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*1

INTERNAL SPECIFICATIONS

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This paper describes the internal specifications of *1. It is intended that it be detailed enough so that it could be used by someone learning to maintain the system, but organized in such a way that someone who wants to know only enough to use some part of the meta-language can extract what he wants without too much trouble.

The language consists entirely of a set of macros. It is therefore coded completely in the 360 macro language*. A knowledge of this language may or may not be necessary, depending on one's use of these specifications. This paper consists of descriptions of the function of each macro and descriptions of the use of each global SET symbol.

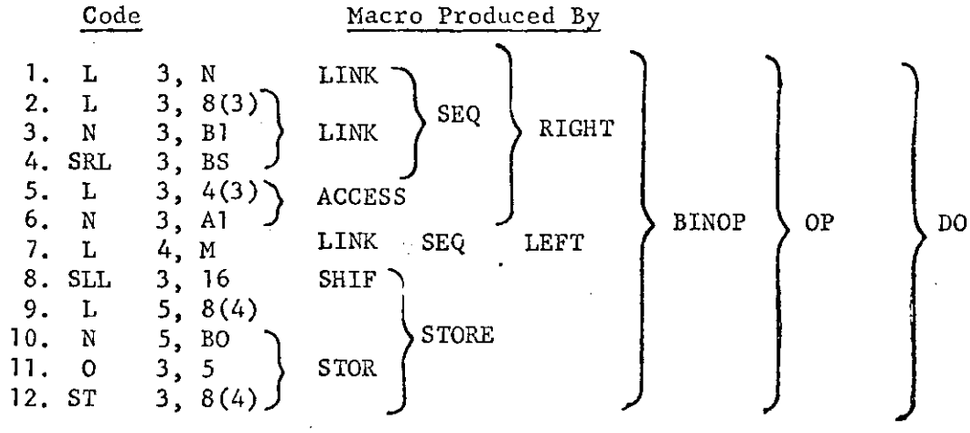
First we shall present one *1 statement and the code it produces as an example. Assume that the following definitions have been made:

```
BASFIELD    M
BASFIELD    N
FIELD       A, 1, (16, 31)
FIELD       B, 2, (0, 15)
```

Then this statement

```
DO    (MB, ←, NBA)
```

produces the following code:



Explanation: (1) loads the contents of base field N into register 3; (2) loads the word containing the B-field of the block pointed to by N; (3) extracts the

* IBM System /360 Basic Operating System Language Specifications, Assembler (16K Disc/Tape)

field contents; B1 is a mask which has 1's in the bit positions of field B and 0's elsewhere; (4) shifts it over so that it can be used as a pointer; BS is a constant which is the number of bits that the right end of field B is away from the right end of its word. These 3 have accomplished linking through that field. (5) and (6) access the A-field of the block presently pointed to, but do no shifting. This will come later if necessary. (7) loads base field M. (8) now realizes that the quantity NBA must be at the same position in its register as a B-field, so it shifts register 3 over to get it to that position. (9) loads the word containing the B-field of the block pointed to by M into a new register. Register 4 is needed for later use. Since we are storing into this B-field, we must first destroy its old contents. (10) does this since B0 is a mask with 0's in the bit positions of field B and 1's elsewhere. We can now OR in the quantity we want to store with (11) and store it back in memory from whence it came with (12).

MACRO DESCRIPTIONS

Each macro of the *1 system is described in the following format:

Macro	The name of the macro.
Called by	A simple list of the macros which call the macro.
Inputs	All the parameters of the macro will be listed with explanations of what they are. Some of the globals used in the macro which function explicitly as inputs will also be explained. The absence of a global from this part or from output doesn't indicate that it definitely could not be considered an input or output of the macro.
Macros called	A list of all macros called by the macro. Some will have explanations beside them. The absence of an explanation means that either the use of the macro can be understood from reading its description or it will be explained below under Action.
Outputs	A list similar to Inputs.
Code*	A look at the code produced and macros called by the macro in order and with parameters. Some explanation will be given here, but usually the code and the reason for it is explained under Action. The use of any globals shown here or in a listing of the macros may be found by consulting the list of global descriptions.
Action	This explains what the macro accomplishes and how.

Since each of the macros which is affected by the meta-language is affected in the same way, this explanation is made separately of these macros. It is under the heading META-LANGUAGE even though this is not a macro.

*May not appear in some descriptions.

