RECOMP II USERS' PROGRAM NO. 1056

PROGRAM TITLE:	MULTIPLICATION OF MATRICES (RELOCATABLE)
PROGRAM CLASSIFICATION:	Subroutine
AUTHOR:	F. Keefe B. Metivier Melpar, Inc. Watertown, Massachusetts
PURPOSE:	To compute in floating point form the product matrix $C = AB$ To compute in floating point form the product matrix $C = A^tB$
DATE:	25 January 1961

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Program No. M-102
25 January 1961
Programmer: F. Keefe
B. Metivier

Program Title: Multiplication of Matrices (Relocatable)

1. PURPOSE

1.1 To compute in Floating point form the product matrix

$$C = AB$$

1.2 To compute in floating point form the product matrix

$$C = A^tB$$

2. RESTRICTIONS

2.1 Maximum matrix size approx. 17 x 17. May be changed by varying address constants (see 4.5)

2.2 Routine dependent on matrices being stored in memory prior to operation

Matrix A - stored row-wise 0200-on
Matrix B - stored row-wise 1400-on

2.3 No output - Product matrix is stored row-wise 4000-on

3. METHOD

3.1 AB = C

$$C_{ij} = \sum_{k=1}^{l} A_{ik} B_{kj}$$

$$C_{(mxn)} = A_{(mx1)} \cdot B_{(1xn)}$$

3.2 $A^tB=C$

$$C_{ij} = \sum_{k=1}^{m} A_{ki} B_{kj}$$

$$C_{(1xn)} = (A^t)_{(1xm)} \quad B_{(mxn)}$$

4. USAGE

4.1 m, n, 1 must be entered in numeric format in locations 0135, 0136, 0137 - binary 39

4.2 Options

4.2.1 The program is set for finding AB. If you want to change it to find A^tB, start at 0013.0, and it will automatically make the necessary changes.

4.2.2 To change the program to find C = AB once it has been set to find $C = A^tB$, start at 0033.0.

4.2.3 If you don't need to change the program, start at 0037.0.

4.2.4 The routine stops on an HTR 0037.0 in location 0113.0. This may be replaced by any other exit if desired.

4.3 Storage.

Relocatable
(0000 - 0017 - Routine to change program from C=AB to C=A^tB
(0020 - 0036 - Routine to change program from C=A^tB to C=AB
(0037 - 0121 - Program
(0130 - 0161 - Constants and modified addresses

Remaining storage free for matrices or other uses. (see 2.2, 2.3, 4.5).

Note: Relocation does not affect matrix addresses.

4.4 Timing examples (either option)

4.4.1 (16 x 10) (10 x 16) = (16 x 16) 20 minutes

4.4.2 (10 x 16) (16 x 10) = (10 x 10) 15 minutes

4.5 Routine may be modified to act on matrices in different locations by changing the following address constants:

01 54 - (Matrix A address) 1/2 + 00 0000,0 0 00 xxxx.0

01 55 - Matrix B address + 00 0000.0 0 00 xxxx.0

01 56 - (Matrix C address) 1/2 + 00 0000.0 0 00 xxxx.0

For example, if you want A.A = c, you would store:

01 54 + 00 00000 0 00 0100.0)
) Matrix A address = 0200.0
01 55 + 00 0000.0 0 00 0200.0)

