AN ANALYSIS OF STOCKING STRATEGY IN A MULTI-ECHELON ASSEMBLY SYSTEM BY COMPUTER MODELLING

VOLUME II

APPENDIX B

FULL PROGRAM DESCRIPTION

The structure of the simulation model is described in detail to provide a more complete definition than in the main text and permit later maintenance and modification if required.

Reference should be made to

Appendix C - File Descriptions

and

Appendix D - Data Dictionary

for certain definitions.

The programs are defined by a narrative summary, logic flowchart, the program source listing and sample output prints where applicable.

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B1 - MASTER PROGRAM STOCKMODEL

The master STOCKMODEL program performs five primary tasks;

a) definition of the probability density functions utilised by the model.
b) establishment of the parameters controlling each experiment, known as the run parameters.
c) selection of the seeds required by the pseudo random number generator.
d) establishment of the initial status of the model.
e) control of the simulation experiment.

1. Probability Density Functions

A total of twelve probability density functions are used by the model, being either frequency histograms defined by parameter and relative frequency, or normal distributions defined by the mean and co-efficient of variance. Histogram definitions are contained within the DATA statement, and normal distribution parameters are specified as an arithmetic expression.

No probability density function may change its characteristics during the execution of a simulation experiment, and the parameters may only be changed by altering the source program.

2. Run Parameters

The parameters controlling each experiment are presented to the program as external data at the start of each simulation experiment. The parameters may be classified as either simple or complex, according to their impact on the model logic.

Complex parameters I have defined as those substantially altering the processing logic. For example, the mode of manufacture may be specified as make to order only, make to stock only, or mixed production. The priority rules for selection of orders from each queue may be specified as first-in-first-out or due date priority.

Simple parameters are those which affect an element in an arithmetic expression but do not directly influence the processing logic. Examples include the buffer stock parameters, order book planning rules, schedule response period, capacity utilisation and order mix trends.

3. Random Number Seeds

The seeds required to initiate the pseudo random number streams are presented to the program as external data. The performance of each sampling activity is controlled by providing a separate seed for each activity and maintaining the identity of each seed throughout the simulation experiment.

The pseudo random number generator has been designed to accommodate negative seeds where antithetic sequences are required and, in some instances, will cause a switch from stochastic to deterministic mode on presentation of a zero seed.

4. Initial Conditions

Two types of initial conditions are required by the program. Certain parameters which control the internal operation of the model are internally initialised; examples include the timing mechanisms and performance indices. Externally specified initial conditions describe the status of the system files at the commencement of each experiment. Specification of the initial conditions fulfils two purposes. Firstly, to enable certain logical processes which are dependent upon previous periods, and secondly to reduce the time to achieve steady state conditions.

Wherever possible, the various system files are created from a common source of input data to ensure integrity of dispersed data. Initial conditions are classified as orders related, or parts related. Ordersrelated files are all derived from the Orders Placed File (OPFILE) and include the queues (ALLQ, LINEQ, TESTQ), assembly and test work-in-progress (IFILE), order book (ORDBK) and total order load (TOTAL). The orders received history (ORDHIST) is created by simulating a twelve month order input pattern, using the order generation logic contained in subroutine ORDERS. This ensures consistency with the subsequent simulation experiment.

Parts related conditions include the line running rates (R) and the previous material plan (ONP) for products, the previous sub-assembly programme (SUBFILE) and sub-assembly queue (SUBQ) for sub-assemblies, and the supplier schedule (SCHEDULE) and material input file (INPUT) for components.

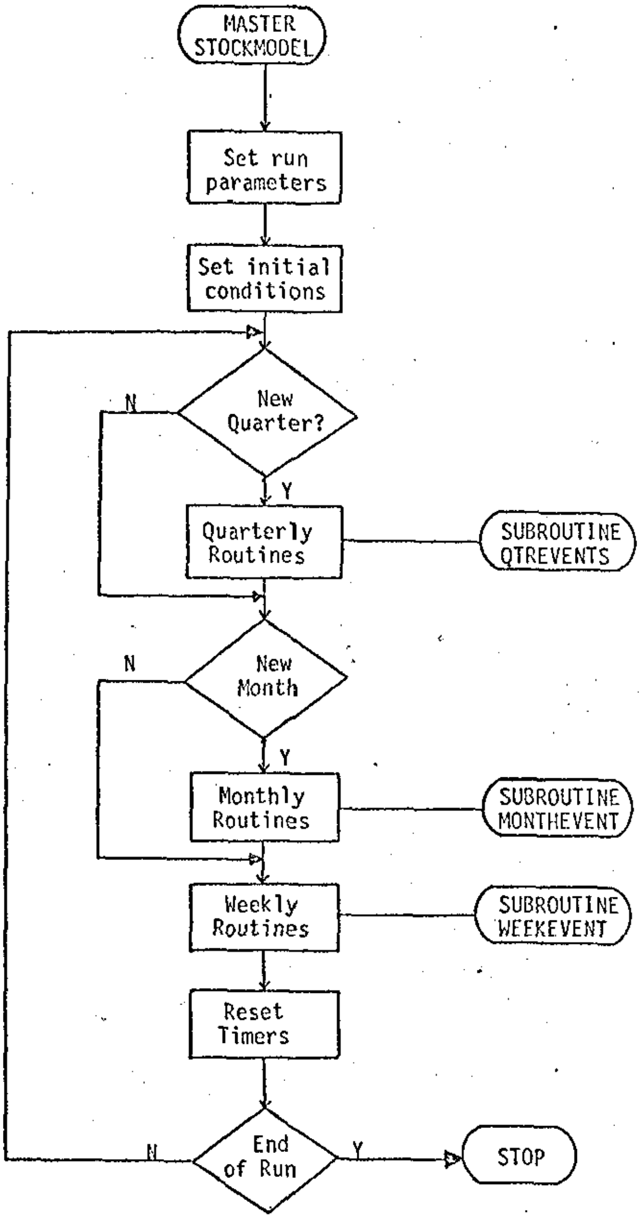
Products and sub-assemblies in allocation cause the reservation of components in IFILE. The initial stock status is contained within the item master file, which also defines a number of static parameters and relationships defining each product or component.

5. Experimental Control

The master STOCKMODEL program provides executive control over each simulation experiment. The simulation environment is first established by reference to the run parameters, initial conditions and sampling profiles, following which the start conditions may, optionally, be displayed.

The execution of the simulation experiment is by cycling through the three primary execution segments; QTREVENTS, MONTHEVENTS and WEEKEVENTS. The quarterly and monthly activities are by-passed if the appropriate control timers are not zero. The control timers (TQTR, TMONTH) are reset by their dependent segments.

Following each cycle, the control timers are decremented, as is the timing field in each of the product queues. The week counter is incremented and the elapsed simulation time compared with the pre-defined run time. Completion of the simulation experiment causes an "end of run" message to be displayed and the run to be terminated.



Summarised Flow Chart- Master Program Stockmodel

```
      PROGRAM(STKM)
      COMPRESS INTEGER AND LOGICAL
      INPUT 1=CR0
      OUTPUT 2=LP0
      END
      MASTER STOCKMODEL
      REAL AFILE(25,3),TREND(7),PRODMIX(7)
      INTEGER TABLE1(7,2),TABLE2(7,2),TABLE3(7,2),TABLE5(7,2),TABLE6(7,2
     1),TABLE7(7,2),TABLE8(2,2),TABLE11(2,2),IFILE(25,23),OCFMIN,OCFNOM,
     2RESPONSE,EQUBUFR,PCBBUFR,COMPRUFR,RUNTIME,ORDHIST( 5,12),ONP(10,7)
     3,R(10,10),SUBFILE(12,26),SCHEDULE(25,13),INPUT(25,52),OPFILE(125,5
     4,5,10),ORDBK(5,52,20,5),TOTAL(5,52),COL(10,7),WEEK,REFWEEK,    EXF
     5ILE(25,52),REQFILE(25,52),ORDCOUNT,DELPLAN( 5,52),ALLQ(12,50,6),LI
     6NEQ(5,50,5),TESTQ(5,50,5),EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(
     72,30),NETPLAN(5,52),PIPELINE(20,6,4),DUE,QTY,TIME,ORDNO,ITEMNO,CAP
     8,LEADTM(5,52),SUBQ(50,4),DIAGFILE(10,2),ICOUNT(25),ISHORT(25)
      DATA TABLE1(1,1)/-4/,TABLE1(2,1)/-3/,TABLE1(3,1)/-2/,TABLE1(4,1)/-
     11/,TABLE1(5,1)/0/,TABLE1(6,1)/1/,TABLE1(7,1)/2/,TABLE1(1,2)/1/,TAB
     2LE1(2,2)/ 3/,TABLE1(3,2)/ 9/,TABLE1(4,2)/23/,TABLE1(5,2)/63/,TABLE
     31(6,2)/93/,TABLE1(7,2)/100/,TABLE2(1,2)/15/,TABLE2(2,2)/30/,TABLE2
     4(3,2)/80/,TABLE2(4,2)/ 95/,TABLE2(5,2)/100/,TABLE2(6,2)/100/,TABLE
     52(7,2)/100/,TABLE3(1,2)/ 5/,TABLE3(2,2)/15/,TABLE3(3,2)/30/,TABLE3
     6(4,2)/50/,TABLE3(5,2)/75/,TABLE3(6,2)/90/,TABLE3(7,2)/100/,TABLE5(
     71,2)/35/,TABLE5(2,2)/65/,TABLE5(3,2)/85/,TABLE5(4,2)/95/,TABLE5(5,
     82)/100/,TABLE5(6,2)/100/,TABLE5(7,2)/100/,TABLE6(1,2)/40/,TABLE6(2
     9,2)/65/,TABLE6(3,2)/80/,TABLE6(4,2)/100/,TABLE6(5,2)/100/,TABLE6(6
     A,2)/100/,TABLE6(7,2)/100/,TABLE7(1,1)/1/,TABLE7(2,1)/2/,TABLE7(3,1
     B)/5/,TABLE7(4,1)/10/,TABLE7(5,1)/25/,TABLE7(6,1)/50/,TABLE7(7,1)/1
     C00/,TABLE7(1,2)/10/,TABLE7(2,2)/25/,TABLE7(3,2)/50/,TABLE7(4,2)/70
     D/,TABLE7(5,2)/85/,TABLE7(6,2)/ 95/,TABLE7(7,2)/100/,TABLE8(1,1)/1/
     E,TABLE8(2,1)/2/,TABLE8(1,2)/25/,TABLE8(2,2)/100/,TABLE11(1,1)/1/,T
     FABLE11(2,1)/2/,TABLE11(1,2)/20/,TABLE11(2,2)/100/,BLNK/'        '/
C
C      SET LEVEL OF DIAGNOSTICS
C
      CALL PNMFCREATE(AFILE,IFILE)
    5 READ(1,110)(DIAGFILE(I,1),I=1,10),(DIAGFILE(I,2),I=1,10)
  110 FORMAT(10I5/10I5)
      WRITE(2,112)(DIAGFILE(I,1),I=1,10),(DIAGFILE(I,2),I=1,10)
  112 FORMAT(1H1,6X,'DIAGNOSTIC PROFILE'//6X,'WEEK',9X,10I4/6X,'DIAG. LE
     1VEL',2X,10I4/)
      IPRINT=DIAGFILE(1,2)
      WRITE(2,111)IPRINT
  111 FORMAT(1H0,6X,'DIAGNOSTIC LEVEL SELECTED =',I1//6X,' DIAGNOSTIC CH
     1OICE IS:'//6X,'1  DETAIL DIAGNOSTICS/WARNINGS'/6X,'2  TRANSACTION
     2 DETAILS/WARNINGS'/6X,'3  WEEKLY SUMMARIES/WARNINGS'/6X,'4  MONTHL
     3Y SUMMARIES/WARNINGS'/6X,'5  QUARTERLY SUMMARIES/WARNINGS'/6X,'6
     4RUN SUMMARY/INITIAL CONDITIONS'/6X,'7  RUN SUMMARY ONLY'////)
      WEEK=0
      REFWEEK=0
      MONTH=3
      ORDCOUNT=0
  900 READ(1,910)MODE,ISORT
  910 FORMAT(2I1)
      IF(MODE.EQ.0)GO TO 2000
      GO TO (920,940,960),MODE
  920 WRITE(2,930)
  930 FORMAT(1H0,6X,'MODE SELECTED IS MAKE TO STOCK ONLY')
      GO TO 965
  940 WRITE(2,950)
  950 FORMAT(1H0,6X,'MODE SELECTED IS MIXED STOCK AND ORDER')
      GO TO 965
  960 WRITE(2,970)
  970 FORMAT(1H0,6X,'MODE SELECTED IS MAKE TO ORDER ONLY')
  965 I=ISORT+1
      GO TO (971,975),I
  971 WRITE(2,973)
  973 FORMAT(1H0,6X,'PRIORITY RULE IS FIRST-IN-FIRST OUT')
      GO TO 979
  975 WRITE(2,977)
  977 FORMAT(1H0,6X,'PRIORITY RULE IS DUE DATE')
  979 DO 980 I=1,5
      IF(IFILE(I,11).GT.1)GO TO 980
      IFILE(I,16)=0
  980 CONTINUE
  990 DO 10 I=1,7
      TABLE2(I,1)=I
      TABLE3(I,1)=I
      TABLE5(I,1)=I
   10 TABLE6(I,1)=I
      AVGE4=5.0
      CVARN4=0.3
      AVGE9=0.04
      CVARN9=0.3
      AVGE10=6.0
      CVARN10=0.3
      AVGE12=8.0
      CVARN12=0.3
      DO 12 I=1,25
      ICOUNT(I)=1
   12 ISHORT(I)=0
      IF(IPRINT.GT.6) GO TO 120
      WRITE(2,15)
   15 FORMAT(1H0,6X,'SAMPLING DISTRIBUTIONS:-'/)
      WRITE(2,20)(TABLE1(J,1),J=1,7),(TABLE1(J,2),J=1,7)
   20 FORMAT(1H0,6X,'NORMAL INPUT'//6X,7I10//6X,7I10//)
      WRITE(2,30)(TABLE2(J,1),J=1,7),(TABLE2(J,2),J=1,7)
   30 FORMAT(1H0,6X,'ARREARS INPUT'//6X,7I10//6X,7I10//)
      WRITE(2,40)(TABLE3(J,1),J=1,7),(TABLE3(J,2),J=1,7)
   40 FORMAT(1H0,6X,'EXPEDITED INPUT'//6X,7I10//6X,7I10//)
      WRITE(2,50)(TABLE5(J,1),J=1,7),(TABLE5(J,2),J=1,7)
   50 FORMAT(1H0,6X,'NUMBER OF ITEMS'//6X,7I10//6X,7I10//)
      WRITE(2,60)(TABLE6(J,1),J=1,7),(TABLE6(J,2),J=1,7)
   60 FORMAT(1H0,6X,'PRODUCT'//6X,7I10//6X,7I10//)
      WRITE(2,70)(TABLE7(J,1),J=1,7),(TABLE7(J,2),J=1,7)
   70 FORMAT(1H0,6X,'QUANTITY'//6X,7I10//6X,7I10//)
      WRITE(2,80)(TABLE8(J,1),J=1,2),(TABLE8(J,2),J=1,2)
   80 FORMAT(1H0,6X,'PART SHIP = 1, NO PART SHIP = 2'//6X,2I10//6X,2I10/
     1/)
      WRITE(2,90)(TABLE11(J,1),J=1,2),(TABLE11(J,2),J=1,2)
   90 FORMAT(1H0,6X,'REJECT INPUT'//6X,2I10//6X,2I10//)
      WRITE(2,100)AVGE4,CVARN4,AVGE9,CVARN9,AVGE10,CVARN10,AVGE12,CVARN1
     12
  100 FORMAT(1H0,6X,'NORMAL DISTRIBUTIONS'//30X,'AVERAGE',6X,'CO-EFF.OF
     1VARIANCE'//6X,'NO OF ORDERS',10X,F8.2,10X,F8.2//6X,'REJECT PERCENT
     2',8X,F8.2,10X,F8.2//6X,'RESCHED. INPUT',8X,F8.2,10X,F8.2//6X,'PICK
     3ING TIME',10X,F8.2,10X,F8.2////)
C
C     ESTABLISH RUN PARAMETERS
C
  120 READ(1,130)OCFMIN,OCFNOM,RESPONSE,EQUBUFR,PCBBUFR,COMPBUFR,UTIL,
     1(TREND(J),J=1,7)
  130 FORMAT(6I5,F4.2/7F5.2)
      IF(IPRINT.GT.6)GO TO 144
      WRITE(2;135)OCFMIN,OCFNOM,RESPONSE,EQUBUFR,PCBBUFR,COMPBUFR,UTIL
  135 FORMAT(1H0,6X,'RUN PARAMETERS'//6X,'MINIMUM ORDER BOOK (OCFMIN)=';
     1I6//6X,'NOMINAL ORDER BOOK(OCFNOM)=',I6//6X,'SCHEDULE RESPONSE TIM
     2E IN MONTHS(RESPONSE)=',I6//6X,'BUFFER STOCK WEEKS FOR'//12X,'EQUI
     3PMENTS=';I6//12X,'SUB-ASSEMBLIES=',I6//12X,'COMPONENTS=',I6//6X,'P
     4.C.B. CAPACITY UTILISATION = ',F4.2)
  144 IF(IPRINT.GT.6)GO TO 146
      WRITE(2;145)(TREND(J);J=1,7)
  145 FORMAT(1H0,6X,'TREND PARAMETERS',7(5X,F5.2))
  146 PRODMIX(1)=TABLE6(1;2)
      DO 147 J=1,6
  147 PRODMIX(J+1)=FLOAT(TABLE6(J+1,2)-TABLE6(J,2))
      IF(IPRINT.GT.6)GO TO 137
      WRITE(2;148)(PRODMIX(J),J=1;7)
  148 FORMAT(1H0,6X,'PRODMIX'/10X;7F7.2)
  137 DO 170 I=1,25
      LEVEL=IFILE(I,11)
      IF(LEVEL.EQ.0)GO TO 170
      GO TO(140,150,155;160),LEVEL
  140 IFILE(I;20)=EQUBUFR
      GO TO 170
  150 IFILE(I;20)=PCBBUFR
      GO TO 170
  155 IFILE(I;20)=0
      GO TO 170
  160 IFILE(I;20)=COMPBUFR
  170 CONTINUE
      READ(1,180)RUNTIME
  180 FORMAT(I5)
C
C     SELECT RANDOM NUMBER SEEDS
C
  185 READ(1,410)ISEED1;ISEED2;ISEED3,ISEED4,ISEED5,ISEED6,ISEED7,ISEED8
     1;ISEED9;ISEED10,ISEED11,ISEED12
  410 FORMAT(11(I6/);I6)
      WRITE(2;450)(I;I=1,12),ISEED1,ISEED2;ISEED3,ISEED4,ISEED5,ISEED6,I
     1SEED7,ISEED8;ISEED9;ISEED10;ISEED11,ISEED12
  450 FORMAT(1H0,6X,'RANDOM NUMBER SEEDS'//6X,12I7//6X,12I7)
C
C     ESTABLISH INITIAL CONDITIONS
C
      CALL INITODS(ORDHIST;TABLES;TABLE6,TABLE7,ORDCOUNT,PIPELINE,ISEE
     1D4,ISEED5,ISEED6,ISEED7,AVGE4,CVARN4;IFILE,TABLE8,ISEED8,IPRINT)
      IF(IPRINT.GT:6)GO TO 200
      WRITE(2;190)
  190 FORMAT(1H0,6X,'INITIAL CONDITIONS'////)
  200 READ(1,210)TYPE
  210 FORMAT(A8)
      IF(IPRINT.GT.6) GO TO 217
      WRITE(2;215)TYPE
  215 FORMAT(1H0,6X,A8/)
  217 CALL COMP8(TYPE,BLNK;IT)
      GO TO(300,220)IT
  220 CALL TRANSLATE 3(AFILE,TYPE;N,&2000)
      LEVEL=IFILE(N,11)
      GO TO(230,250,250;270),LEVEL
  230 READ(1,240) (ONP(N,J),J=1,7),(R(N,J),J=1,10)
  240 FORMAT(7I5/10I5)
      IF(IPRINT.GT.6)GO TO 200
      WRITE(2,245)(ORDHIST(N,J),J=1,12),(ONP(N,J),J=1,7),(R(N;J),J=1,10)
  245 FORMAT(1H0,6X,'ORDER HISTORY',16X,12I5//6X,'PREVIOUS MATERIAL PLAN
     1',7X,7I5//6X;'RECOMMENDED LINE RATES',7X,10I5//)
```

```
      GO TO 200
  250 READ(1,260)(SUBFILE(N,J),J=1,16)
  260  FORMAT(16I5)
      IFILE(N,18)=0
      J=0
  262 J=J+1
      READ(1,263)ORDNO,ITEMNO,DUE,QTY,TIME
  263 FORMAT(5I5)
      IF(QTY.EQ.0)GO TO 264
       OUTPUT =FLOAT(TIME)
      IMAX=1
      M=N
      CALL STKALL(IFILE,QTY,M,ALLQ,ORDNO,ITEMNO,DUE,OUTPUT,ICOUNT,ISHORT
     1,IPRINT,IMAX,AFILE,&264)
      IF(J.LE.50)GO TO 262
  264 J=0
  265 J=J+1
      IF(J.GT.50)GO TO 272
      IF(SUBQ(J,1).NE.0)GO TO 265
      READ(1,275)(SUBQ(J,K),K=2,4)
  275 FORMAT(3I5)
      IF(SUBQ(J,3).EQ.0)GO TO 266
      SUBQ(J,1)=N
      IF(IPRINT.GT.1)GO TO 269
      WRITE(2,268)AFILE(N,1),(SUBQ(J,K),K=2,4)
  268 FORMAT(1H0,6X,'ITEM ADDED TO SUBQ FOR PRODUCT ',A8/6X,
     1'DUE = ',I5,'QTY = ',I5,'TIME= ',I5)
  269 IFILE(N,18)=IFILE(N,18)+SUBQ(J,3)
      GO TO 265
  272 IF(IPRINT.GT.6)GO TO 200
  266 WRITE(2,267)(SUBFILE(N,J),J=1,16)
  267 FORMAT(1H0,6X,'SUB-ASSY PROG',10X,16I5)
      GO TO 200
  270 READ(1,280)(SCHEDULE(N,J),J=2,13),(INPUT(N,J),J=14,26)
  280 FORMAT(12I5/13I5)
      IF(IPRINT.GT.6)GO TO 200
      WRITE(2,290)(SCHEDULE(N,J),J=1,13),(INPUT(N,J),J=14,26)
  290 FORMAT(1H0,6X,'SUPPLIER SCHEDULE',10X,13I5//6X,'MATERIAL INPUT',13
     1X,13I5)
      GO TO 200
  300 CALL OPFCREATE(OPFILE,ORDBK,TOTAL,ALLQ,LINEQ,TESTQ,ORDCOUNT,REFWEE
     1K,IFILE,ISEED4,ICOUNT,ISHORT,IPRINT,AFILE,SUBQ)
      IF(IPRINT.GT.6)GO TO 400
      CALL OPFPRT(OPFILE,AFILE)
      CALL ORDBKPRT(ORDBK,AFILE,IFILE,TOTAL,REFWEEK)
      CALL AQPRINT(ALLQ,WEEK,AFILE,REFWEEK)
      CALL LQPRINT(LINEQ,WEEK,AFILE,REFWEEK)
      CALL SQPRINT(SUBQ,WEEK,AFILE,REFWEEK)
      CALL TQPRINT(TESTQ,WEEK,AFILE,REFWEEK)
      CALL PNMFPRINT(AFILE,IFILE)
C
C     START SIMULATION RUN
C
 400   TQTR=0.0
      TMONTH=0.0
  500 IF(TQTR.GT.0.0)GO TO 600
      CALL WEEKPRINT(ICOUNT,ISHORT,EQUPERF,ITEMPERF,ORDPERF,IFILE,AFILE,
     1REFWEEK,WEEK,LEADTM)
  550 CALL QTREVENTS(ORDHIST,AFILE,IFILE,IPRINT,COL,ONP,R,RESPONSE,ISEED
     11,TABLE1,ISEED2,TABLE2,OCFMIN,OCFNOM,SCHEDULE,INPUT,OPFILE,ORDBK,T
     2OTAL,WEEK,REFWEEK,TQTR,EXFILE,REQFILE,DELPLAN,NETPLAN,ICOUNT,ISHOR
     3T,CAP,UTIL,LEADTM,TREND,TABLE6,PRODMIX,ALLQ,MODE,EQUPERF,ITEMPERF,
     4ORDPERF,EQUBUFR)
  600 IF(TMONTH.GT.0.0)GO TO 700
      CALL MONTHEVENT(AFILE,IFILE,REQFILE,SUBFILE,WEEK,ORDHIST,IPRINT,TM
     1ONTH,MONTH,OPFILE,DELPLAN,NETPLAN,OCFMIN,ORDBK,ALLQ,TOTAL)
      IF(IPRINT.GT.4)GO TO 700
      CALL WEEKPRINT(ICOUNT,ISHORT,EQUPERF,ITEMPERF,ORDPERF,IFILE,AFILE,
     1REFWEEK,WEEK,LEADTM)
  700 CALL WEEKEVENT(AFILE,IFILE,TABLE3,TABLE5,TABLE6,TABLE7,TABLE11,AVG
     1E4,CVARN4,AVGE9,CVARN9,AVGE10,ISEED3,ISEED4,ISEED5,ISEED6,ISEED7,I
     2SEED8,ISEED9,ISEED10,ISEED11,ISEED12,TABLE8,AVGE12,CVARN12,CVARN10
     3,ORDCOUNT,PIPELINE,DELPLAN,OCFMIN,WEEK,TOTAL,ORDBK,OPFILE,ORDHIST,
     4INPUT,EXFILE,SCHEDULE,REQFILE,ALLQ,LINEQ,TESTQ,SUBFILE,EQUPERF,ITE
     5MPERF,ORDPERF,NETPLAN,REFWEEK,IPRINT,ICOUNT,ISHORT,CAP,LEADTM,ISOR
     6T,SUBQ,DIAGFILE,MODE,RUNTIME)
      WEEK=WEEK+1
      TQTR=TQTR-1.0
      TMONTH=TMONTH-1.0
      DO 800 I=1,12
      DO 800 J=1,50
      ALLQ(I,J,5)=ALLQ(I,J,5)-5
  800 CONTINUE
      DO 810 I=1,5
      DO 810 J=1,50
      TESTQ(I,J,5)=TESTQ(I,J,5)-5
      LINEQ(I,J,5)=LINEQ(I,J,5)-5
  810 CONTINUE
      DO 820 J=1,50
  820 SUBQ(J,4)=SUBQ(J,4)-5
      IF((REFWEEK+WEEK).LT.RUNTIME)GO TO 500
      WRITE(2,1000)
 1000 FORMAT(1H0,6X,'END OF RUN')
      GO TO 900
 2000 STOP
      END
```

