations can be performed, changing only the contents of 72 and 73. An overflow in addition or subtraction is indicated by a 1 in cell 74.

b. Operating Instructions

If the 22-bit Fractional Arithmetic non-relocatable program tape is
loaded at 00, it may be run as is. Since the executable part of the routine can be relocated anywhere above 100 one can load the relocatable tape anywhere and then add the new load address minus 100 to the entrance addresses given above and enter the resulting sums in registers 0002 thru 0005. This is the only change necessary to relocate the program.

3. Space Required
   a. Low Core

      Besides locations 0002 thru 0005 and 0007 specified above, cells 70 thru 77 are used as temporary storage.

   b. High Core

      The executable subroutines start at location 100 and run to location 573. The following is a breakdown for the various subroutines:

<table>
<thead>
<tr>
<th>Subroutines</th>
<th>Entrance Address</th>
<th>Space Required Octal Decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 ADD</td>
<td>0105</td>
<td>113 75</td>
</tr>
<tr>
<td>22 SUB</td>
<td>0100</td>
<td>120 80</td>
</tr>
<tr>
<td>22 MULT</td>
<td>0220</td>
<td>161 113</td>
</tr>
<tr>
<td>22 DIV</td>
<td>0401</td>
<td>173 123</td>
</tr>
</tbody>
</table>

   with a total length of $316_{10} = 474_8$.

8. Error Return

   If the divisor is less than or equal to the dividend, an error return is signaled by a non-zero accumulator upon return from the subroutine (a normal return from a subroutine will have a zero in the accumulator). The input to registers 70 thru 73 is restored and if the dividend equals the divisor, location 74 will contain 4000.

10. Input and Output Format
    a. Positive 22-bit Fractions

      The most significant 11 bits of the fraction are placed in the "high order" word and the least significant 11 bits in the "low order" word with the left-most bit of both words being zero; e.g., in the division routine, cells 70 and 71 would contain the high and low order parts of the dividend respectively and cells 72 and 73 the high and low order parts of the divisor.
b. Negative Fractions

The add and subtract routines do 24 bit complementary arithmetic. Thus, a negative 22 bit fraction is broken up into the high and low order parts as above and then one's complement of all 24 bits is taken and entered into the high and low order words (which the computer will then regard as negative since the left-most bit of each word will contain a one bit.) Thus, if the result appearing in 70 and 71 is negative, the magnitude of the number may be found by complementing both the high and low order words. The high and low order parts of an input number must agree in sign, otherwise an incorrect answer will be given.

11. Timing

<table>
<thead>
<tr>
<th>Subroutine</th>
<th>Execution Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 ADD</td>
<td>225 microseconds</td>
</tr>
<tr>
<td>22 SUB</td>
<td>300 microseconds</td>
</tr>
<tr>
<td>22 MULT</td>
<td>5 - 10 milliseconds</td>
</tr>
<tr>
<td>22 DIV</td>
<td>10 milliseconds</td>
</tr>
</tbody>
</table>

12. Cautions

Since cell 74 (the overflow indicator) is set equal to zero at the beginning of each addition, subtraction or division, the user should check for overflow at the end of each of these operations if he intends to do a sequence of computations. In using any other subroutines related to 22-bit arithmetic, one should be careful to distinguish whether they are applicable to 22-bit fractional arithmetic.

13. Accuracy

All subroutines result in 22-bit positive fractions or 24-bit one's complement negative fractions. In multiplication, the product is rounded to 22-bits. In division, the quotient is truncated to 22-bits.

II. IDENTIFICATION

Title: Nine-Bit Quick Sine - Ident II.05
Programmer: S. Elkin, August 1961, Control Data Corporation

PURPOSE

This subroutine will obtain the sine of any angle whose magnitude is less than 90°, in about 3 milliseconds, with the answer accurate to about 9 bits.

USAGE:

1. Operational Procedure

   The angle x must be put in the A register before entering the routine, and the answer sin x will be put in the A-register. The format of x must be that of a signed binary fraction, i.e. $4000_8 \leq x \leq 3777_8$, and it is interpreted as a fraction of 90°. For example, $x = 2000_8$ means $x = 45^\circ$, and $x = 4000_8$ means $x \approx -89.956^\circ$. Sin x should also be interpreted as a signed binary fraction. The routine is entered at the symbolic address SINFX, and XTSIN (location 3) must contain the return address. Finally, ADRMPY (location 4) must contain the address of the 9-bit Quick Multiply.

3. Space Required

   For the Sine routine alone, $38 \times 10 = 468$ locations, plus location 3 for the exit address. However, the 9-bit Quick Multiply requires $181 \times 10 = 2658$ locations plus 5 locations in low core.

11. Timing

   Approximately 2.85 ms average, 3.1 ms maximum.

13. Accuracy

   Average error from 0° to 67.5° is less than .001, from 67.5° to 80° is less than .002, and between 80° and 90° is less than .004.


MATHEMATICAL METHOD

The Tchebychev equation

\[
\sin \frac{\pi}{2} x = x(C_3 - x^2(C_2 - x^2(C_1)))
\]

is used, where \(C_3 = 1.5703\), \(C_2 = .6419\), \(C_1 = .0715\), and \(-1 < x < 1\).

The machine implementation of the equation is

\[
\sin x = 2x(3110_8 - x^2(1222_8 - x^2(0111_8)))
\]

where \(x\) is a binary fraction of \(\frac{\pi}{2}\).
II.
IDENTIFICATION

Title: Matrix Inversion - Ident. II.06
Programmer: D. M. Lytle, September 1962, CODA

PURPOSE

This subroutine is written in 160 FORTRAN (160 FORTRAN-A) for finding the inverse of a square matrix.

USAGE

1. Calling Sequence: The following two statements must be in the main program.

\[
\text{DIMENSION } A(n,n), L(n), M(n) \\
N = n
\]

where \( n \) = size of square matrix.

The inverse matrix of \( A \) is stored back into \( A \). Communication between the subroutine and main program is accomplished by the \texttt{NON LOCAL} statement in the subroutine.

3. Space Requirement: The subroutine requires \( 747-8 \ (4871) \) locations.

A 17x17 matrix could be inverted in the 160 and 33x33 for 160-A.

11. Timing:

\[
\begin{array}{c|c}
\text{Size} & \text{Time} \\
3 \times 3 & 3 \text{ seconds} \\
10 \times 10 & 53 \text{ seconds} \\
20 \times 20 & 6\frac{1}{2} \text{ minutes} \\
30 \times 30 & 20 \text{(estimated minutes)} \\
\end{array}
\]


METHOD

The Gaussian Elimination Method is used for the inversion.
C PROGRAM FOR FINDING THE INVERSE OF A N X N MATRIX

256 FORMAT ( 320.5 )
DIMENSION A(3,3),L(3),M(3)

SUBROUTINE INVERX
NONLOCAL A,L,M,N

C SEARCH FOR LOWEST ELEMENT
I=1,0
DO30 K=1,N
L(K)=K
M(K)=K
BIGA=A(K,K)
DO20 I=K,N
DO20 J=K,N
IF(ABS(BIGA)-ABS(A(I,J)) 10,20,20
10 BIGA=A(I,J)
L(K)=I
M(K)=J
20 CONTINUE
J=L(K)
IF(L(K)-K) 35,35,25
25 DO30 I=1,N
HOLD=A(K,I)
A(K,I)=A(J,I)
30 A(J,I)=HOLD

C INTERCHANGE COLUMNS
35 I=M(K)
IF(M(K)-K) 45,45,37
37 DO40 J=1,N
HOLD=A(J,K)
A(J,K)=A(J,I)
40 A(J,I)=HOLD
45 DO55 I=1,N
46 IF(I-K)50,50,50
50 A(I,K)=A(I,K)/(-A(K,K))
55 CONTINUE
C REDUCE MATRIX
60 IF(I-K)57,65,57
65 CONTINUE
68 IF(J-K)70,75,70
70 A(K,J)=A(K,J)/A(K,K)
75 CONTINUE
D=D+A(K,K)
A(K,K)=1.0/A(K,K)
80 CONTINUE
C FINAL ROW AND COLUMN INTERCHANGE

subroutine
K=N
100  K=(K-1)
    IF(K) 150,150,103
105  I=L(K)
    IF(I-K) 120,120,105
105  DO110 J=1,N
    HOLD=A(J,K)
    A(J,K)=-A(J,I)
110  A(J,I)=HOLD
120  J=M(K)
    IF(J-K) 100,100,125
125  DO130 I=1,N
    HOLD=A(K,I)
    A(K,I)=-A(J,I)
130  A(J,I)=HOLD
    GO TO 100
150  CONTINUE
RETURN
IDENTIFICATION

Title: Program Structure - Ident. All.07
Programmer: Elizabeth Phillips, October 1962, MSU - Computer Laboratory

PURPOSE

This program determines all those permutations $\pi$ which leave a structure $(S,R)$ invariant, and all those permutations $\rho$ which leave $(S,R)$ self-dual.

A structure $(S,R)$ is a finite set $S$ (which may as well be the first $n$ positive integer) together with a relation $R$ on the set, which is symmetric and reflexive, though not necessarily transitive. The permutation $\pi$ leaves $(S,R)$ invariant if $aRb$ if and only if $\pi(a)R\pi(b)$; $\rho$ leaves $(S,R)$ self-dual if $aRb$ if and only if $\rho(a)\neq \rho(b)$, in both cases for all $a,b$ in $S$ except for $a = b$.

A matrix $C(S,R)$ is associated with $(S,R)$ where $C(S,R) = (a_{ij})$ and $a_{ij} = 1$ if $iRj$; $a_{ij} = 0$ if $i = j$. Then $\pi$ leaves $(S,R)$ invariant if and only if $a_{ij} = a_{\pi(i)\pi(j)}$; and $\rho$ leaves $(S,R)$ self-dual if and only if $a_{ij} = \bar{a}_{\rho(i)\rho(j)}$ of all $i$ and $j$ in $S$ except $i = j$. Here $\bar{\rho(i)}\rho(j)$ means the Boolean Complement.

This program accepts a matrix $C(S,R)$ and produces all permutations which leave $(S,R)$ invariant and all those (if there are any) which leave $(S,R)$ self-dual.

USAGE

1. Operation Procedure:

Master clear, clear both memory banks. Load Fortran Interpreter (AC1.00-3D) according to operating instructions for 160 Fortran-A. Input object code. At stop, position data tape in reader and run.


10. Input and Output Formats:

   (i) Carriage return. A two digit integer equal to the order of the matrix to be permuted.

   (ii) Carriage return. A two digit integer, either "00" or "01." Use "01" if intermediate output is desired after every 1000th permutation for stopping and restarting purposes. For cases of $n \leq 8$, this would not be necessary.
a. Input (cont.)

(iii) Carriage return. A one digit integer for each element of the matrix. These are read in by columns, each element preceded by a carriage return. There will be \( n^2 \) of these.

(iv) Carriage return. A two digit integer for each member of the first permutation to be tried. Each integer is preceded by a carriage return. There will be \( n \) of these. These will be of the form \( n_1, n_2, n_3, \ldots, n_q \) which means the permutation

\[
\begin{array}{cccc}
1 & 2 & 3 & q \\
& n_1 & n_2 & n_3 & n_q
\end{array}
\]

(v) If (ii) is "00", this completes the data. If (ii) is "01", additional information needs to be input—to allow for starting in the middle of the run. This consists of a carriage return and a two digit integer equal to "00" only if it is desired to start at the beginning of the problem; "01", to start in the middle. Then for the initial input, \( 2(n-1) \) "00"s are punched, each "00" being preceded by a carriage return. On successive runs, these values will have been output (thus telling you how far the problem got and from where to continue next).

b. Output

The headings "Invariant Permutation" or Self-Dual Premutation" are punched out followed by the order of the matrix \( n \) and the \( n \) components to be interpreted as follows:

\[
\begin{align*}
n & : 03 \\
x_1 & : 03 \\
x_2 & : 01 \\
x_3 & : 02
\end{align*}
\]

this means the matrix is of order 3, the permutation is 03 01, 01 02, 02 03, or 1 2 3

3 1 2 .

If (ii) on the input tape was "01" then after every 10000th permutation (for \( n=8 \), this would be 40 times) there will be \( 2(n-1) \) two digit integers output (leading zeroes are suppressed). This is the information that is put back in in step (v) above, preceded by "01", if restarting at this point is desired.
METHOD OR ALGORITHM:

The method used to obtain the \( n! \) permutations of the set of \( n \) integers is one developed by H. F. Trotter. It changes the order of the given set once each loop around, so that after \( n! \) loops, all \( n! \) permutations have been generated. For each permutation generated, the original matrix, \( M \) (which is input), is permuted, first by rows, then columns. This new matrix is then compared with the original matrix, element by element. If the new matrix is exactly like the original, the output represents a permutation which leaves the matrix invariant. If the new matrix is the complement of the original excluding diagonal elements, the output is printed out as self-dual. In comparing the two matrices, if at any time an element is discovered which contradicts either of these restrictions, the comparison is abandoned and a new permutation is generated.
C PROGRAM STRUCTURE

0140 format (21hinvariant;permutation)
0141 format (21hnself;dual;permutation)
0100 format (12)
0101 format (11)
0102 format (/)
0103 dimension k(24), is(12), js(12), m(12,12), mp(12,12), mpp(12,12)
0104 read 100, n,lstop
0105 n2 = 2'n
0106 n3 = n+1
0107 read 101,((M(i,j),i=1,n),j=1,n)
0108 read 100, (K(i),i=n3,n2)
0109 do 110 i=1,n
0110 k(i) = i
0111 LFIRST = 0
0031 read 100, Ifirst, (IS(I), JS(I), i=2,n)
0032 kount =0
C BEGIN PERMUTE N NUMBERS
0004 nt = n
0005 if (LFIRST) 10,6,10
0006 do 6 i=2,n
0007 is(i) = 0
0008 js(i) = 1
0009 LFIRST = 1
0010 m i= 0
0011 L = IS(NT) +JS(NT)
0012 IS(NT) = L
0013 if (L-NT) 15,13,15
0014 go to 18
0015 if (L) 23,16,23
0016 JS(NT) = 1
0017 M i= M+1
0018 if (NT-2) 21,21,19
0019 NT = NT-1
0020 go to 11
0021 L = 1
0022 LFIRST = 0
0023 L = L+M1
0024 n1 = n+L
0025 k1 = K(N1)
0026 K(N1) = K(N1+1)
0027 K(N1+1) = KT
0028 if (LSTOP) 33,29,33
0033 kount = kount +1
0034 if (KOUNT= 1000) 29,35,29
0035 kount =0
0036 punch 100, (IS(I), JS(I), i=2,n)
punch 102
BEGIN PERMUTE MATRIX
0029 do 116 i = 1, n
  in = I + N
0112 nl = K(I)
0113 L = K(IN)
0114 do 115 j = 1, n
0115 mp(nl, j) = M(L, j)
0116 continue
0117 do 123 i = 1, n
  in = I + N
0119 nl = K(I)
0120 L = K(IN)
0121 do 122 j = 1, n
0122 mpp(j, nl) = MP(j, L)
0123 continue
C COMPARE MATRICES FOR INVARIANCE+ SELF-DUALITY
0125 do 128 i = 1, n
0126 do 128 j = 1, n
0127 if (M(i, j) - MPP(i, j)) 180, 128, 180
0128 continue
punch 140
go to 129
0180 do 134 i = 1, n
  do 134 j = 1, n
0131 if (I - J) 132, 133, 132
0132 if (M(i, j) - MPP(i, j)) 134, 170, 134
0133 if (M(i, j) - MPP(i, j)) 170, 134, 170
0134 continue
punch 141
0129 punch 100, n, (K(I), i = n3, n2)
0130 punch 102
0170 if (IFIRST) 4, 144, 4
0144 pause 0001
go to 104
end
end
JL.
IDENTIFICATION

Title: LINEAR PROGRAM I (SIMPLEX METHOD) - Ident JL.00.
Programmer: John F. Quinlan, August 1962, Control Data Corporation

PURPOSE

This program is written in FORTRAN for the Control Data 160 or 160-A computer. The Simplex Method is the computational technique used and the input data must imply a first feasible solution. This condition is not limiting since any LP problems can be arranged to meet it by the proper manipulation of input parameters. Examples of the manipulation are given in the sample problem.

