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June 5, 1959

7030 Operating Techniques Memo No. 5

SUBJECT: Specifications for a Debugging Console-Defining Routine

Introduction

Since the STRETCH console is an interpretive input-output device, a programmed console-defining routine is necessary to define any specific functions one wishes to perform through it. The object of this memo is to specify a console-defining routine, CONDEF-1, which will illustrate the possibilities and versatility of this type of console. CONDEF-1 is primarily oriented toward assisting the programmer in his debugging. It is intended to be used before any multiprogram supervisory programs are ready. However, any supervisory program should contain a console-defining routine.

Defined within the structure of CONDEF-1 is a primitive defining system CONDEF-0. This is meant to be an initial minimal working system. By appending to this initial system in a modular fashion, it can be enlarged to the complete CONDEF-1 routine. From CONDEF-1, one may easily extrapolate to a much more elaborate system. No attempt is made at this time to define a more elaborate defining routine, since it should not be a direct extension but rather a complete reworking. Also, the experience gained from the usage of CONDEF-0 and CONDEF-1 will influence any future defining routines. These defining routines must be evaluated first.

CONDEF-1

The present console-defining routine is restrained to use the center bank of switches and keys on either side of the typewriter and the leftmost digital potentiometer. Thus, 16 switches, 37 keys, and two digital potentiometers are at the disposal of the individual installation. The keys and switches assigned to CONDEF are subdivided into three categories according to their respective functions. The three functions which the switches and keys perform are address determination, format determination, and action determination.

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1. Address Determination

Inherent to all the rest of the CONDEF specification is the set of switches which designates the source and destination of the information. CONDEF contains three specific address source switches:

SOURCE TYPEWRITER
SOURCE NUMERICAL SWITCHES
SOURCE DIGITAL POTENTIOMETER

When either the SOURCE TYPEWRITER or the SOURCE NUMERICAL SWITCHES switch is on, the address information is taken from the typewriter or the numerical switches respectively. When the SOURCE DIGITAL POTENTIOMETER switch is on, the digital potentiometers will, in general, furnish an incremental value which is then properly added to an existing address. The exact manner in which one specifies the address information depends upon the format information or action desired. If more than one of the source switches is on at once, the error indication "Incompatible Combination" is typed on the typewriter. If none of the switches are on, the source of the address information comes from a location within CONDEF, labeled, the data entry address.

The data entry address is a running address. It is intended primarily as an address source for entering or displaying a list of data. After each reference to the data entry address, it is incremented by the field length then in effect. The data entry address is initially set to address zero. By means of the

SET DATA ENTRY ADDRESS

action key and the three address source switches, one may alter the data entry address arbitrarily. With this action key, the data entry address is set to the address specified by the source switches. If the SOURCE TYPEWRITER switch is on, this address is the next thing typed. The address may be terminated by either a typed colon, indicating the start of data to be entered, or the END key. If the SOURCE NUMERICAL SWITCHES switch is on, the data entry address is set to the bit address on the left numerical switches. If the left numerical switches are totally blank, the address is taken from the data description instruction which is also within CONDEF. The left address of this instruction is always used. In this case, should the EFFECTIVE ADDRESS switch be on, the effective address rather than the nominal address is inserted as the new data entry address. A further description of the data description instruction occurs in the format section. If the SOURCE DIGITAL POTENTIOMETER switch is on, the product of the current format field length and the digital potentiometer setting is added to

the data entry address. The digital potentiometer setting has the range -64 to +63. If no source switch is on, the instruction counter is taken as the data entry address. If more than one source switch is on, the error indication "Incompatible Combination" is typed on the typewriter. The current data entry address is normally displayed on the eight leftmost places of the numerical display.

Complementary to the source switches are the destination switches which normally specify the units to which information is sent from CONDEF. The five defined destination switches are

DESTINATION TYPEWRITER
PRINTER
TAPE
CARDS
DISK

The result of the action is sent to the designated units. If no destination switch is on, the information is placed on the typewriter. Certain of the action keys and switches imply a particular destination. In these cases, the destination switches are ignored.

The question of which particular unit of the same type is assigned to these destination switches is determined by the

ASSIGN I/O UNITS

key. This key will specify input-output units to be assigned to the destination switches, except for DESTINATION TYPEWRITER, which assumes the typewriter as the initiating console . The units used are those whose STRAP mnemonics are listed in any order on the typewriter. Each mnemonic is separated by a comma. If more than one unit of the same kind, e.g., two tape units, are typed, the error indication "Typing Error" will appear on the typewriter, except that both a reader and a punch may be assigned to CARDS. Any invalid symbols will produce the error indication "Typing Error" on the typewriter. Space on the disk is assigned by typing the disk mnemonic followed by a colon and the disk locations (arcs), thus DISK: 0319-0348. The block includes both limits. Presumably, some check must be made that this block is not otherwise assigned. If the output to any unit causes an out-of-material condition (end of tape and end of assigned disk block are included), the indication "Unit X Out of Material" will appear on the typewriter.

Each new assignment of input-output units wipes out any previous assignments. Any use of an unassigned destination switch will result in the error indication "Incompatible Combination" on the typewriter.

2. Format Determination

When one wishes to utilize the contents of an arbitrary location, one must know certain information concerning the format of the contents of that location. This information can be supplied to CONDEF from either of two locations, the right numerical switches or the data description instruction which is internal to CONDEF.