B2 - SUBROUTINE ALLOCATE

Subroutine ALLOCATE is the order release mechanism which determines the quantity and timing of a factory order.

The process described demonstrates one of the basic differences between the procedure currently employed and a full M.R.P. approach. In M.R.P., order release is recommended by the system as planned orders become due, and the detail of each shop order in terms of quantity and timing is calculated to support the Master Production Schedule and ultimately, the customer order commitment. The present system does not support a customer order book **nor** , by definition, a Master Production Schedule which reflects the known customer order commitment in a dynamic manner. Customer orders are contained within a factory order book which is manually maintained, and supporting procedures are required to interpret the factory order book into time phased order releases, or "allocations".

The subroutine has been separated into two distinct sectors; the logic required to support sub-assembly manufacture, and the logic required to produce equipments.

a) <u>Sub-assemblies</u>

Each sub-assembly has a new programme re-generated at the time of the quarterly planning process, as defined in subroutine EBQ and SUBPROG. This weekly programme is reviewed each month to accommodate any deviation from plan which results in excess or lack of stock.

Since the weekly programme SUBFILE maintained by subroutine SUBPROG is considered to be always current, the requirement of subroutine ALLOCATE is to search for items which are due for order release and initiate order release action.

The sub-assembly programme in SUBFILE contains make quantities against the week that they are required to be completed and available in stock. Thus the subroutine must search for items with a due date equal to or less than the current week <u>plus</u> the manufacturing and component picking lead time. Items due for release have the sub-assembly reference, quantity and due date passed to subroutine STKALL for allocation to take place.

b) Equipment

The procedure for equipments differs substantially from that for sub-assemblies. The requirement to allocate is not available in a time-phased plan because of the inability to maintain a factory order book within the system. The factory order book must be scanned each week to search for customer orders which are due for release, some of which may be recent additions to the order book.

The segment for equipments is further sub-divided for ease of processing into two parts; a segment for overdue products and a segment for due products. The logic in each case is similar.

For each manufactured batch, the first requirement is to determine the quantity and timing of the order release. The value of work in progress is compared with the nominal queue (or lead time) contained within IFILE. If the queue is less than the nominal queue plus one week extended by the plan rate within REQFILE an order release will be recommended. The quantity recommended for release will be two weeks worth of requirement.

The next stage is to determine which customer orders are due for allocation. The product order book contained within ORDBK is searched by due date to identify a requirement which has not yet been dispatched. The corresponding orders placed file record contained within OPFILE is then retrieved to identify any requirements which are still in "open" status.

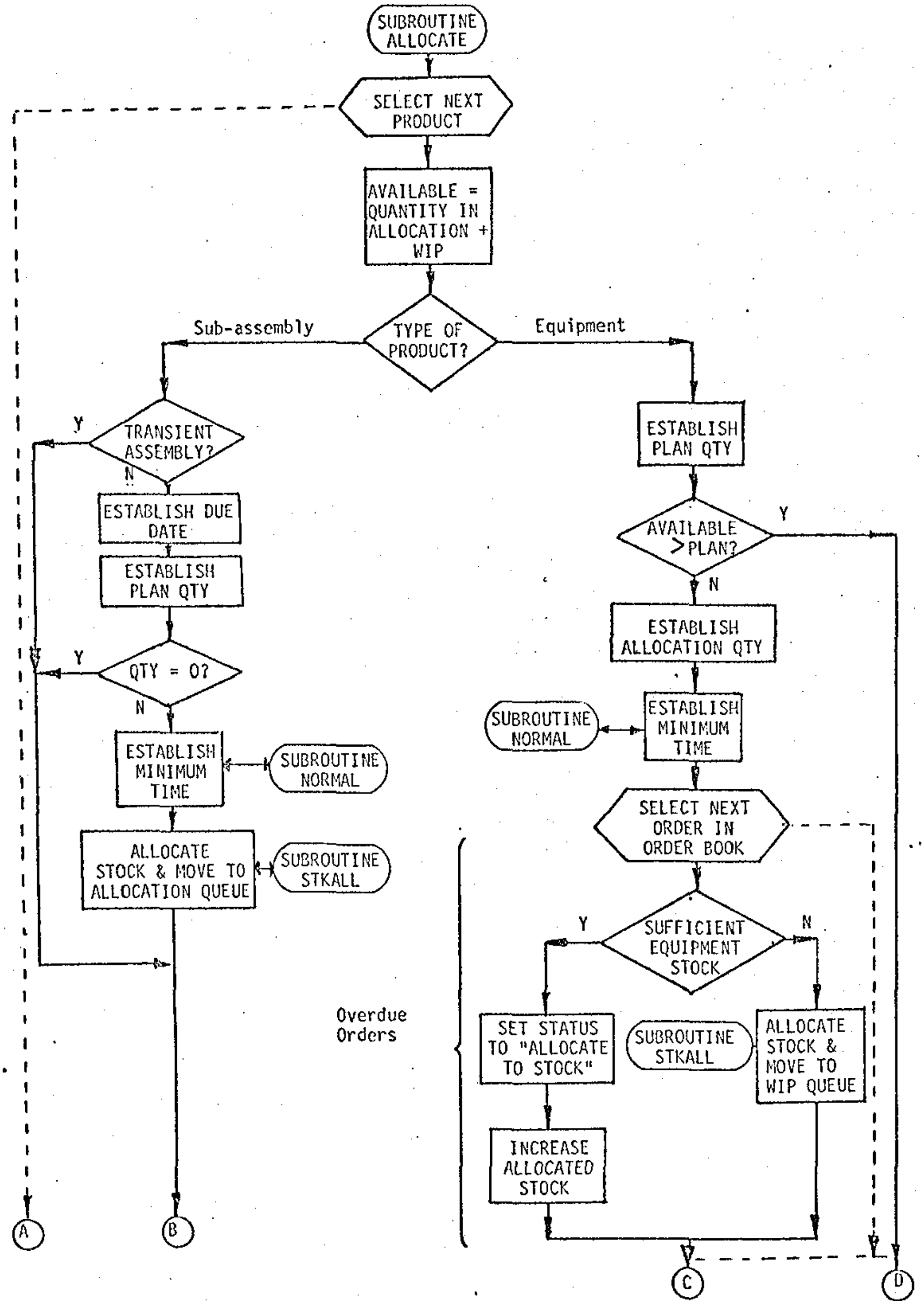
Orders may be satisfied from two sources; semi-finished stock or make to order. Semi-finished stock is held between the line assembly and test activities and serves two purposes. Firstly, to buffer the production lines against the unstable order input patterns, and secondly to offer a shorter delivery lead time than fully make to order.

The free stock for the required product is checked and, if the full item quantity required can be satisfied from stock, the allocated stock will be augmented by the required quantity and the OPFILE status changed from "unallocated" to "ex-stock".

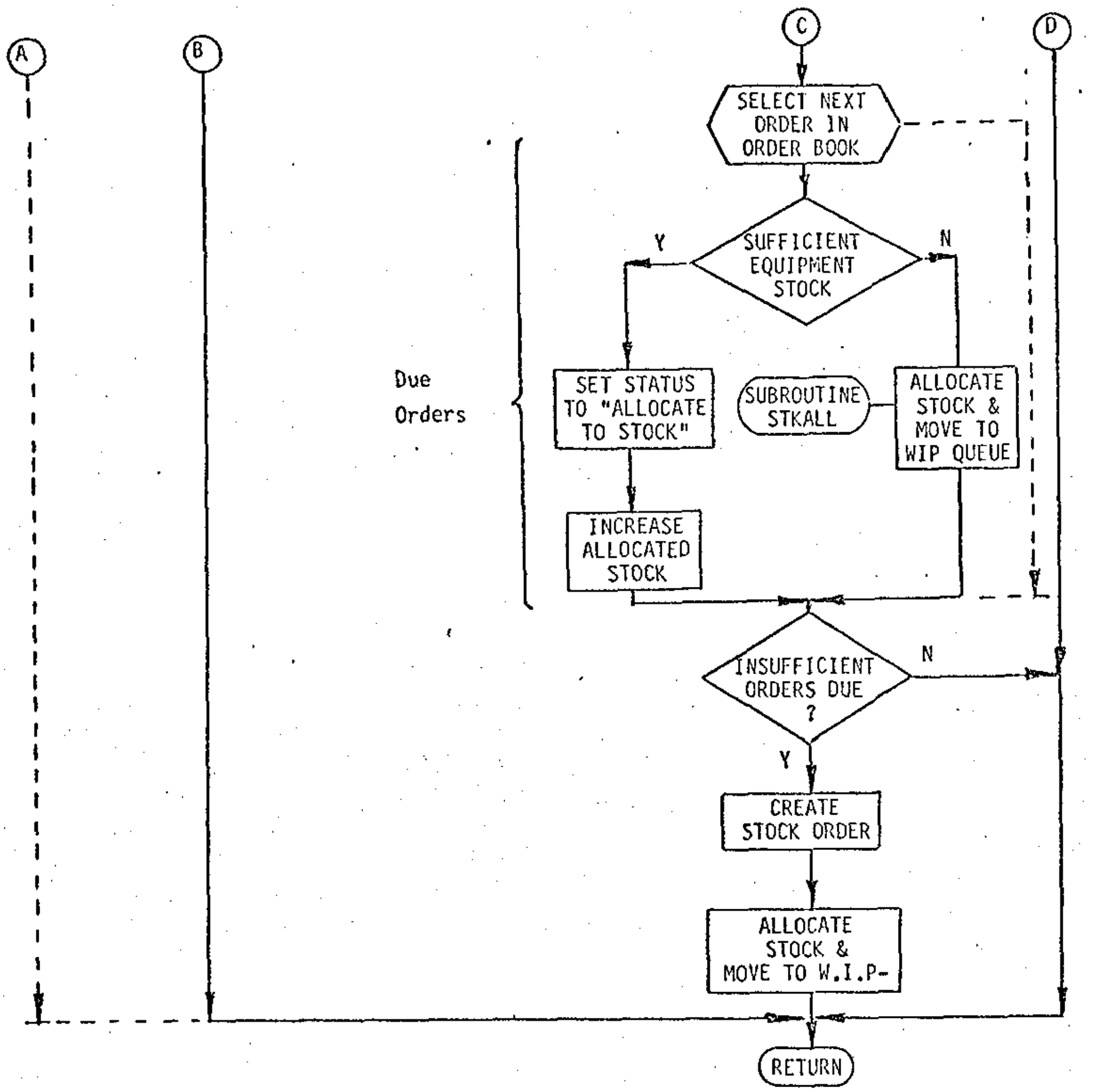
If the item quantity cannot be satisfied from stock, the order will be wholly or partially satisfied from the next batch to be manufactured.