USAGE

1. Operational Procedures

Using technique for FORTRAN, the first set of restraints and minimizing coefficients are read in. After punching out answer, computer will stop (A=1111). The next set of coefficients can be placed in reader and run. Computer will then repeat - punch answers, and stop (A=1111).

3. Space Requirements

The size of the LP problems handled by the program are given by the equation

\[ 2(M+N) + (M+1)(N+1) \leq G \]

where
- \( G = 245 \) for 160 computer
- \( G = 1117 \) for 160-A computer
- \( G = (\text{estimated 6 banks}) 6237 \) for 160-A FORTRAN

\( M = \) number of restraining equations
\( N = \) number of non-slack variables

Slack variables either natural or artificial, are not included in assessing \( N \).
Sample Problem I

Minimize

\[ x_1 + x_2 + x_3 \]

Subject to

(1) \(-x_1 + x_2 - x_3 \leq -2\)
(2) \(-x_1 - x_2 + x_3 \leq 1\)

Since restraint (1) has a right hand side less than zero, multiply it through by \(-1\) giving

(1) \(x_1 - x_2 + x_3 \geq 2\)

Since the relationship is now one of \(\geq\), another non-slack variable \(x_4\) is introduced giving

(1) \(x_1 - x_2 + x_3 - x_4 = 2\)

Because an equality exists, it is necessary to associate an artificial slack with this restraint. Thus the inputs will be taken from the following system:

Minimize

\[ 10s_1^* + x_1 + x_2 + x_3 \]

Subject to

(1) \(s_1 + x_1 - x_2 + x_3 - x_4 = 2\)
(2) \(y_2 - x_1 - x_2 + x_3 = 1\)

\(s_1^*\) is placed here as the artificial slack is also to be minimized.
10 is arbitrarily chosen, 100 would do just as well.
Sample Problem 1 (continued)

Where $x_1$ is an artificial slack and

$x_2$ is a natural slack

The identifiers on output will be as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_1$</td>
<td>1</td>
</tr>
<tr>
<td>$y_2$</td>
<td>2</td>
</tr>
<tr>
<td>$x_1$</td>
<td>3</td>
</tr>
<tr>
<td>$x_2$</td>
<td>4</td>
</tr>
<tr>
<td>$x_3$</td>
<td>5</td>
</tr>
<tr>
<td>$x_4$</td>
<td>6</td>
</tr>
</tbody>
</table>

In this problem $M = 2$, $N = 4$

The input and output for this problem are shown below

input

```
0.00000000/  
10.00000000/  
0.00000000/  
1.00000000/  
1.00000000/  
1.00000000/  
0.00000000/  
1.00000000/  
-1.00000000/  
1.00000000/  
-1.00000000/  
2.00000000/  
-1.00000000/  
-1.00000000/  
1.00000000/  
0.00000000/  
1.00000000/  
```