When using the right numerical switches, the format description used adheres closely to the data description form of STRAP-1, i.e., mode, length, byte size. The eight right numerical switches are subdivided as the following diagram illustrates:

$$\underline{X\,X\,X}_{\text{Mode}} \quad \underset{B_1 a_n k}{X} \quad \underline{X\,X}_{\text{Length}} \quad \underset{B_1 a_n k}{X} \quad \underline{X}_{\text{Byte Size}}$$

Depending upon the internal structure, the mode digits have the following coding:

Mode	On Numerical Switches	On Numerical Display
Instruction	1	1 _ _
Binary, signed	32	- 2 _
Binary, unsigned	2	2 _ _
Decimal, signed	310	- 1 0
Decimal, unsigned	10	1 0 _
Floating Point normalized	41	. 1 _
Floating Point unnormalized	40	. 0 _
Index Word	333	- - -

Thus for this function, 3 and 4 in the three leftmost right numerical switches are equivalent respectively to minus and period on the numerical display. The position of the characters within the three mode positions on the switches is not important. If the right numerical switches are all reset to blank, the format information is taken from the data description instruction. Any other combination of characters is invalid. For instruction, floating point or index word formats, anything but blank in the length and byte size digits is invalid.

The length digits may have any value between 0 and 64. 64 and 0 will both imply a length of 64. Any other value is invalid.

The byte size digit may have any value between 0 and 8. Zero and eight are equivalent to a byte size of eight. A nine is invalid. A blank here implies that the byte size information comes from the mode digits in the same manner as in STRAP-1.

If any character other than blank appears in the two columns set aside as separators, an error indication will occur. For any of the possible invalidities, the typewriter will type out the error indication, "Invalid Numerical Switches". The recommended procedure for entering a format would be to first clear the right numerical switches and then insert the proper format information.

Internal to CONDEF is the data description instruction. This instruction will, in general, be the last instruction entered by ENTER DATA DESCRIPTION INSTRUCTION key. Originally, this location will be cleared, that is, it will contain a BRANCH ENABLED instruction with an address of zero.

Now the format description may be made to depend upon the type of instruction in the data description instruction location. If the instruction in this location is an integer arithmetic or radix conversion instruction, the format is VFL and the mode, length, and byte size information are taken as defined in the instruction. For the input-output, data transmission, and STORE ZERO instructions, the mode is taken as binary unsigned; the length, 64; and the byte size, 8. For the connect instructions, the mode is taken as binary unsigned, and the length and byte size are as defined within the instruction. For the floating point instructions, the mode is taken as floating point normalized or unnormalized as defined by the instruction. With direct or immediate index and the refill instructions, the mode is taken as an index word. For the branch and execute instructions, the mode is taken as an instruction.

With the

ENTER DATA DESCRIPTION INSTRUCTION

action key and the source switches, one may arbitrarily alter the data description instruction. Activating this key will cause an instruction to be entered as the data description instruction from the source specified by the source switches.

When the SOURCE NUMERICAL SWITCHES switch is on, the instruction which becomes the data description instruction is constructed, using the address from the left numerical switches and the format from the right numerical switches. If the left switches are totally blank, the data entry address is used. Within the format setting, the mode digits produce their particular operation codes. Binary, binary unsigned, decimal or decimal unsigned mode settings result in a VFL ADD operation code. Floating point mode settings result in a floating point ADD operation code. The index word mode setting produces an ADD IMMEDIATE TO COUNT operation code. Finally, the instruction mode setting produces a BRANCH ENABLED operation code. When necessary, the length and byte size are used as they appear on the right numerical switches. The I and J index fields and the offset field, where applicable, are set to zero. If the numerical switches are totally blank, the instruction is taken from the memory location specified by the instruction counter. If the numerical switches are not set to an allowable format, the error indication "Invalid Numerical Switch Setting" is typed on the typewriter.

When the SOURCE TYPEWRITER switch is active, an instruction is taken from the typewriter and entered as the data description instruction. If the SIGNAL key is used to initiate console action, the data description instruction is cleared, that is, it becomes a BRANCH ENABLED instruction with an address of zero. If the ENTER key is used, the instruction which last appears on the typewriter when the END key is next depressed becomes the data description instruction. If the END key is used immediately after the ENTER key was activated, the instruction of some previous console activity on the typewriter becomes the data description instruction. This instruction is the last one which appeared on the typewriter either as output by the machine or as input by the operator.

The SOURCE DIGITAL POTENTIOMETER switch is ignored. If both SOURCE TYPEWRITER and SOURCE NUMERICAL SWITCHES switches are on, the error indication "Incompatible Combination" is typed on the typewriter. If none of the address source switches are on, the instruction is taken from the memory location specified by the data entry address. If, however, the data entry address is not a full or half word address, or the contents of the data entry address or the instruction counter produce invalid bit combinations in the positions checked to determine format, then the error indication "Invalid Instruction" is typed on the typewriter.

In general for output, the numerical portions of the formats are decimal. The floating point, index word, and variable field length formats are distinguished by different groupings as appropriate to them. For floating point, the format is

signed fraction, signed exponent, sign $(^{T}_{0})$ $(^{U}_{0})$ $(^{V}_{0})$;

for index words,

signed bit address, count field, refill field $(^{F}_{0})$ $(^{F}_{0})$ $(^{F}_{0})$;

and for variable field length,

signed integer, $(^{Z}_{0})$ $(^{Z}_{0})$ $(^{Z}_{0})$ $(^{Z}_{0})$ sign $(^{T}_{0})$ $(^{U}_{0})$ $(^{V}_{0})$.

The sign byte in the variable field length representation is truncated according to the sign byte information in the format. For the instruction format STRAP symbolic notation and format are used.

When requesting a floating point or index word format, address information which is not a full word address will produce the error "Incompatible Combination" on the typewriter. For the instruction format, address information which is not either a full or half word address will also produce the error indication "Incompatible Combination" on the typewriter. If an invalid operation code appears in the instruction format, the "Invalid Instruction" error indication is typed on the typewriter.