Macro	ACCESS		
Called by	LINK, RIGHT		
Inputs	Globals		
		OLD	Register pointing to block of field to be accessed.
		NEW	Register to get field.
		C	The name of the field being accessed.
Macros called		SETUP	To set up F and G to represent to word of the field.
	Globals		
Outputs		NEW	The register into which the fiels has been accessed.
Action	Code:		
	L NEW, FG		
	N NEW, C1		

It accesses the field contents, but does not shift to the right side of their register

* Affected by Meta-language

Macro	ADDD	
Called by	BINOP	
Inputs	None	
Macros called	EASY	with parameter "A", to produce the code to do addition.
Outputs	None	
Action	Code:	
	EASY	A

Macro	ADDX	
Called by	BSTORE	
Inputs	Parameters	
	R0	A register to which RX may be added.
Macros called	None	
Outputs	None	
Action	If RX = 0, we do nothing. Otherwise we code	
	AR R0, RX	
	and we set RX to 0. This is because we are about to use an instruction which cannot name double indexing, so if we have an index register, we must add it to the one base register we are using, R0.	

Macro	AND
Called by	BINOP
Inputs	Globals
	RR,EX, F,G
Macros called	SHIF, STOR
Outputs	None
Action	Code:
	SHIF
	O RR, CO
	N RR, FG
	STOR (with NEW=RR, EX=FALSE)

First we place 1's all around the quantity and then we AND it directly into the word containing the field. Then we put it back in memory.

Macro	BASBLOCK	
Called by	Source Language	
Inputs	Parameters	
	B	The name of the block
	BOUNDS	The lower bound and size of the block.
Macros called	BLOCK	Block is called with the same parameters, except that BASE=1.
Outputs	None	
Action	Sets up compile-time information about the block.	

Macro	BASFIELD	
Called by	Source Language	
Inputs	Parameters	
	BUG	The name of the base field.
	LOC	Its location.
Macros called	None	
Outputs	BUGS	This is the column of the bug table which contains the bug names.
Globals	GBLA	
	B	Index to most recent storage location for base fields.
	TB	Index to bug table.
Action	BUG is set equal to LOC if it is passed or to the storage location (indexed by B) if it is not.	

Macro BINDEC

Called by BINOP

Inputs Parameters

F2	The field on the right which contains a binary number.
F1	The field on the left which will contain decimal digits.

Macros called RIGHT, TABLEF

ADDX	To check for adding RX to OLD since UNPK cannot use double indexing.
SETUP	To set up F for UNPK.

Code

```
RIGHT   F2
SRL     RR,POS
CVD     RR,DOUB
SEQ     F1
UNPK    INC(L, OLD), DOUB
```

(where INC has been set to access the first byte of F2 and L = length of F1 in bytes)

Action We calculate F2 right justified in RR. We convert it to decimal into DOUB. Then we calculate F1 and unpack DOUB into the field that it points to.

Macro	BINOP	
Called by	OP, TEST	
Inputs	Parameters	
	SEQ	The sequence on the left.
	OP	The operator.
	QUAN	The quantity on the right.
Macros called	BINDEC,DECBIN	If the operator is D ← B or B ← D it calls those immediately.
	DO	If the operation is push or pop, it calls DO with the appropriate arrangement of operands to perform the operation.
	RIGHT	Otherwise RIGHT is called with QUAN as a parameter. This calculates the quantity on the right.
	LEFT	Then LEFT is called to calculate the sequence on the left except for its last element.
	STORE,BSTORE,DIV,MULT,ADDD,ORR,AND,XOR,GT,LT, EQ,BEG	Then depending on the operator, the appropriate macro is called to execute the operation or test indicated.
Outputs	None	
Action	Codes the operation or test passed to it.	

Macro — BLINK

Called by — SEQ, RIGHT, LEFT

Inputs — Globals

C — The block through which we are linking.

Macros called — TABLEBK, RIGHT, RET

Outputs — See Action

Action

1. If C is a static base block we code

   LA NEW, C.

2. If C is a static block we increment INC by C's lower bound.
3. If C is a dynamic block, we push down a number of globals used in RIGHT, then we call RIGHT on the lower bound of C. This leaves the increment we want in RR. Then,
   a. If C is a base block we just set OLD to be RR so it will link through that next.
   b. If RX is zero, we set RX to RR so that RR will be used as an index register in the next access.
   c. If RX already has an index register, we code AR RX, RR.

Then we pop back all the quantities that we pushed.

Macro	BLOCK	
Called by	Source Language, BASBLOCK	
Inputs	Parameters	
	B	The name of the block.
	BOUNDS	The lower bounds and size of the block.
	Globals	
	BASE	= 1 if its a base block, = 0 otherwise.
Macros called	TESTSEQ	To test the lower bound to see whether it is dynamic.
Outputs	BLKS,LB,DLB,SIZ	Each of these is a column in the table of blocks. BLKS contains the block name, LB the lower bound if it is a static field and not a base field, DLB the lower-bound if it is dynamic, and SIZ the size.
Action	If it is a static base block, the block name is set equal to the lower bound.	

