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E10 - 10543

V.P.Shirikov, D.C.Marinescu

THE PARAMETER PASSING MECHANISM IMPLEMENTATION IN DIFFERENT FORTRAN COMPILERS

1977

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V.P.Shirikov, D.C.Marinescu*

THE PARAMETER PASSING MECHANISM IMPLEMENTATION IN DIFFERENT FORTRAN COMPILERS

* On leave of absence from the Institute for Atomic Physics, Bucharest, Romania

Ширяков В.П., Маринеску Д.К.

E10 - 10543

Применение и реализация механизма передачи параметров в различных трансляторах с языка ФОРТРАН

В работе содержится характеристика типов передачи параметров между различными программными модулями и способа реализации этих типов в различных вариантах трансляторов (в основном, трансляторов с языка ФОРТРАН). Изложение ведется применительно к используемым в настоящее время системам математического обеспечения ЭВМ серии ЕС, ЭВМ фирмы СДС и IBM , ЭВМ БЭСМ-6.

Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1977

Shirikov V.P., Marinescu D.C.

E10 - 10543

The Parameter Passing Mechanism Implementation in Different FORTRAN Compilers

This report contains some considerations, remarks and comparison for the types and methods of parameter transmissions between different programming modules and also for the methods of implementation for these transmissions in different compilers versions (first of all, FORTRAN compilers). The compilers under consideration are the compilers for the software systems which are used now with EC, CDC, IBM and BESM-6 computers.

The investigation has been performed at the Laboratory of Computing Techniques and Automation, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1977

It is very important for any programmer to recognize in which way the parameters are communicated from one module to another for every implementation of the programming languages available.

For most programming languages this talk is not so different since the designers of the compilers have no other choice but to implement that particular type of call as stated by people who have designed the language. For example:

- in ALGOL the default argument transmission mechanism is by name; it can be changed to transmission by value by specifying the parameter as such in the procedure header.

- In PL/1 the default argument transmission mechanism is by reference; it changes to transmission by value when the argument is enclosed in an extra set of paranthesis, in the CALL statement or in the function reference. Also transmission by value arises when the argument is a constant or involves operators.

- In COBOL the arguments are transmitted by reference.

As far as FORTRAN is concerned several approaches are used:

- the strategy announced in CDC manuals [1,2] is said to be the call by name with the call by value of expressions appearing as actual parameters; also the call by value is used by internal functions. This approach applies to both FTN and RUN compilers available on CYBER machines.
- the IBM approach[3] used in FORTRAN F , G , H compilers makes use of the call by value result, parameter passing mechanism, as default, with the user option to request the call by reference, by enclosing the dummy arguments between slashes.

The practical implications of such different points of view are: sometimes the same program compiled by different FORTRAN com-

pilers (and even at different optimization levels of the same compiler) gives different results when executed.

This might look queer for someone not aware of the fact that for FORTRAN the convention concerning the parameter passing mechanism is lax and somehow it is left to the compiler designer to decide about the parameter passing mechanism.

To illustrate this idea we present in table 1 the results obtained when the main program and the subroutine from example # 1 were translated by several compilers available around.

```
  X = 1.0                              SUBROUTINE SUB (A,B,C,D)
  Y = 2.0                              B = A + A
  Z = 7.0                              D = A + C
  CALL SUB (X,X,X+Y,Z)                 RETURN
  PRINT 1,X,Y,Z                        END
1 FORMAT(1H, 3F15.1)
  STOP
  END
```

EXAMPLE 1.

COMPILER	TYPE OF CALL, ACCORDING TO THE MANUALS	VALUES X	Y	Z	OBSERVATIONS
FTN OPT=0	Call by name	2	2	5	User request OPT=0
FTN OPT=1	Call by name	2	2	4	User request OPT=1
FFORTRAN	Call by value/ result	2	2	4	Used the default type of call.
FFORTRAN	Call by reference	2	2	5	The user requested call by reference.
RUN	Call by name	2	2	4	
BESM-6	Call by reference	2	2	5	

TABLE 1.

Let us briefly examine the four basic types of parameter communication mechanisms and some details of their practical implementation.