The three switches

EFFECTIVE ADDRESS
BINARY
OCTAL

can modify the general output format. If the EFFECTIVE ADDRESS switch is on, the addresses in the instruction format will be effective addresses. Normally, the effective address will be the nominal address modified by the value field of the proper index word. For progressive indexing, however, the effective address is the value field of the proper index word. If the addresses are unindexed, the switch will have no effect. When the address is an effective one, the index field of the instruction will contain the symbol E as a system symbol, instead of the dollar sign, $. For example,

(E 15) would appear instead of ($15).

If the OCTAL switch is on, the numerical portions of the format will appear in octal. If the BINARY switch is on, the entire contents of the designated location is given in binary, still retaining the characteristic groupings appropriate to the various formats. However, for instruction formats, the binary bits are grouped according to the actual machine instruction format and not STRAP instruction format. The grouping of the binary bits for the instruction is given in the appendix. If the BINARY and OCTAL switches are both on, the error indication "Invalid Combination" is typed on the typewriter.

3. Action Determination

The role of CONDEF's action keys and switches is to convey information to and from the computer directly and conveniently. These keys and switches can be subdivided into four categories, namely, input of information, output of information, setting of stop conditions, and setting of the operational mode.

Input of Information

There are three types of input information. These are address input to CONDEF, format input to CONDEF, and data input to the problem program. Several keys and switches are used to handle each type.

The action keys

SET DATA ENTRY ADDRESS
SET INSTRUCTION COUNTER
SET STOP BOUNDARIES

deal with the input of address information. The SET DATA ENTRY ADDRESS key was fully explained earlier in the section on address determination.

The SET INSTRUCTION COUNTER key is provided in order to change the problem program's instruction counter. When it is on, the bit address specified by the source switches replaces the contents of the instruction counter. If the SOURCE TYPEWRITER switch is on, the next quantity typed is taken as the address. Here the action may only be terminated by the END key. If the action is terminated by a colon, the error indication "Typing Error" is typed on the typewriter. If the SOURCE NUMERICAL SWITCHES switch is on, the bit address is obtained in the same fashion as it is in the set data entry address action. If the SOURCE DIGITAL POTENTIOMETER switch is on, the product of the current format field length and digital potentiometer setting is added to the contents of the instruction counter. If no source switch is on, the instruction counter is set to the current data entry address. The error

indication "Incompatible Combination" appears on the typewriter if more than one source switch is on at once. This error indication will also appear if the address being entered is less than 32 or is not a half or full word address. The current instruction counter is normally displayed on the eight rightmost places of the numerical display.

The SET STOP BOUNDARIES switch provides a means of recording in CONDEF the address stopping boundaries. These boundaries are taken from the source specified by the source switches. If the SOURCE NUMERICAL SWITCHES switch is on, the stop boundaries are taken from the numerical switches. Stopping will occur at the address specified on the left bank of numerical switches if the right bank is set to blank. Stopping will occur within the range of addresses indicated on the left and right banks of numerical switches if the left address is less than the right address. If the left address is greater than the right address, stopping will occur outside of the indicated range. In either case, the left address is included in the stopping range while the right address is not. If both addresses are equal, or the left address is completely blank, or either address is partially blank or is a meaningless address, then the error indication "Invalid Numerical Switch Setting" is typed on the typewriter. Any bit address is truncated down to the nearest half word for instruction fetch stopping.

If the SOURCE TYPEWRITER switch is on, the next material typed as input will be considered as the address boundary information. This may be either a single address or a pair of addresses separated by a comma. The relation which exists between the ordering of the addresses and the stopping range as described for the SOURCE NUMERICAL SWITCHES switch applies here too.

The SOURCE DIGITAL POTENTIOMETER switch is ignored. If no address source switch is on, the data entry address becomes the effective stopping address. If more than one source switch is on, the error indication "Incompatible Combination" occurs.

The three action keys

ENTER DATA DESCRIPTION INSTRUCTION
ENTER INDICATOR LIST
ASSIGN I/O UNITS

deal with the input of format details. The ENTER DATA DESCRIPTION INSTRUCTION key was described in the format section, and the ASSIGN I/O UNITS key was described in the address section.

The ENTER INDICATOR LIST key enables one to enter a list of indicators for which stopping is desired. This list of indicators must be typed on the typewriter in either a mnemonic or a numerical fashion, each separated by a comma. Only the indicators 22 (Lost Carry) through 47 (the last Program Indicator) are allowable. Any other indicators or meaningless mnemonics will produce the error indication "Typing Error". This action key does not alter the mask. A new list of indicators entered by further use of this key will completely supercede the list previously used.

Finally, for entering data, CONDEF has the four keys and one switch

ENTER FROM BINARY KEYS (Switch)
DELETE
CLEAR
ENTER
LOAD STRAP .

The ENTER FROM BINARY KEYS switch enables one to place into an address specified by the source switches in the usual manner, a full 64-bit word displayed on the binary keylights. The DELETE and CLEAR keys are similar to each other. With the DELETE key, information within an indicated range can be deleted and replaced by the NO OPERATION code. With the CLEAR key, an indicated range of memory can be replaced by a sequence of BRANCH ENABLED AND WAIT instructions, each branching back to itself. The address source switches behave in the same fashion as they do with the SET STOP BOUNDARIES key, except that they indicate the range to be cleared or deleted. The source addresses for these two action switches must be full or half word addresses, if they are not, the error indication "Incompatible Combination" is typed on the typewriter.