Orders eligible for manufacture are allocated in subroutine STKALL until the full allocation quantity recommended for order release has been taken up. Items thus allocated are moved from "open" to "on-line" status in OPFILE.

The order book is searched for customer requirements up to two weeks beyond the normal allocation date. If sufficient customer orders are not available within this period, a stock order is initiated to take up any balance in the allocation quantity. The stock order is assigned a negative order number to differentiate it from customer orders, since no ORDBK or OPFILE records will be created for stock requirements.


SUBROUTINE ALLOCATE
SELECT NEXT PRODUCT
AVAILABLE = QUANTITY IN ALLOCATION + WIP
TYPE OF PRODUCT?
Sub-assembly
Equipment
TRANSIENT ASSEMBLY?
Y
N
ESTABLISH DUE DATE
ESTABLISH PLAN QTY
QTY = 0?
Y
N
ESTABLISH MINIMUM TIME
SUBROUTINE NORMAL
ALLOCATE STOCK & MOVE TO ALLOCATION QUEUE
SUBROUTINE STKALL
ESTABLISH PLAN QTY
AVAILABLE > PLAN?
Y
N
ESTABLISH ALLOCATION QTY
SUBROUTINE NORMAL
ESTABLISH MINIMUM TIME
SELECT NEXT ORDER IN ORDER BOOK
SUFFICIENT EQUIPMENT STOCK
Y
N
Overdue Orders
SET STATUS TO "ALLOCATE TO STOCK"
SUBROUTINE STKALL
ALLOCATE STOCK & MOVE TO WIP QUEUE
INCREASE ALLOCATED STOCK
A
B
C
D

Cont. over.


A
B
C
D
SELECT NEXT ORDER IN ORDER BOOK
SUFFICIENT EQUIPMENT STOCK
Y
N
Due Orders
SET STATUS TO "ALLOCATE TO STOCK"
SUBROUTINE STKALL
ALLOCATE STOCK & MOVE TO WIP QUEUE
INCREASE ALLOCATED STOCK
INSUFFICIENT ORDERS DUE ?
N
Y
CREATE STOCK ORDER
ALLOCATE STOCK & MOVE TO W.I.P-
RETURN

Summarised Flow Chart - Subroutine Allocate

```
C
C     ALLOCATE
C
      SUBROUTINE ALLOCATE(IFILE,REQFILE,ORDBK,STKORD,WEEK,OPFILE,ISEED12
     1,ALLQ,ICOUNT,ISHORT,SUBFILE,AVGE12,CVARN12,REFWEEK,IPRINT,AFILE,DI
     2AGFILE,MODE,RUNTIME,LINEQ)
      REAL AFILE(25,3)
      INTEGER WEEK,REQFILE(25,52),IFILE(25,23),WIP,ALLQTY,STKORD(20),Z,O
     1RDBK( 5,52,20,5),OPFILE(125,5,5,10),ORD,ALLQ(12,50,6),QTY,SUBFILE(
     212,26),DDATE,REFWEEK,DIAGFILE(10,2),RUNTIME,ICOUNT(25),ISHORT(25)
     3,LINEQ(5,50,5)
      IF(IPRINT.GT.1)GO TO 1
      WRITE(2,400)
  400 FORMAT(1H0,6X,'* * * *  ALLOCATE  * * * *'//)
    1 DO 200 I=1,12
      IAVAIL=0
      ISTK=0
      DO 4 K=1,50
      IF(ALLQ(I,K,1).GE.0)GO TO 5
      ISTK=ISTK+ALLQ(I,K,4)
    5 IF(LINEQ(I,K,1).GE.0)GO TO 4
      ISTK=ISTK+LINEQ(I,K,4)
    4 IAVAIL = IAVAIL + ALLQ(I,K,4)
      IAVAIL = IAVAIL + IFILE(I,18)
      IF=IFILE(I,11)
      GO TO (8,2,2,200),IF
C
C     SEGMENT FOR SUB-ASSEMBLIES
C
    2 ORDNO=0
      ITEMNO=0
      IF(IFILE(I,15).EQ.1)GO TO 200
      IDATE=WEEK+IFILE(I,12)+1+REFWEEK
      QTY=SUBFILE(I,WEEK)
      IF(QTY.EQ.0)GO TO 200
      IMAX=0
      OUTPUT=8.0
      IF(ISEED12.EQ.0)GO TO 7
      CALL NORMAL(AVGE12,OUTPUT,ISEED12,CVARN12)
      IF(OUTPUT.GE.0.0)GO TO 7
      OUTPUT=0.0
    7 CALL STKALL(IFILE,QTY,I,ALLQ,ORDNO,ITEMNO,IDATE, OUTPUT,ICOUNT,ISH
     1ORT,IPRINT,IMAX,AFILE,&200)
      GO TO 200
C
C     SEGMENT FOR EQUIPMENTS
C
    8 ALLQTY=0
      IPLAN=0
C
C     CHECK FOR HIGH W.I.P. * IN ALLOCATION
C
      M=WEEK+IFILE(I,12)+2
      DO 10 J=WEEK,M
   10 IPLAN=IPLAN+REQFILE(I,J)
      IF(IAVAIL.GE.IPLAN)GO TO 200
C
C     ESTABLISH ALLOCATION QUANTITY,ORDER NUMBER & TIME
C
      IMAX=1
      DO 15 M=1,50
      IF(ALLQ(I,M,6).LE.IMAX)GO  TO 15
      IMAX=ALLQ(I,M,6)
   15 CONTINUE
      IMAX=IMAX+1
      OUTPUT=8.0
      IF(ISEED12.EQ.0)GO TO 19
      CALL NORMAL(AVGE12,OUTPUT,ISEED12,CVARN12)
      IF(OUTPUT.GE.0.0)GO TO 19
      OUTPUT=0.0
   19 DO 20  M=WEEK+2,WEEK+3
   20 ALLQTY=ALLQTY+REQFILE(I,M)
      IF(IPRINT.GT.2)GO TO 21
      WRITE(2,300)AFILE(I,1),ALLQTY,IMAX,OUTPUT
  300 FORMAT(1H0/  6X,'PRODUCT =',A8,2X,'ALLOCATION QTY =',I6,2X,'SHOP O
     1RDER=',I6,2X,'TIMER=',F6.1)
C
C     N = ORDNO     M = ITEMNO     J = QTY     K = WEEK DUE
C
   21 IF(ALLQTY.LE.0)GO TO 200
C
C      SEGMENT FOR OVERDUE ITEMS
C
       DO 100 K=1,52
       DO 100 L=1,20
       IF(ORDBK(I,K,L,4).EQ.0)GO TO 100
       DDATE=K-52
       IF(ORDBK(I,K,L,3).EQ.0)GO TO 100
       N=ORDBK(I,K,L,1)
       M=ORDBK(I,K,L,2)
       J=ORDBK(I,K,L,3)
       DO 25 KEYNO=1,125
       IF(OPFILE(KEYNO,1,1,10).EQ.N)GO TO 27
    25 CONTINUE
       GO TO 33
    27 DO 30 JJ=1,5
       IF((OPFILE(KEYNO,M,JJ,3)-REFWEEK).EQ.DDATE)GO TO 40
    30 CONTINUE
    33 IF(IPRINT.GT.5)GO TO 100
       WRITE(2,35)N,M,DDATE,OPFILE(KEYNO,M,JJ,3),REFWEEK
    35 FORMAT(1H0,6X,'INCOMPATIBLE DATA IN OPFILE FOR ORDER NO. ',I4,' IT
      1EM NO.',I4,' DUE WEEK ',I4/6X,'ACTUAL WEEK ',I4,2X,'REFWEEK ',I4)
       IPRINT=1
       DO 37 IZ=1,10
    37 DIAGFILE(IZ,2)=1
       RUNTIME=REFWEEK+WEEK+4
       GO TO 100
    40 IF(OPFILE(KEYNO,M,JJ,4).EQ.0)GO TO 100
       IF(OPFILE(KEYNO,M,JJ,4).GT.(IFILE(I,16)+ISTK-IFILE(I,17)))GO TO
      150
C
C      TAKE FROM STOCK
C
       IFILE(I,17)=IFILE(I,17)+OPFILE(KEYNO,M,JJ,4)
       OPFILE(KEYNO,M,JJ,5)=OPFILE(KEYNO,M,JJ,5)+OPFILE(KEYNO,M,JJ,4)
       OPFILE(KEYNO,M,JJ,4)=0
       GO TO 100
C
C      MAKE ON LINE
C
    50 IF(MODE.EQ.1)GO TO 100
       IF(ALLQTY.LE.OPFILE(KEYNO,M,JJ,4))GO TO 150
       QTY=OPFILE(KEYNO,M,JJ,4)
       IDATE=OPFILE(KEYNO,M,JJ,3)
      CALL STKALL(IFILE,QTY,I,ALLQ,N,M,IDATE, OUTPUT,ICOUNT,ISHORT,IPRIN
     1T,IMAX,AFILE,&100)
      OPFILE(KEYNO,M,JJ,6)=OPFILE(KEYNO,M,JJ,6)+QTY
      OPFILE(KEYNO,M,JJ,4)=0
      ALLQTY=ALLQTY-QTY
  100 CONTINUE
C
C     SEGMENT FOR DUE ITEMS
C
      DO 142 K=1,WEEK+13
      DO 140 L=1,20
      DDATE=K
      IF(ORDBK(I,K,L,4).EQ.1)GO TO 140
      IF(ORDBK(I,K,L,3).EQ.0)GO TO 140
      N=ORDBK(I,K,L,1)
      M=ORDBK(I,K,L,2)
      J=ORDBK(I,K,L,3)
      DO 110 KEYNO=1,125
      IF(OPFILE(KEYNO,1,1,10).EQ.N)GO TO 115
  110 CONTINUE
      GO TO 125
  115 DO 120 JJ=1,5
      IF((OPFILE(KEYNO,M,JJ,3)-REFWEEK).EQ.K)GO TO 130
  120 CONTINUE
  125 IF(IPRINT.GT.5)GO TO 140
      WRITE(2,35)N,M,DDATE,OPFILE(KEYNO,M,JJ,3),REFWEEK
      IPRINT=1
      DO 127 IZ=1,10
  127 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
      GO TO 140
  130 IF(OPFILE(KEYNO,M,JJ,4).EQ.0)GO TO 140
      IF(OPFILE(KEYNO,M,JJ,4).GT.(IFILE(I,16)+ISTK-IFILE(I,17)))GO TO
     1135
C
C     TAKE FROM STOCK
C
      IFILE(I,17)=IFILE(I,17)+OPFILE(KEYNO,M,JJ,4)
      OPFILE(KEYNO,M,JJ,5)=OPFILE(KEYNO,M,JJ,5)+OPFILE(KEYNO,M,JJ,4)
      OPFILE(KEYNO,M,JJ,4)=0
      GO TO 140
C
C     MAKE ON LINE
C
  135 IF(MODE.EQ.1)GO TO 140
      IF(ALLQTY.LE.OPFILE(KEYNO,M,JJ,4))GO TO 150
      QTY=OPFILE(KEYNO,M,JJ,4)
      IDATE=OPFILE(KEYNO,M,JJ,3)
      CALL STKALL(IFILE,QTY,I,ALLQ,N,M,IDATE, OUTPUT,ICOUNT,ISHORT,IPRIN
     1T,IMAX,AFILE,&140)
      OPFILE(KEYNO,M,JJ,6)=OPFILE(KEYNO,M,JJ,6)+QTY
      OPFILE(KEYNO,M,JJ,4)=0
      ALLQTY=ALLQTY-QTY
      IF(MODE.EQ.3)GO TO 140
      IF(K.GE.WEEK+6)GO TO 145
  140 CONTINUE
  142 CONTINUE
      IF(MODE.EQ.3)GO TO 200
  145 STKORD(I)=STKORD(I)-1
      M=1
      N=STKORD(I)
      IDATE=WEEK+4+REFWEEK
```

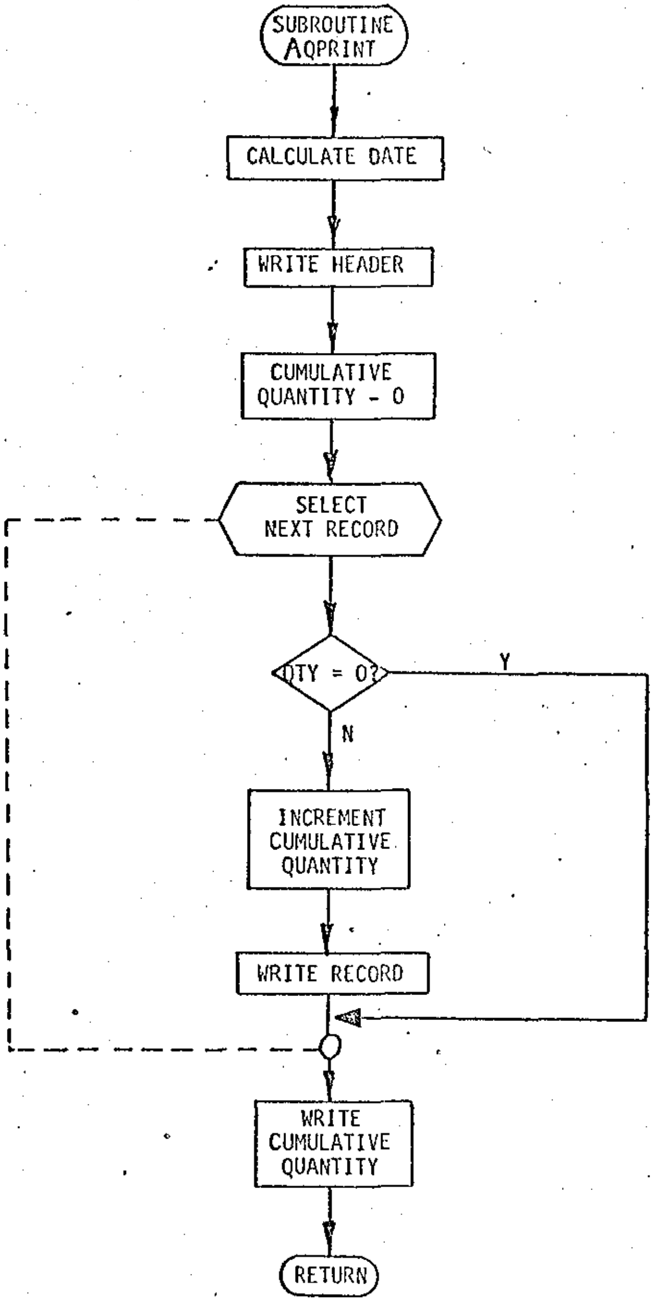
```
C
C     NEGATIVE ORDER NUMBER DENOTES STOCK ORDER
C
      GO TO 180
  150 IDATE=OPFILE(KEYNO,M,JJ,3)
  180 CALL STKALL(IFILE,ALLQTY,I,ALLQ,N,M,IDATE, OUTPUT,ICOUNT,ISHORT,IP
     1RINT,IMAX,AFILE,&200)
      IF(N.LE.0)GO TO 200
      OPFILE(KEYNO,M,JJ,4)=OPFILE(KEYNO,M,JJ,4)-ALLQTY
      OPFILE(KEYNO,M,JJ,6)=OPFILE(KEYNO,M,JJ,6)+ALLQTY
  200 CONTINUE
      IF(IPRINT.GT.3)GO TO 500
      CALL AQPRINT(ALLQ,WEEK,AFILE,REFWEEK)
  500 RETURN
      END
```

B3 - SUBROUTINE AQPRINT (LQPRINT: TQPRINT: SQPRINT)

Four print routines are available as diagnostic aids to report the contents of the queues; ALLQ, LINEQ, TESTQ, SUBQ.

Each queue may be reported at any time, and is identified by the week number provided by the calling segment.

Details of each queue are presented in product sequence (except for SQPRINT), but only for each product with a finite queue content. SQPRINT presents the contents of the sub-assembly queue in the sequence defined in SUBQ. Summary values indicating the quantity in each independent queue are displayed for ease of analysis.