- A./ Call by reference

It is eventually the easiest to implement and practically consists of passing the addresses of the actual arguments to the called program. As far as our example 1 is concerned, the expression:

W = X + Y

is first evaluated and a stack consisting of the addresses of X,X,W and Z is constructed (see appendix 1.2 and figure #1)

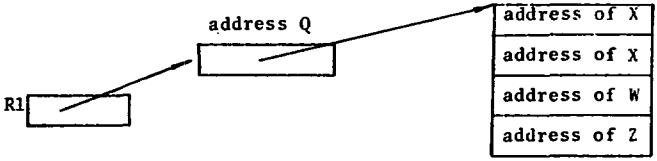

FIGURE #1. The call by reference implementation in FORTRAN F compiler.

The calling program loads in general purpose register R1 the address of a memory location Q where a pointer to the stack is to be found. It is the responsibility of the linkage editor to fill Q with the stack address.
When entered the subroutine copies the stack and throughout the computation operates with the locations in the main storage for X,X,W and Z, as defined by the calling program.

In this situation , side effects can occur; one of the most unpleasant ones occures when a constant is passed as an actual argument and the called module attempts to modify the dummy argument to which the constant is associated. In case of example #2 presented below, most FORTRAN compilers would lead to the result J=11.

```
      N = 8                          SUBROUTINE S (I,J,K)
      .....                          K = K + J
      M = 6                          I = I + 2
      J = 8                          RETURN
      CALL S (1,M,N)                 END
      J = J + 1
      PRINT 1,J
1     FORMAT (1H , I5)
      STOP
      END
```

EXAMPLE #2.

Sometimes to protect against unpleasant surprises, FORTRAN manuals [3] warn that "input parameters must not be changed inside the called module" (must not appear as the left-hand side of an assignation statement).

Another type of side effect is due to the fact that the call by reference is associated with the call by value of expressions appearing as actual parameters, as in the case of example #1; there, the expression is first evaluated using the old value for X. This type of side effect does not occur if the rule of not modifying the input parameters is observed and if every variable appearing in the expression is considered as an input parameter.

- B./ Call by value

Instead of passing the parameter addresses , in this case their values are communicated in a stack.

If the machine has enough registers the values of the parameters can be passed into the registers, thus saving time.

It should be noticed that there is no feedback from the called module to the calling one so that, though this strategy is most suitable for input parameter passing, it leaves no hope for output parameter communication. This is precisely the reason why this type of call has a limited use. As stated before the FTN compiler uses this type of call for internal functions since only input parameters are to be passed, their number is limited and anyway

the result is returned as a variable with the same name as the function name.

- C./ Call by value/result

As in the previous case the values of the actual parameters are passed but also a pointer to a stack of parameter addresses is communicated. As a result, the called module opperates with the values passed, but before returning to the calling module the values of actual arguments are updated.

If we examine appendix 1.2 we see that when the subroutine SUB is entered, the general purpose register R1 contains the address Q, where a pointer to the stack of addresses is inserted by the linkage editor; a copy of parameter values is made (the sequence of instructions starting at label A20). Then the computation suggested by statements 2 and 3 of the subroutine is performed (the sequence of instructions starting at label A52).

Before returning, R1 is loaded with the address of a memory location, where a pointer to the stack of parameter addresses is to be found (the sequence of two instructions starting at label A36), then all four parameters X,X,W,Z get their values updated (the four pairs of instructions, load and move constant).

It results that in addition to the side effects previously encountered, in connection with the call by reference, here occures an additional one; the computations performed by the called module are using the initial values of the input parameters.

- D./ Call by name

The call by name seems to be the most natural to communicate parameters since it is ment to implement the textural substitution and thus no side effects can possibly occur.

In case of our example #1, A is substituted by X, B by X, C by X+Y, D by Z and the executable statements of the subroutine are:

```
X = X+X ; /X = 1+1 = 2/
Z = X+(X+Y);/Z = 2+2+2 = 6/.
```

Obviously since the names of variables have a significance only within a module some sophisticated mechanism must be available so that when a reference is made to X in the called module, its address should be supplied. It means that at run-time, a routine must be entered every time a parameter is referred to, to supply

its address. This leads to considerable inefficiency and it is rather difficult to construct.