When the ENTER key is active, the data next entered from the typewriter is placed in the memory at the bit address specified by the source switches. If the SOURCE TYPEWRITER switch or the SET DATA ENTRY ADDRESS key is also active, the data starts only after the first colon has been typed. The length and format of the data as it is stored internally is determined by the right numerical switches, or, if they are entirely blank, by the data description instruction. The general typing format should agree with the given internal mode indication. For floating point, the typing format is

signed fraction, signed exponent, sign $\binom{T}{0}$ $\binom{U}{0}$ $\binom{V}{0}$;

for index words,

signed bit address, count field, refill field, $\binom{F}{0}$ $\binom{F}{0}$ $\binom{F}{0}$;

and for variable field length data,

signed integer, $\binom{Z}{0}$ $\binom{Z}{0}$ $\binom{Z}{0}$ $\binom{Z}{0}$ sign $\binom{T}{0}$ $\binom{U}{0}$ $\binom{V}{0}$

In entering an instruction, STRAP formats and symbolic notation are used.

A certain amount of flexibility is allowed to the format entered on the typewriter in that (1) spaces are ignored; (2) if a field is shorter than it is to be in the memory, it is right-justified in the memory; (3) if the field is longer than it is to be in memory, it is truncated on the left; (4) a right to left drop out of fields in the instruction format is used as in STRAP; (5) omitted fields are interpreted as zero except for the usual STRAP conventions in the data description field and the or-ing of sign bits from the numerical and sign byte fields.

If the memory bit address is not a full or half word address when entering an instruction or a full word address when entering floating point or index word data, the error indication "Incompatible Combination" will be typed on the typewriter. This error indication occurs when CONDEF tries to store the data. If an invalid operation code is typed, the "Typing Error" indication will occur.

In general, the numerical portions of the entered data is in decimal. However, if the OCTAL switch is on, the numerical portions should be typed in octal. The use of the decimal digits 8 or 9 will produce the "Typing Error" indication on the typewriter. If the BINARY switch is on, the data entered is to be typed entirely in binary still retaining the characteristic format grouping except for the instruction format. For instructions, the binary digits are typed according to the machine instruction format rather than the STRAP format.

The EFFECTIVE ADDRESS switch is ignored and an E in the I field of an instruction produces the error indication "Typing Error". Symbols other than $\$\_$ or $\$X\_$ in the I field of an instruction also produce the error indication "Typing Error". Both the BINARY and OCTAL keys on together produce the usual "Incompatible Combination" error indication. If the bit address is taken from the data entry address, the latter address is incremented by the field length after the entry action.

The LOAD STRAP key enables one to load into memory a block of binary STRAP output from an input-output unit, e.g., tape or disk. The "destination" switches determine from which input-output unit the loading is to occur. However, the DESTINATION TYPEWRITER and PRINTER switches are not compatible with this key and their use produces the "Incompatible Combination" error setting.

Output of Information

The second category into which the action keys and switches fall is that of the output of information. One of the output devices on the console is the numerical display, which is directly accessible through the three keys

DISPLAY FORMAT
DISPLAY DIGITAL POTENTIOMETERS
DISPLAY STOP BOUNDARIES.

Corresponding to each of these keys is a binary light which is on when its corresponding key is active. The DISPLAY FORMAT key results in the display of the format currently in use on the right half of the numerical display. This would then replace the display of the instruction counter, but the data entry address would remain displayed on the left half of the numerical display. The DISPLAY STOP BOUNDARIES key enables one to display on the left and right halves of the numerical display, the address stopping boundaries currently recorded in CONDEF. The DISPLAY DIGITAL POTENTIOMETERS key causes the settings of the three digital potentiometers to be displayed on the numerical display. The settings on the leftmost potentiometer are displayed as signed numbers ranging from -64 to +63. The settings on the center and right potentiometers are displayed as numbers ranging from 0 to 127. The left, center, and right potentiometers are displayed on the numerical display in positions 1-3, 7-9, and 13-15, respectively. As long as this key is down, the settings are reset each 1/4 second. Once the key is released, the SIGNAL or ENTER key must be pressed to restart the process again. If more than one of the keys DISPLAY FORMAT, DISPLAY STOP BOUNDARIES, or DISPLAY DIGITAL POTENTIOMETERS, is on, the error indication "Incompatible Combination" appears on the typewriter.

The action switch

DISPLAY ON BINARY KEY-LIGHTS

causes a 64-bit word beginning at the bit address specified by the source switches in the usual manner to be displayed on the binary key-lights. If, however, one of the keys is latched, the error indication "Incompatible Combination" will appear on the typewriter.

Since the typewriter produces the only permanent type of output at the console, it is desirable to record there the state of such transitory items as the time clock and the numerical display. The keys

TYPE TIME
TYPE NUMERICAL DISPLAY

are provided for these functions. The current reading of the time clock in hours, minutes, and seconds is typed on the console typewriter as

TIME XXXXX : XX : XX

when the TYPE TIME key is active. When the TYPE NUMERICAL DISPLAY key is on, the typewriter will type the legend NUM DISP followed by the contents of the numerical display character by character. If any of the lights DISPLAY FORMAT, DISPLAY STOP BOUNDARIES, or DISPLAY DIGITAL POTENTIOMETERS, are on, the corresponding legends FORMAT, STOP BDY. or DIG. POT. is typed following the contents of the display.

The keys

WRITE
WRITE ACCUMULATOR

furnish a general way for the output of information. The WRITE key causes both the bit address specified by the source switches and the contents of this bit address to be displayed on the units specified by the destination switches. The source switches specify the bit address in the same fashion as they do in conjunction with the SET INSTRUCTION COUNTER key. If the address is taken from the data entry address, it is incremented by the field length after the address is used for the output. The format variations are described in the format section.

With the WRITE ACCUMULATOR key, the accumulator may be displayed on the units specified by the destination switches. The format of the accumulator is determined by the right numerical switches or the data description instruction. If the format mode is floating point, the double precision quantity is written; if VFL, the entire accumulator left of the offset is written, omitting lead zeros. If the format source is the data description instruction, its offset is used. In all other cases an offset of zero is assumed. In any case following the sign byte, the offset used is typed as OFF XXX. The BINARY and OCTAL external switches provide the usual options of decimal, binary, or octal output. Instruction or index word formats are not valid, and cause the indication "Incompatible Combination" to be typed.