Macro — BRAKTEST

Called by — SEQ

Inputs — Parameters

STRING	A sequence which is being linked through.

Globals

I	The index of a character in the sequence.
C	That character.

Outputs — Globals

I	(The index of the next name in the sequence) - 1.
C	The name of the sequence which begins with the input C.

Action — If C is not "[", it does nothing. If it is, it stores into C all the characters between the "[" and the next "]" and sets I to be the index of the "]".

Macro	BSTORE
Called by	BINOP
Inputs	None
Macros called	TABLEBK, ADDX, GPAIR, SETG, CLEAR
Outputs	None
Code	If the right side is a quantity,

```
        ST    RR,INC.G
        CLEAR  (INC=INC+4, SIZE=size of left block-4)
```

If the right side is a Z word block,

```
        LM    OLD, OLD+1, INCR(RR)
        STM   OLD, OLD+1, INC(OLD)
        CLEAR (INC=INC+8, SIZE=size of left block-8)
```

Otherwise

```
        MVC   INC(L, OLD), INCR(RR)
        CLEAR (INC=INC+L, SIZE=size of left block-L)
```

where L = size of right block.

Action: We do the store in one of three ways; then we set up the inputs for CLEAR, which zeroes the rest of the left block.

Macro CALL

Called by UNOP

Inputs Parameters

DEST A quantity which supplies the address of the subroutine.

Macros called DO, RIGHT

Outputs None

Code

if DEST is a sequence	if DEST is a label
DO ([MS], +, 1)	DO ([MS], +, 1)
DO ([MS][FO],←0,*+N_1)	RIGHT DEST
B DEST	DO ([MS][FO],←0,*+N_2)
	BR RR

(where MS is the pointer to the mark stack for subroutines, FO is the 0th full word in its block, N_1 and N_2 are constants adjusted so that the address of the next command after the branch is stored in the mark stack)

Action: We push down the mark stack, put in it the return address and go to the beginning of the subroutine.

Macro	CHANGE
Called by	Source Language, PRIORITY
Inputs	Parameters
	MACROS — A list of macros to be substituted for when called.
	THINGS — A list of fields, blocks, etc. for which the above macros are altered.
	TAG — A string designating this particular call on CHANGE.
Macros called	ENTER, ENTERB To make entries in the change table for fields, and for base fields.
Outputs	For each combination of a macro and a field or block, TAG is entered in the spot in the change table corresponding to that field or block and macro. i.e. If LINK and Field A, where A is the 3rd field, then LINK(3) ← TAG. If ACCESS and base field B, where B is the 2nd base field, then ACCESSB(2) ← TAG. If "FIELDS" or "BFIELDS" occurs, all entries in that column are made.
Action	See Output

Macro CLEAR

Called by BSTORE

Inputs Globals

SIZE The size of the block to be cleared.

Macros called GREG

Outputs None

Code

```
SR    R,R
ST    R,INC.G
ST    R,[INC+4],G
 .     .
 .     .
```

Action: First we set R to zero and then store it into each word of the block with a succession of ST statements.

Macro COMP

Called by UNOP

Inputs SEQ The sequence defining the field to be complemented.

Macros called LEFT, GREB, STOR

Outputs None

Action: Code:

```
LEFT
L       R, FG
X       R, C1
STOR          (with NEW=R, EX=0)
```

We get the word containing the field into R and exclusive or with a mask containing 1's in the bit positions of the field.

Macro DECBIN

Called by BINOP

Inputs Parameters

F2 The field on the right which contains decimal digits.

F1 The field on the left which will get a binary number.

Macros called SEQ, TABLEF, GREG, STORE

SETUP To set up F for the PACK instruction.

ADDX To check for adding RX to OLD since PACK cannot use double indexing.

Code

```
SEQ    F2
PACE   DOUB,INC(L, OLD)
CVB    RR, DOUB
LEFT   F1    (pos = 0)
STORE
```

(where INC has been set up to access the first byte of F2 and L = length of right field in bytes)

Action: We calculate F2 and pack it in a double word DOUB. We then convert it to binary into register RR, and from there store it with the left field.

Macro DEF

Called by INPUT

Inputs Parameters

BLK The name of the I/O block.

Macros called DTFCD, DTFPR To define the files for the blocks.

OPEN To open the I/O area.

Output BLK is entered in IOBL, the label table for I/O labels. The index of this entry is then the integer which is added to LAB to produce the label of the DTF.