As far as the FTN compiler is concerned the type of call is by no means a call by name. Appendix 2.1 proves this statement when optimization level one is requested. Examining the COMPASS expansion we see that:

- registers X5,X4,X3,X2 are loaded with the addresses of X,X,W and Z using the pointer to the stack, provided in AØ.
- the initial value of X (value 1), is loaded into X1.
- the new value for X (value 2) is computed in X7 and the memory location reserved for X is updated.
- when Z is computed, the old value of X, existing in X1, is used so that the result 4=1+3 is obtained.

In appendix 2.2 we see that when optimization level zero is requested, the same procedure is followed, but for X it is used the value in memory address and not the one in register; so that the result 5=2+3 is obtained.

A summary of values to be expected for the program in example #1 for the four possible types of parameter passing mechanisms is presented in table 2.

TYPE OF CALL	VALUES/EXAMPLE 1		
	X	Y	Z
Call by reference	2.0	2.0	5.0
Call by value	1.0	2.0	7.0
Call by value/ result	2.0	2.0	4.0
Call by name	2.0	2.0	6.0

TABLE 2

CONCLUDING REMARKS

-1. The call by name is by far the best method of parameter passing since it gives no side effects; it is the most diffi-

cult to implement and eventually leads to inefficiency as far as execution time is concerned. It has not been encountered in any of the compilers under scrutinity.

-2. As far as the unprejudiced programmer is concerned he must not take for granted whatever manuals state, but he must try to understand what lies behind each type of call and he must be able to test the compiler he is using.

References

1. FORTRAN Extended Reference Manual. CDC publication #60329100.
2. FORTRAN Reference Manual. CDC publication #60174900.
3. FORTRAN Reference Manual. IBM publication.
4. G.J.Myers. IBM Systems Journal, vol. 15, #3, 1976.

Received by Publishing Department
on March 30, 1977.

APPENDIX 1. Tests made with the FORTRAN F compiler.

FORTRAN main program and its ASSEMBLER expansion.

The subroutine SUB in FORTRAN and its ASSEMBLER expansion

1. When call by value result is used (APPENDIX 1.1)
2. When call by reference is used (APPENDIX 1.2)

```
DOS FORTRAN IV 360N-FO-479 3.8          MAINPGM          DATE  2
0001              X=1.0
0002              Y=2.0
0003              Z=7.0
0004              CALL SUB(X,X,X+Y,Z)
0005              WRITE(3,1) X,Y,Z
0006           1  FORMAT(1H ,3F9.1)
0007              STOP
0008              END

DOS FORTRAN IV 360N-FO-479 3.8          MAINPGM          DATE  27

LOCATION    STA NUM      LABEL    OP        OPERAND
000000                            BALR      15,0
000002                            LM        2,3,34(15)
000006                            L         13,30(0,15)
00000A                            LA        15,2(0,15)
00000E                            ST        15,4(0,13)
000012                            BCR       15,2
000014                       A4   DC        00000000
000018                            DC        07D4C1C9
00001C                            DC        0507C7D4
000020                            DC        00000000
000024                            DC        00000000
000028                            DC        00000000
00010R                       A57  L         13,4(0,13)
00010C                            L         14,12(0,13)
000110                            LM        2,12,28(13)
000114                            MVI       12(13),255
000118                            BCR       15,14
00011A                       A36  L         15,112(0,13)
00011E                            LR        12,13
000120                            LR        13,4
000122                            BAL       14,64(0,15)
000126                            LR        13,12
000128              1             LE        0,204(0,13)
00012C                            STE       0,96(0,13)
000130              2             LE        0,208(0,13)
000134                            STE       0,100(0,13)
000138              3             LE        0,212(0,13)
00013C                            STE       0,104(0,13)
000140              4             LE        0,96(0,13)
000144                            AE        0,100(0,13)
000148                            STE       0,216(0,13)
00014C                            LA        1,116(0,13)
000150                            L         15,108(0,13)
000154                            BALR      14,15
000156                            BC        0,4(0,0)
00015A              5             L         15,112(0,13)
00015E                            BCR       0,0
000160                            BAL       14,4(0,15)
000164                            DC        00000003
000168                            DC        000000B0
00016C                            L         15,112(0,13)
000170                            BAL       14,8(0,15)
000174                            DC        04700060
000178                            BAL       14,8(0,15)
00017C                            DC        04700064
000180                            BAL       14,8(0,15)
000184                            DC        04700068
000188                            BAL       14,16(0,15)
00018C              7             L         15,112(0,13)
000190                            BAL       14,52(0,15)
000194                            DC        05404040
000198                            DC        4040
                                  END
 TOTAL MEMORY REQUIREMENTS 00019A BYTES
```