01 56 + 00 0000.0 0 00 2000.0 Matrix C address = 4000.0

4.6 Both L and V loops are used by the routine.

4.7 To restart for new multiplication, reset new m, n, 1, check your address constants (if you changed them) and start as in no. 4.2.

```
0000.0 +66.0050.0  CTV
       +00.0132.0  CLA

0001.0 +11.0141.0  MPY
       +43.0000.0  XAR

0002.0 +03.0141.0  SUB
       +60.0161.0  STO

0003.0 +11.0137.0  MPY
       +43.0000.0  XAR

0004.0 +60.0145.0  STO
       +00.0133.0  CLA

0005.0 +11.0141.0  MPY
       +43.0000.0  XAR

0006.0 +03.0141.0  SUB
       +01.0145.0  ADD

0007.0 +01.0154.0  ADD
       +41.0025.0  ALS


0010.0 +03.0135.0  SUB
       +52.7762.1  TRP

0011.0 +60.0133.0  STO
       +03.0137.0  SUB

0012.0 +00.0000.0  ---
       -00.0000.0  ---

0013.0 +64.0000.0  CTL
       +65.0040.0  CFL

0014.0 +00.0010.0  CLA
       +60.0061.0  STO

0015.0 +00.0011.0  CLA
       +60.0101.0  STO

0016.0 +57.0037.0  TRA
       +00.0000.0  CLA

0017.0 +00.0000.0  ---
       -00.0000.0  ---


0020.0 +66.0050.0  CTV
       +00.0133.0  CLA

0021.0 +11.0141.0  MPY
       +43.0000.0  XAR

0022.0 +03.0141.0  SUB
       +11.0137.0  MPY

0023.0 +43.0000.0  XAR
       +60.0145.0  STO
```

```
0024.0 +00.0132.0  CLA
       +11.0141.0  MPY

0025.0 +43.0000.0  XAR
       +03.0141.0  SUB

0026.0 +60.0161.0  STO
       +01.0145.0  ADD

0027.0 +01.0154.0  ADD
       +41.0025.0  ALS


0030.0 +03.0137.0  SUB
       +52.7762.1  TRP

0031.0 +60.0133.0  STO
       +03.0135.0  SUB

0032.0 +00.0000.0  ---
       -00.0000.0  ---

0033.0 +64.0020.0  CTL
       +65.0040.0  CFL

0034.0 +00.0030.0  CLA
       +60.0061.0  STO

0035.0 +00.0031.0  CLA
       +57.0015.1  TRA

0036.0 +00.0000.0  ---
       -00.0000.0  ---

0037.0 +64.0040.0  CTL
       +57.7760.0  TRA


0040.0 +66.0050.0  CTV
       +00.0133.0  CLA

0041.0 +11.0141.0  MPY
       +43.0000.0  XAR

0042.0 +03.0141.0  SUB
       +11.0137.0  MPY

0043.0 +43.0000.0  XAR
       +60.0145.0  STO

0044.0 +00.0132.0  CLA
       +11.0141.0  MPY

0045.0 +43.0000.0  XAR
       +03.0141.0  SUB

0046.0 +60.0161.0  STO
       +01.0145.0  ADD

0047.0 +01.0154.0  ADD
       +41.0025.0  ALS
```

```
0050.0 +42.0146.0  STA
       +00.0134.0  CLA

0051.0 +11.0141.0  MPY
       +43.0000.0  XAR

0052.0 +03.0141.0  SUB
       +60.0151.0  STO

0053.0 +00.0161.0  CLA
       +11.0136.0  MPY

0054.0 +43.0000.0  XAR
       +01.0151.0  ADD

0055.0 +57.0120.0  TRA
       +42.0146.1  STA

0056.0 +57.0146.0  TRA
       +00.0132.0  CLA

0057.0 +64.0060.0  CTL
       +57.7760.0  TRA


0060.0 +01.0140.0  ADD
       +60.0132.0  STO

0061.0 +03.0137.0  SUB
       +52.7762.1  TRP

0062.0 +57.0037.0  TRA
       +50.0037.0  TRZ

0063.0 +00.0140.0  CLA
       +60.0132.0  STO

0064.0 +66.0070.0  CTV
       +00.0133.0  CLA

0065.0 +11.0141.0  MPY
       +43.0000.0  XAR

0066.0 +03.0141.0  SUB