The

DUMP

key provides a means of getting an ordinary dump between limits. With the DUMP key data between the addresses indicated on the left and right,numerical switches may be placed in dump format on the units specified by the destination switches. The dump range extends from the location set in the left numerical

switches up to but not including the location set in the right numerical switches. Each address taken from these switches is truncated to a half word address. If the right bank of numerical switches is totally blank, only the single location designated by the left address is interpreted and dumped. If the right address is less than or equal to the left address, or if either address is partially blank or invalid, then the error indication "Invalid Numerical Switch Setting" is typed.

A dump will consist of a location and the representations of its contents as an instruction, a binary number, a floating point number and an index word. The standard physical form in which this appears depends upon the location to be dumped and its destination. This will be discussed in the appendix. If the destination is printer or typewriter, this dump format is printed directly. If the destination is tape or disk, this format is recorded in 6-bit 705 code so that it can be used in peripheral printer equipment to produce a correct listing. If the destination is cards, the format is punched (on two cards) such that it may be listed correctly.

If either the BINARY or OCTAL switch is on, the typewriter or printer are not valid destinations. The error indication "Incompatible Combination" is given if they are used. If the OCTAL switch is on with any other destination switch, the memory is dumped in straight binary in the STRAP loading format and is preceded by further STRAP loading information which records the contents of the problem program's internal registers and contain the necessary instructions to restart the problem program where it was terminated. If the BINARY switch is on, a similar dump is made except that now it is in the necessary format to be loaded and restarted by the INITIAL PROGRAM LOAD key, rather than by the STRAP loading program. The EFFECTIVE ADDRESS switch is ignored. If the BINARY and OCTAL switches are both on, the error indication "Incompatible Combination" will appear on the typewriter.

Stop Conditions

Stopping at arbitrary places within a problem program is a very desirable feature for debugging. Several action keys are provided to furnish several alternatives. The key

IF ADDRESS STOP

permits stopping when an attempt is made to fetch any part of an instruction from the area defined by the stop boundaries set in CONDEF. At the time of this type of stop, the instruction counter will contain the address of the instruction causing the stop. This instruction will not have been executed. It the program is restarted here, at least one instruction is executed before stopping.

When the stop is for this reason, the IF STOP light is illuminated. The keys

DF ADDRESS STOP
DS ADDRESS STOP

have the same action as the IF ADDRESS STOP key except that the stop occurs for data fetching and storing and the corresponding DF STOP light or DS STOP light is turned on. The error indication "Incomplete Combination" will occur if more than one of the keys IF ADDRESS STOP, DF ADDRESS STOP, or DS ADDRESS STOP is on.

The

BRANCH POINT STOP

key enables the program to stop before executing any successful branch. When the stop occurs, the instruction counter contains the address of the branch instruction. When the program is restarted, at least one instruction is executed before stopping.

The key

INDICATOR STOP

will enable the program to stop upon interruption by any of the indicators specified by the ENTER INDICATOR LIST key. When this type of stop occurs, the typewriter will type IND STOP (indicator) (location of causing instruction). The instruction counter retains the address of the next instruction to be executed upon restarting. This, in general, will be the first location of the fixup routine for this indicator.

Operational Mode

The operational mode is the final category for which action keys and switches are provided. The

START

key causes the problem program to start, beginning at the location currently in the instruction counter. The execution of the problem program may be stopped by depressing the SIGNAL or ENTER key on the console, or by one of the stop action switches. The

SINGLE STEP
MULTIPLE STEP

keys cause the same action as the START key, but result in only a limited amount of program execution. With the SINGLE STEP key, only a single

in the problem program is executed. With the MULTIPLE STEP key, the number of instructions executed is taken from the setting on the digital potentiometer. A negative or zero setting will produce the "Incompatible Combination" error indication. One of the stop action keys may cause a stop prior to executing the specified number of instructions. The

ASSEMBLE STRAP

key permits the reading and assembling of a deck of STRAP mnemonic cards from a card reader. The assembled binary output is placed on the input-output unit designated by the destination switches. The use of the PRINTER destination switch causes a normal listing of the assembled STRAP program. The TYPEWRITER destination switch is invalid and its use will result in the error indication "Incompatible Combination". Also, if more than one of the two keys, START, SINGLE STEP, MULTIPLE STEP, or ASSEMBLE STRAP are on, the error indication "Incompatible Combination" is typed.

The

RUN NOISY MODE

switch permits the problem program to be run in the Noisy Mode condition. It is independent of any other mode in which the program may be operated. A program-originated Noisy Mode takes precedence over the console-originated Noisy Mode condition.

The

TRACE

switch permits tracing of all instructions throughout an arbitrary range specified on the numerical switches. Tracing will occur within the range of addresses indicated on the left and right banks of numerical switches if the left address is less than the right address. The tracing will occur outside of the indicated range if the left address is greater than the right address. In either case, the address set in the left bank of numerical switches is included in the range, while the address in the right bank of switches is excluded. Both addresses are truncated to half word addresses. If either (1) the right address equals the left address, or (2) one of the addresses is totally or partially blank, or (3) one of the addresses is an invalid address, then the error indication "Invalid Numerical Switch Setting" is typed.

The trace is recorded on the units designated by the destination switches in the same fashion as in the DUMP case, except that the BINARY, OCTAL and EFFECTIVE ADDRESS switches are ignored. The TRACE format for each trace step consists of

1. the instruction counter,
2. the instruction,
3. the indicators set to one, and
4. the contents of the location(s) changed by the instruction.