APPENDIX 1.1. The subroutine SUB in FORTRAN and its ASSEMBLER expansion produced by the FORTRAN F compiler, when standard (call by value/result) parameter passing is requested.

```
0001        SUBROUTINE SUB(A,B,C,D)
0002        B=A+A
0003        D=A+C
0004        RETURN
0005        END
```

```
DOS FORTRAN IV 360N-FC-479 3-8              SUB                    DATE

                               SCALAR MAP
SYMBOL      LOCATION      SYMBOL      LOCATION      SYMBOL      LOCATI
B               90        A               94        D               98

DOS FORTRAN IV 360N-FC-479 3 8              SUB                    DATE

LOCATION   STA NUM   LABEL   OP      *   OPERAND
 000000                      BC          15,12(0,15)
 000004                      DC          07E2E4C2
 000008                      DC          40404040
 00000C                      STM         14,12,12(13)
 000010                      LM          2,3,40(15)
 000014                      LR          4,13
 000016                      L           13,36(0,15)
 00001A                      ST          13,8(0,4)
 00001E                      STM         3,4,0(13)
 000022                      BCR         15,2
 000024                      DC          00000000
 000028                      DC          00000000
 00002C                      DC          00000000
 0000D8              A20     L           2,0(0,1)
 0000DC                      MVC         100(3,13),0(2)
 0000E2                      L           2,4(0,1)
 0000E6                      MVC         96(3,13),0(2)
 0000EC                      L           2,8(0,1)
 0000F0                      MVC         108(3,13),0(2)
 0000F6                      L           2,12(0,1)
 0000FA                      MVC         104(3,13),0(2)
 000100                      BALR        2,0
 000102                      L           3,6(0,2)
 000106                      BCR         15,3
 000108                      DC          00000000
 00010C              A36     L           1,4(0,13)
 000110                      L           1,24(0,1)
 000114                      L           2,0(0,1)
 000118                      MVC         0(3,2),100(13)
 00011E                      L           2,4(0,1)
 000122                      MVC         0(3,2),96(13)
 000128                      L           2,8(0,1)
 00012C                      MVC         0(3,2),108(13)
 000132                      L           2,12(0,1)
 000136                      MVC         0(3,2),104(13)
 00013C                      L           13,4(0,13)
 000140                      L           14,12(0,13)
 000144                      LM          2,12,28(13)
 000148                      MVI         12(13),255
 00014C                      BCR         15,14
 00014E       2      A52     LE          0,100(0,13)
 000152                      AE          0,100(0,13)
 000156                      STE         0,96(0,13)
 00015A       3              LE          0,100(0,13)
 00015E                      AE          0,108(0,13)
 000162                      STE         0,104(0,13)
 000166       4              SR          15,15
 000168                      L           1,0(0,13)
 00016C                      BCR         15,1
                             END
TOTAL MEMORY REQUIREMENTS 00016E BYTES
```

The results obtained in this case:

X = 2.0   Y = 2.0   Z = 4.0

Indeed a call by value results is used.