Summarised Flow Chart - Subroutine Aqprint

```
C
C       AQPRINT
C
      SUBROUTINE AQPRINT(ALLQ,WEEK,AFILE,REFWEEK)
      REAL AFILE(25,3)
      INTEGER ALLQ(12,50,6),WEEK,REFWEEK
      IDATE=WEEK+REFWEEK
      WRITE(2,10) IDATE
   10 FORMAT(1H0  /6X,'ITEMS IN ALLOCATION FILE FOR WEEK',I6//10X,'ORDER
     1NO.',5X,'ITEM NO.',5X,'DUE DATE',5X,'QUANTITY',8X,'TIMER',5X,
     2'SHOP ORDER'//)
      DO 200 I=1,12
      IQTY=0
      IF(ALLQ(I,1,4).EQ.0)GO TO 200
      WRITE(2,20)AFILE(I,1)
   20 FORMAT(1H0,6X,A8)
      DO 100 J=1,50
      IF(ALLQ(I,J,4).EQ.0)GO TO 100
      IQTY=IQTY+ALLQ(I,J,4)
      WRITE(2,30)(ALLQ(I,J,K),K=1,6)
   30 FORMAT(1H ,5X,6(7X,I6))
  100 CONTINUE
      WRITE(2,150)IQTY
  150 FORMAT(1H+,90X,'TOTAL =',I6)
  200 CONTINUE
      RETURN
      END
```

```
ITEMS IN ALLOCATION FILE FOR WEEK    19

    ORDERNO.      ITEM NO.     DUE DATE     QUANTITY        TIMER      SHOP ORDER


 MF6AM 01
            -2             1            21           86            0             4
            23             1            28           50            0             4
            26             4            29           25            9             5
            -3             1            23          111            9             5         TOTAL =    272

 MF6AM 02
            -3             1            21           73           -3             4
            24             2            28            7           -3             4
            24             3            28           33            9             5
            -4             1            23           47            9             5         TOTAL =    160

 MF6AM 03
            -4             1            22           46            2             5         TOTAL =     46

 AT12345
             0             0            21          160           -2             0         TOTAL =    160

 AT12801
             0             0            22          100            1             0         TOTAL =    100

 AT12802
             0             0            21           92           -2             0
             0             0            22           92            8             0         TOTAL =    184
```

Sample Allocation File

```
C
C      LQPRINT
C
       SUBROUTINE LQPRINT(LINEQ,WEEK,AFILE,REFWEEK)
       REAL AFILE(25,3)
       INTEGER LINEQ(5,50,5),WEEK,REFWEEK
       IDATE=WEEK+REFWEEK
       WRITE(2,10) IDATE
    10 FORMAT(1H0  /6X,'ITEMS IN LINE QUEUE (WIP) FOR WEEK',I6//10X,'ORDE
      1R NO.',5X,'ITEM NO.',5X,'DUE DATE',5X,'QUANTITY',5X,'TIMER'//)
       DO 200 I=1,5
       IQTY=0
       IF(LINEQ(I,1,4).EQ.0)GO TO 200
       WRITE(2,20)AFILE(I,1)
    20 FORMAT(1H0,6X,A8)
       DO 100 J=1,50
       IF(LINEQ(I,J,4).EQ.0)GO TO 100
       IQTY=IQTY+LINEQ(I,J,4)
       WRITE(2,30)(LINEQ(I,J,K),K=1,5)
    30 FORMAT(1H ,5X,5(7X,I6))
   100 CONTINUE
       WRITE(2,150)IQTY
   150 FORMAT(1H+,80X,'TOTAL =',I6)
   200 CONTINUE
       RETURN
       END
```

```
ITEMS IN LINE QUEUE (WIP) FOR WEEK     19

    ORDER NO.      ITEM NO.      DUE DATE      QUANTITY      TIMER


MF6AM 01
             11             1             19            20           -12
             -1             1             19            87            -7
             11             1             20            36           -12
             11             1             20            39            -7
             -2             1             21            86             3
             16             3             27            10            -7
             23             1             28            50             3        TOTAL =    328

MF6AM 02
             15             1             19            10           -12
             -2             1             19            78            -7
             14             1             20            25           -12
             -3             1             21            73             3
             18             1             25             2            -7
             24             2             28             7             3        TOTAL =    195

MF6AM 03
             -2             1             19            32            -7
             -3             1             20            46            -2        TOTAL =     78

AC15PU
             11             2             18            18            -7
             15             2             19             4            -7
             15             2             19            16            -7
             15             2             20            20            -7
             -1             1             20            10            -2
             15             2             21             8            -7
             15             2             21            12            -2
             16             4             27            22            -2        TOTAL =    110
```

Sample W.I.P. File

```
C
C     TQPRINT
C
      SUBROUTINE TQPRINT(TESTQ,WEEK,AFILE,REFWEEK)
      REAL AFILE(25,3)
      INTEGER TESTQ(5,50,5),WEEK,REFWEEK
      IDATE=WEEK+REFWEEK
      WRITE(2,10) IDATE
   10 FORMAT(1H0  /6X,'ITEMS IN TEST QUEUE (WIP) FOR WEEK',I6//10X,'ORDE
     1R NO.',5X,'ITEM NO.',5X,'DUE DATE',5X,'QUANTITY',5X,'TIMER'//)
      DO 200 I=1,5
      IQTY=0
      IF(TESTQ(I,1,4).EQ.0)GO TO 200
      WRITE(2,20)AFILE(I,1)
   20 FORMAT(1H0,6X,A8)
      DO 100 J=1,50
      IF(TESTQ(I,J,4).EQ.0)GO TO 100
      IQTY=IQTY+TESTQ(I,J,4)
      WRITE(2,30)(TESTQ(I,J,K),K=1,5)
   30 FORMAT(1H ,5X,5(7X,I6))
  100 CONTINUE
      WRITE(2,150)IQTY
  150 FORMAT(1H+,80X,'TOTAL =',I6)
  200 CONTINUE
      RETURN
      END
```

```
      ITEMS IN TEST QUEUE (WIP) FOR WEEK     19

          ORDER NO.     ITEM NO.     DUE DATE     QUANTITY     TIMER


       MF6AM 01
                  2            1           17           20       -12
                 11            1           17           25       -12
                  5            3           17           25        -7
                 11            1           18           19       -12
                 11            1           18           43        -7
                 11            1           18           13        -2
                 11            1           19           55        -2
                 11            1           19           20         3          TOTAL =    220

       MF6AM 02
                  5            4           17           10       -12
                 14            1           18           15       -12
                 14            1           18           10        -7
                 15            1           18           10        -7
                 14            1           19           25        -2
                 15            1           20           10        -2
                 15            1           19           10         3          TOTAL =     90

       MF6AM 03
                  9            1           16            8       -22
                  9            1           16            7       -17
                  5            1           17           16       -17
                  5            1           17            9       -12
                 13            1           18            5       -12
                 13            2           18            5       -12
                 13            3           18            4       -12
                 13            3           18            1        -7
                 13            4           18            5        -7          TOTAL =     60

       AC15PU
                 11            2           17           20        -2
                 11            2           18            2        -2
                 11            2           18           18         3
                 15            2           19            4         3          TOTAL =     44
```

Sample Test W.I.P. File

```
C
C     SQPRINT
C
      SUBROUTINE SQPRINT(SUBQ,WEEK,AFILE,REFWEEK)
      REAL AFILE(25,3)
      INTEGER WEEK,SUBQ(50,4),REFWEEK
      IDATE=WEEK+REFWEEK
      WRITE(2,10) IDATE
   10 FORMAT(1H0/6X,'ITEMS IN SUB-ASSEMBLY W.I.P. FOR WEEK',I6//10X,
     1'PART NO.',5X,'DUE',5X,'QUANTITY',5X,'TIMER'//)
      IQTY=0
      DO 100 J=1,50
      IF(SUBQ(J,3).EQ.0)GO TO 100
      IQTY=IQTY+SUBQ(J,3)
      IPROD=SUBQ(J,1)
      WRITE(2,50)AFILE(IPROD,1),(SUBQ(J,N),N=2,4)
   50 FORMAT(1H ,10X,A8,4X,I4,6X,I4,8X,I4)
  100 CONTINUE
      WRITE(2,150)IQTY
  150 FORMAT(1H+,60X,'TOTAL =',I6)
      RETURN
      END
```

```
      ITEMS IN SUB-ASSEMBLY W.I.P. FOR WEEK     19

          PART NO.     DUE     QUANTITY     TIMER


          AT12801       18        62          -12
          AT12802       18        92          -12
          AT12345       18       160           -7
          AT12345       19       160           -2
          AT27896       20       122          -12
          AT12345       20       160           -2
          AT12801       20       100           -2
          AT12345       21       160            3
          AT12802       21        92            3              TOTAL =   1108
```

Sample Sub-assembly Queue

B4 - SUBROUTINE ARRIVAL

The receipt of purchased items is simulated in the subroutine ARRIVAL. The pattern of receipts for each part number has been derived from the supplier schedule in subroutine RECEIVE and contained in the file named INPUT.

The week number is available to the subroutine, thus the expected receipt for each component for the appropriate week can be derived from file INPUT.

Subroutine ARRIVAL spans the events from receipt at the receiving bay to location in stock. The facility to audit quality is provided within the logic, but the quantity received complies with the data specified in file INPUT.

The quality audit logic follows the process outlined below:

a) A histogram is sampled to determine the presence of poor quality. Items which pass this test will proceed to the stock update phase.

b) Items which fail will have a second sample taken to determine the size of the reject quantity. If this is less than 5%, the reject items are returned to the supplier. The remainder will update the stock file. Reject quantities of greater than 5% cause rejection of the complete batch.

c) Quantities which have been rejected are rescheduled in file INPUT by sampling from a histogram defining the number of weeks required to recycle the batch.

A finite receipt quantity will cause two actions:

- update of the physical stock field in IFILE
- adjustment of the supplier schedule.

Receipts are assumed to downdate the file SCHEDULE in chronological sequence, starting with any arrears where applicable. Maintenance of the supplier schedule status is important to the correct functioning of the quarterly material planning logic and the relative stability of the supplier commitment.

The sampling profiles employed by subroutine ARRIVAL are:

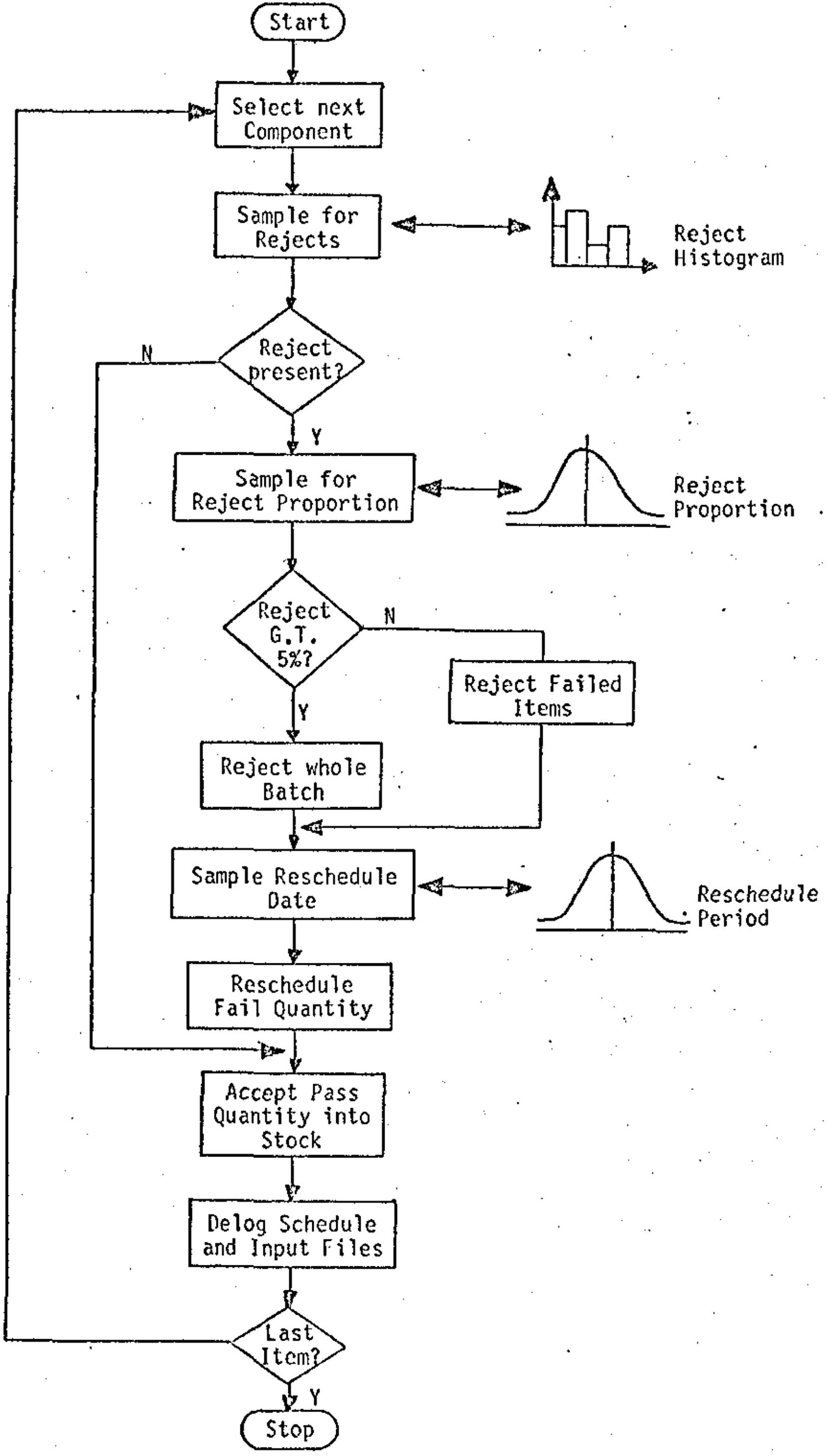
(i) Probability that a reject batch has arrived. Histogram contained within TABLE 11.

Value	1 (Fail)	2 (Pass)
Relative frequency	20	80

(ii) Proportion of batch rejected.
Normal distribution as defined by AVGE9, CVARN9
(eg. average = 0.04; coefficient of variation= 0.3)

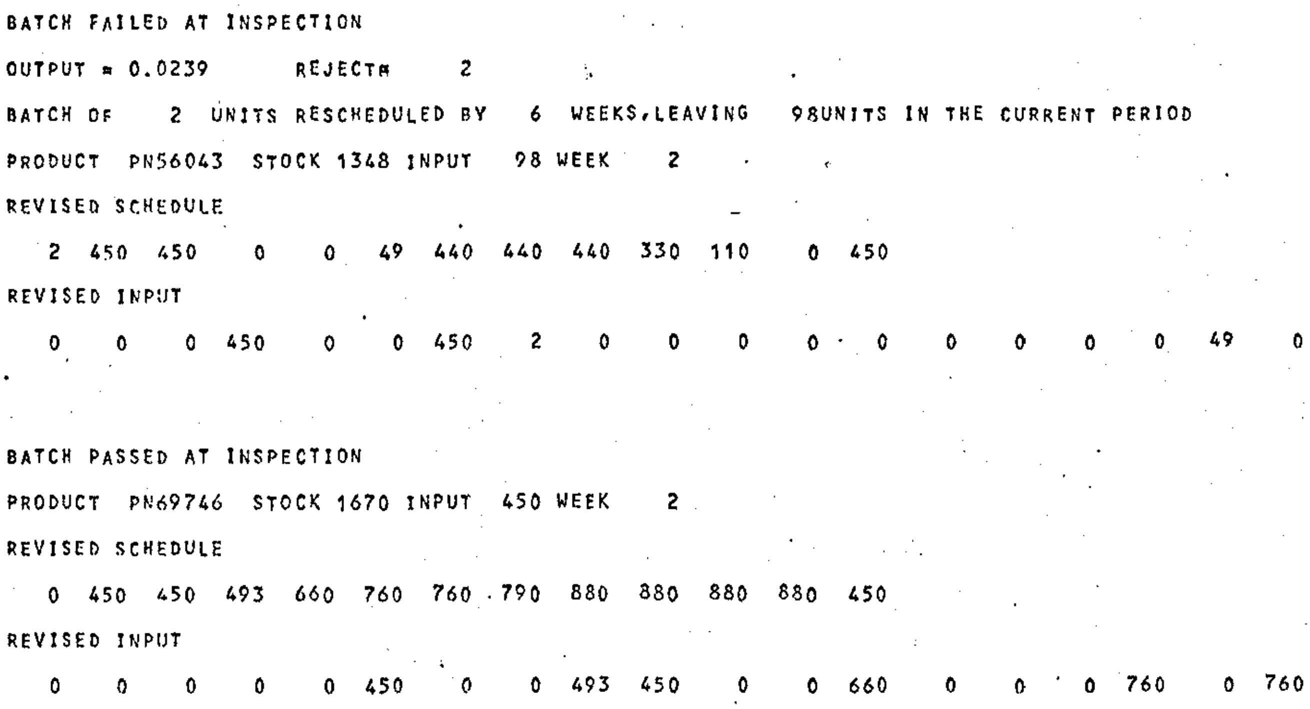
(iii) Number of weeks rescheduled.
Normal distribution as defined by AVGE10, CVARN10
(eg. average = 4.0; coefficient of variation = 0.3)

SUBROUTINE ARRIVAL



Summarised Flow Chart - Sub-routine Arrival

```
   ARRIVAL

   SUBROUTINE ARRIVAL(SCHEDULE,INPUT,IFILE,WEEK,IPRINT,AVGE9,CVARN9,A
  1VGE10,CVARN10,ISEED9,ISEED10,ISEED11,TABLE11,AFILE)
   REAL AFILE(25,3)
   INTEGER SCHEDULE(25,13),INPUT(25,52),IFILE(25,23),WEEK,TABLE11(2,2
  1),REJECT
   IF(IPRINT.GT.1)GO TO 350
   WRITE(2,400)
400 FORMAT(1H0,6X,'* * * *  ARRIVAL  * * * *'//)
350 DO 100 J=1,25
   IF(IFILE(J,11).NE.4)GO TO 100
   IF(INPUT(J,WEEK).EQ.0)GO TO 100

   SAMPLE FOR REJECTS .......PASS=2   FAIL=1

   IF(ISEED11.EQ.0)GO TO 8
   CALL HSAMPLE 2(ISEED11,NUMBER,TABLE11)
 15 GO TO (1,8),NUMBER

   DETERMINE REJECT PROPORTION.......GREATER THAN 5 PC REJECTS FULL BATCH

  1 IF(IPRINT.GT.2)GO TO 2
   WRITE(2,410)
410 FORMAT(1H0,6X,'BATCH FAILED AT INSPECTION')
  2 CALL NORMAL(AVGE9,OUTPUT,ISEED9,CVARN9)
   IF(OUTPUT.LT.0.05)GO TO 3
   REJECT=INPUT(J,WEEK)
   GO TO 4
  3 REJECT=NINT(FLOAT(INPUT(J,WEEK))*OUTPUT)
  4 IF(IPRINT.GT.2) GO TO 5
   WRITE(2,500)OUTPUT,REJECT
500 FORMAT(1H0,6X,'OUTPUT = ',F6.4,6X,'REJECT=',I6)
  5 CALL NORMAL(AVGE10,X,ISEED10,CVARN10)
   N=NINT(X)
   INPUT(J,WEEK+N)=INPUT(J,WEEK+N)+REJECT
   INPUT(J,WEEK)=INPUT(J,WEEK)-REJECT
   IF(IPRINT.GT.2)GO TO 9
   WRITE(2,7)REJECT,N,INPUT(J,WEEK)
  7 FORMAT(1H0,6X,'BATCH OF',I5,2X,'UNITS RESCHEDULED BY',I4,2X,'WEEKS
  1,LEAVING',I5,'UNITS IN THE CURRENT PERIOD')
   GO TO 9
  8 IF(IPRINT.GT.2)GO TO 9
   WRITE(2,420)
420 FORMAT(1H0,6X,'BATCH PASSED AT INSPECTION')
  9 IFILE(J,16)=IFILE(J,16)+INPUT(J,WEEK)
   IF(IPRINT.GT.2)GO TO 10
   WRITE(2,200)AFILE(J,1),IFILE(J,16),INPUT(J,WEEK),WEEK
200 FORMAT(1H0,6X,'PRODUCT',2X,A8,' STOCK',I5,' INPUT',I5,' WEEK',I5)
 10 DO 50 K=1,13
   IF(INPUT(J,WEEK).GE.SCHEDULE(J,K))GO TO 20
   SCHEDULE(J,K)=SCHEDULE(J,K)-INPUT(J,WEEK)
   INPUT(J,WEEK)=0
   GO TO 60
 20 INPUT(J,WEEK)=INPUT(J,WEEK)-SCHEDULE(J,K)
   SCHEDULE(J,K)=0
 50 CONTINUE
 60 IF(IPRINT.GT.3)GO TO 100
   WRITE(2,300)(SCHEDULE(J,K),K=1,13)
300 FORMAT(1H0,6X,'REVISED SCHEDULE'//6X,13I5)
   WRITE(2,600)(INPUT(J,K),K=1,20)
600 FORMAT(1H0,6X,'REVISED INPUT'//6X,20I5///)
100 CONTINUE
   RETURN
   END
```



```
BATCH FAILED AT INSPECTION
OUTPUT = 0.0239       REJECT=     2
BATCH OF    2  UNITS RESCHEDULED BY   6  WEEKS,LEAVING    98UNITS IN THE CURRENT PERIOD
PRODUCT  PN56043  STOCK 1348 INPUT   98 WEEK    2
REVISED SCHEDULE
   2  450  450    0    0   49  440  440  440  330  110    0  450
REVISED INPUT
   0    0    0  450    0    0  450    2    0    0    0    0    0    0    0    0    0   49    0

BATCH PASSED AT INSPECTION
PRODUCT  PN69746  STOCK 1670 INPUT  450 WEEK    2
REVISED SCHEDULE
   0  450  450  493  660  760  760  790  880  880  880  880  450
REVISED INPUT
   0    0    0    0    0  450    0    0  493  450    0    0  660    0    0    0  760    0  760
```

Sample Receiving Report

B5 - SUBROUTINE DELPERF

Subroutine DELPERF extracts the base data for delivery performance to be calculated and summarises the statistics in histogram form.