The instruction counter is that of the problem program. The instruction is given in STRAP format with effective addresses. This is followed by a numerical list of those indicators which are set to one at the completion of the instruction. This list starts with indicator number 15, unless the instruction is an input-output one, in which case the list begins with indicator number 6. If the contents of any location changes as a result of the instruction, this change is recorded. The manner in which the contents is displayed depends upon the traced instruction as given in the following table:

Instruction Traced	Format of Changed Result
Floating Point (except for the compares)	The result will appear as a decimal floating point number in single precision for all To-Memory operations and double precision for the other operations.
Index Arithmetic (except for the compares), COUNT AND BRANCH; COUNT, BRANCH AND REFILL; REFILL; REFILL ON COUNT ZERO; TRANSMIT; and SWAP with direct counts.	The result will appearmas an index word.
Integer Arithmetic (except for the compares), and Radix Conversion.	The result will appear in octal if the mode is binary and in decimal if the mode is decimal. The sign byte is given if the operation is a signed one. The length of result is taken from the instruction for To-Memory operations. For other operations, the entire accumulator is given. If the VFL instruction has progressive indexing, the index word changed will also be presented.
Connectives.	For all connective operations, both the left zeros and all-ones counters are given in decimal. For CONNECT and CONNECT TO MEMORY, an additional octal quantity is given. For CONNECT, this is the entire accumulator. For CONNECT TO MEMORY, this data is specified by the field length of the instruction.

Instruction Traced	Format of Changed Result
Branches, Compares, TRANSMIT or SWAP with immediate count, CONTROL, LOCATE, STORE ZERO, and RELEASE	These instructions result in no output for this portion of the format.
READ or WRITE	The result given is the control word both before and after the execution of the I/O instruction.
EXECUTE, or EXECUTE INDIRECT AND COUNT	The result depends upon the nature of the instruction(s) executed.

The standard physical form of the trace output, which is dependent upon its destination is discussed in the appendix.

For an EXECUTE instruction in addition to the four types of information usually given, the instruction executed and its location are given. If a long chain of execute-type instructions occurs, it is traced in detail through only four levels. However, the entire operation is executed. The location changed is determined by the non-execute type instruction executed. The EXECUTE INDIRECT AND COUNT instruction behaves in the same way as EXECUTE except that the location of the pseudo-instruction counter is also exhibited at each level.

When an I/O instruction is encountered in the problem program, it is executed and the tracing program waits for its completion before printing.

If a problem program instruction causes an interruption, the indicator causing the interruption is followed by an asterisk in its listing. The entire fixup routine will be traced if it is in the tracing range. Interruptions caused by the indicators 0-19 are handled by the tracing program. Only the indicators 20-47 may cause interruptions to the problem program. The tracing program remembers whether the problem program is disabled or enabled, and handles all the interruptions accordingly. The actual state of the interruption mechanism can not be changed by the problem program during tracing.

The

CONTROL TRACE

switch initiates the same action as the TRACE switch except that tracing occurs only for each successful branch-type instruction.

CONDEF-0

CONDEF-0 is specified as a minimal but useful console-defining routine. It is defined within the framework of CONDEF-1 but with many actions and combinations inoperative. By adding to CONDEF-0 in a modular fashion, it should eventually expand into CONDEF-1.

Of the address switches available, only SOURCE NUMERICAL SWITCHES, TAPE and DESTINATION TYPEWRITER are in any sense operative. Except for decimal locations in a dump, all output is in binary. Hence the format interpreting portions are inoperative and the data description instruction is not available. Only the BINARY format switch is active. The data entry address is available. The SET DATA ENTRY ADDRESS action key is available to modify the address. However, the new address must come from the numerical switches. Hence the SOURCE NUMERICAL SWITCHES switch must be set on with this action key. Otherwise, the error indication "Incompatible Combination" is typed on the typewriter.

In general, upon stopping, the numerical display will contain in the left half, the data entry address; and in the right half, the instruction counter. The only action key which will produce anything else there is the DISPLAY STOP BOUNDARIES key.

For starting and stopping action, the following keys are available:

START
SINGLE STEP
IF ADDRESS STOP
DF ADDRESS STOP
DS ADDRESS STOP.

In conjunction with these keys are the SET INSTRUCTION COUNTER and SET STOP BOUNDARIES keys. The address information to be entered either is the data entry address or it is on the numerical switches. For the latter case, the SOURCE NUMERICAL SWITCHES switch must be on. The stop boundary addresses must be full word addresses, otherwise the error indication "Incompatible Combination" is typed on the typewriter.

The switches ENTER FROM BINARY KEYS and DISPLAY ON BINARY KEY-LIGHTS are available to enter or display a full word of general information. Also, the DELETE and CLEAR keys are active. With these switches and keys, only the SOURCE NUMERICAL SWITCHES switch is active. If it is on, the numerical switches supply the address information. Otherwise, the data entry address is used. To get a permanent record of the time clock and the numerical display, the TYPE TIME and TYPE NUMERICAL DISPLAY keys are enabled.

Finally, a modified form of dump is available through the DUMP key. With the DUMP key, either the DESTINATION TYPEWRITER or TAPE must be on. If neither is on, the "Invalid Combination" error indication is typed on the typewriter. The dump format is truncated to give a decimal location in half word increments and its contents in binary. However, when the TAPE destination swithc is on, the BINARY format switch is applicable. With it on, the information is dumped in straight binary with the necessary information to be reloaded by means of the INITIAL PROGRAM LOAD key.