APPENDIX 1.2. The subroutine SUB and its ASSEMBLER expansion when call by reference is requested by the user.

```
0001                SUBROUTINE SUB(/A/,/B/,/C/,/D/)
0002                B=A+A
0003                D=A+C
0004                RETURN
0005                END

DOS FORTRAN IV 360N-FO-479 3.8          SUB                     DATE

                        SCALAR MAP
SYMBOL      LOCATION    SYMBOL      LOCATION    SYMBOL      LOCATIO
B             90        A             94        D             98

DOS FORTRAN IV 360N-FO-479 3.8          SUB                     DATE

LOCATION    STA NUM     LABEL     OP          OPERAND
000000                            BC          15,12(0,15)
000004                            DC          07E2E4C2
000008                            DC          4040C040
00000C                            STM         14,12,12(13)
000010                            LM          2,3,40(15)
000014                            LR          4,13
000016                            L           13,36(0,15)
00001A                            ST          13,8(0,4)
00001E                            STM         3,4,0(13)
000022                            BCR         15,2
000024                            DC          00000000
000028                            DC          00000000
00002C                            DC          00000000
000030                A20         L           2,0(0,1)
000034                            LA          2,0(2,0)
000038                            ST          2,100(0,13)
00003C                            L           2,4(0,1)
000040                            LA          2,0(2,0)
000044                            ST          2,96(0,13)
000048                            L           2,8(0,1)
00004C                            LA          2,0(2,0)
000050                            ST          2,108(0,13)
000054                            L           2,12(0,1)
000058                            LA          2,0(2,0)
00005C                            ST          2,104(0,13)
000060                            BALR        2,0
000062                            L           3,6(0,2)
000066                            BCR         15,3
000068                            DC          00000000
000070                A36         L           1,4(0,13)
000074                            L           1,24(0,1)
000078                            L           13,4(0,13)
00007C                            L           14,12(0,13)
000080                            LM          2,12,28(13)
000084                            MVI         12(13),255
000088                            BCR         15,14
00008A              2   A52       L           10,100(0,13)
00008E                            LE          0,0(0,10)
000092                            AE          0,0(0,10)
000096                            L           11,96(0,13)
00009A                            STE         0,0(0,11)
00009E              3             LE          0,0(0,10)
0000A2                            L           12,108(0,13)
0000A6                            AE          0,0(0,12)
0000AA                            L           10,104(0,13)
0000AE                            STE         0,0(0,10)
0000B2              4             SR          15,15
0000B4                            L           1,0(0,13)
0000B8                            BCR         15,1
0000BA                            END
 TOTAL MEMORY REQUIREMENTS 0000BE BYTES
```

The results obtained in this case:

X = 2.0 Y = 2.0 Z = 5.0

They indicate that it is really a call by reference.

APPENDIX 2. Tests with the FORTRAN Extended - FTN compiler.

Appendix 2.1. Main program and subroutine COMPASS expansion when OPT=1.

Appendix 2.2. The same but for the case OPT= 0

```
AM START        73/74    OPT=1                                          FTN 4.6+428

        PROGRAM START (INPUT,OUTPUT)
        X=1.0
        Y=2.0
        Z=7.0
        CALL SUB(X,X,X+Y,Z)
        PRINT 1,X,Y,Z
      1 FORMAT(1H ,3F15.1)
        STOP
        END
004144 DATA.                                              CON.  BSS 0B
004144 DATA.     17204000000000000000                       DATA 17204000000000000000B
004145 DATA.     17214000000000000000                       DATA 17214000000000000000B
004146 DATA.     17227000000000000000                       DATA 17227000000000000000B
004147 DATA.     00000000000000000000                       DATA 00000000000000000000B
                                                            EXT       STOP.
                                                            EXT       OUTCI.
                                                            EXT       SUB
                                                            EXT       Q8NTRY.
004150 DATA.                                              X         BSS 1B
004151 DATA.                                              Y         BSS 1B
004152 DATA.                                              Z         BSS 1B
                                                                      USE     CODE.
                                                          *                           LI
004113 CODE.     5150004144             DATA.                         SA5     CON.
                           5140004145   DATA.                         SA4     CON.+1B
004114 CODE.     5130004146             DATA.                         SA3     CON.+2B
                           5110004125   CODE.                         SA1     CAP1
004115 CODE.     10755                                                BX7     X5
                       30045                                          FX0     X4+X5
                           10644                                      BX6     X4
004116 CODE.     5170004150             DATA.                         SA7     X
                           24700                                      NX7     B0,X0
004117 CODE.     5160004151             DATA.                         SA6     Y
                           10633                                      BX6     X3
004120 CODE.     5170004132             CODE.                         SA7     ST.
                           5160004152   DATA.                         SA6     Z
004121 CODE.     0100000000             <EXT>                 +       RJT     SUB,5B
                           0005004111
004122 CODE.     5110004133             DATA.                         SA1     JIO1
004123 CODE.     0100000000             <EXT>                 +       RJT     OUTCI.,6B
                           0006004111
004124 CODE.     5120004147             DATA.                         SA1     CON.+3B
                           0400000000   <EXT>                         EQ      STOP.
004125 CODE.                                                CAP1      BSS     0B
004125 CODE.     00000000000000004150   DATA.                         APL     X
004126 CODE.     00000000050000004150   DATA.                         APL     X
004127 CODE.     00000000000000004132   CODE.                         APL     ST.
004130 CODE.     00000000000000004152   DATA.                         APL     Z
004131 CODE.     00000000000000000000                                 APL
004132 CODE.                                                ST.       BSS     1B
                                                            Z.        END     START
```