output

```
M, N
3
Z
2
0.00000000
0.00000000
0.00000000
0.00000000

NOTE:
Coefficients
for $a_1$ and $y_2$
are not included
here

Execution Time -- 9 seconds
Sample Problem II*

In this problem, \( M = 5 \), \( N = 4 \).

Maximize
\[ x_1 + 2x_2 \]

Subject to

\[
\begin{align*}
(1) & \quad -x_1 + 3x_2 \leq 10 \\
(2) & \quad x_1 + x_2 = 6 \\
(3) & \quad x_1 - x_2 = 2 \\
(4) & \quad x_1 + 3x_2 = 6 \\
(5) & \quad 2x_1 + x_2 = 4
\end{align*}
\]

Since the relationships of (4) and (5) are non-slack variable, another non-slack variable must be introduced, \( x_6 \) and \( x_7 \), giving

\[
\begin{align*}
(4) & \quad -x_1 - 3x_2 - x_6 = -6 \\
(5) & \quad -2x_1 - x_2 - x_7 = -4
\end{align*}
\]

Now \( M = 5 \) and \( N = 4 \)

Minimize
\[ -x_1 - 2x_2 \]

Subject to

\[
\begin{align*}
(1) & \quad y_3 = x_1 + 3x_2 = 10 \\
(2) & \quad y_4 + x_1 + y_2 = 6 \\
(3) & \quad y_5 + x_1 - x_2 = 2 \\
(4) & \quad y_8 + x_1 + 3x_2 - x_6 = 6 \\
(5) & \quad y_8 + 2x_1 + x_2 - x_7 = 4
\end{align*}
\]

Sample Problem II (continued)

where $x_3, x_4, x_5$, are natural slacks
$x_8, x_9$ are artificial slacks
$x_i \geq 0 \quad i = 1, 2, \ldots, 9$

The identifiers on output will be as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_3$</td>
<td>1</td>
</tr>
<tr>
<td>$y_4$</td>
<td>2</td>
</tr>
<tr>
<td>$y_5$</td>
<td>3</td>
</tr>
<tr>
<td>$y_8$</td>
<td>4</td>
</tr>
<tr>
<td>$y_9$</td>
<td>5</td>
</tr>
<tr>
<td>$x_1$</td>
<td>6</td>
</tr>
<tr>
<td>$x_2$</td>
<td>7</td>
</tr>
<tr>
<td>$x_6$</td>
<td>8</td>
</tr>
<tr>
<td>$x_7$</td>
<td>9</td>
</tr>
</tbody>
</table>
Sample Problem II (continued)

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>0504/</td>
<td>8</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>.80000001e 01</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>2</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>.40000002e 01</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>3</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>.40000000e 01</td>
</tr>
<tr>
<td>-1.0e0/</td>
<td>7</td>
</tr>
<tr>
<td>-2.0e0/</td>
<td>.40000000e 01</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>6</td>
</tr>
<tr>
<td>0.0e0/</td>
<td>.20000000e 01</td>
</tr>
<tr>
<td>-1.0e0/</td>
<td>-999999999e 01</td>
</tr>
<tr>
<td>3.0e0/</td>
<td>(1)</td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>10.0e0/</td>
<td>(2)</td>
</tr>
<tr>
<td>1.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>6.0e0/</td>
<td>(3)</td>
</tr>
<tr>
<td>1.0e3/</td>
<td></td>
</tr>
<tr>
<td>-1.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>2.0e0/</td>
<td>(4)</td>
</tr>
<tr>
<td>1.0e0/</td>
<td></td>
</tr>
<tr>
<td>3.0e0/</td>
<td></td>
</tr>
<tr>
<td>-1.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td>(5)</td>
</tr>
<tr>
<td>6.0e0/</td>
<td></td>
</tr>
<tr>
<td>2.0e0/</td>
<td></td>
</tr>
<tr>
<td>1.0e0/</td>
<td></td>
</tr>
<tr>
<td>0.0e0/</td>
<td></td>
</tr>
<tr>
<td>-1.0e0/</td>
<td></td>
</tr>
<tr>
<td>4.0e0/</td>
<td></td>
</tr>
</tbody>
</table>

Execution Time -- 12 Seconds
7. There are no ERROR stops.

9. Input is from paper tape reader and output is from the paper tape punch.

10. Input and Output Formats

The first line of input contains the numbers defining $M$ and $N$. This is followed by the cost coefficients for the functional, one element to a line. The coefficients for the slacks are entered first followed by the coefficients for the non-slack variables. The cost coefficients for the slacks are ordered according to the row position of the unit in the unit column vector associated with that slack. The cost coefficients are followed by the elements of the row vectors describing the coefficients of the non-slack variables. These are ordered by vector in the same order as the cost coefficients for these variables.

Within each row vector the order is by restraint equation, so that $k$ within a vector is associated with restraint $k$. The row vectors associated with the non-slack variables are followed by the column vectors describing the right hand side. All elements defining the r.h.s. vector must be greater than or equal to zero and all row vectors are entered one element to a line.

Thus, for a program with $M$ restraints and $N$ non-slack variables, it is required that $M$, $N$, $(M+N)$ cost coefficients, and $M$ row vectors, each with $M$ elements, be entered. Artificial slacks are handled by the pricing out technique, that is, by associating with them as cost coefficients a positive number which is large relative to the other cost coefficients so that the artificial slacks will be forced out of the basis.

The computation, always minimizes. Therefore, to maximize a functional, multiply the original functional by a minus one during set-up.

The output consists of an identified and value for each variable in the optimal basic solution and the optimal value of the functional. A slack is identified by an integer from 1 thru $M$ where the integer indicated the restraint associated with that slack. A non-slack variable is identified by an integer from $(M+1)$ thru $(M+N)$ where the integer is associated with the ordering of the inputs pertaining to the variable. Thus the ordering of the cost coefficients for each variable, slack and non-slack, determines the identifier for that variable.
C      LINEAR PROGRAM USING SIMPLEX METHOD
19      FORMAT(312)
20      FORMAT(14,5)  
      DIMENSION D(431)
31      CONTINUE
        READ 10,K,N
        N1 = N + 1
        M1 = N + 1
        L = N + N
        IA = N ' M
        J = IA + 1
        KA = IA + L
        READ 20, (D(I), I = J, KA)
        IB = M'N1
        READ 20, (D(I), I = 1, IB)
        I = IB + 1
        DO 20 J = I, IA
20       D(J) = 0.0
        DO 2 I = 1, L
          IX = KA + I
2       D(IX) = D
          DO 25 J = 1, M
            IC = (I-1)'N1
            ID = IA + I
            DO 25 J = 1, N1
              IX = IC + J
            TEMP = D(IX) * D(ID)
25          IE = IB + J
          D(IE) = D(IE) + TEMP
          DO 28 J = 1, N
            K = J + M + IA
            IE = IB + J
28         D(IE) = D(IE) - D(K)
18         TEMP = 0.0
          DO 5 J = 1, N
            IE = IB + J
3          IF (D(IE) = TEMP ) 3,3,4
4          L = J
          TEMP = D(IE)
5          CONTINUE
          IF (L) 10,10,5
5         TEMP = 99999999931
6          K = 0
          DO 6 I = 1, M
            IC = (I-1)'N1
            ID = IC + L
          IF (D(ID)) 6,6,9
6         IX = IC + N
          TEMP = D(IX) / D(ID)
          IF (TEMP = TEMP *) 9,6,6
9          TEMP = TEMP1
10         K = I
6          CONTINUE
IF (K)
10   IX 50  I= 1,M
   IX = KA + I
   J = D(IX)
   PUNCH 19, J
   KD=(I-1)'N1 +N1
   PUNCH 20, D(KD)
30  CONTINUE
   PUNCH 20, D(IA)
   PAUSE 1111
   GO TO 31
11   IX = K+KA
   I = D(IX)
   J = M+L
   IX = J+KA
   IY = K + KA
   D(IY) = D(IX)
   D(IX) = I
   DO 12  I=1,M
   J = (I-1)'N1 + L
   IX = I + IA
   D(IX) = D(J)
   12   D(J)= 0.0
   J = (K-1)'N1 + L
   D(J) = 1.0
   DO 13  J=1,N1
   JA=(K-1)'N1 + J
   IX = IA + K
   13   D(JA) = D(JA) / D(IX)
   DO 14  I=1,M
   IF(K = I ) 15,14,15
   14   DO 14  J=1,N1
   JA=(I-1)' N1 + J
   JB=(K-1)' N1 + J
   IX = IA + I
   D(JA) = D(JA) - ( D(JB)' D(IX) )
15  CONTINUE
   GO TO 18
END
IDENTIFICATION

Title: Equation Solver - Ident. AJ 1.01
Programmer: (Lockwood, Kessler and Bartlett, Inc.) September 1962

PURPOSE

This program will solve 30 linear equations with 30 unknowns. A modified Gaussian Elimination Method is used. The program has the ability to output the derived matrix before executing the back solution to solve for the unknowns. This is accomplished by letting ike be 01. If the derived matrix is not desired, let ike be 02.

The program outputs the final matrix, the element location, and the value; i.e., \( A_{2,4} = 6628.44 \) would be output as 2 4 6628.44.

The value of the unknowns are elements \( A_{i,n+1} \), where \( i = 1,2,\ldots,n \).

LIMITATIONS

The elements on the diagonal must not be zero.

EQUIPMENT AFFECTED

CDC 160-A, Flexowriter.

SOURCE PROGRAM

(See following page)

INPUT FORMAT

CR
SSNCR
DDDDDD.DDCR
DDDDDD.DDCR
...
DDDDDD.DD

Where SS is the value for ike either 01 or 02
NN is number of unknowns
DDDD.DD is the element. Elements are entered by rows.
4. Source Program

EQUATION SOLVER

100 FORMAT(1212)
101 FORMAT(F8.2)
102 FORMAT(212, F8.2)

DIMENSION A(30,30)

READ 100, I, K

IF(N-30)25, 26, 27

J=1

NN=NN+1

DO 1 I=1, N

DO 1 K=1, NN

READ 101, A(I, K)

1 =NN

A(J, I)=A(J, 1)/A(J, J)

IF(I-J)17, 17, 18

I=I-1

GO TO 19

IF(N-J)4, 4, 3

K=J+1

I=NN

A(K, I)=A(K, I)-A(J, I)*A(K, J)

IF(I-J)23, 23, 24

I=I-1

GO TO 5

IF(N-K)7, 7, 6

K=K+1

GO TO 8

J=J+1

GO TO 9

GO TO (21, 20), 4K

DO 22 I=1, N

DO 22 J=1, NN

PUNCH 102, I, J, A(I, J)

22 I=I-1

K=K+1

X=0.

X=A(I, K)*A(K, NN)+X

IF(K-N)10, 11, 11

K=K+1

GO TO 12

A(I, NN)=A(I, NN)-X

IF(I-I)13, 13, 14

I=I-1

GO TO 15

DO 16 I=1, N

DO 16 J=1, NN

PUNCH 102, I, J, A(I, J)

STOP

PAUSE 1111

GO TO 25

END
OPERATING PROCEDURE

1. Load 160 FORTRAN A Compiler III
2. Mount object program
3. Clear and run
4. Mount data tape
5. Turn on punch
6. Cycle run switch

Note: If NN = 30, program will halt with 1111 displayed in a register.
Correct data tape and cycle run switch.

<table>
<thead>
<tr>
<th>SAMPLE INPUT</th>
<th>SAMPLE OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 4</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>1 1 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1 2 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1 3 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1 4 1.00</td>
</tr>
<tr>
<td>5.00</td>
<td>1 5 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>2 1 .00</td>
</tr>
<tr>
<td>-1.00</td>
<td>2 2 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>2 3 .00</td>
</tr>
<tr>
<td>1.00</td>
<td>2 4 .00</td>
</tr>
<tr>
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<td>3 1 .00</td>
</tr>
<tr>
<td>2.00</td>
<td>3 2 .00</td>
</tr>
<tr>
<td>-1.00</td>
<td>3 3 1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>3 4 .00</td>
</tr>
<tr>
<td>1.00</td>
<td>3 5 3.00</td>
</tr>
<tr>
<td>2.00</td>
<td>4 1 .00</td>
</tr>
<tr>
<td>1.00</td>
<td>4 2 .00</td>
</tr>
<tr>
<td>1.00</td>
<td>4 3 .00</td>
</tr>
<tr>
<td>1.00</td>
<td>4 4 1.00</td>
</tr>
<tr>
<td>6.00</td>
<td>4 5 -1.00</td>
</tr>
</tbody>
</table>
IDENTIFICATION
Title: Spiralled Way Alignment - Ident. AK1.01
Programmer: (Lockwood, Kesler & Bartlett, Inc.), September 1962

I. Description of Problem

This program computes the alignment and curve data for a horizontal alignment containing spirals and circular curves in any combination.

The alignment is defined by coordinates of the P. I.'s or by intersecting the P. I. from coordinates of two known points and the bearings of the P. I.

The curves are defined by the radius or degree of curve and the lengths of the leading spiral and the trailing spiral.

Chord or arc definition may be used for degree of curve controlled by the program (with use of a jump switch setting on the computer).

Values of Radius below 50 feet are assumed to be degree of curve and those values of 50 feet or above are used as radius of curve.

All descriptive headings are typed out to facilitate use of output data.

This program also computes the station and coordinates of all detail points on the alignment.
II. Limitations

1. The number of curves which can be computed is unlimited.

2. Output is provided via on-line typewriter.

3. Input is limited to tape produced on off-line flexowriter.

III. Accuracy

Input and output of distances and coordinates are limited to 10 significant digits with a maximum of 4 decimal places. Angles are rounded to the nearest 0.01 of a second.

IV. Equipment Affected

1. 160-A with on-line typewriter.

2. Off-line flexowriter required to produce input data tape.

V. Memory Allocation

<table>
<thead>
<tr>
<th>Loc.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000-0081</td>
<td>Sin-cos ( s/r )</td>
</tr>
<tr>
<td>0082-0157</td>
<td>Arctan ( s/r )</td>
</tr>
<tr>
<td>0158-0211</td>
<td>Square root ( s/r )</td>
</tr>
<tr>
<td>0212-0309</td>
<td>P I Intersection</td>
</tr>
<tr>
<td>0310-0399</td>
<td>Bearing and angle typeout</td>
</tr>
<tr>
<td>0400-0527</td>
<td>Spiral Routine</td>
</tr>
<tr>
<td>0530-0551</td>
<td>Station typeout</td>
</tr>
<tr>
<td>0552-0661</td>
<td>Alpha Storage</td>
</tr>
<tr>
<td>0680-0799</td>
<td>Numeric &amp; Temporary Storage</td>
</tr>
<tr>
<td>0800-1603</td>
<td>Main Program</td>
</tr>
<tr>
<td>1700-1713</td>
<td>Input Storage</td>
</tr>
<tr>
<td>1800-1813</td>
<td>Input Storage</td>
</tr>
<tr>
<td>1900-1913</td>
<td>Input Storage</td>
</tr>
<tr>
<td>1920-1937</td>
<td>Input Storage</td>
</tr>
</tbody>
</table>
Operating Procedure

1. Margin and tabs
   Margin at 20
   All tabs down
   Output paper at 12

2. Load Sicom

3. Place the program

4. Established typewriter input mode

5. Type 52 0000 /
   Reads the program and stops

6. Jump switch 1
   On for chord definition of degree of curve
   Off for arc definition of degree of curve

7. Place Flexowriter input tape

8. Type x 01 0800 /
   Reads one block of input tape and computes

9. Output and stops at 5

10. For next problem
    Cycle Run
    Repeat from step 6

11. Error indications
    (1) Program types "Spiral Overlap" and amount of overlap in degrees, and stops at 3 which indicates overlapping spirals on the curve.

    (2) Program types "Curve Overlap" and amount of overlap in feet, and stops at 4 which indicates overlapping curves between P I's.

12. After inspection of error typeout computations may be resumed by:
    Cycle Run
VII Description of Input

Job No. (up to 8 alpha characters)

Date (up to 16 alpha characters)

Station at beginning of increments (up to 10 digits)

Increments on curves (up to 10 digits)

Increments on tangents (up to 10 digits)
If incremented stations are not required enter very large numbers for both curves and tangents.

North coordinate of origin point (up to 10 digits)
East coordinate of origin point (up to 10 digits)
Station of origin point (up to 10 digits)

For Each P I.

P I number (up to 8 alpha characters)
Radius or degree of curve (Rc or Dc)
** Degree of curve entered as: DD.MMSSXX
Length of leading spiral (enter 0. if not used)
Length of trailing spiral (enter 0. if not used)
North coordinate of P I (if known)*
East coordinate of P I (if known)*
Repeat for each P I

* If P I coordinates are not known, enter in these locations the coordinates of a point on tangent, the bearing to the P I, the coordinates of a point on the next tangent and the bearing to the P I.

The program will automatically intersect the two tangents and store the P I coordinates in proper locations.

To terminate the problem enter only the P I number, . (this number will not be typed out) and the coordinates of the terminus point.

**: Degree of curve may be either arc or chord definition, (See operating instructions).
VIII. **Description of Output**

This program will type the following information:

1. Title of Program
2. Job No.
3. Date
4. Station and coordinates of origin and the bearing to the first P.I.
5. Curve No. of the first curve and the bearing to the next P.I.
6. Data for the leading spiral (if any)
7. Data for the trailing spiral (if any)
8. Curve Data for the circular portion of the curve consisting of:
   - Radius ($R$)
   - Degree of Curve ($D_c$)
   - Internal Angle ($I_c$)
   - Length of Curve ($L_c$)
   - Tangent of Curve ($T_c$)
   - Chord Distance ($C_c$)
   - External ($E_c$)
   - Middle Ordinate ($M_c$)
**ALIGNMENT**

<table>
<thead>
<tr>
<th>JOB NO.</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LKB-02</td>
<td>SEPTEMBER 1963</td>
</tr>
</tbody>
</table>

Sta. Deg. of Increments: 7654.0000000

Increments on Curves: 20.0000000

Increments on Tangent: 50.0000000

**ORIGIN**

<table>
<thead>
<tr>
<th>NORTH</th>
<th>EAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>3396.3</td>
<td>956</td>
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</table>

| STATION | 7.61498 |

<table>
<thead>
<tr>
<th>PL No.</th>
<th>R or Dc</th>
<th>Ls</th>
<th>Ls ¹</th>
<th>NORTH</th>
<th>EAST</th>
<th>BEARING</th>
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<tr>
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<td>350</td>
<td>350</td>
<td>54720.766</td>
<td>184703.776</td>
<td>18/707.776</td>
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<tr>
<td>2</td>
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<td>0</td>
<td>547771.570</td>
<td>184608.018</td>
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<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>547051.251</td>
<td>1845707.978</td>
<td></td>
</tr>
</tbody>
</table>
FLEXWRITER TAPE PREPARATION

;LKB 02  JOB NO.
;Sept. 1 1962  DATE
76500.  STA. BEGINNING OF INCREMENTS
200.  INCREMENT ON CURVE
500.  INCREMENT ON TANGENT
537534.956  ORIG. H.I. COORD
1815553.618  "  "  "  "  "
76198.96  "  "  STATION
/;1  P.I. A
2864.79  RADIUS OF CURVE
350.  LEADING SPIRAL LENGTH
350.  TRAILING "  "
541220.761  Y COORD OF P.I.
1814903.376  X  "  "  "
/;2  P.I. A
3819.72  RADIUS OF CURVE
0.  LEADING SPIRAL LENGTH
0.  TRAILING "
544771.57  Y COORD OF P.I.
1816081.018  X  "  "  "
/;3 547051.251  Y COORD OF TERMINAL POINT
1815707.978  X  "  "  "  "
### Alignment

#### Job No. LKB 02

**Date:** Sept. 1, 1962

<table>
<thead>
<tr>
<th>ORIGIN</th>
<th>STATION</th>
<th>NORTH</th>
<th>EAST</th>
<th>BEARING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>761+98.960</td>
<td>539634.9560</td>
<td>1815533.6180</td>
<td>N 22° 17' 43.96 W</td>
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</table>

<table>
<thead>
<tr>
<th>CURVE No.</th>
<th>STATION</th>
<th>NORTH</th>
<th>EAST</th>
<th>BEARING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEADING SPIRAL</th>
<th>p = 1.7814</th>
<th>k = 174.9782</th>
<th>x = 349.8694</th>
<th>y = 7.1248</th>
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<td>Ls= 350.000</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ld= 233.3769</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST= 116.7081</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LE = 349.9419</td>
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<tr>