Code For input:

```
        B       ON
LAB     DTFCD   TYPEFLE = INPUT,
                RECFORM = FIXUNB,
                BLKSIZE = 80
                DEVICE = 1442
                DEVADDR = SYSRDR,
                EOFADDR = {EA / BLK(2) if specified
                IOAREA1 = BLK
ON      OPEN    LAB
```

For output:

```
LAB     DTFPR   RECFORM = FIXUNB,
                BLKSIZE = 120,
                DEVADDR = SYSLST,
                DEVICE = 1443,
                IOAREA1 = BLK
ON      OPEN    LAB
```

Action: The indicated I/O block is defined and opened.

Macro DIV

Called by BINOP

Inputs Parameters

OP =/ if quotient is wanted or = MOD if remainder.

Macros called SHIF, GREG, STOR

GPAIR To get a pair of registers for the division.

Outputs None

Code: Let R1 and R2 are a pair of contiguous registers, R1 is even, and R is a third register

```
                SHIF
                L     R2, FG
                SR    R1, R1
                LR    R, R1
                N     R2, C1
                DR    R1, RR
                           MOD
SLL     /          R2,CS          STOR   (OLD=R, NEW = R1)
STOR               (OLD = R, NEW = R2)
```

Action: We shift the quantity in RR to match the position of the left quantity. We load the word containing the left field into R2 and zero R1. We copy the word into R. Then we extract the field contents in R2, and divide the pair by RR. This leaves the quotient in R2 and the remainder in R1. The quotient will be right justified, however, so in that case we shift it left to match the field position and then store it. The remainder is already in the correct position, so in case of "MOD", we just store it.

Macro	DO	
Called by	Source Language, BINOP, CALL, RETURN	
Inputs	Parameters	
	P1,...,P8	Parenthesized operations of source language
Macros called	OP	Called once with each operation as a parameter.
Outputs	None	

Action: Codes each operation.

Macro	EASY	
Called by	ADDD, SUB, ORR, XOR	
Inputs	Parameters	
	OP	A letter indicating the operation to be performed (A,S,O,X)
Macros called	SHIF, STOR	
Outputs	None	
Code	SHIF	
	OP RR, FG	
	STOR (NEW=RR, EX=0)	

Action: The quantity on the right is shifted over so that it matches the right side of the left field. Then it is added (or subtracted, etc.) right into the word containing the field. The result is then stored back into memory.

Macro	ENTER	
Called by	CHANGE	
Inputs	Parameters	
	MACROS	A list of macros in whose columns, entries are to be made.
	TAG	A string which is the entry which is to be made.
	Globals	
	T1	The index of the entries which are to be made.
Macros called	None	
Outputs	The above entries are made for columns LINK, STOR, STORE, or ACCESS	

Macro ENTERB

Same as ENTER except that the column names all have B's after them.

Macro	EQ	
Called by	BINOP	
Inputs	Parameters	
	OP	The relation (=, =o, -=, -=o)
Macros called	REL	With parameter E for equality test.
	NOTANY	With parameter OP, to set up K and N for REL.
Outputs	None	

Action: Produces code to make the test.

Macro — FIELD

Called by — Source Language

Inputs — Parameters

FD	The name of the field.
N	The word of the block in which it resides.
BITS	The beginning and ending bits of the field.

Macros called — GREG,RRESS — To get and return registers used for computing the mask.

Outputs — FLDS, WORD, WID, SHIF, EXT

Each of these is a column in the table of fields. FLDS contains the field name, WORD the number of bytes to be incremented to access the correct word of the block, WID the width of the field in bits, SHIF the number of bits the field is from the right side of its word, EXT=1 if the field is not a full word so that extracting is necessary.

Code — Let R and R1 be two registers, LD and RD be the distance of the field from the left and right hand side of its word in bytes. ONES=X'FFFFFFFF'. The code:

```
L    R, ONES  }
LR   R1, R    }  This produces a mask with
SRL  R, LD    }  1's in the bits of the
SLL  R1, RD   }  field in R.
```

Macro FIELD - cont'd.

```
NR    R, R1
LR    R1, R          } This puts its
X     R1, ONES       } complement in R1
```

Action: This code computes the two marks.

They then are stored in the next two available storage locations for masks (indexed by M).

Let F be the field name. F1 = the ones mask, F0 = the zeroes mask.

Also FS = the entry in SHIF.

Macro	FINAL		
Called by	Source Language		
Inputs	None		
Macros Called	CLOSE	To close each of the I/O blocks.	
	EOJ	To end the run.	
Outputs	None		
Code	CLOSE	LAB	(For each I/O block)
	EA	EOJ	

Action: EA is the end-at-file address for I/O blocks for which the programmer does not specify one.