APPENDIX 2.1. The subroutine SUB in FORTRAN and its COMPASS expansion when the user requested optimization level one /OPT=1/ to the FTN.

```
JTINE SUB          73/74    OPT=1                       FTN 4.6+42

        SUBROUTINE SUB(A,B,C,D)
        B=A+A
        D=A+C
        RETURN
        END
```

COMPASS code as generated by the FTN compiler :

```
                                                          USE  DATA.
                                                          USE  START.
000000 START.    23250255555555000003                     TRACE    SUB,SUB,4B
000001 START.    00000000000000000000
000002 START.    51300010001020300000                     PENTRY   SUB,ENTRY.,0,0
000003 START.    04004000030100045000
000004 START.    74000540105160000001
                                                          FORPAR   A
                                                          FORPAR   B
                                                          FORPAR   C
                                                          FORPAR   D
                                                          USE  DATA..
                                                          USE  DATA.
                                                                   USE      CODE.
                                                      *
000005 CODE.     54500                                             SA5      A0
                      5640000002                                   SA4      A0+2B
000006 CODE.     5030000001                                        SA3      A0+1B
                           5620000003                              SA2      A0+3B
000007 CODE.     53150                                             SA1      X5
                      30711                                        FX7      X1+X1
                           53540                                   SA5      X4
                                53730                              SA7      X3
000010 CODE.     30651                                             FX0      X5+X1
                      24600                                        NX6      B0,X0
                           53620                                   SA6      X2
000011 CODE.     0400000002                START.                  EQ       EXIT.
                                                      Z.           END
```

The results obtained in this case (they indicate a call by value/result parameter passing mechanism):

X = 2.0   Y = 2.0   Z = 4.0

The FORTRAN Extended Reference manual[1] states that the call by name constitutes the standard parameter passing mechanism, associated with a call by value for expressions appearing as actual parameters. Differences between different optimization levels in this respect are not mentioned.

APPENDIX 2.2. **The subroutine SUB in FORTRAN and its COMPASS expansion when the user requested optimization level zero /OPT=0/.**

```
SUB          73/74    OPT=0 TRACE                          FTN 4.6+428

      SUBROUTINE SUB(A,B,C,D)
      C=A+A
      D=A+C
      RETURN
      END
```

COMPASS code as generated by the FTN compiler

```
                                                        USE DATA.
                                                        USE START.
000000 START.    23250255555555000004                   TRACE    SUB,SUB,4B
000001 START.    00000000000000000300
000002 START.    51300600015203000000                   PENTRY   SUB,ENTRY.,0,1
000003 START.    61027777536162300000
000004 START.    04004000346100046000
000005 START.    74600540105160000001
                                                        FORPAR   A
                                                        FORPAR   B
                                                        FORPAR   C
                                                        FORPAR   D
                                                        USE DATA..
                                                        USE DATA.
                                                                 USE     CODE.
                                                   *
000006 CODE.     6102000002                                      SB0     B2+2B
                              54500                              SA5     A0
                                    53450                        SA4     X5
000007 CODE.     30744                                           FX7     X5+X4
                        5030000001                               SA3     A0+1B
                                    53730                        SA7     X3
                                                   *
000010 CODE.     6102000003                                      SB0     B2+3B
                              54500                              SA5     A0
                                    53450                        SA4     X5
000011 CODE.     5030000002                                      SA3     A0+2B
                              5020000003                         SA2     A0+3B
000012 CODE.     53530                                           SA5     X3
                        30054                                    FX0     X5+X4
                              24700                              NX7     B0,X0
                                    53720                        SA7     X2
                                                   *
000013 CODE.     6102000004                                      SB0     B2+4B
                              0400000002 START.                  EQ      EXIT.
                                                   Z.            END
```