<td>OC = 3° 30' .00</td>
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<tr>
<td>f = 1° 9' 59.87</td>
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**Center of Curve**

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8 February 1963

**CURVE N° 2**

**CIRCULAR CURVE**

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**CENTER OF CURVE**

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**ON CURVE**

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**ON TANGENT**

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**TERMINAL**

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</table>
1. Description of Problem

For this program, a traverse is defined as a series of measured distances and directions, starting from a point of known coordinates, and terminating at a point of known coordinates.

The program provides for the output of either the unadjusted or adjusted traverse (according to Compass Rule).

Input of directions can be in the form of either bearings or north azimuths, and output of directions, regardless of input, can be either bearings or north azimuths.

The computed precision, length of traverse, Y error, X error and resultant error are printed first, giving the user the option of examining the results and interrupting computations if necessary.

The program provides alphanumeric identification and column headings.

The program computes the area in square feet and acres of the unadjusted traverse. The area is printed at the end of the unadjusted output.

2. Accuracy

The program accepts distances and coordinates accurate to 0.001 units and direction angles accurate to 0.01 seconds.

The computed distances and coordinates are rounded to 0.001 units, and the angles are rounded to 0.01 seconds.

3. Limitations

The traverse may contain 200 maximum courses and may be in any one of the four quadrants.

All input is via Flexowriter tape.
1. **Description of Problem**

For this program, a traverse is defined as a series of measured distances and directions, starting from a point of known coordinates, and terminating at a point of known coordinates.

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2. **Accuracy**

The program accepts distances and coordinates accurate to 0.001 units and direction angles accurate to 0.01 seconds.

The computed distances and coordinates are rounded to 0.001 ± units, and the angles are rounded to 0.01 ± seconds.

3. **Limitations**

The traverse may contain 200 maximum courses and may be in any one of the four quadrants.

All input is via Flexowriter tape.
4. Equipment Affected

CDC 160-A, 161
Flexowriter

5. Memory Allocation

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<th>Function</th>
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<td>0082 - 0157</td>
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<td>0158 - 0211</td>
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<tr>
<td>0212 - 0229</td>
<td>Station Typeout routine</td>
</tr>
<tr>
<td>0230 - 0266</td>
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<td>0267 - 0353</td>
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<tr>
<td>0354 - 0401</td>
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<td>0402 - 0437</td>
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<tr>
<td>0500 - 0734</td>
<td>Main program</td>
</tr>
<tr>
<td>0800 - 1998</td>
<td>Input storage</td>
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</table>
6. Operating Procedure

(1) Margin and tabs
   Margin at 20
   Every other tab down
   Output paper at 10

(2) Load Sicom-A (May 1962)

(3) Place the program

(4) Establish typewriter input mode

(5) Type
   52 0000 /
   Reads the program and stops

(6) Jump switch 1
   On for punch output (punch on)
   Off for type output

(7) Jump switch 2
   On for adjusted traverse
   Off for unadjusted traverse

(8) Place Flexowriter input tape

(9) Type
   x 01 0500 /
   Reads the data tape and computes

(10) Output
    Stops at 4 for unadjusted traverse
    Stops at 3 for adjusted traverse

(11) For the next problem
    Cycle Run (stops at 5)
    Cycle Run again (halts)
    Repeat from step (6)
7. **Description of Input and Output**

Input is prepared on off-line Flexowriter.

Job number, traverse number, Y code, X code, point No. of 1st point, and all other point numbers (as identification) are entered as one alpha word. Date is entered as two alpha words.

Computation time is approximately 2 1/2 seconds per course for punch output and 12 seconds per course for typewriter output.


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<td>224° 42' 26&quot;</td>
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<td>A-103</td>
<td>563.177</td>
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FLEXWRITER TAPE PREPARATION

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TERMINAL POINT NO

DISTANCE TO 2ND POINT

BEARING TO 2ND POINT

3RD POINT NO

DISTANCE TO 3RD POINT

BEARING TO TERMINAL POINT

/
8 February 1963

SALE

x010500/

Job N° 1234-5

Date AUG. 13 1962

UNADJUSTED TRAVERSE

<table>
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<tr>
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<th>DIRECTION</th>
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area

sq.ft. 4366.500

acres  .100

x010500/

Job N° 1234-5

ADJUSTED TRAVERSE

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<th>DIRECTION</th>
<th>NORTH</th>
<th>EAST</th>
<th>POINT</th>
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<td>S 26°4'</td>
<td>18.18 W</td>
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<td>S 26°4'</td>
<td>18.18 W</td>
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</tbody>
</table>
IDENTIFICATION
Title: Lines and Circle - Ident. AK1.03
Programmer: (Lockwood, Kessler & Bartlett, Inc.), August 1962

I. Statement of Problem

This program consists of the following five independent parts. The known data may be located in any of 4 quadrants.

Part I Intersections of Two Lines

The coordinates of two points are given to define the slope of each straight line. It is required to compute; (1) the coordinates of intersection of two lines, and (2) distances from each given point to the intersection.

Part II Intersection of Line and Circle

The coordinates of two points on a straight line, the coordinates of the center of a circle, and the radius of the circle are given. It is required to determine the coordinates of the intersections of the line and circle.

Part III Distance and Bearing

The coordinates of two points on a straight line are known. It is required to compute; (1) the distance between the two points, and (2) the bearing of the line.

Part IV Height of Triangle

The coordinates of three corners of a triangle are given. It is required to determine, (1) the height of triangle, and (2) the distance from first corner to the foot of perpendicular.

Part V Tangent, Arc, and Segment

The radius of a circle and the angle at the center of the circle are given. It is required to compute, (1) the tangent distance, (2) the arc length, and (3) the area of segment.
II. Limitations

1. The input data with proper mathematical signs, for all five parts, may be located in any one of four quadrants.

2. Part II: When there is no intersection of the given line and circle, the radius of the circle will be typed out as an error indication.

3. Part III: The interior angle I at the center of a circle must be less than 180°.

III. Equipment Affected

CDC 160-A
CDC 161
Flexowriter

IV. Memory Allocation

1000 - 1007   All Parts
1008 - 1069   Part I
1070 - 1099   Part II
1100 - 1117   Input all Parts
1118 - 1119   Constant
1120 - 1161   Part II
1162 - 1183   Part III
1184 - 1306   Part IV
1307 - 1335   Part V
1336 - 1349   Constants and intermediate storage
1350 - 1381   All Parts
1400 - 1482   Sin-cos s/r
1500 - 1559   Angle conversion s/r
1600 - 1645   Radius to Bearing s/r
1700 - 1776   Arctan s/r
1800 - 1854   Square root s/r
1000 - 1854   Program Tape
V. Description of Input Data

An angle as the input data is entered as degrees, minutes and seconds with degrees as integers, in the following form:

DDD.MMSSXX

Computation time will not exceed more than five seconds for any Part.

Part I: Intersection of two Lines
Loc. 1100 y Coordinate on 1st line
   1102 x1  
   1104 y2  
   1106 x2  
   1108 y3  Coordinate on 2nd line
   1110 x3  
   1112 y4  
   1114 x4  

Part II: Intersection of Line and Circle
Loc. 1100 y Coordinate on a line
   1102 x1  
   1104 y2  
   1106 x2  
   1108 yc Coordinate of the center
   1110 xc  
   1112 R  Radius of the circle

Part III: Distance and Bearing
Loc. 1100 y Coordinate of 1st point
   1102 x1  
   1104 y2  
   1106 x2  

Part IV: Height of Triangle
Loc. 1100 y Coordinate of 1st corner
   1102 x1  
   1104 y2  Coordinate of 2nd corner
   1106 x2  
   1108 y3  Coordinate of 3rd corner
   1110 x3  

Part V: Tangent, Arc, and Segment

Loc. 1100 R Radius of circle in ft.
1102 I Interior angle

VI. Description of Output Data

Part I: Intersection of two lines

N  E Coordinates of intersection

d_1 Distance from 1st point to intersection on first line
d_2 Distance from 2nd point to intersection on first line
d_1+d_2 Distance from 1st to 2nd point on first line

d_3 Distance from 3rd point to intersection on second line
d_4 Distance from 4th point to intersection on second line
d_3+d_4 Distance from 3rd to 4th point on first line

Part II: Intersection of Line and Circle

N' E' Coordinates of one intersection
N'' E'' Coordinates of other intersection

Part III: Distance and Bearing

d N DD MM SS E

Part IV: Height of Triangle

h l b - l

h = Perpendicular distance from 3rd corner to base
l = Distance from 1st corner to foot of perpendicular
b = Distance from 1st corner to second corner

Part V: Tangent, Arc and Segment

T L A

T = Tangent length
L = Arc length
A = Segment area in sq. ft.
VII. Operating Procedure

1. Margin and tabs
   (1) Margin at 20
   (2) All tabs down
   (3) Paper at 0

2. Load Sicom

3. Place the program tape

4. Input mode?
   (1) Flex input,
       Cycle Run to read the program (Stop 3)
   (2) Type input,
       11/ to read the program (Stop 3)

5. Jump switch 2
   (1) On for type output
   (2) Off for Flex output (punch on)

6. Jump switch 1
   (1) On for type input, go to step 7
   (2) Off for Flex input, go to step 10
       (Provide 5/ at the end of the tape)

7. Cycle Run (halts for type input)

8. Type input data (1100 - 1114)
   Type / after the last tab or CR for each solution.

9. Output of each solution
   Repeat from step 8

10. Cycle Run (for Flex input)

11. Reads the Flex input tape and output for each solution.

12. To alter the condition of input or output mode for the next
    solution, change positions of switch 1 or 2 as in steps 5
    and 6 during computations.
VIII. Sample Input

Part I: Intersection of Two Lines

221053.462   189725.723  
220355.616   190441.971  
220004.625   189804.966  
220983.902   190941.195  
0.            /  

Part II: Intersection of Line and Circle

206791.463   290535.797  
204302.986   290775.556  
205468.028   290520.962  
1165.920     0.    /  

Part III: Distance and Bearing

395326.986   640001.947  
396178.421   640646.194  
0.            /  

Part IV: Height of Triangle

919904.111   634350.135  
920112.1     634206.425  
920172.861   634467.323  
0.            /  

Part V: Tangent, Arc and Segment

475.          11.1137  
0.             /  

IX. Sample Output

Part I: Intersection of Two Lines

220460.690 190334.126
849.431
150.569
1000.000
698.574
801.426
1500.000

Part II: Intersections of Line and Circle

204329.672 290772.985
206633.561 290551.011

Part III: Distance and Bearing

1067.706 N 37° 06' 48" E

Part IV: Height of Triangle

249.184 154.488 98.320

Part V: Tangent, Arc and Segment

46.547 92.799 139.933
IDENTIFICATION

Title: Transformation of Coordinates - Ident AK1.04
Programmer: (Lockwood, Kessler & Bartlett, Inc.), September 1962

I. Statement of Problem

This program will rotate and translate the coordinate of a series of points which define an enclosed area of traverse, compute the bearings and distances between these points, and find the area enclosed.

The input consists of the angle of rotation between the given system and the desired system, the x and y coordinates of the starting point in the desired system, and the x and y coordinates of each point in the given system.

II. Limitations

1. The number of points which can be computed is limited to 198.
2. Angle of rotation may be clockwise or counter clockwise, up to 360°.

III. Accuracy

Input and output of distances and coordinates are limited to 10 significant digits with a maximum of 4 decimal places. Angles are computed to 0.01 decimal places.

IV. Equipment Affected

1. 160-A with on line typewriter.
2. An off-line flexowriter may be used for input or output.

V. Memory Allocation

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<th>Description</th>
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<td>Sin-cos s/r</td>
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<tr>
<td>0184-0237</td>
<td>Square root s/r</td>
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<tr>
<td>0239-0314</td>
<td>Arctan s/r</td>
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<tr>
<td>0318-0319</td>
<td>Alpha storage</td>
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<td>0400-0745</td>
<td>Main program</td>
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<tr>
<td>0800-1999</td>
<td>Input storage</td>
</tr>
</tbody>
</table>
(3) Input data that is repeated for each solution
   a. Parcel number (up to 8 alpha characters) CR /
   b. Angle of rotation;
      if clockwise
      - if counter clockwise (up to 10 digits) CR
   c. y coordinate of starting point in the desired system.
      (up to 10 digits) CR
   d. x coordinate of starting point in the desired system
      (up to 10 digits) CR
   e. Identification number of point (up to 8 alpha characters,
      but not more than 6 spaces, if less fill field of 6 with
      space code) CR
   f. y coordinate of first point to be transformed (up to 10
      digits) CR
   g. x coordinate of first point to be transformed (up to 10
      digits) CR

(4) Repeat steps e., f., and g., for each succeeding point.

(5) After type-in of last x coordinate
   1. type 0. CR
   2. type 0. CR
      Program computes solution and returns to type-in state ready
      for entry of data at step (3) for next solution.

7. Program halts

   (1) End of solutions (For flex tape input)
      1. Selective Stop 2 on will cause program to halt after
      each solution
      2. 5 / on tape after last input data will halt computations
         (For type input)
      1. Program halts at end of each solution (see step 6. (5) ).

   (2) Error alarm halt
      1. Stop 4 is used to indicate number of points limit has
         been exceeded.
VI. Operating Procedure

1. Margin and tabs
   (1) Margin at 15
   (2) All tabs down
   (3) Paper at 0

2. Load Sicom and set type in mode.

3. Load program
   (1) Type 52 0000 / (reads program and stops)
   (2) Type x 010400 / (stops at 4)
   (3) Set Selective Jump 2 on

4. Set input mode
   (1) For flex tape input: Selective
       Jump 1 off and place input data tape on photo-reader.
   (2) For typewriter input: Selective
       Jump 1 on
   (3) For input verification: Selective
       Jump 4 on

5. Set output mode
   (1) For typewriter output: program is now set
   (2) For tape output:
       1. Master clear and cycle run
       2. Type 12/
       3. Type x 010413 / (stop 4)

6. Read input and compute
   (1) Cycle run
       A. For flex tape input; program reads tape for one solution
          and computes. Input form of tape is the same as that
          described below for type input.
       B. For typewriter input (with Selective Jump 4 off)
   (2) Input for first parcel only; program stores this data for use
       with succeeding solutions
       Type
       1. Previous Area (up to 10 digits) CR
       2. Job number and date (up to 24 alpha characters) CR /
8 February 1963

SAMPLE INPUT

0. STARTING RUN
19156-75 JOB NUMBER
1 Sept
1 25 1562 DATE
1/77 PARCEL NUMBER
-18.159 ANGLE OF ROTATION
6.128.545 Y COORD OF STARTING POINT IN THE DESIRED SYSTEM
33343.644 X COORD
173.5 POINT NO.
12345.670 Y COORD OF FIRST POINT (STARTING POINT) TO BE TRANSFORMED
54321.987 X COORD
174.2 POINT NO.
12467.183 Y COORD OF SECOND POINT TO BE TRANSFORMED
54344.15 X COORD
177.1
11763.755
55052.93
177.2
11766.634
55033.656
176.2
11442.462
54048.048
176.2a POINT NO.
12345.670 Y COORD OF LAST POINT TO BE TRANSFORMED
54321.987 X COORD
0 END CODES
5/
### Parcel No. 77

**Job No. 9156-05**

**Sept 25, 1962**

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<th>BEARING</th>
<th>DISTANCE</th>
<th>Y COORDINATE</th>
<th>X COORDINATE</th>
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<td>49.10 W</td>
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<td>S 63 19</td>
<td>21.03 E</td>
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<td>19.01 E</td>
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<td>39.95 W</td>
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**Area**

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<th>acres</th>
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<td>16.0988</td>
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<td>701267.5800</td>
<td>16.0988</td>
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I. Statement of Problem

Given basic data to define the vertical alignment of a highway the program will compute all the required data and elevations at even incremented stations.

The program is divided into two parts. The first part computes grades, PVI stations and elevations, vertical curve lengths and stopping sight distance for the selected curve.

The program will stop after computing part I to allow any change to be made before beginning part II.

Part II computes the elevation at incremented stations. The increment on vertical tangents may differ from the increment on vertical curves. In addition to evenly incremented stations the program will compute and type out the high points and low points on the curve, the elevation of odd stations not covered by the increments, the Middle Correction at each PVI and all other data required to fully define a highway profile.