Delivery performance statistics are held at three levels; equipment, item and order. Each delivery transacted in subroutine DESPATCH will cause a delivery performance assessment to be made. The data required for delivery performance calculation is the quantity despatched and the delay in weeks compared with the original due date. The despatch point is taken as the movement from test to the commercial warehouse, or despatch department. Negative delays represent early deliveries.

Each histogram will accommodate delays of up to 19 weeks and early deliveries of up to 8 weeks in weekly increments. Deviations in excess of these limits are held in two further categories; 20 weeks or more overdue and 9 weeks or more early.

a) Equipments

Equipment level records are held separately for each product to enable comparison to be made between products subject to different influences (egs. order mix trends, stock policies, lead times). As each delivery is made, the appropriate delay interval is augmented by the quantity of equipments despatched.

b) Items

The item level record represents the performance achieved in despatching a complete order line against each due date. Thus, an item containing a quantity of equipments phased over five weeks will be analysed as five independent deliveries. Each completed delivery will increment the interval representing the final delivery by a quantity of one. Item level records are held for each equipment type.

c) Orders

Order statistics are maintained separately for "part shipment" and "no part shipment" orders. For "part shipment" orders, a completed delivery is acknowledged when all of the order line items for a particular week due have been despatched. "No part shipment" orders will not be acknowledged as despatched until the final delivery batch regardless of delivery phasing.

The order performance logic performs a second important function. When the delivery criteria have been met and a delivery initiated, the equipments will be removed from "in despatch" status in the orders placed file (OPFILE) signifying shipment to the customer. Until the final delivery against an order (or delivery week in the case of "part shipment") has been made, the equipments already despatched will remain in stock in the finished goods warehouse.

The magnitude of this "marshalled" stock is a function of the delivery performance and the degree of part shipment permissible.

The subroutine DELPERF is activated each time a delivery is registered in subroutine DESPATCH. The delay is determined by comparing the clock week against the week due held in the order book (ORDBK), allowing for overdue orders which have been relocated in ORDBK for reasons of file economy. The delay is truncated to the range -20 to +9 inclusive and modified to index a file with a range of 1 to 30.

The equipment performance is registered by augmenting the file EQUPERF for the appropriate equipment type and calculated delay by the quantity despatched. Each quantity delivered will initiate a check against the orders placed file (OPFILE).

If the quantity in "despatch" status is equal to the total item quantity for the delivery week, the histogram representing item performance, ITEMPERF, will have the interval for the appropriate equipment and delay incremented by a quantity of one. Since the performance is measured by order line item and week due, the delay is identical to that used to determine equipment performance.

Failure to achieve a complete item delivery will result in an exit from the subroutine. A completed item will move into the order performance segments.

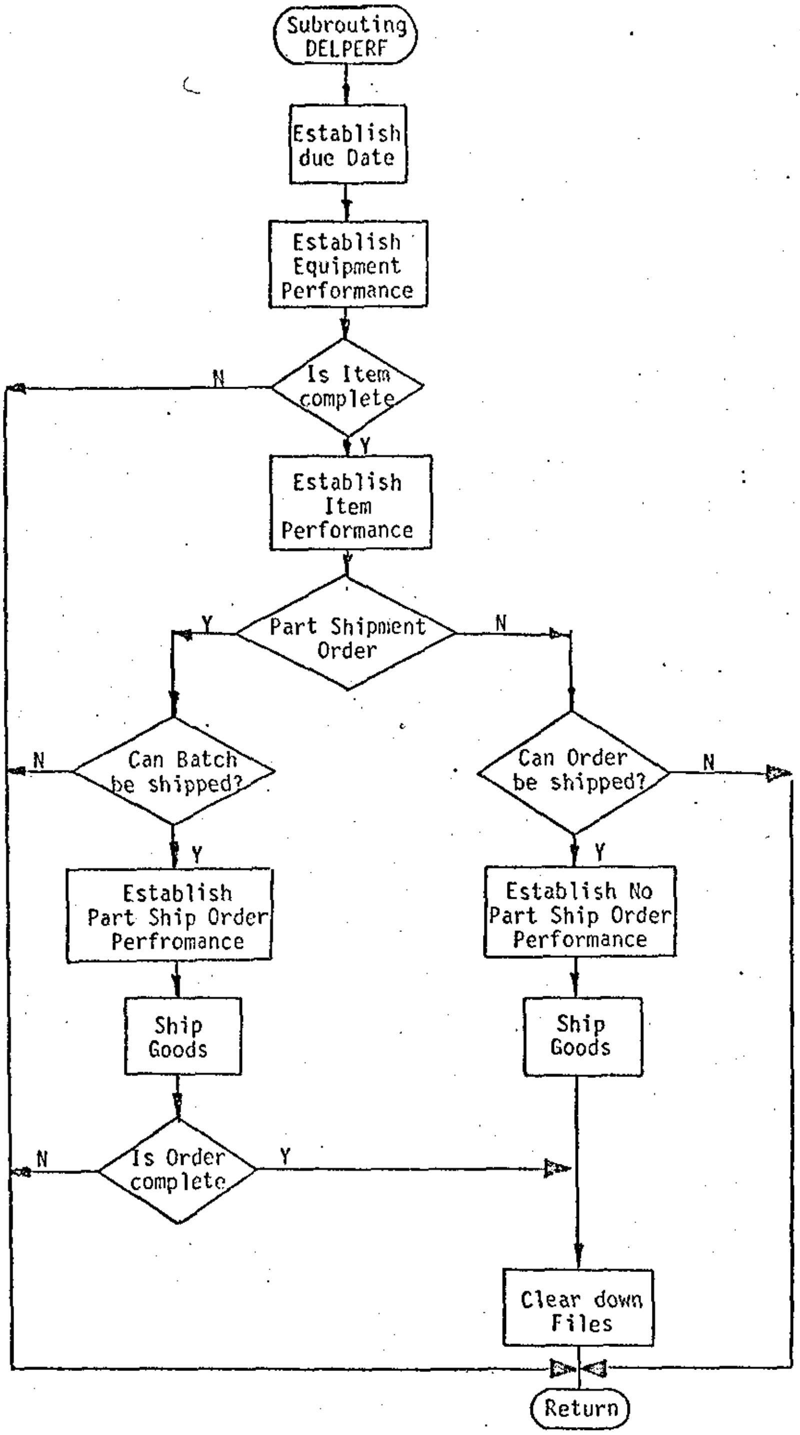
Orders which have been designated "part shipment permissible" may be shipped when all items promised against a common due date have been moved to despatch. In practice there are many different rules for part shipment, ranging from monthly deliveries, or to meeting certain transport line schedules.

The essence of part shipment is whether the customer will pay for the goods he receives, which is often related to the usefulness of the consignment. Consignment and subsequent invoicing with little chance of receiving payment moves the financial burden from commercial stock (valued at factory costs) to debtors (at sales invoice value). The compromise adopted by the model, of shipping complete weeks worth of equipment across all order lines, is reasonable in terms of customer acceptability.

The "part shipment" performance is established by searching OPFILE for all order lines with the same due date as the last despatched quantity. If all items with the common due date are in despatch, a shipment may be made and the performance statistics incremented accordingly. The delay is again identical to that used to determine equipment and item performance.

"No part shipment" performance follows a similar logic to "part shipment" performance, except that the full order is checked for "despatch" status. If the order is completed the delay is then calculated, being the difference between the calendar week at the longest due date on the order.

For "part shipment" orders, a shipment will cause the ORDBK record for the constituent products to be cleared. Shipment of a "no part shipment" order, and the final shipment of a part shipment order, will cause both the applicable ORDBK and OPFILE records to be cleared.



Summarised Flow Chart - Sub-routine Delperf

```
C
C      DELPERF
C
      SUBROUTINE DELPERF(ORDBK,OPFILE,PROD,KEYNO,ITEM,DUE,WEEK,M,N,IPRIN
     1T,EQUPERF,ITEMPERF,ORDPERF,QTY)
      INTEGER ORDBK( 5,52,20,5),OPFILE(125,5,5,10),PROD,ORDNO,ITEM,DUE,W
     1EEK,EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(2,30),DELAY,QTY
      IF(IPRINT.GT.1)GO TO 5
      WRITE(2,7)
    7 FORMAT(1H0,6X,'* * * *  DELPERF  * * * *'//)
    5 ORDNO=ORDBK(PROD,DUE,N,1)
      L=DUE
C
C     DETERMINE DUE DATE
C
      IF(ORDBK(PROD,DUE,N,4).EQ.0)GO TO 10
      DELAY=WEEK+52-DUE
      GO TO 20
   10 DELAY=WEEK-DUE
C
C     DETERMINE EQUIPMENT PERFORMANCE
C
   20 IDELAY=DELAY
      IF(DELAY.LE.20)GO TO 30
      IDELAY=20
   30 IF(DELAY.GE.-9)GO TO 40
      IDELAY=-9
   40 IDELAY=21-IDELAY
      EQUPERF(PROD,IDELAY)=EQUPERF(PROD,IDELAY)+QTY
      IF(IPRINT.GT.2)GO TO 45
      WRITE(2,43)PROD,DELAY,ORDNO,ITEM,OPFILE(KEYNO,ITEM,M,3),QTY
   43 FORMAT(1H0,6X,'EQUIPMENT DELIVERY PERFORMANCE FOR PRODUCT NO.',I6,
     12X,'DELAY = ',I6/6X,'ORDER',I5,2X,'ITEM',I5,2X,'DUE'
     2,I5,2X,'QTY',I5,2X,'DESPATCHED')
C
C     DETERMINE ITEM PERFORMANCE
C
   45 IF(OPFILE(KEYNO,ITEM,M,2).NE.OPFILE(KEYNO,ITEM,M,9))GO TO 100
      ITEMPERF(PROD,IDELAY)=ITEMPERF(PROD,IDELAY)+1
      IF(IPRINT.GT.2)GO TO 49
      WRITE(2,47)PROD,DELAY
   47 FORMAT(1H0,6X,'ITEM DELIVERY PERFORMANCE FOR PRODUCT NO.',I6,2X,'D
     1ELAY = ',I6)
C
C     CHECK FOR PART SHIPMENT
C
   49 IF(ORDBK(PROD,DUE,N,5).EQ.2)GO TO 60
C
C     DETERMINE ORDER PERFORMANCE - PART SHIP
C
      IDUE=OPFILE(KEYNO,ITEM,M,3)
      DO 50 I=1,5
      DO 50 J=1,5
      IF(OPFILE(KEYNO,I,J,3).NE.IDUE)GO TO 50
      IF(OPFILE(KEYNO,I,J,2).NE.OPFILE(KEYNO,I,J,9))GO TO 100
   50 CONTINUE
      ORDPERF(1,IDELAY)=ORDPERF(1,IDELAY)+1
      IF(IPRINT.GT.2)GO TO 56
      WRITE(2,55)DELAY
   55 FORMAT(1H0,6X,'ORDER PERFORMANCE (PART SHIP) , DELAY =',I6)
C
C     SHIP GOODS
C
```

```
      WRITE(2,200)OPFILE(KEYNO,ITEM,M,10),IDUE
  200 FORMAT(1H0,6X,'ORDER NO.',I6,2X,'DUE WEEK',I6,2X,'DESPATCHED')
   56 DO 57 I=1,5
      DO 57 J=1,5
      IF(OPFILE(KEYNO,I,J,3).NE.IDUE)GO TO 57
      OPFILE(KEYNO,I,J,9)=0
   57 CONTINUE
C
C     CHECK IF ORDER IS COMPLETE
C
      IQTY=0
      DO 59 I=1,5
      DO 59 J=1,5
      DO 58 K=4,9
   58 IQTY=IQTY+OPFILE(KEYNO,I,J,K)
      IF(IQTY.NE.0)GO TO 100
   59 CONTINUE
      GO TO 90
C
C     DETERMINE ORDER PERFORMANCE - NO PART SHIP
C
   60 IMAX=0
      DO 70 I=1,5
      DO 70 J=1,5
      IF(OPFILE(KEYNO,I,J,2).NE.OPFILE(KEYNO,I,J,9))GO TO 100
      IF(OPFILE(KEYNO,I,J,3).LE.IMAX)GO TO 70
      IMAX=OPFILE(KEYNO,I,J,3)
   70 CONTINUE
      IDELAY=DELAY+OPFILE(KEYNO,ITEM,M,3)-IMAX
      IF(IDELAY.LE.20)GO TO 73
      IDELAY=20
   73 IF(IDELAY.GE.-9)GO TO 77
      IDELAY=-9
   77 IDELAY=21-IDELAY
      ORDPERF(2,IDELAY)=ORDPERF(2,IDELAY)+1
      IF(IPRINT.GT.2)GO TO 90
      WRITE(2,80)DELAY
   80 FORMAT(1H0,6X,'ORDER PERFORMANCE (NO PART SHIP) , DELAY =',I6)
      WRITE(2,300)OPFILE(KEYNO,1,1,10)
  300 FORMAT(1H0,6X,'ORDER NO.',I6,2X,'DESPATCHED')
C
C     CLEAR DOWN OPFILE AND ORDBK
C
   90 DO 110 I=1,5
      DO 110 J=1,5
      DO 110 K=1,10
  110 OPFILE(KEYNO,I,J,K)=0
      DO 120 IPROD=1,5
      DO 120 L=1,52
  105 DO 120 K=1,20
      IF(ORDBK(IPROD,L,K,1).NE.ORDNO) GOTO 120
      DO 120 I=1,5
      ORDBK(IPROD,L,K,I)=0
  120 CONTINUE
  100 RETURN
      END
```

B6 - SUBROUTINE DESPATCH

Equipments which have been tested are moved to the warehouse, which is regarded as commercial stock, by subroutine DESPATCH. Two alternative priority rules which determine the sequence of processing are available; first-in-first-out or by due date.

Equipments for despatch are contained in the file TESTQ. Selection of the due date priority rule will cause TESTQ to be sorted into due date sequence prior to processing. Bypassing the sort segment will result in first-in-first-out logic.

The size of the delivery batch is determined by the delivery plan contained in file DELPLAN for the appropriate period, assuming that sufficient equipments are eligible for delivery. If the delivery capacity is under-utilised due to insufficient eligible equipments in the queue, the excess capacity is considered lost and cannot be carried forward into future periods.

Items are selected sequentially from TESTQ, and the appropriate OPFILE and ORDBK records located. Equipments are not eligible for delivery within a minimum period of three days of entering the test queue, recognising a realistic expedited throughput time. Each item selected will have the whole or part of the batch quantity despatched, this quantity being dependent upon the balance of the delivery plan available.

Successful despatch of a quantity will cause a number of files to be updated, reflecting the changed status of the order.

a) TESTQ will have the quantity balance reduced by the quantity despatched.

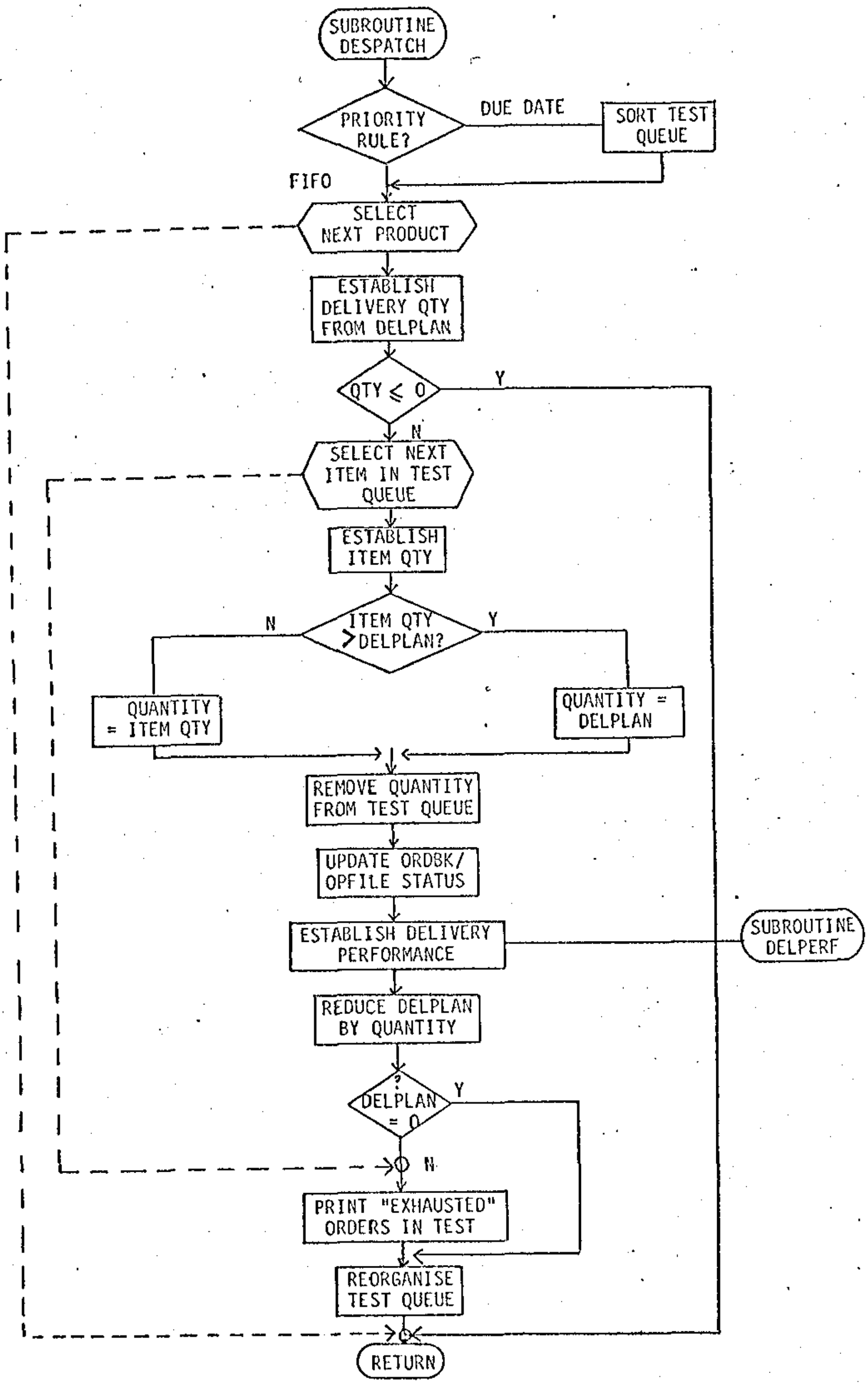
b) OPFILE will show the despatched quantity as having moved from TEST to DESPATCH status.

c) ORDBK will show a reduction in the outstanding balance by the quantity despatched.

d) TOTAL will show a reduction in total load for non-overdue orders.

e) The balance of the delivery plan, DELPLAN, for the appropriate week will be reduced by the despatched quantity.