       +11.0136.0  MPY

0067.0 +43.0000.0  XAR
       +60.0152.0  STO


0070.0 +00.0134.0  CLA
       +11.0141.0  MPY

0071.0 +43.0000.0  XAR
       +03.0141.0  SUB

0072.0 +01.0152.0  ADD
       +01.0156.0  ADD

0073.0 +41.0025.0  ALS
       +42.0153.0  STA
```

```
0074.0 +30.0142.0  FCA
       +57.0153.0  TRA

0075.0 +00.0140.0  CLA
       +60.0132.0  STO

0076.0 +30.0130.0  FCA
       +35.0142.0  FST

0077.0 +64.0100.0  CTL
       +57.7760.0  TRA


0100.0 +00.0133.0  CLA
       +01.0140.0  ADD

0101.0 +60.0133.0  STO
       +03.0135.0  SUB

0102.0 +52.7763.0  TRP
       +57.0037.0  TRA

0103.0 +50.0037.0  TRZ
       +00.0140.0  CLA

0104.0 +60.0133.0  STO
       +00.0134.0  CLA

0105.0 +01.0140.0  ADD
       +60.0134.0  STO

0106.0 +66.0110.0  CTV
       +03.0136.0  SUB

0107.0 +52.0110.0  TRP
       +57.0037.0  TRA


0110.0 +50.0037.0  TRZ
       +57.0111.0  TRA

0111.0 +30.0130.0  FCA
       +35.0142.0  FST

0112.0 +00.0140.0  CLA
       +60.0134.0  STO

0113.0 +77.0037.0  HTR
       +00.0000.0  CLA

0114.0 +00.0000.0  ---
       -00.0000.0  ---

0115.0 +00.0000.0  ---
       -00.0000.0  ---

0116.0 +00.0000.0  ---
       -00.0000.0  ---

0117.0 +00.0000.0  ---
       -00.0000.0  ---
```

```
0120.0 +11.0141.0  MPY
       +43.0000.0  XAR

0121.0 +01.0155.0  ADD
       +57.7775.1  TRA

0122.0 +00.0000.0  ---
       -00.0000.0  ---

0123.0 +00.0000.0  ---
       -00.0000.0  ---

0124.0 +00.0000.0  ---
       -00.0000.0  ---

0125.0 +00.0000.0  ---
       -00.0000.0  ---

0126.0 +00.0000.0  ---
       -00.0000.0  ---

0127.0 +00.0000.0  ---
       -00.0000.0  ---

0130.0 +00.0000.0  ---
       -00.0000.0  ---

0131.0 +00.0000.0  ---
       -00.0000.0  ---

0132.0 +00.0000.0  ---
       -00.0000.1  ---

0133.0 +00.0000.0  ---
       -00.0000.1  ---

0134.0 +00.0000.0  ---
       -00.0000.1  ---

0135.0 +00.0000.0  ---
       -00.0000.0  ---

0136.0 +00.0000.0  ---
       -00.0000.0  ---

0137.0 +00.0000.0  ---
       -00.0000.0  ---

0140.0 +00.0000.0  ---
       -00.0000.1  ---

0141.0 +00.0000.0  ---
       -00.0001.0  ---

0142.0 +00.0000.0  ---
       -00.0000.0  ---

0143.0 +00.0000.0  ---
       -00.0000.0  ---

0144.0 +00.0000.0  ---
       -00.0000.0  ---
```

```
0145.0 +00.0000.0  ---
       -00.0000.0  ---

0146.0 +30.0200.0  FCA
       +07.1400.0  FMP

0147.0 +04.0142.0  FAD
       +35.0142.0  FST

0150.0 +57.7776.1  TRA
       +00.0000.0  CLA

0151.0 +00.0000.0  ---
       -00.0000.0  ---

0152.0 +00.0000.0  ---
       -00.0000.0  ---

0153.0 +35.4000.0  FST
       +57.7775.0  TRA

0154.0 +00.0000.0  ---
       -00.0100.0  ---

0155.0 +00.0000.0  ---
       -00.1400.0  ---

0156.0 +00.0000.0  ---
       -00.2000.0  ---

0157.0 +00.0000.0  ---
       -00.0000.0  ---

0160.0 +00.0000.0  ---
       -00.0000.0  ---

0161.0 +00.0000.0  ---
       -00.0000.0  ---
```