Macro	GOTO		
Called by	UNOP		
Inputs	Parameters		
	DEST	The quantity which specifies the address to go to.	
Macros called	RIGHT		
Outputs	None		
Code	If a quantity		If a sequence
	B	DEST	RIGHT DEST
			BR RR

Action: We compile a branch to the given destination. If it is a sequence we get it into RR and then branch to it.

Macro	GPAIR	
Called by	MULT, DIV, BSTORE	
Inputs	None	
Macros called	None	
Outputs	GBLA	
	R	Number of the first register of the pair.
Globals	REG	Register column.

Action: Finds the first pair of contiguous unused registers starting with an even register. They are both set to 1 to show that they are in use.

Macro	GREG	
Called by	Many things	
Inputs	None	
Macros called	None	
Outputs	Globals	
	R	Number of register found

Action: The first unused register (REG(R) = 0) is found and its entry is set to 1. showing that it is now in use.

Macro GT

Same as EQ except parameter is H for high.

Macro	IF	
Called by	Source Language, IFANY	
Inputs	Parameters	
	P1,...,P8	A number of tests followed by THEN followed by a number of operations.
	GBLB	
	ANY	=0 if called from source language =1 if called by IFANY
Macros called	TEST	Called with each test as parameter.
	OP	Called with each operation as parameter.
	RREGS	Called after each call of TEST or OP to mark. The registers they had used as unused.
Outputs	None	

Action: First it produces the code for the tests. These will produce branches to OUT on false if ANY = 1 and branches to IN on true if ANY = 0. Then it produces the code for the operations with the appropriate labels. For example, with 2 tests and 2 operations we get

	IF		IF ANY
	Test		Test
	Branch on False to OUT		Branch on true to IN
	Test		Test
	Branch on False to OUT		Branch on true to IN
	Operation		Branch to OUT
	Operation	IN	Operation
OUT	NOPR		Operation
		OUT	NOPR

Macro	IFANY	
Called by	Source Language	
Inputs	Parameters	
	P1,...,P8	A number of tests followd by THEN followed by a number of operations.
Macros called	IF	With same parameters as IFANY, except that ANY = 1.
Outputs	None	

Action: Produces code to execute the operation if any of the tests are true.

Macro	IN	
Called by	Source Language	
Inputs	Parameters	
	BLK	The name of the block into which a card is to be read.
Macros called	TABLEL	To look up the block name and set its DTF label.
	GET	To input the card.
Outputs	None	

Action: The next card is read into block BLK.

Macro	INITIAL
Called by	Source Language
Inputs	None
Macros called	BASFIELD, FIELD
Outputs	None

Code

```
BEGIN    BALR    2,0
         USING   *,2
         B       ON
ONES     DC      12C'  '
DOUB     DS      1D
ON
```

and others

Action: Initial declares certain storage areas, standard constants, and standard fields and/or base fields.

Macro	INPUT	
Called by	Source Language, OUTPUT	
Inputs	Parameters	
	P1,...,P8	Input blocks.
Macros called	DEF	With each of the parameters in turn.
Output	Globals	
	OUT	Is reset to False

Action: DEF compiles the DTF for each input block.

Macro	LEFT	
Called by	BINOP, SHIFT, COMP	
Inputs	Parameters	
	SEQ	The sequence to be linked through in preparation for an operation or test.
Macros called	GREG, TABLEF, INBLEB	
	SEQ	This links through all the names of the sequence except the last.
	SETUP	To set up the right characters in F and G so that the proper field can be accessed in macros which follow.
Outputs	GBLB	
	EX	=1 if the program should extract in working with the last field.
	F and G	Contain the first and second parts of the character string needed to access the last field. See Setup.
	BKL	=True if the last name in the sequence is a block.
	C	has the last name in the sequence.

Action: Links through the sequence and leaves the outputs described above.

Macro	LINK*	
Called by	SEQ	
Inputs	Parameters	None
	Globals	
	OLD	A register pointing to a block.
	NEW	A register which will point to a new block obtained by linking through the C field of the old block.
Macros called	ACCESS	
Outputs	Globals	
	OLD	The register which points to the new block and will now be OLD for the next link.
Code	ACCESS	
	SRL	NEW, CS

We get the word of the field into NEW, extract it, and shift it. Then we set OLD to NEW.

Macro LT

Same as EQ except parameter is L for LOW.

*Affected by Meta-Language

META-LANGUAGE

All macros which are affected by the meta-language are affected in the following way:

Let the macro be MAC. If MAC(T1) is not null, we call CHANGES with parameter MAC(T1). Otherwise the macro is processed normally. MACB is used if the macro is processing a base field instead of a field.