The results obtained in this case (they indicate a call by reference, parameter passing mechanism):

X = 2.0   Y = 2.0   Z = 5.0

```
      PROGRAM START (INPUT,OUTPUT)
      X=1.0
      Y=2.0
      Z=7.0
      CALL SUB(X,X,X+Y,Z)
      PRINT 1,X,Y,Z
    1 FORMAT(1H ,3F15.1)
      STOP
      END
004151 DATA.                                                       CON. BSS 0B
004151 DATA.      17204000000000000000                               DATA 17204000000000000003
004152 DATA.      17214000000000000000                               DATA 17214000000000000003
004153 DATA.      17227000000000000000                               DATA 17227000000000000003
004154 DATA.      00000000000000000000                               DATA 00000000000000000003
                                                                     EXT      STOP.
                                                                     EXT      OUTCI.
                                                                     EXT      SUB
                                                                     EXT      FTNRPV.
004155 DATA.                                                       X        BSS 1B
004156 DATA.                                                       Y        BSS 1B
004157 DATA.                                                       Z        BSS 1B
                                                                              USE      CODE.
                                                                   *
004114 CODE.      6102000002                                                  SB0      B2+2B
                            5150004151 DATA.                                  SA5      CON.
004115 CODE.      10755                                                       BX7      X5
                        5170004155       DATA.                                SA7      X
                                                                   *
004116 CODE.      6102000003                                       +          SB0      B2+3B
                            5150004152 DATA.                                  SA5      CON.+1B
004117 CODE.      10755                                                       BX7      X5
                        5170004156       DATA.                                SA7      Y
                                                                   *
004120 CODE.      6102000004                                       +          SB0      B2+4B
                            5150004153 DATA.                                  SA5      CON.+2B
004121 CODE.      10755                                                       BX7      X5
                        5170004157       DATA.                                SA7      Z
                                                                   *
004122 CODE.      6102000005                                       +          SB0      B2+5B
                            5150004155 DATA.                                  SA5      X
004123 CODE.      5140004156             DATA.                                SA4      Y
                            5110004132 CODE.                                  SA1      CAP1
004124 CODE.      30045                                                       FX0      X4+X5
                        24700                                                 NX7      B0,X0
                            5170004137 CODE.                                  SA7      ST.
004125 CODE.      0100000000             <EXT>                     +          RJT      SUB,5B
                            0005004111
                                                                   *
004126 CODE.      6102000006                                                  SB0      B2+6B
                            5110004100 DATA.                                  SA1      1I01
004127 CODE.      0100000000             <EXT>                     +          RJT      OUTCI.,6B
                            0006004111
                                                                   *
004130 CODE.      6102000010                                                  SB0      B2+10B
                            5110004154 DATA.                                  SA1      CON.+3B
004131 CODE.      0400000000             <EXT>                                EQ       STOP.
004132 CODE.                                                        CAP1      BSS      0B
004132 CODE.      00000000000000004155 DATA.                                  APL      X
004133 CODE.      00000000000000004155 DATA.                                  APL      X
004134 CODE.      00000000000000004137 CODE.                                  APL      ST.
004135 CODE.      00000000000000004157 DATA.                                  APL      Z
004136 CODE.      00000000000000000000                                        APL
004137 CODE.                                                        ST.       BSS      1B
                                                                    Z.        END      START
```

Издательский отдел Объединенного института ядерных исследований.
Заказ 23106. Тираж 475. Уч.-изд. листов 0,72.
Редактор Э.В.Ивашкевич. Подписано к печати 13.5.77 г.
Корректор Т.Е.Жильцова