The grades and elevations can either be rounded or unrounded as required. Appropriate errors alarms are built into the program with proper identification.

II. Limitations

1. The maximum number of PVI's is 33.
2. All elevations must be entered as being above zero.
3. The maximum number of "Odd Stations" is 49.
4. The starting point must be on tangent.
5. Except for Sight Dist. this program will work in Metric System.
III. Accuracy

1. Grades are rounded to the nearest 0.01' or when unrounded are carried as 10 significant digits.

2. Elevations are rounded to nearest 0.01'.

3. Vertical Curves are rounded upward to next 50' when total length is under 1000'. When length is over 1000', curves are rounded upward to next 100'.

IV. Equipment Affected

CDC 160-A
CDC 161 (Typewriter)
Flexowriter

V. Memory Allocation

| 0000 - 0002 | Program |
| 0005 - 0059 | Sq. Rt. Subroutine |
| 0060 - 0117 | Program Subroutines |
| 0125 - 0199 | Main Program Part I |
| 0200 - 0267 | Alpha Storage |
| 0300 - 0493 | Main Program Part I |
| 0496 - 0886 | Main Program Part II |
| 1370 - 1399 | Temporary Storage |
| 1400 - 1499 | Input Storage (Odd Sta.) |
| 1500 - 1773 | Storage |
| 1774 - 1799 | Input Storage (Starting Block) |
| 1800 - 1999 | Input Storage (PVI Data) |
| 0000 - 0886 | Program Tape |
VI. Description of Input Data

Initial Data:

1774 Job No: Alpha-numeric identification of Job, up to 8 characters.
1776 Date: Up to 16 alpha-numeric characters but more than 8.
1780 K Crest: The lengths of curves are computed by \( L = KA \), where \( A \) is the algebraic difference in grades. Enter the proper constant, based on design speed if the program is to compute length of curve. Enter any No. if the lengths are given.
1782 K Sag: See description above.
1784 Max. Grade: The program distinguishes between entered grades or elevations by comparing with this value. Any number greater than this value is assumed to be an elevation.
1786 Start Typeout: The program will not output any incremented stations until this station is reached. Enter a rounded station.
1788 Inc. on Tang.: Stations and elevations on vertical tangents will be output at this interval.
1790 Inc. on Curves: Stations and elevations on vertical curves will be output at this interval.
1792 Stop Type Out: The program will stop output when this station is reached.
1794 Starting Station: Station at which profile begins.
1796 Starting Elevation: Elevation of beginning of profile.

Note: The starting point must be on a vertical tangent.

1798 Add Constant to Elevation: This value will be added to all elevations. The ability to add (or subtract) a constant allows the user to run a parallel profile by changing just one value.
PVI Data:

1800 Station of PVI: Enter zero if the station is to be computed by intersecting two grades. (see sample problems)

1802 Elevation or Grade: The program accepts either elevations in feet or grades in %. All values less than the value in loc 1784 are assumed to be grades. Enter a negative elevation when it is necessary to hold the elevation regardless of the rounding of the grades. (see sample)

Note: When working with elevations near zero, it is necessary to add a constant to all input elevations and then enter the negative of the constant in loc 1798. The final elevations output will be the correct values. This same procedure will work when working with negative elevations. (Do not use negative elevations as input except as noted above.)

1804 Vertical Curve: Enter length of vertical curve if known. Enter -1. if the program is to compute the proper length of curve. (See loc 1780 and 1782)

Enter up to a total of 33 PVI's in a similar manner.

Note: For last point, enter only the station and elevation then / (slash)

Odd Stations:

1400 - 1496 Enter up to 49 Odd Stations
If there are no odd stations enter O. CR/
VII. Description of Output Data

The output is in two parts. Part I types the curve data in the following form:

Tab No., Grade to PVI, Station, Elevation, Curve length and Sight distance.

Part II computes and outputs the incremented stations and the corresponding elevations. Odd stations, highpoints, lowpoints and all curve data required to define the vertical profile are also output.

VIII. Special Storage

A. Storage of values computed in Part I

<table>
<thead>
<tr>
<th>No.</th>
<th>Station</th>
<th>Elevation</th>
<th>Grade</th>
<th>V.C.</th>
</tr>
</thead>
<tbody>
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<td>1504</td>
<td>1506</td>
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<td>1522</td>
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<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
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<tr>
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<td>1768</td>
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</table>

Location = No. x 8 + (ADDR of No. 0).

Example: The location of the elevation of the 10th PVI = 10 x 8 + 1502 = 1582

B. Special Locations

(1) Loc' 0060 Station typeout format, 42 0602
(2) Loc 0064 Elev. and MC typeout format, 42 0602
(3) Loc 0068 Elev. typeout format, 42 0602
(4) Loc 0072 Curve and sight distance typeout format, 42 0600
(5) Loc 0076 Grade typeout format, 42 0604
(6) Loc 0228 Contains the limit by which the elevations may vary.
    See Operating Procedure, Steps 21 & 22
    The constant 0.01 is stored in this location.
(7) Loc 0254 This location contains the length of curve above which the computed lengths are rounded upwards by 100' rather than 50'. The constant 1000 is stored in this location.

Example: If the program computes a length of curve of 907' it will round to 950'. If the computed curve is 1120' the program will round to 1200'.

(8) Loc 0256 Contains the station, elevation and grade round off. The constant 0.005 is stored.
IX. Operating Procedure

1. Margin and tabs
   (1) Margin at 15
   (2) All tabs set
   (3) Paper at 0

2. Load Sicom and establish the type input mode

3. Place the program tape

4. Read the program
   52 0000 / (halts)

5. Stop switch 1
   (1) On to stop for corrections after reading input tape
   (2) Off to continue computations

6. Stop switch 2
   (1) On to stop after computations but before typeout of Part I
   (2) Off to typeout of Part I

7. Jump switch 2
   (1) On for non-rounding of grades and elevations
   (2) Off for rounding to nearest 0.01

8. Place Flex input tape and type x 01 0000 / (Stop 3)

    Part I

9. Cycle Run (to read the input tape and compute)

10. Stop 1 for correction?
   (1) No correction
       Cycle Run to continue
   (2) Correct the data
       (a) Clear and Run
       (b) 50 ADDR /
       (c) Type corrections
       (d) Resume computations x 01 0001 /
11. Stop 2 to eliminate Part I?
   (1) To type out Part I
       Cycle Run
   (2) To by-pass type out of Part I
       (a) Clear and Run
       (b) Go to step 13 and to step 14 (3)

12. Output of Part I (Stop 3)

   Part II

13. Jump Switch 1
   (1) On for Flex output of Part II
       (turn on punch)
   (2) Off for type output of Part II

14. To change any computed values of Part I, if not go to step 15
   (1) Clear and Run
   (2) 50 ADDR /
       (See the list of Special Storage)
   (3) Compute Part II
       x 01 0002 /
       Go to Step 16

15. Cycle Run (to compute Part II)

16. Output of Part II (halts after final station and elevation)

17. For next solution, repeat from Step 5

18. "ERROR too many PVI's" (Stop 4)
   When this indication is typed out, revise input data and start again.
   (1) Clear and Run
   (2) Repeat from Step 5

19. "ERROR too many Odd Station's" (Stop 4)
   When this indication is typed out, remove excess odd stations and start again.
   (1) Clear and Run
   (2) Repeat from 5
20. "Curve Overlap" (Stop 4)
Part I will type out the amount of overlap, when one curve overlaps the previous curve.
(1) Repeat from step 14, or
(2) Cycle Run to continue

21. "ERROR" in PVI Elevation (Stop 4)
If the elevation computed in part II for the PVI does not agree within previously defined limits with the PVI elevation, the amount of discrepancy is typed out labeled ERROR.
Cycle Run to resume computations.

22. "ERROR" in PVT Elevation (Stop 4)
The PVT elevation is computed two different ways. If they do not agree, the same error indication as above is typed out.
Cycle Run to resume computations.

23. Stop 4
The Stop 4 is provided for other errors without error typeout.
Check input data carefully and try again.
(1) Clear and Run
(2) Repeat from Step 5
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<th>ERECT. CURVE</th>
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Enter /after last point

**Enter 1, if unknown**
| Job No. | Date   | K Crest | K Sag | Max Grade | Start Typeout | Inc on Tang. | Inc on Curve | Stop Typeout | Start Station | Start Elev. | Add Constant | PVI Sta. | Elev. | V C | Sta. | EL | V C (Computer to Design Curve) | Sta. | Grade | V C | Sta. | (Computer to intersect PVI Sta) | Grade (to PVI) | V C | Grade (From PVI) | Sta. | Elev. (Elev. Must be given for PVI after Intersection) | V C | Sta. | Elev. (The - Sign means this Elev. Must be held) | Odd Station |
|---------|--------|---------|-------|-----------|--------------|---------------|--------------|--------------|--------------|--------------|-------------|-------------|---------|------|----|------|----|----------------|-------|------|------|----------------|------|-------|----------------|-------|------|----------------|-------|------|----------------|-------|
8 February 1963 4-195 TM-(L)-993

Part I

PROFILES

Job No. 396 09
Date Nov. 19 1962

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LONG SECTION

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IDENTIFICATION
Title: Composite Beams - Ident. AK4.01
Programmer: (Lockwood, Kessler & Bartlett, Inc.), September 1962

1. Description of Problem

This program has been developed to design interior or exterior steel beams for simple span highway bridges. Basically, the program is divided into two parts. The first part computes a solution for interior beams; the second part computes a solution for fascia or exterior beams. Each part may be run independently of the other. Provision can be made to use this program for selecting "built-up sections" as well as rolled shapes.

These programs store the properties of all wide flange shapes from a 30WF 108 to a 36WF 300 inclusive, together with various combinations of bottom cover plates. These stored properties are the cover plate width, cover plate thickness, beam depth, beam area and moment of inertia of beams. The 160-A Computer automatically tests each beam and chooses one or more that will satisfy the design criteria. Since several satisfactory solutions may be obtained for each problem, the engineer may base his final selection on the total weight of beam which is one of the output items.

2. Limitations

The span length must be greater than 40 feet.

This program will handle "simple" spans only.

This program does not have the provision to handle a top cover plate or concrete haunch.

3. Equipment Affected

CDC 160-A, 161
Flexowriter
4. Memory Allocation

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<tr>
<th>Loc</th>
<th>Description</th>
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<tbody>
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<td>0612-1199</td>
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5. Operating Procedure

(1) Margin and Tabs
   Margin at .15
   Tabs at 26, 38, 41, 42, 43, 51, 64, 77, 90, 105
(2) Load SICOM
(3) Establish Typewriter I/O Mode
(4) Mount Program Tape
(5) Type 520046/
    Reads Program and Stops
(6) Type 501348/
    Enter Input Data per Input Sheet
(7) When Last Input Item has been Entered
    Type X010100/ for Interior
    Calculations or X010612/ for Fascia
    Calculation

Notes:

1. Program Stops

   a) If all the stored beams are tried and none are
      satisfactory or if only two are satisfactory and
      five solutions have been asked for, the computer
      will print "Exceed Table".

   b) If the ratio of the span in inches to the depth
      of the composite beam is greater than 25, the
      computer will print "Too Big F1".

   c) If the ratio of the span in inches to the depth
      of steel is greater than 30, the computer will
      print "Too Big F2".

   d) If the stringer spacing exceeds 14 feet, the
      computer will print "Too Big M1" and halt.

2. The number of solutions per problem (now set at 5)
   may be changed as follows:
   a) Interior beams
      Change location 0106 to 0 14 00 DR
   b) Fascia beams
      Change location 0618 to 0 14 00 DR where
      DR equals 1 less than the number of desired
      solutions.
      ie. For 3 solutions DR = 02
          For 1 solution DR = 00
3. To compute for a specific beam size (i.e. to keep fascia depths equal) proceed as follows:
   a) Interior beams
      Change location 0108 to 1 12 00 DR
      0111 to 2 02 00 DR
   b) Fascia beams
      Change location 0620 to 1 12 00 DR
      0623 to 2 02 00 DR where
      DR is the "Line" corresponding to the desired beam (see table).

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<th>Line</th>
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4. Plate Girder Design Procedure
   a) Interior girders
      1) Change command in location 0106 to 0 04 0000
         (gives single solution)
      2) Change command in location 0331 to 0 64 0333
         (will not print DDWFDDD)
      3) Enter cover plate thickness in location 1646 in inches
      4) Enter cover plate width in location 1600 in inches
      5) Enter area of girder in location 1300 in square inches
      6) Enter depth of girder in location 1400 in inches
      7) Enter moment of inertia of girder in location 1500 in inches
b) Fascia girder

1) Change command in location 0618 to 0 14 0000 (gives single solution)
2) Change command in location 0924 to 0 64 9926 (will not print DDWFDDD)

Repeat steps (3), (4), (5), (6), and (7) if fascia girder is not the same as the interior girders.

c) For interior and fascia

1) Make allowable minimum stress low (location 1394 = 5.0) and allowable maximum stress high (location 1396 = 50.0) to insure typeout.
2) Enter cover plate thickness. Change location 1246 to; (BS) (LC) by XXXX where XXXX is cover plate thickness (i.e. XXXX = 1.25, max. 3 numbers and decimal point).
### Composite Beams

**Job No.** B-4620-S  
**Bridge** Throgs Neck  
**Date** 9/20/62  
**By** EMB

<table>
<thead>
<tr>
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**Notes:**

1. For full length plate enter 1.; for computed length plate enter 0.
2. Smaller of following: 1/4 of span, center to center of beams or 12 times slab thickness.
3. Can be 0, 1, 2, or 3.
4. For spirals enter 1; for studs enter 2.
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FINISHES
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8. References
a) American Association of State Highway Officials (AASHO)
b) Steel Construction Manual of the American Institute of Steel Construction (AISC)
K5.
IDENTIFICATION

Title: Horizontal Adjustment - Ident. AK5.01
Programmer: (Lockwood, Kessler & Bartlett, Inc.), November 1962

I. Statement of Problem

It is desired to obtain map or grid coordinates of photogrammetric points, namely the horizontal pass points, as the results of stereotriangulation.

The map coordinates of horizontal control points are given. The instrument coordinates of the control points and the pass points are observed for a triangulated strip of controlled photography.

Two basic transformation equations expressed in the form of a polynomial of a second degree are based on the theory of errors by Army Map Service. The coefficients of the equations are determined by the method of least squares for the given map coordinates and the observed instrument coordinates of the control points.

The map coordinates of pass points on the strip are then computed by the transformation equations for the observed instrument coordinates.

II. Limitations

1. The number of horizontal control points (CP) on a strip shall not be less than 3 or more than 40.

2. An infinite number of horizontal pass points (PP) on the strip may be processed in groups of 200 or less at a time.

3. The X and Y map coordinates may range from 0 to 10,000,000.00 units.

4. The instrument x and y coordinates may range from 0.01 to 100,000.00 units.

5. The instrument x and y coordinates can not be zero and the y coordinates can not be negative values.

6. A maximum number of 50 control points in any order may be entered at a time to eliminate or to restore the previous data for the analysis of residuals.

*Photogrammetric Engineering, Sept. 1953, p. 627.
7. Identification numbers of pass points may range from 1 to 9999, starting from any number for first pass point and in numerical sequence for others.

III. Accuracy

The error of computed map coordinates will be less than ± 0.005 units.

IV. Equipment Affected

CDC 160-A
CDC 161
Flexowriter

V. Memory Allocation

0200 - 0649 Program
0700 - 0753 Alpha Storage
0754 - 0759 Punch s/r
0760 - 0761 Coeff.
0766 - 0841 Temporary Storage
1000 - 1099 Temporary Storage
1200 - 1999 Input Storage of PP Data
1600 - 1999 Input Storage of CP Data

0200 - 0761 Program Tape
VI. Description of Input Data

Control Points:

The information of control points consists of the identification, instrument coordinates and map coordinates for each point. A sequence of the control points can be in any order.

1. Alpha-numeric identification of a control point, up to 8 characters
2. Instrument x coordinate in the direction of triangulation
3. Instrument y coordinate
4. Map coordinate in feet or meters; northing
5. Map coordinate in feet or meters; easting

The above input data can be prepared on a CDC Flexowriter or entered through the typewriter 161 according to the following format.

; I_1 tab x_1 tab y_1 tab Y_1 tab X_1 CR
; I_2 ----------