However, before this check is made, we check CH. If this is true, it means that we have already called CHANGES.from this macro and that CHANGES has called it back again. In this case we set CH to False and then process the macro normally. Thus, if the meta-language programmer wants CHANGES to call the same macro which called it, he must set CH to true first.

Macro	MULT
Called by	BINOP
Inputs	None
Macros called	SHIF, GREG, STOR
	GPAIR — To get a pair of registers for the multiplications
Outputs	None
Code	Let R1 and R2 are a contiguous pair of registers, R1 is even, and R is a third register.

```
        SHIF
        L       R2, FG
        LR      R, R2
        N       R2, C1
        MR      R1, RR
        SRDL    R1, CS
        STOR    (OLD=R, NEW=R2)
```

Action: We shift the quantity in RR to match the position of the left quantity. We load the word containing the left field into R2 and R. We extract the field contents in R2 and multiply the pair by RR. Because it is multiplication, the result will be shifted over to the left twice as far as it should be for the position of the field. So we shift it back to the right. The shift is double since it might extend over both registers. We then store it back into R and put that back in memory.

Macro	NOTANY	
Called by	TEST, EQ, GT, LT	
Inputs	Parameters	
	OP	An operator which may or may not start with ¬.
Macros called	None	
Outputs	Globals	
	LAB	=OUT if called from IF, = IN otherwise, the label is followed by an integer (IO) to make it unique from other statements.
	K	=2 if OP starts with "¬", =1 otherwise.

Action: Sets LAB and K.

Macro	OP	
Called by	DO, IF	
Inputs	Parameters	
	OPER	A parenthesized operation.
Macros called	RETURN	With no parameter in case the operation has only one member.
	UNOP	With the 2 members of the operation as parameters if the operation has 2 members.
	BINOP	As with UNOP if the operation has 3 members.
Outputs	None	

Action: Codes the operation.

Macro ORR

Same as ADDD, except that the parameter is 0.

Macro OUT

Same as IN except that PUT is called to print a line.

Macro	OUTPUT	
Called by	Source Language	
Inputs	P1,...,P8	Output Blocks.
Macros called	Input	With same parameters except that OUT is set True.

Action: The DTF's for the blocks are compiled.

Macro — PRIORITY

Called by — Source Language

Inputs — Parameters

BUG	The name of the bug which is to be made a priority bug.
SW	=OFF if the priority of the bug is to be turned off rather than on.

Macros called — CHANGE, GREG, TABLEB

SAVE	To save the register which will hold the bug from being returned by RREGS.
RET	To return this register when we are finished with it.

Outputs — The entry for the bug in the PRIO column of the bug table is set to the number of the register that the bug is loaded into.

Code

if SW ≠ OFF

```
L     R, BUG
CHANGE (ACCESS), (BUG), A
CHANGE (LINK), (BUG), L
CHANGE (STORE), (BUG), ST
```

if SW = OFF

```
ST    R, BUG
CHANGE (ACCESS, LINK, STORE), (BUG), OFF
```

Action: The changes which one setup here must then be carried out by calling the macro "PRIORS" from CHANGES.

Macro	PRIORS
Called by	CHANGES
Inputs	Parameters

TAG	The tag that was passed to CHANGES.
PRIO(TI)	The register which the prioritybug now resides in.

Macros called	RET
Outputs	See Action

Action: If TAG = A, we return the register R which was just gotten, and set NEW = PRIO(TI), because NEW is the output register for an access. If TAG = L, we just set OLD = PRIO(TI) because OLD is the output register for a link.

If TAG = ST, we code

```
LR   PRIO(TI), RR
```

This stores the quantity into the bug.

Macro	RREGS
Called by	DO, IF
Inputs	None
Macros called	None
Outputs	None

Action: Sets all entries to 0 which are 1 in the register column. It is marking these registers unused.

Macro	REL
Called by	EQ, GT, LT
Inputs	Parameters
	OP =E for equality, = H for >, =L for <
Macros called	ACCESS
Outputs	None
Code	ACCESS
	SHIF
	CR NEW, RR
	B(N)OP LAB

Action: Right has already left a quantity in RR. We access the contents of the field at the end of the left sequence. We shift the right one over to match it. We compare them. We branch depending on various things to the appropriate label(See NOTANY, IF).

Macro	RETURN
Called by	OP
Input	None
Macros called	DO
Outputs	None
Code	DO ([MS], -, 1)
	DO (GOTO, [MS][F1])
	(where MS is a pointer to the mark stack and F1 is the 1st (not 0th) full word in its block).

Action: We pop the mark stack, and then go to the address we just popped.