If a finite delivery plan balance remains the next item will be selected from TESTQ. If TESTQ has no further eligible orders, or the delivery plan has been exhausted, TESTQ will be reset by removing fully despatched items and consolidating the balance of the file.



Summarised Flow Chart -. Subroutine Despatch

```
C
C       DESPATCH
C
      SUBROUTINE DESPATCH(TESTQ,OPFILE,WEEK,DELPLAN,IFILE,ORDBK,EQUPERF,
     1 ITEMPERF,ORDPERF,TOTAL,IPRINT,AFILE,REFWEEK,ISORT,DIAGFILE,RUNTIM
     2E)
      REAL AFILE(25,3)
      INTEGER TESTQ(5,50,5),OPFILE(125,5,5,10),WEEK,DELPLAN( 5,52),IFILE
     1(25,23),ORDBK( 5,52,20,5),EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(2
     2,30),TOTAL(5,52),REFWEEK,QTY,DIAGFILE(10,2),RUNTIME
      IF(IPRINT.GT.1)GO TO 1
      WRITE(2,2)
    2 FORMAT(1H0,6X,'* * * *  DESPATCH  * * * *'//)
C
C       SORT TEST QUEUE
C
    1 IF (ISORT.EQ.0)GO TO 4
      DO 3 I=1,5
      DO 3 J=1,49
      DO 3 K=J+1,50
      IF(TESTQ(I,K,4).EQ.0)GO TO 3
      IF(TESTQ(I,J,3).LE.TESTQ(I,K,3))GO TO 3
      DO 3 L=1,5
      M=TESTQ(I,J,L)
      TESTQ(I,J,L)=TESTQ(I,K,L)
      TESTQ(I,K,L)=M
    3 CONTINUE
    4 DO 200 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 200
      IF(DELPLAN(I,WEEK).LE.0)GO TO 200
      IF(IPRINT.GT.2)GO TO 5
      WRITE(2,520)AFILE(I,1),DELPLAN(I,WEEK)
  520 FORMAT(1H0,6X,'DELIVERY BATCH FOR ',A8,' = ',I5)
    5 DO 60 J=1,50
      IF(TESTQ(I,J,5).GT.0)GO TO 60
      IF(TESTQ(I,J,4).EQ.0)GO TO 60
   10 JA=TESTQ(I,J,1)
      JB=TESTQ(I,J,2)
      JC=TESTQ(I,J,3)
      DO 15 KEYNO=1,125
      IF(OPFILE(KEYNO,JB,1,10).EQ.JA)GO TO 17
   15 CONTINUE
      GO TO 25
   17 DO 20 M=1,5
      IF(OPFILE(KEYNO,JB,M,3).EQ.JC)GO TO 31
   20 CONTINUE
   25 IF(IPRINT.GT.5)GO TO 60
      WRITE(2,30)JA,JB,JC,OPFILE(KEYNO,JB,M,3),REFWEEK
   30 FORMAT(1H0,6X,' INCOMPATIBLE DATA IN OPFILE FOR ORDER NO,',I4,'ITE
     1M NO.',I4,'DUE WEEK',I4/6X,'ACTUAL WEEK ',I4,6X,'REFWEEK ',I4)
      IPRINT=1
      DO 29 IZ=1,10
   29 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
      GO TO 60
   31 NOD=0
      IF(JC.GT.REFWEEK)GO TO 32
      NOD=52
   32 JD=JC-REFWEEK+NOD
      DO 33 N=1,20
      IF(ORDBK(I,JD,N,1).NE.JA)GO TO 33
      IF(ORDBK(I,JD,N,2).EQ.JB)GO TO 40
   33 CONTINUE
```

```
      IF(IPRINT.GT.5)GO TO 60
      WRITE(2,35)JA,JD,AFILE(I,1),JC
   35 FORMAT(1H0,6X,'INCOMPATIBLE DATA IN ORDER BOOK FOR ORDER NUMBER',I
     16,2X,'DUE WEEK',I6,2X,'FOR PRODUCT NUMBER',A8,2X,'ACTUAL WEEK',I6)
      IPRINT=1
      DO 37 IZ=1,10
   37 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
      GO TO 60
   40 IF(TESTQ(I,J,4).LT.DELPLAN(I,WEEK))GO TO 45
      QTY= DELPLAN(I,WEEK)
      GO TO 50
   45 QTY = TESTQ(I,J,4)
   50 TESTQ(I,J,4)=TESTQ(I,J,4)-QTY
      IFILE(I,19)=IFILE(I,19)-QTY
      OPFILE(KEYNO,JB,M,9)=OPFILE(KEYNO,JB,M,9)+QTY
      OPFILE(KEYNO,JB,M,8)=OPFILE(KEYNO,JB,M,8)-QTY
      ORDBK(I,JD,N,3)=ORDBK(I,JD,N,3)-QTY
      IF(ORDBK(I,JD,N,4).EQ.1)GO TO 55
      TOTAL(I,JD)=TOTAL(I,JD)-QTY
   55 CALL DELPERF(ORDBK,OPFILE,I,KEYNO,JB,JD,WEEK,M,N,IPRINT,EQUPERF,IT
     1EMPERF,ORDPERF,QTY)
      DELPLAN(I,WEEK)=DELPLAN(I,WEEK)-QTY
      IF(DELPLAN(I,WEEK).EQ.0)GO TO 150
   60 CONTINUE
  500 IF(IPRINT.GT.2)GO TO 150
      WRITE(2,510)AFILE(I,1)
  510 FORMAT(1H0,6X,'EXHAUSTED ORDERS IN TEST FOR PRODUCT',2X,A8)
  150 DO 160 MM=1,49
      IF(TESTQ(I,MM,4).GT.0)GO TO 160
      DO 153 M=(MM+1),50
      IF(TESTQ(I,M,4).GT.0)GO TO 155
  153 CONTINUE
      GO TO 200
  155 DO 158 N=1,5
       TESTQ(I,MM,N)=TESTQ(I,M,N)
      TESTQ(I,M,N)=0
  158 CONTINUE
  160 CONTINUE
  200 CONTINUE
      IF(IPRINT.GT.3)GO TO 250
      CALL TQPRINT(TESTQ,WEEK,AFILE,REFWEEK)
  250 RETURN
      END
```

B7 - SUBROUTINE EBQ

Sub-assembly programmes are based on forecast quarterly demand and use a simple "Economic Batch Quantity" formula to determine the size and frequency of batches within the quarter.

The total quarterly demand for the sub-assembly is derived from the file REQFILE, following which the number of batches in the quarter is calculated. The number of batches per annum is derived from the standard EBQ formula.

$$N = \sqrt{\frac{rC_1}{2C_3}}$$

where r = demand/annum
C_1= holding cost/unit
C_3= set up cost

If q is the quarterly demand and C' is the unit value, it is assumed that the interest rate is 10% and the set up cost is £10.* Thus

$$N = \sqrt{\frac{4q \times 0.1 \times C'}{2 \times 10}}$$

$$= \sqrt{0.02qC'}$$

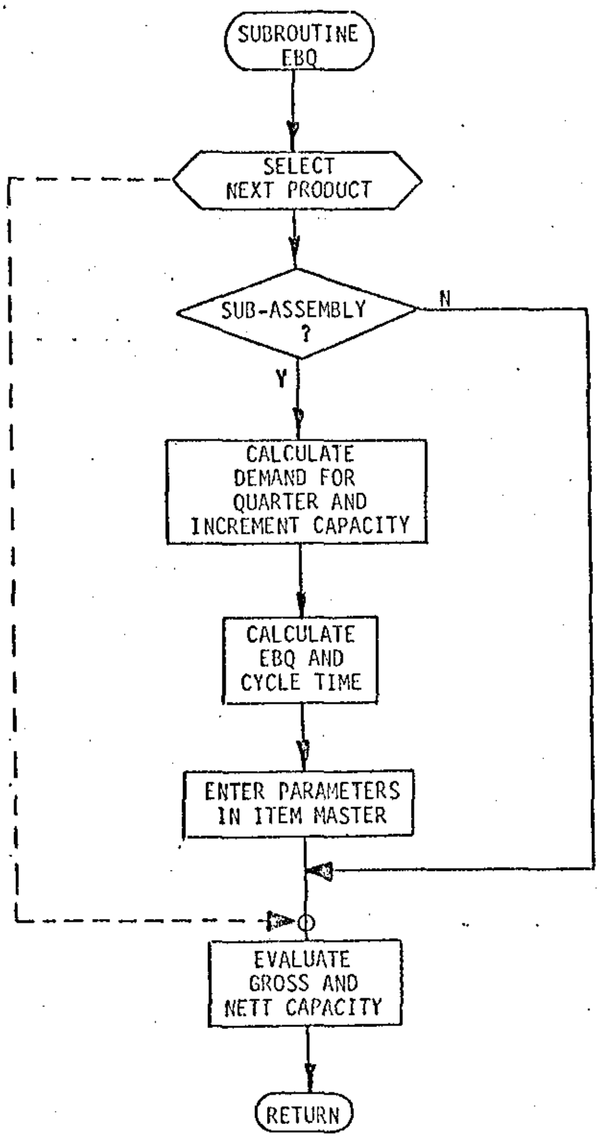
The unit value is derived from IFILE by summing the material and labour value. The number of batches per quarter is thus

$$n = 1/4 \sqrt{0.02qC'}$$

Since it is required to phase the batches evenly throughout the thirteen week period, only integer values of1, 2, 3, 4, 6 or 13 are permissible as the number of batches (n').

The nominal "economic batch quantity" is the quarterly demand divided by n'. The cycle time between batches is $13/n'$. Both parameters are retained in IFILE for subsequent use in the sub-assembly programme SUBPROG.

* Note: Values currently used in practice.


SUBROUTINE EBQ
SELECT NEXT PRODUCT
SUB-ASSEMBLY ?
N
Y
CALCULATE DEMAND FOR QUARTER AND INCREMENT CAPACITY
CALCULATE EBQ AND CYCLE TIME
ENTER PARAMETERS IN ITEM MASTER
EVALUATE GROSS AND NETT CAPACITY
RETURN

Summarised Flow Chart - Subroutine EBQ

```
C
C      EBQ
C
      SUBROUTINE EBQ(REQFILE,IFILE,IPRINT,AFILE,CAPACITY,UTIL)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23),REQFILE(25,52),WEEK,DEMAND,CAPACITY
      IC=0
      DO 30 I=1,25
      IF(IFILE(I,11).EQ.2.OR.IFILE(I,11).EQ.3)GO TO 5
      GO TO 30
    5 DEMAND=0
      DO 10 J=1,13
      IF(IFILE(I,15).EQ.1)GO TO 10
      IC=IC+REQFILE(I,J)
   10 DEMAND=DEMAND+REQFILE(I,J)
      N=NINT(SQRT(DEMAND*(IFILE(I,13)+IFILE(I,14))*0.02)/4.0)
      IF(N.GT.0)GO TO 15
      N=1
   15 IF(N.LE.4)GO TO 20
      IF(N.GT.6)GO TO 17
      N=6
      GO TO 20
   17 N=13
   20 IFILE(I,21)=DEMAND/N
      IFILE(I,22)=NINT(13.0/N)
      IF(IPRINT.GT.4)GO TO 30
      WRITE(2,50)AFILE(I,1),IFILE(I,21),IFILE(I,22)
   50 FORMAT(1H0,6X,'SUB-ASSY NO.  ',A8,6X,'EBQ',I5,6X,'CYCLE TIME',I5)
   30 CONTINUE
      CAPACITY=IFIX(IC/UTIL)
      IF(IPRINT.GT.3)GO TO 70
      WRITE(2,60)IC,UTIL,CAPACITY
   60 FORMAT(1H0,6X,'P.C.B. CAPACITY . . . . CAPACITY REQD =',I6/27X,
     1'UTILISATION =',F4.2/27X,'GROSS CAPACITY =',I6)
   70 RETURN
      END
```

B8 - SUBROUTINE EXPEDITE

x

Under normal conditions, the assumption has been made that material will arrive from the supplier according to the call-off schedule modified by a probabilistic element within the subroutine RECEIVE. Within the logic of the model, the assumption is maintained provided there is a finite level of free stock to service production requirements. If, however, the level of free stock falls below zero, the item concerned is considered to change from the normal "unexpedited" mode to "expedite" mode.

The prime objective of a material expeditor, or "progress chaser", is to obtain shortage items at the earliest possible opportunity. This success will depend, for example, upon whether or not the item can be procured through secondary sources, the current load on the supplier, the notice given to the supplier to respond and any other items that could possibly be "unexpedited" to release capacity for the urgent item.

In practice there are three levels of expediting:

a) the item is a "line hold", which signifies that a batch of material with a known (or subsequently discovered) shortage is in work in progress and is a probable line stopper.

b) the item is a "shortage to allocation", which implies that free stock has become negative.

c) the item is in arrears to the supplier call-off schedule.

All three conditions may exist concurrently.

The line hold situation is considered in the model to be covered by the shortage to allocation activity. Any item which becomes a line hold but was not identified as a shortage to allocation previously would normally be as a result of incorrect material being issued, a stock record error, a bill of material error, a late engineering change or a scrap problem.

Noneof these eventualities has specifically been addressed by the model.

The arrears to schedule situation has been considered in the establishment of an input profile within subroutine INPUT.

Subroutine EXPEDITE, therefore, considers only the shortage to allocation, or negative free stock situation.

The stock file record within the item master file, IFILE, is scanned at the start of a weekly cycle. The existence of negative free stock for a bought-out (level 4) part, will cause the expediting sequences to be invoked.

The quantity short, which is calculated as allocated stock less physical stock, is compared with the forward input schedule.

When an input batch has been identified, file EXFILE is interrogated to ascertain whether the batch has been subject to previous expediting activity. The assumption is made that a batch may be expedited once only.

If the batch is not already subject to expediting action, the next step is to determine the amount of time that the batch can be pulled forward. Factual information upon which to base an alogorithm is highly complex, depending on such factors as the component type (proprietory item "ex stock" or made to order), the imminence of the next schedule receipt, the existence of a schedule arrear, the existence of a supplier order, the expeditor/supplier relationship and many other considerations.

The objective of the model was to arrive at a reasonable and quantifiable algorithm which could be simply applied. The first stage is to sample from the histogram defined in the table below.

Expedite Histogram

Value	1	2	3	4	5	6	7
Frequency	5	10	15	20	25	15	10

The value generated is the "degree of success" of the expediting effort.

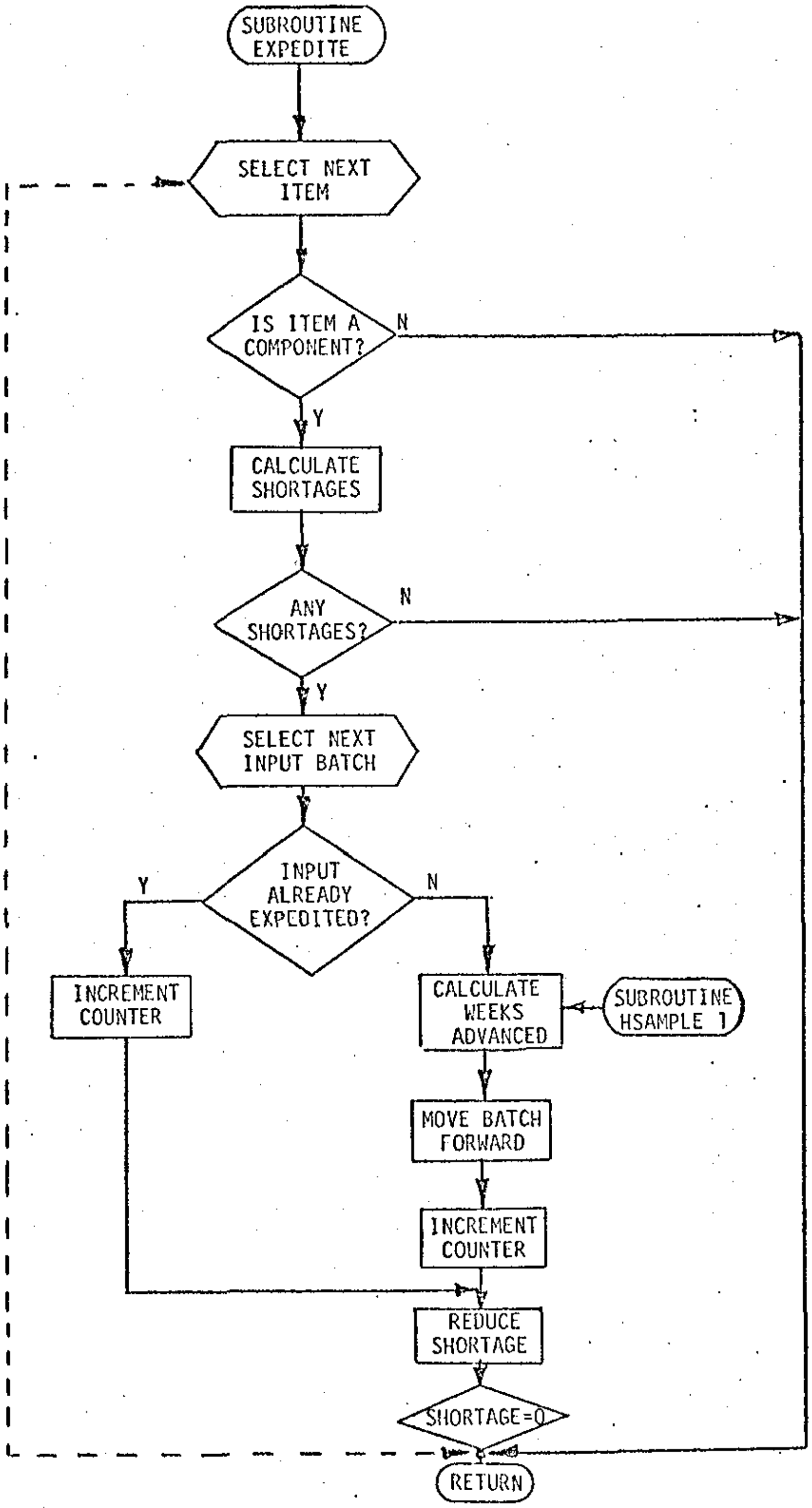
The time remaining before the next batch is due to arrive is divided by the above factor to determine the number of weeks pulled forward. For example, if the current week is 4 and the next batch is due week 8, the time remaining is 4 weeks. If the value sampled is 2, the number of weeks pulled forward is 4/2, i.e. 2 weeks.