; .
; .
; .
; I_n ----------
/

Pass Points:

The information of pass points consists of the instrument x and y coordinates for each point. A sequence of the pass points can be also in any order.

1. Instrument x coordinate of a pass point in the direction of triangulation
2. Instrument y coordinate
The input data of pass points will be prepared on the CDC Flexowriter.

\[
\begin{align*}
&x_1 \tab y_1 \CR \\
&x_2 \tab y_2 \CR \\
&\vdots \\
&\vdots \\
&x_j \tab y_j \CR
\end{align*}
\]

An identification number of first pass point will be entered through the typewriter 161 at the time when the information of the pass points is processed. The identification numbers of other pass points will be in numerical sequence. The numbers may range from 1 to 9999.

VII. Description of Output Data

The information of output data consists of three parts. Part one is the listing of control points. Part two is the computation of residuals. Part three is the computed coordinates of pass points.

The final output data of pass points may be listed through the typewriter 161 or they may be punched on the Flexowriter tape.
VIII. Operating Procedure

1. Margin and tabs
   (1) Margin at 20
   (2) Tabs at 27, 38, 50, 65, 80, 90 and 95
   (3) Paper at 0

2. Load Sicom

3. Place the program tape

4. Input mode?
   (1) Flex input (1 light), go to step 5
   (2) Type input (2 lights), 11/ to read the program and go to step 6

5. Cycle Run (to read the program) (Stop 3)

   Control Points

6. Jump switch 1
   (1) On for type input of CP data, go to step 7
   (2) Off for Flex input of CP tape, go to step 8

7. Type in CP data (1600-1998)
   ; I tab x tab y tab Y tab X CR

   Type / after the last CR (Stop 4)
   Place new page and go to step 10

8. Place CP tape

9. Cycle Run (to read the CP tape)

10. Output of CP data (stop 3)
    Types: jp sw 2 on to pp
11. Jump switch 2
   (1) On to compute PP data, go to step 15
   (2) Off to eliminate CP

12. Cycle Run
    Types: type cp nos.

13. Type CP Nos. in any order (CP = 1 to 40)
    - CP, tab (to eliminate)
    - CP, tab (to restore)
    Type / after the last tab or CR

14. Output of residuals (stop 3)
    Types: jp sw 2 on to pp
    Repeat from step 11

Pass Points

15. Cycle Run
    Types: jp sw 2 on to tape output
    place pp tape type 1st pp no.

16. Place PP tape

17. Type in 1st PP No. (4 digits or less)
    PPPP, tab / (stop 3)

18. Jump switch 2
    (1) On for Flex output, punch on and go to step 19
    (2) Off for type output, go to step 21

19. Cycle Run (to read the PP tape)

20. Output of PP data (stop 4)
    Go to step 25

21. Stop switch 1 (for type output)
    (1) On to stop at 25th PP per page
    (2) Off to ignore 25th PP

22. Place tracing paper and double CR
Control Point Data

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<th>y</th>
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Jp sv 2 on to tape output

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IDENTIFICATION

Title: Soil Consolidation - Ident AK6.01
Programmer: (Lockwood, Kessler & Bartlett, Inc.), October 1962

1. Description of Problem

This program computes the settlement of "n" layers of soil with a maximum of 4 layers and a surcharge load placed in "n" number of lifts which could be totally or partially removed.

The program will also compute the settlement of each layer at various intervals of time after removal of surcharge.

A maximum of 6 offset points per station can be entered as input and the settlement due to the consolidation of the soil at each point under the offsets can be computed.

The program provides alphanumeric identification and column headings.

2. Limitations

A maximum of 4 different layers of soil can be entered per each offset. A maximum of 6 offsets can be entered per station.

Six Pn and Cv values must be entered per each layer. If the laboratory data is applicable to more than one station, the test codes in the input may be set equal and the data should not be repeated.

All input is via flexowriter tape.

3. Equipment Affected

CDC 160-A, 161
Flexowriter
1. **Description of Problem**

This program computes the settlement of "n" layers of soil with a maximum of 4 layers and a surcharge load placed in "n" number of lifts which could be totally or partially removed.

The program will also compute the settlement of each layer at various intervals of time after removal of surcharge.

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3. **Equipment Affected**

CDC 160-A, 161
Flexowriter
4. **Memory Allocation**

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<td>Log 10 X s/r</td>
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<td>Arctan s/r</td>
<td>Station type out routine</td>
<td>Integration routine</td>
<td>Series routine</td>
<td>Interpolation routine</td>
<td>Delta routine</td>
<td>Weight routine</td>
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<td>Temporary storage</td>
<td>Program</td>
<td>Permanent storage</td>
<td>Input storage</td>
<td>Routine storage</td>
</tr>
</tbody>
</table>

5. **Operating Procedure**

1. Margin and tabs
   - Margin at 20
   - Every other tab down
   - Output paper at 10

2. Load Sicom

3. Place the program

4. Establish typewriter input mode

5. Type
   - 52 0000 /
   - Reads the program and stops

6. Place Flexowriter input tape

7. Type
   - x01 0600 /
   - Reads the data tape and computes

6. **Description of Input and Output**

Job number and test number are entered as one alpha word.
Date is entered as two alpha words.

Computation time is approximately 3 minutes per offset with typewriter output.
### Soil Consolidation Input Form

<table>
<thead>
<tr>
<th>FIELD NO. 1</th>
<th>JOB NO.</th>
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<table>
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<table>
<thead>
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<tbody>
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<tr>
<td>L2</td>
<td>5.2 m</td>
</tr>
<tr>
<td>S1</td>
<td>0.5</td>
</tr>
<tr>
<td>Hf</td>
<td>1.0 m</td>
</tr>
<tr>
<td>Pf</td>
<td>2.8 lb/ft;</td>
</tr>
<tr>
<td>M1</td>
<td>3.0</td>
</tr>
<tr>
<td>M2</td>
<td></td>
</tr>
<tr>
<td>t1</td>
<td>1 month;</td>
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<tr>
<td>t2</td>
<td>1/2 month</td>
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<td>Offset 2</td>
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<td>-1.0 m</td>
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<tr>
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Note: All measurements are in meters (m).
FLEXOMETERS TAPE PREPARATION

FIELD No 1
39156-44 Job No
1/0050.00 Station
FIELD No 2
1-52. L

52. L
.5 S
1. H

128. P
6. M
4. M
2. H
1. t

12. t

FIELD No 4
FIELD No 5
6. Z1
4. Z2
2. Z3
-Z2
-2. Z4
-2. Z5

2. Z1-5 FIRST OFFSET
1.

2. Z1-5 SECOND OFFSET
1.

1.
1.
CONTINUE FIELD NO 5

3.
  
1. }  \[ Z_{1-5} \] THIRD OFFSET
  
-1.
-3.
-3.

2.

1. }  \[ Z_{1-5} \] FOURTH OFFSET
  
0.
-1.
-1.

1. }  \[ Z_{1-5} \] FIFTH OFFSET
  
0.
-1.
-2.
-2.

0. }  \[ Z_{1-5} \] SIXTH OFFSET
  
-1.
-2.
-3.

FIELD NO 6

2. 9 1st layer 2. 9 2nd layer 2. 9 3rd layer 2. 9 4th layer

\[
\begin{align*}
&0.67 \ A_0 \quad 0.73 \ A_0 \quad 0.88 \ A_0 \quad 0.9 \ A_0 \\
&0.19 \ C_0 \quad 0.2 \ C_0 \quad 0.39 \ C_0 \quad 0.44 \ C_0 \\
&0.256 \ P_0 \quad 0.256 \ P_0 \quad 0.27 P_0 \quad 0.29 P_0 
\end{align*}
\]
CONTINUE

FIELD NO 6

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<th>Layer 4</th>
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<td>0.512</td>
<td>0.512</td>
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/ REPEAT AS FIELD NO 2 FOR END CODE /
/ 000.00 STATION /
/ END OF FIELD CODE /
SOIL CONSOLIDATION

TEST N° UL-77  

STATION = 100 + 50.00 OFFSET = 50.000 LEFT

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<th>Settled at Time of Removal of Surcharge</th>
<th>Settlement</th>
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<td>2</td>
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<tr>
<td>2</td>
<td>2</td>
<td>.029</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>.385</td>
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<th>Settled at Time = 24 Months After Removal of Surcharge</th>
<th>Settlement</th>
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<td>1</td>
<td>.800</td>
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<td>2</td>
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<tr>
<td>2</td>
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<td>.029</td>
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<td>.385</td>
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<tr>
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<th>Settled at Time = 96 Months After Removal of Surcharge</th>
<th>Settlement</th>
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<tr>
<td>2</td>
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<table>
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<tr>
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TEST N° 11-77  STATION = 100 + 50.00  OFFSET = 30.000  LEFT

SETTLEMENT AT TIME OF REMOVAL OF SURCHARGE

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<td>N° 1</td>
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</tr>
<tr>
<td>N° 2</td>
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SETTLEMENT AT TIME = 12 MONTHS AFTER REMOVAL OF SURCHARGE

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<td></td>
</tr>
<tr>
<td>N° 2</td>
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SETTLEMENT AT TIME = 24 MONTHS AFTER REMOVAL OF SURCHARGE

<table>
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<th>3 Settlement</th>
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<tbody>
<tr>
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<tr>
<td>N° 2</td>
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<tr>
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SETTLEMENT AT TIME = 48 MONTHS AFTER REMOVAL OF SURCHARGE

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<tbody>
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<tr>
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SETTLEMENT AT TIME = 96 MONTHS AFTER REMOVAL OF SURCHARGE

<table>
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<th>3 Settlement</th>
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<tbody>
<tr>
<td>N° 1</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>N° 2</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N° 3</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SETTLEMENT AT TIME = 192 MONTHS AFTER REMOVAL OF SURCHARGE

<table>
<thead>
<tr>
<th>LAYER</th>
<th>1 Settlement</th>
<th>2 Settlement</th>
<th>3 Settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>N° 1</td>
<td>.800</td>
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<td></td>
</tr>
<tr>
<td>N° 2</td>
<td>.001</td>
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</tr>
<tr>
<td>N° 3</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8 February 1963

TEST N°  U1-77

STATION = 100 + 50.00
OFFSET = 10.000

SETTLEMENT AT TIME OF REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004

SETTLEMENT AT TIME = 12 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004

SETTLEMENT AT TIME = 24 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004

SETTLEMENT AT TIME = 48 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004

SETTLEMENT AT TIME = 96 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004

SETTLEMENT AT TIME = 192 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER N° 1 SETTLEMENT = 0.082
LAYER N° 2 SETTLEMENT = 0.115
LAYER N° 3 SETTLEMENT = 0.004
8 February 1963

TEST N° u1-77 STATION = 100 + 50.00 OFFSET = 10.000 RIGHT

<table>
<thead>
<tr>
<th>Layer</th>
<th>Settlement at removal of surcharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>N°1</td>
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</tr>
<tr>
<td>N°2</td>
<td>2</td>
</tr>
<tr>
<td>N°3</td>
<td>3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Layer</th>
<th>Settlement at time = 12 months after removal of surcharge</th>
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</thead>
<tbody>
<tr>
<td>N°1</td>
<td>1</td>
</tr>
<tr>
<td>N°2</td>
<td>2</td>
</tr>
<tr>
<td>N°3</td>
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</tbody>
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<tbody>
<tr>
<td>N°1</td>
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<td>2</td>
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<tr>
<td>N°3</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Layer</th>
<th>Settlement at time = 48 months after removal of surcharge</th>
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</thead>
<tbody>
<tr>
<td>N°1</td>
<td>1</td>
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<tr>
<td>N°2</td>
<td>2</td>
</tr>
<tr>
<td>N°3</td>
<td>3</td>
</tr>
</tbody>
</table>
8 February 1963

<table>
<thead>
<tr>
<th>Layer</th>
<th>Settlement at time of removal of surcharge</th>
<th>Settlement at time = 100.00 + 50.00 offset = 30,000 right</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>1: Settlement = 0.000</td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>N2</td>
<td>2: Settlement = 0.000</td>
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<td></td>
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</tr>
<tr>
<td>N3</td>
<td>3: Settlement = 0.000</td>
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<tr>
<td>Layer</td>
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<td>Settlement at time = 24 months after removal of surcharge</td>
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<td>1: Settlement = 0.000</td>
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<tr>
<td>N2</td>
<td>2: Settlement = 0.000</td>
<td>2: Settlement = 0.000</td>
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<tr>
<td>N3</td>
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<td>Settlement at time = 48 months after removal of surcharge</td>
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<td>----------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>N1</td>
<td>1: Settlement = 0.000</td>
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<tr>
<td>N2</td>
<td>2: Settlement = 0.000</td>
<td>2: Settlement = 0.000</td>
</tr>
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<tr>
<td>N3</td>
<td>3: Settlement = 0.000</td>
<td>3: Settlement = 0.000</td>
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<td>Settlement at time = 96 months after removal of surcharge</td>
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<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>N1</td>
<td>1: Settlement = 0.000</td>
<td>1: Settlement = 0.000</td>
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<td></td>
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<td></td>
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<tr>
<td>N2</td>
<td>2: Settlement = 0.000</td>
<td>2: Settlement = 0.000</td>
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<td></td>
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<tr>
<td>N3</td>
<td>3: Settlement = 0.000</td>
<td>3: Settlement = 0.000</td>
</tr>
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</tr>
<tr>
<td>Layer</td>
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<td>Settlement at time = 192 months after removal of surcharge</td>
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<td>1: Settlement = 0.000</td>
<td>1: Settlement = 0.000</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>2: Settlement = 0.000</td>
<td>2: Settlement = 0.000</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>N3</td>
<td>3: Settlement = 0.000</td>
<td>3: Settlement = 0.000</td>
</tr>
</tbody>
</table>
8 February 1963 4-226 TM-(L)-993

TEST No: ul-77 STATION = 100 + 50.00 OFFSET = 50.000 RIGHT

SETTLEMENT AT TIME OF REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022

SETTLEMENT AT TIME = 12 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022

SETTLEMENT AT TIME = 24 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022

SETTLEMENT AT TIME = 48 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022

SETTLEMENT AT TIME = 96 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022

SETTLEMENT AT TIME = 192 MONTHS AFTER REMOVAL OF SURCHARGE

LAYER No 1 SETTLEMENT = .000
LAYER No 2 SETTLEMENT = .000
LAYER No 3 SETTLEMENT = .000
LAYER No 4 SETTLEMENT = .022
IDENTIFICATION

Title: Statistical Program I (Means, Standard Deviations, Correlation for Two Variables) - Ident. L1.01
Contributor: Dr. C. A. Caceres, August 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the 2 x n array would allow running on the 160). The routine produces the means and standard deviations for two sets of variables and the correlation between corresponding entries in the two lists.

USAGE

1. Operational Procedure:

   Using techniques for FORTRAN the integral value of n and the n-floating point x-values and the n-floating point y-values are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find his results well-labelled.

   To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

   The maximum array size for which the routine is written is 2 x 400.

10. Input and Output Formats:

   Two format statements are used to control the input of data into the routine:

   4 FORMAT (14)
   10 FORMAT (f12.6)

   Three read commands are given with pauses between them. The first read command accepts an integral quantity n (xxx/), and the next two read commands read in successively n x-values and n y-values.

   Note: It has been made the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Statistical Program II (linear Regression) - Ident. L1.02
Contributor: Dr. C. A. Caceres, August 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the 2 x n array would allow running on the 160). The routine produces the following quantities for the two sets of variables:

- Regression coefficients, alpha and beta
- The sum of squares attributable to regression
- The sum of squares of deviations from regression
- The mean square deviation from regression
- The sample standard error of the dependent variable estimated from the independent variable