Macro	RIGHT	
Called by	BINOP, CALL, BINDEC, GOTO, SHIFT, TEST, SEQ	
Inputs	Parameters	
	QUAN	The quantity to be evaluated.
Macros called	GREG, TABLEF, TABLEB	
	SEQ	The link through the sequence if there is one, except for the last element.
	ACCESS	To access the last element of the sequence.
	TESTSEQ	To test whether QUAN is a sequence.
Outputs	Globals	
	RR	If the parameter is a quantity or field sequence, it is left in register RR. If a block sequence, RR points to the block which contains the last block; If a base block, RR = 0.
	POS	This is the number of bits from the right side of the register that this quantity lies.
	INCR	This is the current incrment to be used in displacements for accessing the block on the right. It is only used if we have a block sequence.
	RXR	The current index register to be used in accessing the block on the right if it is a block sequence.
	BKR	Contains the block name if QUAN is a block sequence.

Macro RIGHT - cont'd.

Code

For a three name field sequence

LINK

LINK

ACCESS

Action: If the quantity is an assembler expression, that is loaded in a register. If it is a base field, that is loaded in a register. If it is a sequence, it links through the sequence and then if it ends in a field the final value goes in a register. If it ends in a block, RR will contain a pointer to the containing block and BKR contains the ending block name. Otherwise BKR will be null.

Macro	SAVE
Called by	PRIORITY
Input	Parameters
	R11 The number of a register
Macros called	None
Outputs	None

Action: That entry corresponding to the register in the register column is set to 2, so that it will not be set to 0 by RREGS.

Macro	SEQ	
Called by	RIGHT, LEFT, DECBIN	
Inputs	Parameters	
	STRING	A string of names to be linked through.
Macros called	GREG, TABLEB, TABLEBK	
	BRAKTEST	It checks if the next name in the sequence is bracketed, and if so, puts the name in C.
	LINK	Links from the block pointed to by OLD through field C and points to the new block with register NEW.
	BLINK	To link through a block.
Outputs	Globals	
	ONLY	=TRUE if the sequence consisted of a base field only.
	C	The last name of the sequence.

Action: It links through all names in the sequence except the last. For each field or base field name it calls LINK, and for each block or base block name it calls BLINK.

Macro	SETG	
Called by	SETUP, BSTORE	
Inputs	None	
Macros called	None	
Outputs	Globals	
	G	Sets G as described in SETUP.

Action: Sets G and zeroes RX.

Macro	SETUP	
Called by	LEFT, ACCESS, BINDEC, DECBIN	
Inputs	None	
Macros called	SETG	To set G, see below.
Outputs	Globals	
	F,G	These hold characters which represent how to access the current field. F has the displacement, G has (R) or (R1, R2) where the R's are registers. So we can later write L R, FG and the like.

Action: Besides setting F and G, it zeroes INC and RX after using then to set up F and G.

Macro — SHIF

Called by — STORE, EASY, AND, MULT, DIV, BLINK

Inputs — Globals

POS	The position of the quantity on the right in RR.
ONLY	=TRUE if the quantity came from a base field.
SHIF(TI)	The position of the quantity on the left in its word.

Outputs — None

Action: — Code is produced to shift RR to the position of SHIF(TI)

Macro SHIFT

Called by UNOP

Inputs

Parameters

SIZE A quantity representing the amount of the shift.

SEQ A field sequence which is to be shifted.

Globals

DIR =R if the shift is right, = L otherwise.

Macros called RIGHT, LEFT, GREG, STOR

Outputs None

Code

```
RIGHT     SIZE
SRL       RR, POS
LEFT      SEQ
L         R1, FG
LR        R2, R1
N         R1, C1
S(DIR)L   R1, 0(RR)
STOR      (OLD = R2, NEW = R1)
```

Action: The size is calculated and put right justified in RR. Then the word containing the field to be shifted is put into R1 and R2. The field contents are extracted and shifted using R1 and then they are stored into the copy in R2 and put back in memory.

Macro STOR*

Called by EASY, MULT, DIV, AND, COMP, STORE, SHIFT

Inputs

Globals

OLD — A register containing the word which contains the field which is to be stored into. This may be undefined if EX = FASE.

NEW — A register containing the quantity to be stored.

Macros called None

Outputs None

Code

```
N     OLD, CO
OR    NEW, OLD
ST    NEW, FG
```

Action: We destroy the contents of the field in OLD. Then we OR in the quantity and store it back into memory. IF EX = FALSE only the store is done, so this is used often to do just the store.

Macro STORE*

Called by BINOP

Inputs Parameters None

Globals

F, G	The characters which access the word of the field to be stored into. (i.e. for a field which is in the 2nd word of its block, which is pointed to by register 3, F=2, G=(3)
RR	The register containing the quantity to be stored.
ONLY	=TRUE if we are storing into a basefield.