The input schedule is then modified to reflect the pull forward action and file EXFILE is correspondingly tagged to inhibit any further activity on the expedite batch.

If the first batch is insufficient to satisfy the shortage, further batches are sought and actioned following the same logic.

If no input batch can be identified for the next 13 weeks, the assumption is made that any item can be procured on an eight week lead time. This is a prime assumption, since no account is taken of the type of commodity and the degree of urgency, but is not unrealistic as an average (assuming that the item is not relating to a new product.)

Where expediting action is required and a batch (or batches) has already been subject to a previous expedite, the value in EXFILE for the appropriate week is incremented by one. Thus, the modeller may access the number of times that a part is expedited as part of the analysis of simulation results.



Summarised Flow Chart - Sub-routine Expedite

```
C
C        EXPEDITE
C
       SUBROUTINE EXPEDITE(IFILE,WEEK,INPUT,ISEED3,TABLE3,IPRINT,EXFILE,A
      1FILE)
       REAL AFILE(25,3)
       INTEGER IFILE(25,23),INPUT(25,52),SHORT,WEEK,TABLE3(7,2),EXFILE(25
      1,52)
       IF(ISEED3.EQ.0)GO TO 250
       IF(IPRINT.GT.1)GO TO 10
       WRITE(2,20)
    20 FORMAT(1H0,6X,'* * * *  EXPEDITE  * * * *'//)
    10 DO 100 I=1,25
       IF(IFILE(I,11).NE.4)GO TO 100
       SHORT=IFILE(I,17)-IFILE(I,16)
       IF(SHORT.LE.0)GO TO 100
C
C       FIND NEXT BATCH INPUT
C
       DO 50 J=WEEK,WEEK+13
       IF(INPUT(I,J).EQ.0)GO TO 50
       IF(EXFILE(I,J).EQ.0)GO TO 30
       EXFILE(I,J)=EXFILE(I,J)+1
       IVAL=INPUT(I,J)
       IF(IPRINT.GT.2)GO TO 40
       WRITE(2,200)AFILE(I,1),J
   200 FORMAT(1H0,6X,'BATCH FOR PRODUCT',2X,A8,6X,'DUE WEEK',I5,6X,'ALREA
      1DY EXPEDITED')
       GO TO 40
    30 CALL HSAMPLE 1(ISEED3,NUMBER,TABLE3)
       K=J-NINT(FLOAT(J-WEEK)/NUMBER)
       IF(IPRINT.GT.2)GO TO 32
       WRITE(2,150)AFILE(I,1),J,SHORT,INPUT(I,J),NUMBER,K
   150 FORMAT(1H0,6X,'I=',A8,3X,'J=',I4,3X,'SHORT=',I4,3X,'INPUT(I,J)=',I
      14,3X,'NUMBER=',I4,3X,'K=',I4)
    32 IF(K.GT.0)GO TO 35
       K=1
    35 IVAL=INPUT(I,J)
       INPUT(I,K)=INPUT(I,K)+IVAL
       EXFILE(I,K)=EXFILE(I,K)+1
       INPUT(I,J)=INPUT(I,J)-IVAL
    40 SHORT=SHORT-IVAL
       IF(SHORT.LE.0)GO TO 100
    50 CONTINUE
   100 CONTINUE
   250 RETURN
       END
```

B9 - SUBROUTINE EXPLODE

The parts explosion, or Material Requirements Planning logic, is contained within the subroutine EXPLODE.

The subroutine has access to the basic relationship and stock status data held within the item master file, IFILE. The prime input data is the requirements file, REQFILE, for each part.

To ensure that all requirements have been registered for a part before subsequent explosion takes place, a "low level code" is held in the item master file indicating the lowest level that the part is to be found in any product. Level 1 denotes the top level product, levels 2 and 3 are intermediate sub-assemblies and level 4 denotes purchased parts.

The requirements planning process takes place on a level by level basis, starting at level 1.

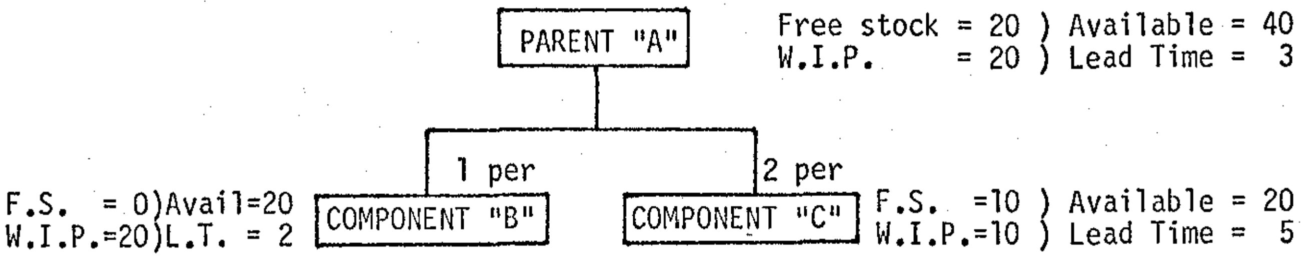
For each item, the free stock is calculated and a net plan derived from the subroutine NETTING. Since the requirements data for a top level product (level 1) is the off-line plan and does not include finished equipment stock, the available stock is taken to be work-in-progress only.

Following the netting process, the resultant plan is off-set by the lead time for "in house" manufactured items. Any "overspill" is held in the first period of the plan.

Each component part of the assembly is then found by reference to the item master record and the requirements file for the component is increased by the generated requirement extended by the quantity per.

The above logic is a reasonable approximation to that incorporated into the existing computer system, with the exception that any netting of intermediate sub-assemblies must be manually input to the system as net + or - value.

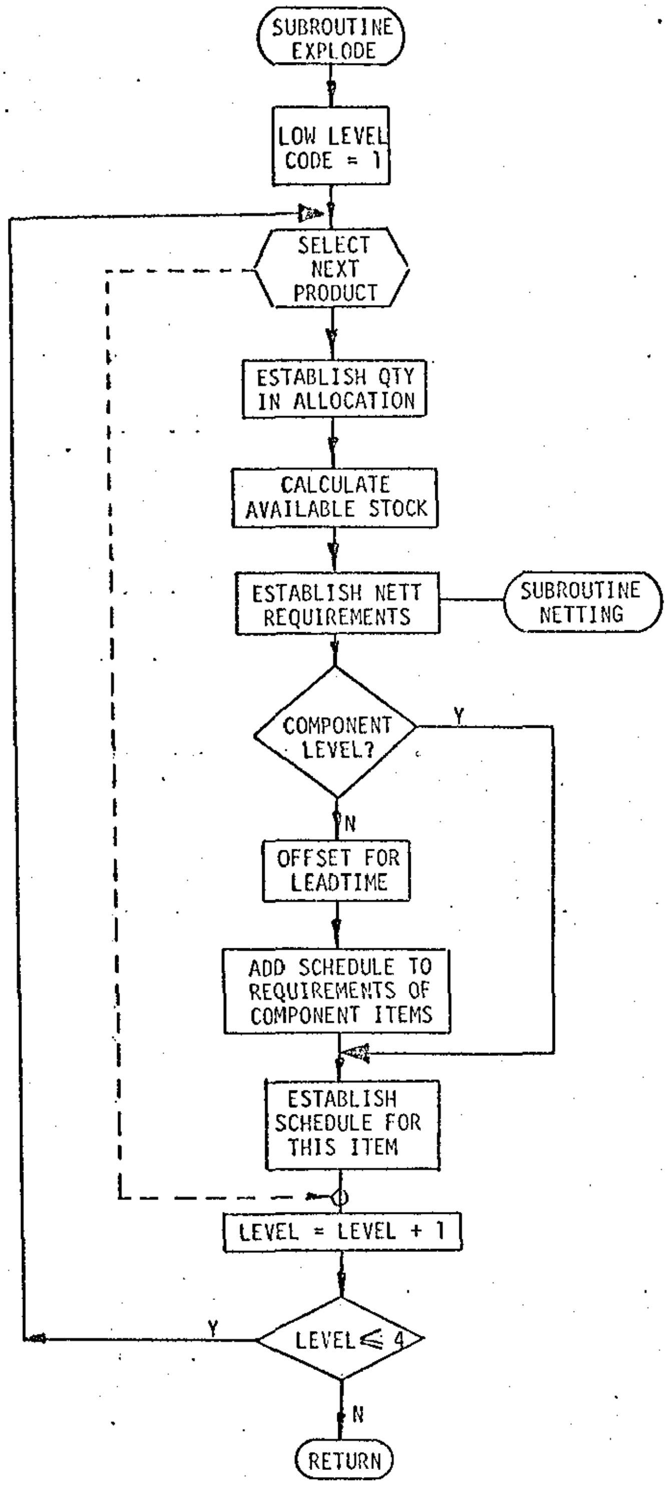
An example of the requirements planning logic is shown below.


PARENT "A"
Free stock = 20) Available = 40
W.I.P. = 20) Lead Time = 3
1 per
2 per
F.S. = 0)Avail=20
W.I.P.=20)L.T. = 2
COMPONENT "B"
COMPONENT "C"
F.S. =10) Available = 20
W.I.P.=10) Lead Time = 5

	PERIOD									
PART "A"	1	2	3	4	5	6	7	8	9	10
REQUIREMENTS	10	10	10	10	10	10	10	10	10	10
NET PLAN	-	-	-	-	10	10	10	10	10	10
LEAD TIME OFFSET	-	10	10	10	10	10	10	10	10	10

	PERIOD									
PART "B"	1	2	3	4	5	6	7	8	9	10
REQUIREMENTS	-	10	10	10	10	10	10	10	10	10
NET PLAN	-	-	-	10	10	10	10	10	10	10
LEAD TIME OFFSET	-	10	10	10	10	10	10	10	10	10

	PERIOD									
PART "C"	1	2	3	4	5	6	7	8	9	10
REQUIREMENTS	-	20	20	20	20	20	20	20	20	20
NET PLAN	-	-	20	20	20	20	20	20	20	20
LEAD TIME OFFSET	80	20	20	20	20	20	20	20	20	20


SUBROUTINE EXPLODE
LOW LEVEL CODE = 1
SELECT NEXT PRODUCT
ESTABLISH QTY IN ALLOCATION
CALCULATE AVAILABLE STOCK
ESTABLISH NETT REQUIREMENTS
SUBROUTINE NETTING
COMPONENT LEVEL?
Y
N
OFFSET FOR LEADTIME
ADD SCHEDULE TO REQUIREMENTS OF COMPONENT ITEMS
ESTABLISH SCHEDULE FOR THIS ITEM
LEVEL = LEVEL + 1
LEVEL ≤ 4
Y
N
RETURN

Summarised Flow Chart - Subroutine Explode

```
C
C       EXPLODE
C
      SUBROUTINE EXPLODE(AFILE,IFILE,REQFILE,IPRINT,ALLQ)
      REAL AFILE(25,3)
      INTEGER LEVEL,IFILE(25,23),BUFFER,AVAIL,REQFILE(25,52),QTY,WORKFIL
     1E(52),ALLQ(12,50,6),ALLQTY
      LEVEL=1
   10 DO 100 I=1,25
      IF(IFILE(I,11).NE.LEVEL)GO TO 100
      IF(LEVEL.EQ.4)GO TO 30
      ALLQTY=0
      DO 20 J=1,50
   20 ALLQTY=ALLQTY+ALLQ(I,J,4)
   30 DO 40 J=1,52
   40 WORKFILE(J)=REQFILE(I,J)
      IF(IPRINT.GT.3)GO TO 50
      WRITE(2,500)AFILE(I,1)
  500 FORMAT(1H0,12X,'REQUIREMENTS FOR PART NUMBER',2X,A8,' * * * * *')
      WRITE(2,510)(WORKFILE(J),J=1,40)
  510 FORMAT(1H0,12X,'REQUIREMENTS'//6X,20I5//6X,20I5)
   50 IF(LEVEL.NE.1)GO TO 55
      AVAIL=IFILE(I,18)
      BUFFER=0
      GO TO 57
   55 BUFFER=IFILE(I,20)
      AVAIL=IFILE(I,16)-IFILE(I,17)+IFILE(I,18)+ALLQTY
   57 CALL NETTING(BUFFER,AVAIL,WORKFILE)
      IF(IPRINT.GT.2)GO TO 59
      WRITE(2,520)(IFILE(I,J),J=16,18),ALLQTY,AVAIL,BUFFER,(WORKFILE(J)
     1,J=1,20)
  520 FORMAT(1H0,12X,'PHYSICAL STOCK =',I5,2X,'ALLOCATED STOCK =',I5,2X,
     1'WIP =',I5,2X,'IN ALLOCATION =',I5/12X,'AVAILABLE =',I5,2X,
     2'BUFFER =',I5,' WEEKS'///12X,'NET PLAN'//6X,20I5)
   59 IF(LEVEL.EQ.4)GO TO 95
      M=52-IFILE(I,12)-2
      DO 60 K=1,IFILE(I,12)+2
   60 WORKFILE(K+1)=WORKFILE(K+1)+WORKFILE(K)
      DO 70 K=1,M
   70 WORKFILE(K)=WORKFILE(K+IFILE(I,12)+2)
      IF(IPRINT.GT.2)GO TO 75
      WRITE(2,530)IFILE(I,12),(WORKFILE(J),J=1,40)
  530 FORMAT(1H0,12X,'OFFSET FOR LEAD TIME =',I5,2X,'PLUS ALLOCATIO
     1N LEAD TIME OF TWO WEEKS'//6X,20I5//6X,20I5)
   75 L=1
   80 N=IFILE(I,L)
      IF(N.EQ.0)GO TO 91
      QTY=IFILE(I,L+1)
      DO 90 M=1,52
   90 REQFILE(N,M)=REQFILE(N,M)+WORKFILE(M)*QTY
   91 L=L+2
      IF(L.GT.9)GO TO 100
      GO TO 80
   95 DO 97 J=1,52
   97 REQFILE(I,J)=WORKFILE(J)
  100 CONTINUE
      LEVEL=LEVEL+1
      IF(LEVEL.LE.4)GO TO 10
  120 RETURN
      END
```

B10 - SUBROUTINE FESALL

Customer orders are selected, in subroutine ALLOCATE, to be taken from stock or to be made from components. Items to be taken from stock are moved to "ex-stock" status in OPFILE and the free stock of the appropriate product is reduced.

Subroutine FESALL will subsequently "allocate" a stock equipment to the customer order and move the order to "test" status in OPFILE. The level of finished equipment stock will also be reduced as stock is moved.

The logic within FESALL is to select each product in turn, and to follow the identical processing sequence twice; once for overdue orders and again for due orders.

For overdue orders, the search horizon is set to 52 weeks and the processing index set to "1". ORDBK is searched for any outstanding orders with the flag set to overdue. If an order is found, the true due date is calculated and the corresponding record selected from OPFILE. If the record cannot be located in OPFILE, an error condition is reported, the diagnostic level set to full detail and the simulation run terminated after a further few weeks. Successful location of the correct record in OPFILE is then followed by a check on the order status. If an order is found in "ex-stock" status, the following activities are initiated, otherwise the search continues to the end of the search horizon.

For orders in "ex-stock" status, the quantity required is compared with the physical stock for the product as held in IFILE. The quantity is set to the lesser of the requirements and the physical stock;

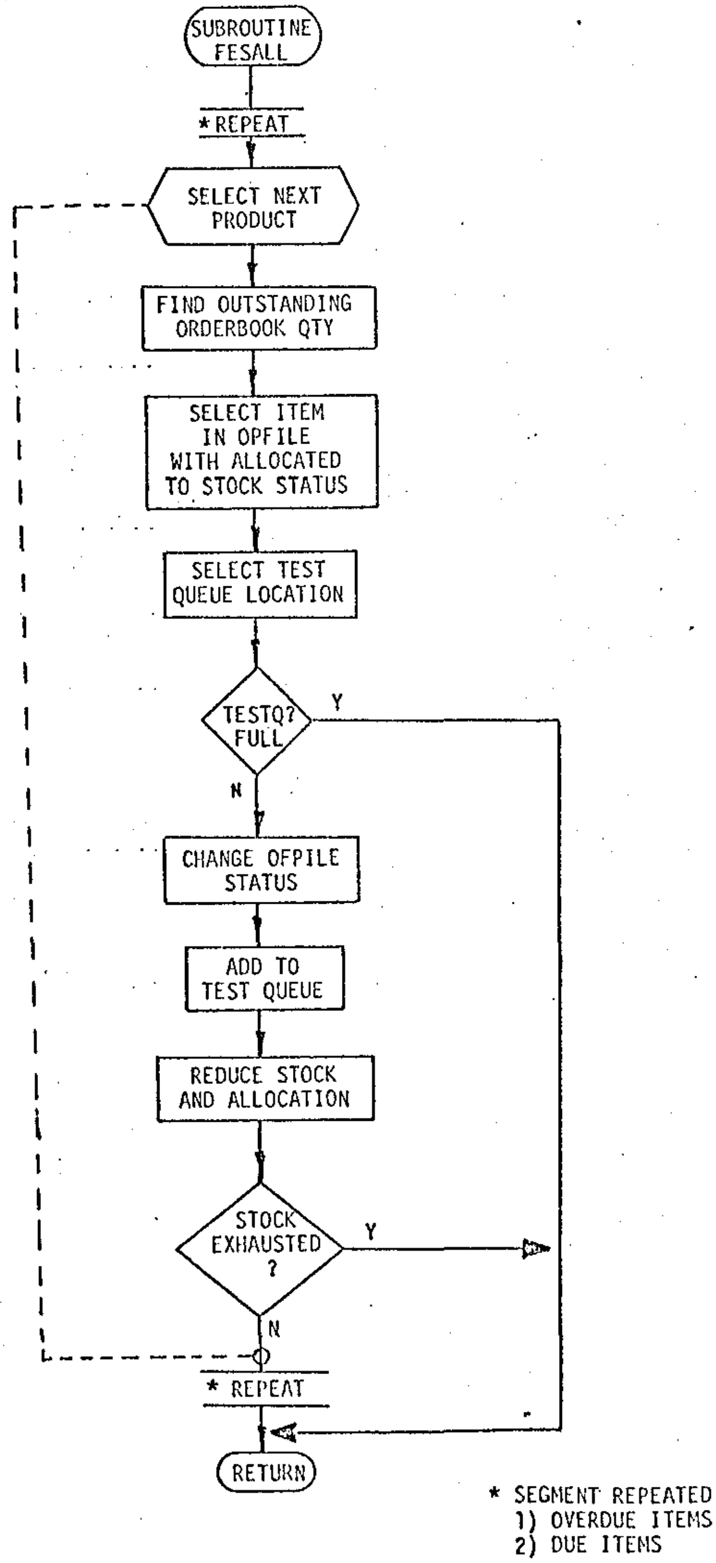
- the quantity is moved from "ex-stock" to "test" status in OPFILE.
- physical stock and allocated stock are reduced by the quantity moved.
- test work in progress is augmented by the quantity moved.

