Warning: Subroutine MC18 performs functions which are adequately treated by routines in other standard subroutine libraries (for example, LAPACK). The use of this routine is not recommended, and it may be removed from future releases of this library.

1 SUMMARY

The Householder algorithm for the conversion of a symmetric matrix **A** to tri-diagonal form **T** involves the pre- and post- multiplication of the original matrix by a series of orthogonal matrices $\mathbf{P}_i$

$$\mathbf{P}_n ... \mathbf{P}_3 \mathbf{P}_2 \mathbf{P}_1 A \mathbf{P}_1 \mathbf{P}_2 \mathbf{P}_3 ... \mathbf{P}_n = \mathbf{T} = \mathbf{Q}\mathbf{A}\mathbf{Q}^T.$$

Subroutine MC04B which performs this tri-diagonalization stores information which describes these $\mathbf{P}_i$ matrices in the upper triangle of **A** (the original full matrix) and produces two vectors (ALPHA and BETA) of the diagonal and off-diagonal elements. Given a vector x, the present subroutine accesses this information and optionally returns either $\mathbf{Q}x$ or $\mathbf{Q}^T x$. This is a necessary operation when a set of linear equations is to be solved via tri-diagonalization.

ATTRIBUTES — Version: 1.0.0. **Types:** MC18A, MC18AD. **Calls:** SDOT/DDOT. **Original date:** May 1975. **Calls:** None. **Remark:** pre-processing by subroutine MC04B is mandatory. **Origin:** W.R. Owen, University of Queensland, Australia.

2 HOW TO USE THE PACKAGE

2.1 The argument list and calling sequence

The single precision version

```
CALL MC18A(X,A,BETA,N,ITF)
```

The double precision version

```
CALL MC18AD(X,A,BETA,N,ITF)
```

X is a REAL (DOUBLE PRECISION in the D version) array of length N containing the vector to be transformed. If ITF = +1 then on return X will contain $\mathbf{Q}x$ and if ITF = –1 then on return X will contain $\mathbf{Q}^T x$.

A is a REAL (DOUBLE PRECISION in the D version) array of dimensions N containing the matrix which was originally tri-diagonalized by MC04B/BD. Only the upper triangle is accessed. The information stored there by MC04 must be unaltered.

BETA is a REAL (DOUBLE PRECISION in the D version) array of length N containing the vector of the off-diagonal elements of the tri-diagonal matrix produced by MC04.

N is an INTEGER giving the size of the matrix **A** and the length of the vector x.

ITF is an INTEGER acting as a switch to control processing –

if ITF = +1 then on return X will contain $\mathbf{Q}x$

if ITF = –1 then on return X will contain $\mathbf{Q}^T x$.

Other values are treated as errors, processing is abandoned and ITF set to zero. The user should check the value of this flag on return.

2.2 The COMMON area

The routine uses a common area (MC18B/BD) which the user may reference.

The single precision version

```
COMMON/MC18B/LUEM
```

The double precision version

```
COMMON/MC18BD/LUEM
```

LUEM is an INTEGER which may be set by the user to the logical unit number of the output device to which error messages are sent. By default it is set to 6. If set to zero, no messages will be generated.

3 GENERAL INFORMATION

Use of common: : Labelled COMMON (MC18B/BD) used.

Workspace: : None required.

Input/output: : Violation of the argument restriction for ITF results in an error message if LUEM in labelled common is not zero.

Restrictions: : Allowable values for ITF are restricted.

The original matrix must have been tri-diagonalized by MC04B/BD which computes and hence defines the matrices **Q** and $\mathbf{Q}^T$ used in the required transformation.

4 ERROR MESSAGES

Whenever the argument restriction on ITF is violated (that is, if ITF is set neither to +1 nor to –1) the message generated is:

```
ERROR IN MC18A – INPUT ARG INVALID, – ITF = n
```

where n is the value of ITF on entry.

5 METHOD

A description of the Householder algorithm including the generation and use of the $\mathbf{P}_i$ matrices as implemented in this subroutine can be found in Ralston and Wilf, *Mathematical Methods for Digital Computing, Vol. 1,* pp.96, 102-103, 105.