Macros called GREG, SHIF, STOR

Outputs None

Code If the right side is a quantity,

```
SHIF
L       R, FG
STOR            (OLD=R,  NEW=RR)
```

If the right side is a block,

```
LA      RR, INCR(RR,RX)  [RX may be absent]
STORE         (POS=0)
```

Action: In the first case we are just storing, so the quantity in RR is shifted to match the position of the field in F. Then we load R with the word containing the old copy of F, and we store. In the second case we are making the left field point to the right block, so we load RR with the address of the beginning of that block and recall store.

* Affected by meta-language

Macro SUB

Same as ADDD, except that the parameter is S.

Macro TABLEB

Same as TABLEF except it works on the bug table.

Macro TABLEBK

Same as TABLEF except it works on the block table.

Macro TABLEF

Called by Many things

Inputs Parameter

FD	The name of the field to be looked up.

Macros called None

Outputs Globals

FOUND	=1 if it finds the name in the table.
T1	= the index of the name in the table.

Action: Looks up the name in the table.

Macro TABLEL

Same as TABLEF except that it works on the label table for I/O.

Macro TEST

Called by IF

Inputs Parameter

OPER	A parenthesized test to be coded.

Macros called

BINOP	If the test is binary, then BINOP is called with the 3 parts of the test as its parameters.
NOTANY	Is called in the case of a test on just a sequence. This puts the correct label in LAB and sets K to 1 or 2 depending on whether there is a ¬ preceding the sequence.
RIGHT	Is called with the sequence as parameter.

Code After calling these macros, let R be a register, then

```
SR      R, R    }
CLR     RR, R   } only produced if no extracter was used to get the quantity in RR.
B(N)Z   LAB
```

(where N depends on ¬ and on whether called from IF or IFANY and LAB depends on latter)

Action: We set the contents of the field into RR, if necessary we compare it with zero, and then we branch according to conditions (see IF).

Macro	TESTSEQ	
Called by	BLOCK, RIGHT	
Inputs	Parameters	
	STRING	A string which may be a sequence.
Macros called	BRAKTEST, TABLEF, TABLEB, TABLEBK	
Outputs	Globals	
	FOUND	=TRUE if string is a sequence.

Action: If the first name in the string is a block or basefield, and every other name is a block or field, then FOUND ← TRUE else FOUND ← FALSE.

Macro	UNOP	
Called by	OP	
Inputs	OP	The unary operator
	THING	Its operand.
Macros called	COMP	With parameter THING if the operator is "¬" to perform the complement operation.
	GOTO	With parameter THING, if the operator is "GOTO".
	SHIFT	With parameters (1) The rest of OP, excluding the →→ or ←← (2) THING and with DIR=R for →→, L for ←←.
	CALL	With parameter THING if operator is "CALL".
Outputs	None	

Action: Perform the unary operation.

Macro XOR

Same as ADDD, except that the parameter is X.

GLOBAL DESCRIPTIONS

GBLA

I	See BRAKTEST.
INC	The displacement which is to be used in the next access of a field within a particular sequence.
IO	A counter used to get unique names for the IN and OUT labels used in IF and IFANY.
LB	See BLOCK.
M	The index of the address of the most recently stored mask.
NEW,OLD	See LINK, ACCESS, or STOR.
POS	See RIGHT.
R	The output register of GREG and GPAIR.
R1, R2	Registers.
REG	The column of registers. It contains a 0 in the entry with index of a register that is not in use. It has a 1 for registers temporarily in use, and a 2 for those permanently in use.
RR	See RIGHT.
RX	The register which is to be used as an index in the next access of a field within a particular sequence. If RX=0, there is no index register needed.
SHIF	See FIELD
SIZ	See BLOCK.
TB	The index of the most recently entered base field in the bug table.
TBK	The index of the most recently entered block in the block table.
TF	The index of the most recently entered field in the field table.
TI	The index of the most recently looked-up entry in the field, base field, or block tables.

TL	The index of the most recently entered lable in the lable table for I/O.
WID	See FIELD.
WORD	See FIELD.

GBLB

ANY	See IF.
BASE	See BASBLOCK.
BKL	= TRUE if the left sequence is a block sequence.
EX	See LEFT.
EXT	See FIELD.
FOUND	= TRUE if the thing looked for in TABLEF, TABLEB, TABLEBK, or TESTSEQ was found.
ONLY	= TRUE if the object we are processing is a base field or base block as opposed to a field or block.

BLKS	See BLOCK.
C	The current or most recently looked-at name which is from a sequence.
DLB	See BLOCK.
F, G	See SETUP.