- The sample standard error of beta and,
- The 't-test' value

Reference: SNEDECOR, Statistical Methods, Iowa State College Press

USAGE

1. Operational Procedure:

Using the techniques for FORTRAN the integral value of n and the n-floating point x-values and the n-floating point y-values are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find the results well-labelled.

To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

The maximum array size for which the routine is written is 2 x 400.

10. Input and Output Formats:

Two format statements are used to control the input of data into the routine:

100 FORMAT (I4)
101 FORMAT (F12.6)

Three read commands are given with pauses between them. The first read command accepts an integral quantity n (xxx/) and the next two read
commands read in successively in x-values and n y-values.

Note: It has been made the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Statistical Program III (Test of Nomality in a Frequency Distribution of Large Size) - Ident L1.03
Programmer: Dr. C. A. Caceres, August, 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the line array would allow running on the 160). The routine produces the following quantities:

$s_1$, $s_2$, $s_3$, $s_4$, $S_2$, $S_3$, $S_4$, $k_1$, $k_2$, $k_3$, $k_4$, $g_1$, $g_2$, $s_1^2$, $s_2^2$, $s_3^2$, $s_4^2$, $k_1$, $k_2$, $k_3$, $k_4$, $g_1$, $g_2$, $s_1^2$, $s_2^2$, $s_3^2$, $s_4^2$, $t$

for $g_1$ and $t$ for $g_2$.

Reference: SNEDECOR, Statistical Methods, Iowa State College Press

USAGE

1. Operational Procedures:

Using techniques for FORTRAN the integral value of $n$ and the $n$-floating point x-values are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find his results well-labelled.

To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

The maximum array size for which the routine is written is $1 \times 800$.

10. Input and Output Formats:

Two format statements are used to control the input of data into the routine:

100 FORMAT (I4)

101 FORMAT (F12.6)

Two read commands are given with a pause between them. The first read command accepts an integral quantity $n$ (xxx/) and the second reads in $n$ values of the variable from paper tape.

Note: It has been the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Statistical Program IV (Mean and Standard Deviation for One Variable) - Ident. L1.04
Contributor: Dr. C. A. Caceres, August 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the line array would allow running on the 160). The routine produces the mean and standard deviation for a single variable.

USAGE

1. Operational Procedure:

Using the techniques for FORTRAN the integral value of n and the n-floating point x-values are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find his results well-labelled.

To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

The maximum array size for which the routine is written is $1 \times 1000^{10}$.

10. Input and Output Formats:

Two format statements are used to control the input of data into the routine:

$$4 \text{ FORMAT (i4)}$$
$$10 \text{ FORMAT (f12.6)}$$

Two read commands are given with a pause between them. The first read accepts an integral quantity n (xxx/) and the second reads in n values of the variable from paper tape.

Note: It has been made the practive to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Statistical Program V (Sums, Sums of Squares, and Sums of Cross Products for Three Variables) - Ident. L1.05
Contributor: Dr. C. A. Caceres, August 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the array would allow running on the 160). The routine produces the basic statistical building blocks for a three-dimensional sample-space, i.e., sums, sums of squares and sums of cross products. This routine would reduce the dog-work for a skilled statistician and enable him to rapidly decide how best to handle his data.

USAGE

1. Operational Procedure:

Using Techniques for FORTRAN the integral value of n and the n-floating point values of each of the three variables are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find the results well-labelled.

To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

The maximum array size for which the routine is written is $3 \times 300_{10}$.

10. Input and Output Formats:

Two format statements are used to control the input of data into the routine:

112 FORMAT (i4)
113 FORMAT (f12.6)

Four read commands are given with three pauses between them. The first read command accepts an integral quantity n (xxx/) and the other three read in n values of each variable from paper tape.

Note: It has been made the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Statistical Program VI (Percentiles) - Ident. L1.06
Contributor: Dr. C. A. Caceres, September 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the four internal storage arrays would allow running on the 160). The routine produces the percentiles at 5 percent intervals after sorting the original data internally.

USAGE

1. Operational Procedure:

Using techniques for FORTRAN the integral value of n and the n-floating point x-values are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find his results well labelled.

To continue the program with new data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

The maximum data array size for which the routine is written is $1 \times 300_{10}$.

10. Input and Output Formats

Two format statements are used to control the flow of data into the routine:

103 FORMAT (i4)
104 FORMAT (f12.6)

Two read commands are given with a pause between them. The first read command accepts an integral quantity n (xxx/), and the next read command reads in the n x-values.

Note: It has been the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

METHOD

The necessary sorting of the data is carried out by means of the "string" sorting technique in which strings of ascending values are identified and the strings lengthened by merging in successive passes until one sorted string results. Besides the two equal-sized areas used for handling the actual floating point data, two integral areas are used to store the starting and ending addresses of the lth string during each merge. As soon as a pass is terminated in which i has not exceeded unity, the sort is known to be completed and the relatively simple process of computing the percentiles can be undertaken.
IDENTIFICATION

Title: Statistical Program VII (Two 't'-tests for 2 Equal or Unequal-sized Line Arrays) - Ident. L1.07
Contributor: Dr. C. A. Caceres, August 1962

PURPOSE

This program is written in FORTRAN for the Control Data 160-A (reducing the dimension size of the line arrays would allow running on the 160). The routine produces and outputs either the t-test value for equal-sized sets or the t-test value for unequal-sized sets, depending on whether the sets are equal or unequal in length. (Also output are intermediate statistical quantities of interest produced during computation.)

Reference: Snedecor, Statistical Methods, Iowa State College Press

USAGE

1. Operational Procedure:

   Using techniques for FORTRAN the integral value of \( n_1 \), the \( n_1 \)-floating point x-values, the integral value of \( n_2 \) and the \( n_2 \)-floating point y-values, are read in from paper tape. The resulting tape from the punch is for listing on the Flexowriter and the user will find his results well-labelled.

   To continue the program with fresh data it is not necessary to reload the program; simply place the new data tape(s) in the reader and run.

3. Space Requirements:

   The maximum array size for which the routine is written is \( 2 \times 400 \).\(^{10}\)

10. Input and Output Formats:

   Two format statements are used to control the input of data into the routine:
   
   \[
   \begin{align*}
   &109 \text{ FORMAT (i4)} \\
   &110 \text{ FORMAT (f12.6)}
   \end{align*}
   \]

   Two read commands are given followed by a pause and two more read commands. The first two read commands accept an integral quantity \( n_1 \) (xxx/) and the \( n_1 \) x-values; the second two read commands bring in \( n_2 \) and the \( n_2 \) y-values.
Note: It has been the practice to oversize the format statement and thus render it mandatory to terminate each piece of data with a slash (and, if desired, carriage return).

IDENTIFICATION

Title: Single Precision Fractional Square Root - Ident. Z1.00
Programmer: Sanford Elkin, February 1961

PURPOSE

This is a demonstration routine. It will find the square root of a proper fraction with a maximum error of $2^{-11}$.

USAGE

1. Operational Procedure:

   Load the bi-octal tape starting at cell 0, and clear. Place the number N in the A register, and start. $X = \sqrt{N}$ will appear in the A register. Place a new N in A and repeat.

3. Space Used: Octal cells 100-206, plus locations 0, 1, 7, and 55-67.


11. Accuracy: Maximum error is $2^{-11}$.

MATHEMATICAL METHOD

Newton-Raphson iteration with $X_{i+1} = 1/2 \left(X_i + N/X_i\right)$ and $X_0 = 1$, stopping when $\Delta X \leq 2^{-11}$. The Single precision Divide Subroutine is used.
IDENTIFICATION

Title: Random Number Generator (12 bit) - Ident. Zl.02
Programmer: J. A. Pederson, July 1961

PURPOSE

Produce 12-bit "random" numbers

USAGE

1. Operational Procedure:

   The routine floats and may be loaded anywhere. Set P = any arbitrary value, set Load switch and Run.

   There are two entrances into the routine. A reset entrance at L and a random number entrance at L + 108 (where L = the initial address of the routine).

   The initial entry is made at L with an exit with the random number displayed in A. Entry again at L restarts the sequence.

3. Space Required: $46_8 = 38_{10}$ locations

4. Temporary Storage: None

10. Timing: 307 microseconds per number generated.

12. Cautions to User: The routine generates a cycle of $1679 \times 1678 = 2,560,000$ 12 bit random numbers without repeating the sequence. Beyond this the cycle repeats itself.

METHOD

The routine generates two number series:

$$a_i + 2 = (a_i + 1 + a_i) \mod 2^{12} - 1$$
$$b_i + 2 = (b_i + 1 + b_i) \mod 2^{12} - 1$$

where

$$a_1 = 1, \ a_2 = 2$$
$$b_1 = 1, \ b_2 = 100_8$$
Each series has a cycle of 1679 values before repeating. The "a" series is shortened to a 1678 cycle by a program stop. The random number is obtained by an exclusive "or" of \( a_1 \) and \( b_1 \).
IDENTIFICATION

Title: ALNUP - Ident. Z3.00
Programmer: C. M. Atchison, April 1961

PURPOSE

This routine will punch character messages in paper tape that are legible to an unskilled observer. These characters are formed in a 5 by 7 matrix on an output tape. The standard 160 Flexowriter coded paper tape is used as input.

USAGE

1. Operational Procedure:
   a. Prepare Flexowriter (Standard CDC 160 code) input tape.
   b. Load BI-OCTAL program tape at location zero.
   c. Turn punch on.
   d. Place Flex input tape in reader.
   e. Run from zero.
   f. Normal stop: P = 140, Z = HLT 77.

3. Space Required
   a. 5748 locations.
   b. 38010 locations.

4. Temporary Storage Requirements
   a. Variable according to length of input file starting at location 6003.

5. Cautions to User
   a. The program does not punch leader or trailer on the output paper tape.

13. Equipment Configuration
   b. 160 computer with paper tape input and output.
IDENTIFICATION

Title: Trajectory Calculation - Ident. AZ3.02
Programmer: Irv. Hecker, August 1961

PURPOSE

Given the target range, the velocity of the projectile, and its angle of inclination, the program will plot the path of the projectile on the typewriter. Appropriate comments are typed to indicate whether the shot hit the target, was too short, or too long. A shot is scored as a hit if it falls within 10.0 feet of the range.

The plot is scaled so that each unit on the X-axis is 1/80 of the distance to the target. Each unit on the y-axis is 1/80 of the maximum height allowed. The maximum allowable height is 1/4 of the target range.

USAGE

1. Operational Procedure
   a. Place the program tape in the paper tape reader
   b. Turn PTR on.
   c. Master Clear
   d. Set the relative bank control to the number of the bank into which the program is to be loaded.
   e. Place "Load-Clear" switch on "Load".
   f. Place "Run-Step" switch on "Run". Tape will be read into the computer memory. Check sum is 0001.
   g. Master Clear
   h. Set all bank controls (buffer not necessary) to the number of the bank in which the program is.
   i. Place "Run-Step" switch on "Run".

9. Input and Output Formats
   a. Entering Data:
The program will request a value for "RANGE(FT)", "VELOCITY (FT/SEC.)" and "ANGLE (DEG.)".

Each value is entered as a fixed point number with up to nine significant digits. A decimal point must be entered in the proper position within the number. Each value must be followed by either a tab or a carriage return. Zero must be entered as "0.0".

b. Output Format:

The routine sets up the output graph so that the scale in the direction of the target is one space equals 1/80 of the range, and one space vertically equals 1/320 of the range. The maximum height attainable by trajectory which will stay on the page is 1/4 of the range. The numerical quantities printed have only two digits to the right of the decimal point.

13. Equipment Configuration

Minimum 160-A and 161 Typewriter

METHOD

The coordinates of the projectile are computed by the equation:

\[ Y_i = X_i \tan \theta - \frac{g}{2} \frac{X_i^2}{V_0^2 \cos^2 \theta} \]

where \( \theta \) = initial angle of inclination

\( V_0 \) = initial velocity

\( g \) = acceleration due to gravity

\( i = 1, 2, 3, \ldots, 16 \)

and since \( X_i \) is computed every five units, \( X_i = \frac{5r}{80} \cdot i \)

where \( r \) = target range.
IDENTIFICATION

Title: MORTGAGE AMORTIZATION - Ident. AZ3.03.
Programmer: (Control Data Corporation), July 1962

PURPOSE

This program has two options:

1. Computes the monthly payment necessary to amortize a given principal amount at a given interest rate for a given duration.

2. Computes the duration necessary to amortize a given principal amount at a given interest rate with a given monthly payment.

In option (2), after computing the necessary duration of the loan, which will generally be a non-integral number of years, a desired duration is requested (some practical value for the number of years) and new monthly payment, close to the desired amount, is calculated.

At the completion of either option, a complete amortization schedule is typed out, showing the payment number, the portion of the payment which goes for interest, the portion which is deducted from the principal and the new balance to be paid.

USAGE

1. Loading instructions
   a. Place the program tape in the paper tape reader.
   b. Turn PRT on.
   c. Master clear.
   d. Set the relative bank control to the number of the bank into which the program is to be loaded.
   e. Place "Load-Clear: switch on "Load."
   f. Place "Run-Step: switch on "Run". Tape will be read into the computer memory. Check sum is 0002.
   g. Master clear.
   h. Set all bank controls (buffer not necessary) to the number of the bank in which the program is contained.
   i. Place "Run-Step" switch on "Run".

2. Operating Instructions:

   The program will request the principal amount of the loan and the rate of interest. Each number must contain a decimal point and following digit. When the values for these two quantities have been supplied,
the program will type "Desired Monthly Payment = ". If a certain monthly payment is desired, the amount is specified at this point, and the program will compute the number of years necessary to amortize the loan. If no specific monthly payment is desired, type "0.0" for the desired monthly payment.

The program will request "Desired Duration of Loan = ". At this point the length of the loan in years must be supplied. The program will compute the monthly payment necessary to amortize the loan. Following this, a payment schedule is typed showing payment number, interest due, amount paid on principal, and balance on loan.

7. Error Stop

If a value is input for desired monthly payment which is too small, the computer will type "Sorry, not possible" and halt. To restart, place run switch in neutral and back to run.


METHOD

The equation used to calculate the monthly payment is:

\[ M = \frac{P \cdot R \cdot (1 + R)^N}{(1 + R)^N - 1} \]

where
- \( P \) = principal
- \( R \) = rate of interest per month (1/12 annual rate)
- \( N \) = number of months

The equation used to calculate the duration of the loan in years is:

\[ D = \frac{\log (1 - PR)}{\log (1 + R)} \]

where \( M \) = monthly payment and \( R \) and \( R \) are defined as above.
IDENTIFICATION

Title: Multiple Precision Package - Ident. Bl.02
Programmer: D. C. Nelson, May 1961

PURPOSE

Perform arithmetic with operands expressed to 6, 12, 18, 24, \ldots 6N binary digit precision.

USAGE

Normally the degree of precision will be set for a particular tape, but this can be changed for other precision without altering any of the subroutines. By specifying the beginning and ending addresses of the A, X, and Q registers plus the address of AHEXT, a one word extension of the A register, the precision can be changed to any desired length, using 6 bits of precision per register word. For 24 bit precision, four 160 words are used per register, etc. The user is cautioned to make sure that the A-register is positioned such that it is a continuation of the Q-register. For example: in 24 bit precision if the low order address of the Q-register is 7624, the high order address of the Q-register is 7627. In this case the low order address of the A-register must be the next address, 7630, with the high order address at 7633, and AHEXT at 7634. Space has been saved for the registers, beginning at 7620 and ending at 7776, in memory. The following cells of the first sixty-four memory locations hold the seven variable addresses:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHEXT</td>
<td>0013</td>
</tr>
<tr>
<td>AH</td>
<td>0015</td>
</tr>
<tr>
<td>AL</td>
<td>0016</td>
</tr>
<tr>
<td>QH</td>
<td>0024</td>
</tr>