In summary, the following are the switches and keys which make up CONDEF-0:

Address switches

SOURCE NUMERICAL SWITCHES
DESTINATION TYPEWRITER
TAPE

Format Switches

BINARY

Action switches

DISPLAY ON BINARY KEY LIGHTS
ENTER FROM BINARY KEYS

Action keys

START
SINGLE STEP
IF ADDRESS STOP
DF ADDRESS STOP
DS ADDRESS STOP
SET INSTRUCTION COUNTER
SET STOP BOUNDARIES
DELETE
CLEAR
TYPE NUMERICAL DISPLAY
TYPE TIME
DISPLAY STOP BOUNDARIES
DUMP

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APPENDIX

Summary Of Defined Keys and Switches

Switches (16)

Address

SOURCE TYPEWRITER
SOURCE NUMERICAL SWITCHES
SOURCE DIGITAL POTENTIOMETER
DESTINATION TYPEWRITER
PRINTER
TAPE
CARDS
DISK

Format

BINARY
OCTAL
EFFECTIVE ADDRESS

Action

DISPLAY ON BINARY KEY-LIGHTS
ENTER FROM BINARY KEYS
RUN NOISY MODE
TRACE
CONTROL TRACE

Keys (27)

Action

SET INSTRUCTION COUNTER
SET STOP BOUNDARIES
SET DATA ENTRY ADDRESS
ENTER DATA DESCRIPTION INSTRUCTION
ENTER MANUALLY
ENTER INDICATOR LIST

DELETE
CLEAR
ASSIGN I/O UNITS
LOAD STRAP
WRITE
WRITE ACCUMULATOR
TYPE NUMERICAL DISPLAY
TYPE TIME
DISPLAY FORMAT
DISPLAY STOP BOUNDARIES
DISPLAY DIGITAL POTENTIOMETERS
DUMP
SINGLE STEP
MULTIPLE STEP
START
ASSEMBLE STRAP
IF ADDRESS STOP
DF ADDRESS STOP
DS ADDRESS STOP
INDICATOR STOP
BRANCH POINT STOP

Order of Sensing

The order in which CONDEF obeys the activated action switches and keys is very important. CONDEF handles the general classifications, 1) address settings, 2) format settings, 3) data entry, 4) data display, 5) starting, and 6) stopping in this order. More specifically the order in which sensing and action on each of the switches and keys occurs is as follows:

1a. SET DATA ENTRY ADDRESS
b. SET LOCATION COUNTER
c. SET STOP BOUNDARIES

2a. ENTER DATA DESCRIPTION INSTRUCTION
b. ENTER INDICATOR LIST
c. ASSIGN I/O UNITS

3a. DELETE
b. CLEAR
c. ENTER FROM BINARY KEYS (switch)
d. ENTER MANUALLY
e. LOAD STRAP

4a. DISPLAY ON BINARY KEY-LIGHTS (switch)
b. DISPLAY DIGITAL POTENTIOMETERS
c. DISPLAY STOP BOUNDARIES
d. DISPLAY FORMATS
e. TYPE TIME
f. TYPE NUMERICAL DISPLAY
g. WRITE ACCUMULATOR
h. WRITE
i. DUMP

5a. SINGLE STEP
b. MULTIPLE STEP
c. START
d. ASSEMBLE STRAP

6a. IF ADDRESS STOP
b. DF ADDRESS STOP
c. DS ADDRESS STOP
d. INDICATOR STOP
e. BRANCH POINT STOP

Instruction Format With The BINARY Switch Active

When the BINARY switch is active, the instruction format does not appear in STRAP form. Rather the binary bits which appear are grouped according to the machine instruction format. The bits are grouped as follows:

for full word instructions,

Bits	0-17 ,	18-23 ,	24-27,	28-31,	32-50 ,	51-63 ;
	Word Address	Bit Address	Code 1000	Index Field		Operation, Modifiers & Index Fields

for half word instructions,

Bits	0-17 ,	18 ,	19-31
	Word Address	Bit Address	Operation, Modifiers, & Index Fields.

The Dump Format

Information is dumped every half word within the range indicated. The general order in which the material appears is as follows:

location, instruction, binary, and floating point or index word.

The location will be dumped as a decimal bit address. The contents of this location will then be interpreted as an instruction in STRAP symbolic format. If at this particular location no valid instruction occurs, the legend INV. OP. appears instead. If the instruction is a full word one, the contents of the next half word is not examined as the start of an instruction. If it is a half word instruction, the next half word is also examined to determine what type of instruction it might be. Thus, for every location except the first dumped, the instruction interpretation may contain either 1) a full word instruction, 2) a half word instruction, 3) the legend INV. OP., or 4) blanks. For the first location, the instruction interpretation can not result in blank. The I fields are presented as (# xx).

The binary representation of the contents of the half word is broken up into four blocks of eight bits each. The data next is represented in the floating point and index word formats on alternate lines. On the lines corresponding to the full word locations, the representation of the full word location as a floating point number follows its binary representation. On the lines corresponding to the half word locations, the representation of the previous full word location as an index word follows the binary representation. The floating point representation will appear as a signed decimal fraction followed by a signed decimal exponent. The three flag bits then follow the exponent. Here the characters T, U, V or zero will appear according to the individual flag bit settings.

The format as it is placed on the printer (or tape or disk) is as follows:

ITEM	CHARACTERS REQUIRED
Location	9
Space	1
Instruction	46
Space	1
Binary	35
Space	1
Floating Point or Index Word	26
	119

A further breakdown of the floating point and index word formats is -

Floating Point

ITEM	CHARACTERS REQUIRED
Sign	1
Decimal Point	1
Fraction	15
Space	1
Sign	1
Exponent	3
Space	1
Data Flags	3
	26

Index Word

ITEM	CHARACTERS REQUIRED
Sign	1
Value Field	9
Space	1
Index Flag	1
Space	1
Count Field	6
Space	1
Refill Field	6
	26

An example of an instruction which requires the maximum of 46 characters is -

CT 0110 (V+ICR) (BU, 40, 6), 123456.32 ($15), 120 ($14).