<tr>
<td>QL</td>
<td>0025</td>
</tr>
<tr>
<td>XH</td>
<td>0021</td>
</tr>
<tr>
<td>XL</td>
<td>0022</td>
</tr>
</tbody>
</table>

Each data word to be used by the MPPN routine must be packed with the four high order octal digits in the low order address, the next four lower octal digits in the next higher address and so forth. Examples of this packed representation are:

<table>
<thead>
<tr>
<th>Octal Number (24 bit precision)</th>
<th>Location</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>6532 4173</td>
<td>1000</td>
<td>6532</td>
</tr>
<tr>
<td>6532 4173</td>
<td>1001</td>
<td>4173</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Octal Number (42 bit precision)</th>
<th>Location</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>56410273561402</td>
<td>2000</td>
<td>5641</td>
</tr>
<tr>
<td>56410273561402</td>
<td>2001</td>
<td>0273</td>
</tr>
<tr>
<td>56410273561402</td>
<td>2002</td>
<td>5614</td>
</tr>
<tr>
<td>56410273561402</td>
<td>2003</td>
<td>0200</td>
</tr>
</tbody>
</table>
Arithmetic is accomplished in 1's complement fashion, with the highest order bit interpreted as a sign bit. For example the 48th bit in 48 bit precision is interpreted as a sign bit following standard conventions of a 1 if negative and a 0 if positive.

1. Principle of Operation - MPPN consists of a control routine and a number of arithmetic subroutines. The control routine makes possible the linkage of any number of subroutines without generating a subroutine linkage in the main program each time one of the MPPN subroutines is used.

The MPPN subroutines are designed to operate using one parameter, the operand address, called PY in the following discussion.

2. Control Routine - The control routine provides the means of tying MPPN subroutines together and performs the function of getting the parameter from memory to a standard location for use by the subroutines.

The entrance to the control routine is ENTR, or 6300. This entrance causes the control routine to continue to interpret calling sequences until the subroutine BASIC is called.

A calling sequence consists of the subroutine mnemonic code followed by the parameter, PY, required by the subroutine.

Example -

To solve the problem, (A+B) C/D and store the result at E, in MPPN, and return to basic 160 machine coding, the following coding (expressed in Assembly Language) will do the job.

<table>
<thead>
<tr>
<th>Location</th>
<th>Op</th>
<th>Address</th>
<th>Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>LDF</td>
<td>03</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>JFI</td>
<td>01</td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>ENTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L4</td>
<td>NEXT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEXT</td>
<td>LDA</td>
<td>A</td>
<td>ADD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>MPY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>DIV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>STA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>BASIC</td>
</tr>
<tr>
<td>L5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
At conclusion of the store A routine, the control routine recognizes the BASIC, and returns control to the main program at 15.

3. MPPN Subroutines.

a) Load MPPN's A-Register.
   Calling sequence
   LDA
   PY
   Operation - Load the octal number beginning at location PY into the MPPN's A-Register.

b) Load Complement MPPN's A-Register.
   Calling sequence
   LQA
   PY
   Operation - Load the complement of the octal number beginning at location PY into the MPPN's A-Register.

c) Store MPPN's A-Register.
   Calling sequence
   STA
   PY
   Operation - Store the octal number in MPPN's A-Register beginning at location PY in memory. The 4 high order octal digits go into PY; the next 4 lower order octal digits into PY + 1 etc.

d) Store MPPN's Q-Register
   Calling sequence
   STQ
   PY
   Operation - Store the octal number in MPPN's Q-Register beginning at location PY in memory. The 4 high order octal digits go into PY; the next 4 lower order octal digits into PY + 1 etc.

e) Addition
   Calling sequence
   ADD
   PY
   Operation - Add the octal number beginning at location PY to the MPPN's A-Register.

f) Subtraction
   Calling sequence
   SUB
   PY
   Operation - Subtract the octal number beginning at location PY from the MPPN's A-Register.
g) Multiplication
Calling sequence
MPY
PY
Description - This is a fractional multiply. Therefore the binary point is assumed to be immediately following the sign bit. Example; the fraction 1/2 would be 0.10 - 0 with N bits, the fraction - 1/4 would be 1.101 - 1 with N bits.

Operation - Multiply the octal number in memory location, PY, by the octal number in the MPPN's A-Register. The most significant N bits of the 2N bit signed product are in the MPPN's A-Register with the least significant N bits in the MPPN's Q-Register.

h) Division
Calling sequence
DIV
PY
Description - This is a fractional divide; see description under multiplication. Therefore an overflow condition, with an incorrect answer, will exist if the divisor is smaller, in absolute terms, than the dividend.

Operation - Divide the octal number in the MPPN's A-Register by the octal number, in memory, beginning at location PY. At the conclusion of the divide instruction, the appropriately signed quotient is in the MPPN's A-Register with the signed, same as dividend, remainder in the MPPN's Q-Register. Note that a halt is executed if division by zero is attempted.

i) A Left Shift
Calling sequence
ALS
PY
Description - This is a end around circular left shift of the MPPN's A-Register. In this case, the operand, PY, is a shift count in octal.

Operation - Shift the MPPN's A-Register left end around PY positions.

j) A Right Shift
Calling sequence
ARS
PY
Description - This is an end off right shift of the MPPN's A-Register. In this case, the operand, PY, is a shift count in octal. In this shift operation the sign bit is extended to the right.
IDENTIFICATION

Title: Paper Tape Verify - Ident. Fl.03
Programmer: R. Beale, January 1961

PURPOSE

The program is used to verify copies of an original paper tape.

USAGE

1. Operation procedure:
   a. Master Clear
   b. Machine load Paper Tape Verify program at zero
   c. Master Clear
   d. Insert original tape into reader
   e. Run
   f. On HLT 01, P = 0107; insert second tape into reader and run without altering console
   g. On HLT 02, P = 0130: the last tape is equivalent to original -- to verify another tape, place it in reader and run without altering console -- upon successful verification step g may be repeated.

3. Space Required: 1358

7. Error Stops: On ERR 01, P = 0132: the last tape is not equivalent to the original -- to continue verifying tapes, place new tape in reader and run without altering console. This will execute Step lg.

10. Timing: 350 frames/second

13. Equipment Configuration: Minimum System

METHOD OR ALGORITHM

A series of sequence-sensitive check sums is formed for each tape and tested for equivalence. There is no limit on the lengths of tapes to be verified.

FLOW CHART - Not applicable.
IDENTIFICATION

Title: Listable Octal Dump, Ident. F3.02

Programmer: Don T. Miller, July 1961

PURPOSE

To produce a listable octal dump of a specified area of core.

USAGE

1. Operational Procedure

   The program may be loaded anywhere greater than address 1. The P register
   should be set to the starting load address, the starting address of the
   area to be dumped put in the A register, and the Run switch put in RUN.
   The program will stop at the load address +128, and the final address of
   the dump should be placed in A. When put into run mode the program will
   punch the required area of core (in Flexowriter code), punch a stop code,
   restore any registers in low core that it uses, and stop at the load
   address +1058.

3. Space Used: 2518 = 16910 locations

9. Output Format: Each line will contain: carriage return, octal address,
   the octal contents of eight registers, four spaces, octal address, and
   the octal contents of eight registers. Duplicate lines will not be punched.

10. Timing: The program operates at punch speed.

12. Caution to user: The punched contents of cell 7777 will be the contents of
    cell 0.

13. Equipment Configuration: Minimum
IDENTIFICATION

Title: BI-OCTAL DUMP 2, Ident.F3.06
Programmer: H. C. Schnackel modified by C. M. Atchison, April 1961

PURPOSE

This program will sequentially dump in BI-OCTAL (machine-load format), the information stored in core memory beginning with the starting address, and ending at the terminating address minus one. The output tape can be loaded by use of the "Load" reader mode on the 160 computer.

USAGE

1. Operational Procedure
   a. Load BI-OCTAL Program Tape at 77328.
   b. Set P register at 77328.
   c. Set A register equal to first word location to be dumped.
   d. Run.
   e. Set A register to last word location to be dumped plus one.
   f. Punch on.
   g. Run.

2. Space Required
   a. Decimal -- 37 locations high core
   b. Octal -- 45 locations high core

3. Temporary Storage Requirements
   Uses and restores location 0.

12. Cautions to User
   a. The program is not relocatable.
   b. The program does not punch leader or trailer in the output tape.
II) Remove the cards from the read hopper and reproduce the damaged cards from the bottom of this stack. Replace the reproduced cards on the bottom of the stack and discard the damaged cards.

III) Push the START button until all cards in the machine have been fed out.

IV) Put the last card fed out in front of the reproduced cards from the read hopper.

V) Place the corrected card stack in the read hopper and push the start button twice to feed two cards.

VI) Put the read stacker switch in the OFF position (toggle it away from you). The NOT READY light will go out and the computer will continue reading cards.

2. Parameters
   a. Entrance parameter
      OWOU as follows:
      \[
      \begin{align*}
      W &= \text{tape control unit number (usually 1)} \\
      U &= \text{logical tape number}
      \end{align*}
      \]
   b. Exit parameters
      Upon normal return, none.
      Upon error return:
      I) for bad tape exit, A = 7775.
      II) for illegal BCD code, A = column number in which first bad code appears.

3. Space Requirements
   1154 locations in the relative bank.
   20 locations in the direct bank.
   254 locations in the indirect bank.

Locations in the indirect bank are assigned by EQU cards, \(1248 = 84_{10}\) locations for the symbol BLKA and \(1308 = 88_{10}\) locations for the symbol BLKB. This storage assignment must be non-overlapping and location (1) 0000 must not be included.
If it is desired to re-arrange the direct storage assignments, only the symbol LCARD may be assigned location (d) 0000. All other direct storage locations may be assigned at will.

6. Error Return

a. If the program is unable to write a record 9 times because of parity errors, the error return occurs with A = 7775. In this case, the card which has just passed the 2nd read station has been read but not processed. The card image for the card immediately preceding the above card is the card image which cannot be put on tape.

b. If an illegal punch combination occurs in a column, the error return occurs with A = first column in which a bad code appears. In this case, the card which has just passed the 2nd read station is in error. The card image for the card immediately preceding the above card is the last card image written on tape.

7. Program Stops

As a closed subroutine, the only program stop is at symbolic location RR17+1 after sensing an End-of-Tape reflective marker. The program rewind-unloads the tape prior to the stop. Mount the next tape and continue.

This stop is at location (r) 1247 when used as an independent program.

As an independent program, two additional stops are provided: at location (r) 0063 for the normal return and location (r) 0065 for the error return.

To continue running from any of the above stops, put the RUN-STEP switch into the STEP position, then into the RUN position.

8. Output Tape Mounting

The output tape is mounted on control unit W with logical selection U as in 2.a. above. The tape must not be file protected.

9. Input and Output Formats

a. Card Input Formats

The presence of both 7 and 9 punches in column 1 identifies a column binary card. All other cards are assumed to be BCD.

b. Tape Output Formats

1) for binary cards, a 168 10 character record, the first 160 10 characters representing the binary card in odd parity bit-for-bit and the next 8 10 characters as follows:
13. Equipment Configuration

   a. Basic 4k 160 with paper tape input and output.
IDENTIFICATION

Title: 160-A Card to Magnetic Tape Routine - Ident. F6.05
Programmer: Larry Brown, November 1961, Control Data Corporation

PURPOSE

This routine accepts standard 80 column BCD or column binary cards and writes their card images with "look-ahead" bits onto magnetic tape. Programmed for the IBM 533 Card Read Punch.

USAGE

1. Calling Sequence and Operational Procedures
   a. As a closed subroutine, entry is made with the following calling sequence:

   L   JPR
   L+1  CDTAP
   L+2  NORMAL
   L+3  RETURN
   L+4  ERROR
   L+5  RETURN
   L+6  OWOU

   b. As an independent program, load the bi-octal tape at location 0000 in either bank, and start at location (r) 0060 with OWOU in the A-register.

   c. 533 Card Read Operation

   Place the cards to be read in the read hopper to feed 9-edge first, face down. Push the START button twice to feed two cards and turn off the NOT READY light. At least two blank cards must follow the deck to be read.

   d. Card Feed Failure

   In case of a card feed failure, follow these procedures:

   1) Put the read stacker switch in the ON position (toggle it toward you).
00 05 00 01 00 05 00 04 if the next image on tape is a binary image in odd parity,

00 04 00 00 00 01 00 00 if the next image on tape is a BCD image in even parity.

II) for BCD cards, a 8810 character record, the first 8010 characters in standard BCD representing the BCD card in even parity and the next 810 characters as follows:

11 11 07 07 20 20 20 20 if the next image on tape is a binary image in odd parity,

20 20 20 20 20 20 20 20 if the next image on tape is a BCD image in even parity.

c. Control Card Formats

I) FILE* in columns 1-5 causes an End-of-File mark to be written on tape. The FILE* card image is not written on tape. The program continues with the next card image following the EOF mark.

II) ENDbb in columns 10-14 causes an End-of-File mark to be written on tape following the END card image. The program continues with the next card image following the EOF mark.

III) FINIS in columns 10-14 causes two End-of-File marks to be written on tape following the FINIS card image. The program rewind-unloads the tape and exits to the normal return. Use of the FINIS card is the only way to legitimately terminate the operation of this program.

10. Timing

Approximately 200 cards per minute read and put on tape. This program operates as fast as the 533 card read unit.

12. Cautions

Do not step through the routine or take the computer out of RUN, else the input-output transfers may not be completed correctly.

13. Equipment Configuration

Minimum 160-A with 163 and 1610 adaptor for the IBM 533 card read punch. The program assumes a 2-bank 160-A. The 163 tape unit is selected in both the character (6-bit) and assembly (12-bit) modes. The buffer channel is used to read cards. Cards are read from the second read station.
15. Miscellaneous
   a. Normal Return
      Follows reading a FINIS card.
   b. Interrupt
      Not used.
   c. Bank settings
      Upon normal and error exits, the direct, indirect, and buffer bank
      assignments are restored to their values at time of entry to the
      subroutine. The subroutine will work in either bank.
   d. Machine Registers
      The Buffer Entrance, Buffer Exit, and A-register are not restored.
   e. Legal BCD codes and card column punch codes as per standard set.
   f. Selective Stop and Selective Jump switches are not used.

METHOD

1. Tape write error procedures.
   Following detection of parity errors on writing the tape, a backspace
   and a new write operation is performed. If 3 tries at writing fail,
   the tape is backspaced, an EOF written, and a backspace is performed
   to skip over about 6 inches of tape and 3 more attempts are made to
   write the record before another EOF-backspace is tried. After 9 attempted
   write operations fail, the tape is backspaced and the error return is
   made with A = 7775.

2. Checking for illegal BCD codes is accomplished by the following equations
   operated on each 12-bit word of the card image read in. The * indicates
   a bitwise logical product and the + indicates a bitwise logical (exclusive)
   OR. The numbers 1, 2, 3.... represent the card row 1, 2, 3....etc. If
   the following equations are not satisfied, an illegal BCD code appears on
   the card.

   \[ 7*9=0 \]
   \[ (7+9)*6=0 \]
   \[ (6+7+9)*5=0 \]
   \[ (5+6+7+9)*2=0 \]
   \[ (2+5+6+7+9)*1=0 \]
(1+2+5+6+7+9)*8=0
3*4=0
(1+2+5+6+7+9)*(3+4)=0
(1+2+3+4+5+6+7+8+9)+8*(3+4) *0*11=0
(1+2+3+4+5+6+7+8+9)+8*(3+4) *0*12=0
11*12=0
References


AUTOCOM/General Information Manual, Control Data Corporation, Minneapolis, Minnesota.

INTERFOR/Reference Manual, Control Data Corporation, Minneapolis, Minnesota.

OSAS-A/The 160-A Assembly System, Control Data Corporation, Minneapolis, Minn.


## DISTRIBUTION LIST

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**Pif-E5 Aerospace**

R. E. Olsen  
T. R. Parkin
System Development Corporation,
Santa Monica, California
160-A REFERENCE MANUAL.
Scientific rept., TM(L)-993, by
E. J. Rosenberg. 8 February 1963,
281 p., 7 refs.
(Contract AF 19(628)-1648, Space
Systems Division Program, for Space
Systems Division, AFSC)

Unclassified report

DESCRIPTORS: Programming (Computers).

Describes and lists all 160-A computer
routines available in the Computer
Program Development Center (CPDC).
Serves as a training aid for new
CPDC personnel.