On the typewriter the format will require two lines. The information appears as follows:

ITEM	CHARACTERS REQUIRED
1st Line	
Location	9
Space	2
Instruction	43
	54
2nd Line	
Indention	4
Binary	35
Space	2
Floating Point or Index Word	26
	67

A single space occurs between the two lines and a double space occurs after the second line.

For output on cards, two cards per location are necessary. The information appears as follows:

ITEM	COLUMNS REQUIRED
1st Card	
Location	9
Card Column Count	1
Instruction	46
Blanks	22
Standard Blanks	2
	80
2nd Card	
Location	9
Card Column Count	1
Binary	32
Floating Point or Index Word	26
Blanks	10
Standard Blanks	2
	80

Trace Formats

The nature of the trace formats depends upon the destination of the information. In each case, the stated space requirements are the maximum. The trace format as it is placed on the printer (or disk or tape) is as follows:

ITEM	CHARACTERS REQUIRED
1st Line	
Location	9
Space	1
Instruction	46
Space	1
Indicators (max. of 20)	59
	116
2nd Line (omitted if unnecessary)	
Indention	4
Indicators (max. of 35)	104
	108
3rd Line (occurs only for EX or EXIC instructions but may be repeated through 4 levels of EX or EXIC instructions)	
Indention	2
Location of Instruction Executed or Pseudo-instruction Counter	8
Space	1
Instruction	46
	57
4th Line	
Indention	4
Results Changed	81
	85

The trace format for the typewriter is as follows:

ITEM	CHARACTERS REQUIRED
1st Line	
Location	9
Space	2
Instruction	46
	57

ITEM	CHARACTERS REQUIRED
2nd Line	
Indention	2
Indicators (max. of 23)	68
	70
3rd Line (omitted if unnecessary)	
Indention	2
Indicators	68
	70
4th Line (omitted if unnecessary)	
Indention	2
Indicators (9)	26
	28
5th Line (occurs only for EX or EXIC, but may be repeated through 4 levels)	
Indention	2
Location of Instruction Executed or Pseudo-instruction Counter	8
Space	1
Instruction	46
	57
6th Line	
Indention	2
Result Changed	53
	55
7th Line (necessary only for progressive indexing or I/O)	
Indention	2
Result Changed (Index or Control Word)	32
	34

The trace format on cards is as follows:

ITEM	COLUMNS REQUIRED
1st Card	
Location	8
Card ~~Column~~ Count	1
Instruction	46
Indicators (11)	22
Blanks	1
Standard Blanks	2
	80

ITEM	COLUMNS REQUIRED
2nd Card (omitted if unnecessary)	
Location	8
Card ~~Column~~ Count	1
Indicators (34)	68
Blank	1
Standard Blanks	2
	80
3rd Card (omitted if unnecessary)	
Location	8
Card ~~Column~~ Count	1
Indicators (10)	20
Blanks	49
Standard Blanks	2
	80
4th Card (occurs only for EX or EXIC but may be repeated through 4 levels)	
Location	8
Card ~~Column~~ Count	1
Location of Instruction Executed or Pseudo-instruction Counter	8
Instruction	46
Blanks	15
Standard Blanks	2
	80
5th Card	
Location	8
Card ~~Column~~ Count	1
Result Changed	53
Blanks	16
Standard Blanks	2
	80
6th Card (necessary only for progressive indexing or I/O)	
Location	8
Card ~~Column~~ Count	1
Result Changed (Index or Control Word)	28
Blanks	41
Standard Blansk	2
	80

Sample Length of the Result Changed Portion of the Trace Format.

Floating Point

ITEM	CHARACTERS REQUIRED	
	Single Precision -	Double Precision
Sign	1	1
Decimal Point	1	1
Fraction (decimal)	15	30
Space	1	1
Sign	1	1
Exponent (decimal)	3	3
Space	1	1
Data Flags	3	3
	26	41

Index Word

ITEM	CHARACTERS REQUIRED
Sign	1
Value Field (decimal)	9
Space	1
Flag	1
Space	1
Count Field (decimal)	6
Space	1
Refill Field (decimal)	6
	26

VFL Binary

ITEM	CHARACTERS REQUIRED			
	Signed	Signed with Progressive Indexing	Unsigned	Unsigned with Progressive Indexing
Octal	43	43	43	43
Space	1	1	-	-
Z one Bits	4	4	-	-
Sign	1	1	-	-
Flag Bits	3	3	-	-
Space	-	2	-	2
Index Word	-	26	-	26
	52	80	43	71

VFL Decimal

ITEM	CHARACTERS REQUIRED			
	Signed	Signed with Progressive Indexing	Unsigned	Unsigned with Progressive Indexing
Decimal	15	15	16	16
Space	1	1	-	-
Zone Bits	4	4	-	-
Sign	1	1	-	-
Flag Bits	3	3	-	-
Space	-	2	-	2
Index Word	-	26	-	26
	24	52	16	44

Connective

ITEM	CHARACTERS REQUIRED	
	Without Progressive Indexing	With Progressive Indexing
Octal	43	43
Space	1	1
Left Zeros Count	4	4
Space	1	1
All Ones Count	4	4
Space	-	3
Index Word	-	26
	53	81

Control Word

ITEM	CHARACTERS REQUIRED
Data Word Address (decimal)	6
Space	1
[illegible] Bits (binary)	7
Space	1
Flag Bits (binary)	3
Space	1
Count Field (decimal)	6
Space	1
Refill Field (decimal)	6
	32

Note: In the case of control words, the total number of characters required is 66, since the control word is given both before and after with two spaces separating them.

June 5, 1959

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