- a record is added to TESTQ, defining the order number, item, due date and quantity.
- the TESTQ timer is set to the minimum throughput time of 3 days.

The above process is repeated until either stock or available orders within the search horizon are exhausted.

The process is repeated for due orders, where the index is set to "O" and the search horizon is set to the current week plus two.

Summarised Flow Chart - Subroutine Fesall



```
C
C      FESALL
C
      SUBROUTINE FESALL(ORDBK,OPFILE,WEEK,IFILE,AFILE,IPRINT,REFWEEK,TES
     1TQ,DIAGFILE,RUNTIME)
      REAL AFILE(25,3)
      INTEGER ORDBK( 5,52,20,5),OPFILE(125,5,5,10),QTY,DUEDATE,ORDNO,ITE
     1MNO,IFILE(25,23),TESTQ(5,50,5),REFWEEK,WEEK,DIAGFILE(10,2),RUNTIME
      IF(IPRINT.GT.1)GO TO 300
      WRITE(2,320)
  320 FORMAT(1H0,6X,'* * * *  FESALL  * * * *'//)
  300 DO 200 I=1,5
      JJ=52
      INDEX=1
  100 DO 60 J=1,JJ
      DO 60 K=1,20
      IF(ORDBK(I,J,K,3).EQ.0)GO TO 60
      IF(ORDBK(I,J,K,4).NE.INDEX)GO TO 60
      DUEDATE=J
      IF(INDEX.EQ.0)GO TO 2
      DUEDATE=J-52
    2 ORDNO=ORDBK(I,J,K,1)
      ITEMNO=ORDBK(I,J,K,2)
      DO 1 KEYNO=1,125
      IF(OPFILE(KEYNO,1,1,10).EQ.ORDNO)GO TO 3
    1 CONTINUE
      GO TO 7
    3 DO 5 L=1,5
    4 IF((OPFILE(KEYNO,ITEMNO,L,3)-REFWEEK).EQ.DUEDATE)GO TO 20
    5 CONTINUE
    7 IF(IPRINT.GT.5)GO TO 60
      WRITE(2,10)ORDNO,ITEMNO,DUEDATE,OPFILE(KEYNO,ITEMNO,L,3),REFWEEK
   10 FORMAT(1H0,6X,'INCOMPATIBLE DATA IN ORDBK AND OPFILE FOR ORDER',I6
     1,2X,'ITEM',I6,2X,'WEEK',I6/6X,'ACTUAL WEEK ',I4,6X,'REFWEEK ',I4)
      IPRINT=1
      DO 15 IZ=1,10
   15 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
      GO TO 60
   20 IF(OPFILE(KEYNO,ITEMNO,L,5).EQ.0)GO TO 60
      DO 30 M=1,50
      IF(TESTQ(I,M,1).EQ.0)GO TO 45
   30 CONTINUE
      IF(IPRINT.GT.5)GO TO 200
      WRITE(2,40)I
   40 FORMAT(1H0,6X,'EXCEEDED TEST QUEUE SIZE FOR PRODUCT',I6)
      GO TO 200
   45 QTY=OPFILE(KEYNO,ITEMNO,L,5)
      IF(OPFILE(KEYNO,ITEMNO,L,5).LT.IFILE(I,16))GO TO 50
      QTY=IFILE(I,16)
   50 OPFILE(KEYNO,ITEMNO,L,5)=OPFILE(KEYNO,ITEMNO,L,5)-QTY
      OPFILE(KEYNO,ITEMNO,L,8)=OPFILE(KEYNO,ITEMNO,L,8)+QTY
      IFILE(I,19)=IFILE(I,19)+QTY
      TESTQ(I,M,1)=ORDNO
      TESTQ(I,M,2)=ITEMNO
      TESTQ(I,M,3)=OPFILE(KEYNO,ITEMNO,L,3)
      TESTQ(I,M,4)=QTY
      TESTQ(I,M,5)=3
      IFILE(I,17)=IFILE(I,17)-QTY
      IFILE(I,16)=IFILE(I,16)-QTY
      IF(IPRINT.GT.2)GO TO 55
      WRITE(2,350) ORDNO,ITEMNO,OPFILE(KEYNO,ITEMNO,L,3),AFILE(I,1),QTY
  350 FORMAT(1H0,6X,'ORDER',I6,4X,'ITEM',I6,4X,'DUE',I6,4X,'PROD.',A8,4X
     1,'QTY',I6,2X,'ALLOCATED AGAINST STOCK')
```

```
 55 IF(IFILE(I,16).LE.0)GO TO 200
 60 CONTINUF
    IF(INDEX.EQ.0)GO TO 200
    JJ=WEEK+2
    INDEX=0
    GO TO 100
200 CONTINUE
    RETURN
    END
```

B11 - SUBROUTINE FORECAST

To support the preparation of the quarterly plan QPLAN, a mechanism for forecasting the orders to be received in future periods is required.

The present method of orders received forecasting is to use as the base a 12 month moving annual total modified by any specific knowledge relating to markets, competition, large order opportunities and other considerations.

The model requires a simple form of forecasting mechanism which may respond to moderate levels of variability and trend as introduced by the orders generator. This mechanism is provided by a basic linear regression method.

Linear regression will determine the "line of best fit" through a number of points, where the "best fit" is that line which minimises the square of the errors. The error is the distance between each observation and the regression line.

If the equation for a straight line is given by

$$x = a + bt$$

where x = demand
t = time

the square of the errors is minimised when

$$a = \frac{(\Sigma x \,.\, \Sigma t^2) - (\Sigma t \,.\, \Sigma x \,.\, t)}{(n \Sigma t^2) - (\Sigma t)^2} \quad \ldots\ldots\ldots \quad \text{(i)}$$

$$b = \frac{n \Sigma x \,.\, t - (\Sigma x \,.\, \Sigma t)}{(n \Sigma t^2) - (\Sigma t)^2} \quad \ldots\ldots\ldots \quad \text{(ii)}$$

or $$a = \frac{\Sigma x - b \Sigma t}{n} \quad \ldots\ldots\ldots \quad \text{(iii)}$$

The model calculates a regression line based on 12 monthly observations derived from the order history file ORDHIST. The observations contained within ORDHIST are the demand data, considered in the model as "Y" axis observations. The "X" axis observations correspond to time and represent periods 1 - 12 inclusive.

Following initialisation, the program calculates the sums

$$\text{SUMX} = \sum_{i=1}^{i=12} i$$

$$\text{SUMX2} = \sum_{i=1}^{i=12} i^2$$

$$\text{SUMY} = \sum_{i=1}^{i=12} x_i$$ where x_i is the i^{th} observation from ORDHIST.

$$\text{SUMY2} = \sum_{i=1}^{i=12} x_i^2$$

$$\text{SUMXY} = \sum_{i=1}^{i=12} i.x_i$$

These are then substituted in equations (ii) and (iii) to give

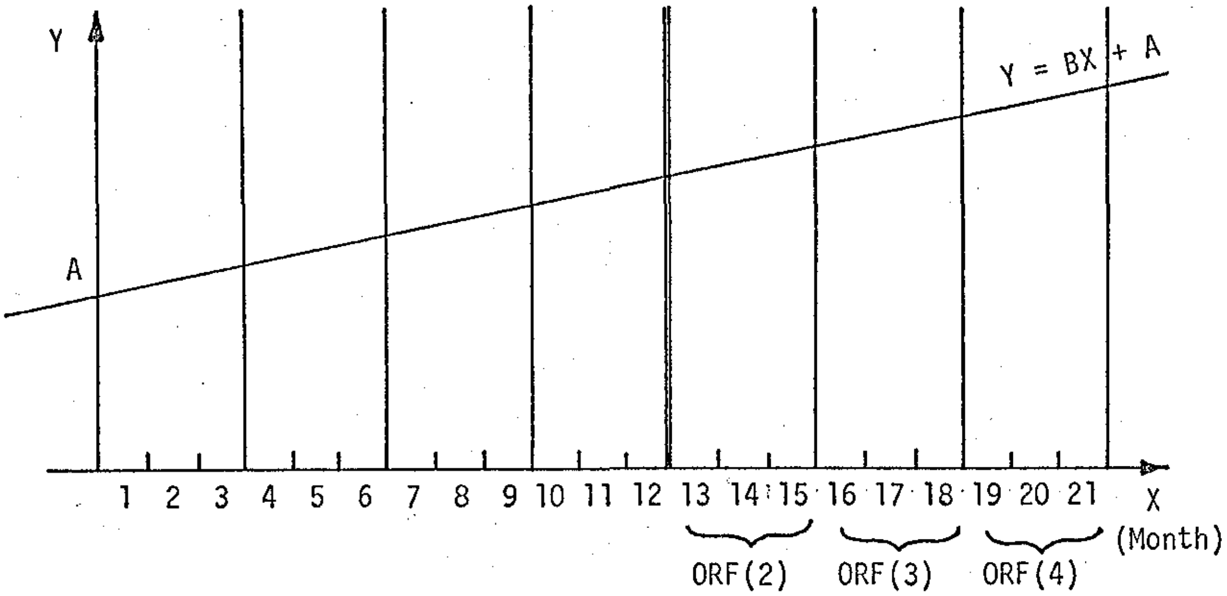
$$B = \frac{12 \,.\, \text{SUMXY} - \text{SUMX} \,.\, \text{SUMY}}{12 \,.\, \text{SUMX2} - \text{SUMX}^2}$$

$$A = \frac{\text{SUMY} - \text{B.} \,.\, \text{SUMX}}{12}$$

The equation of the regression line is then given by

$$Y = BX + A$$

This straight line is then extrapolated to provide a forecast of orders to be received in future periods.



The diagram above shows that the first period to be forecast is for ORF(2) which contains months 13 through 15. Thus,

$$\text{ORF}(2) = \sum_{i=13}^{i=15} x_i$$

where x is the monthly observation given by

$$Y = BX + A$$

and X is the month number.

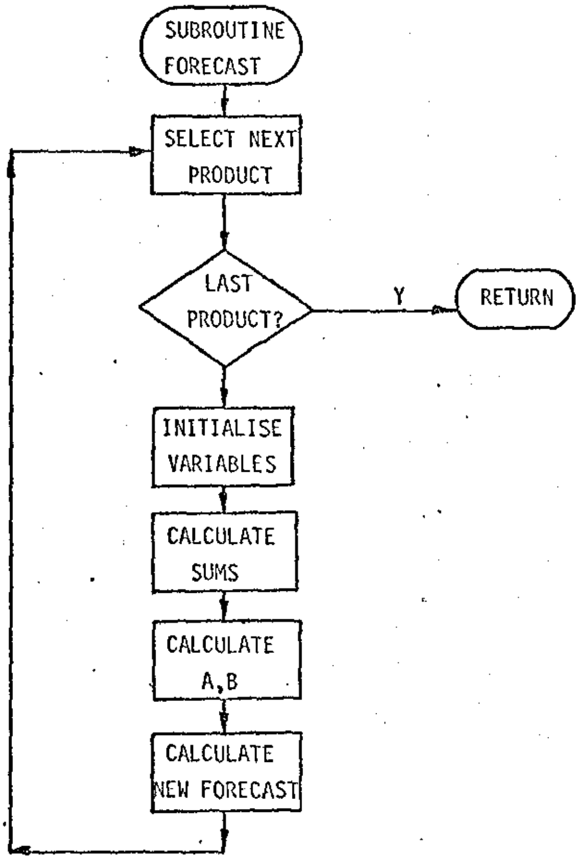
Therefore,

$$\text{ORF}(2) = \sum_{j=13}^{j=15} B.j + A$$

Similarly,

$$ORF(3) = \sum_{j=16}^{j=18} B.j + A$$

etc.



Summarised Flow Chart - Subroutine Forecast

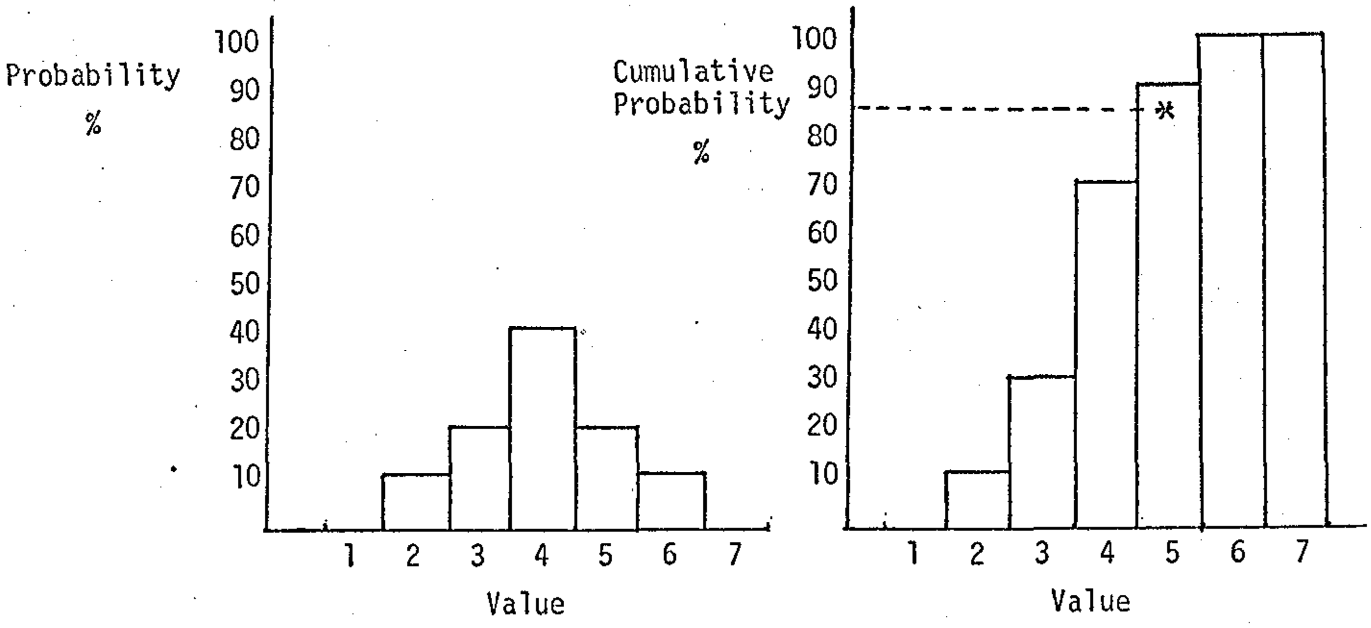
```
C
C      FORECAST
C
      SUBROUTINE FORECAST(ORDHIST,ORF,IPRINT,AFILE,IFILE)
      REAL AFILE(25,3)
      INTEGER ORF(10,7),ORDHIST( 5,12),IFILE(25,23)
      IF(IPRINT.GT.1)GO TO 5
      WRITE(2,200)
  200 FORMAT(1H0,6X,'* * * *  FORECAST  * * * *'//)
C
C     CALCULATE REGRESSION LINE
C
    5 DO 150 M=1,5
      IF(IFILE(M,11).NE.1)GO TO 150
      SUMX=0.0
      SUMXZ=0.0
      SUMXY=0.0
      SUMY=0.0
      SUMY2=0.0
      DO 10 I=1,12
      SUMX=SUMX+FLOAT(I)
      SUMX2=SUMX2+FLOAT(I)**2
      SUMY=SUMY+FLOAT(ORDHIST(M,I))
      SUMY2=SUMV2+FLOAT(ORDHIST(M,I))**2
   10 SUMXY=SUMXY+FLOAT(ORDHIST(M,I))*I
      B=(12*SUMXY-SUMX*SUMY)/(12*SUMX2-SUMX**2)
      A=(SUMY-B*SUMX)/12
      C=SUMY/12
      IF(IPRINT.GT.2)GO TO 70
      WRITE(2,20)AFILE(M,1)
   20 FORMAT(1H0,6X,'EQUATION OF REGRESSION LINE FOR PRODUCT ',A8,' IS')
      IF(A)30,50,50
   30 WRITE(2,40)B,A
   40 FORMAT(1H0,6X,'Y =',F6.1,'X  ',F6.1)
      GO TO 70
   50 WRITE(2,60)B,A
   60 FORMAT(1H0,6X,'Y =',F6.1,'X +',F6.1)
C
C     CALCULATE FORECAST
C
   70 DO 120 I=2,7
      ORF(M,I)=0
      J=3*I+7
      K=J+2
      DO 110 L=J,K
  110 ORF(M,I)=ORF(M,I)*IFIX(B*L+A)
      IF(ORF(M,I).GE.0)GO TO 120
      ORF(M,I)=0
  120 CONTINUE
      IF(IPRINT.GT.3)GO TO 150
      WRITE(2,130)(ORDHIST(M,I),I=1,12),(ORF(M,I),I=2,7)
  130 FORMAT(1H0,6X,'HISTORY (MONTHLY)'//6X,12I6//6X,'FORECAST (QUARTERL
     1Y)'//6X,6I6////)
  150 CONTINUE
      RETURN
      END
```

B12 - SUBROUTINE HSAMPLE

Subroutine HSAMPLE is used to generate random variates as defined by a predetermined histogram. Two subroutines are available; HSAMPLE 1 which samples from a 2 x 7 array, and HSAMPLE 2 which samples from a 2 x 2 array.

The arrays containing the histogram parameters are contained in cumulative form.

The subroutine derives the array (or table) and the random number generators seed from the calling segment. A uniformly distributed random variate defined on the unit interval is expanded to the scale 0 - 100 and the corresponding histogram interval is sought. The value associated with the histogram interval is then returned to the calling segment.



Thus, a sample from RANDOM of, say, 0.84 would provide, from the histogram, a value of 5.

```
C
C     HSAMPLE 1
C
      SUBROUTINE HSAMPLE 1(J,VALUE,TABLE)
      INTEGER TABLE(7,2),VALUE
      CALL RANDOM(E,J)
      NUMBER=100*E
      K=0
   10 K=K+1
      IF(NUMBER.GT.TABLE(K,2))GO TO 10
      VALUE=TABLE(K,1)
      RETURN
      END
```

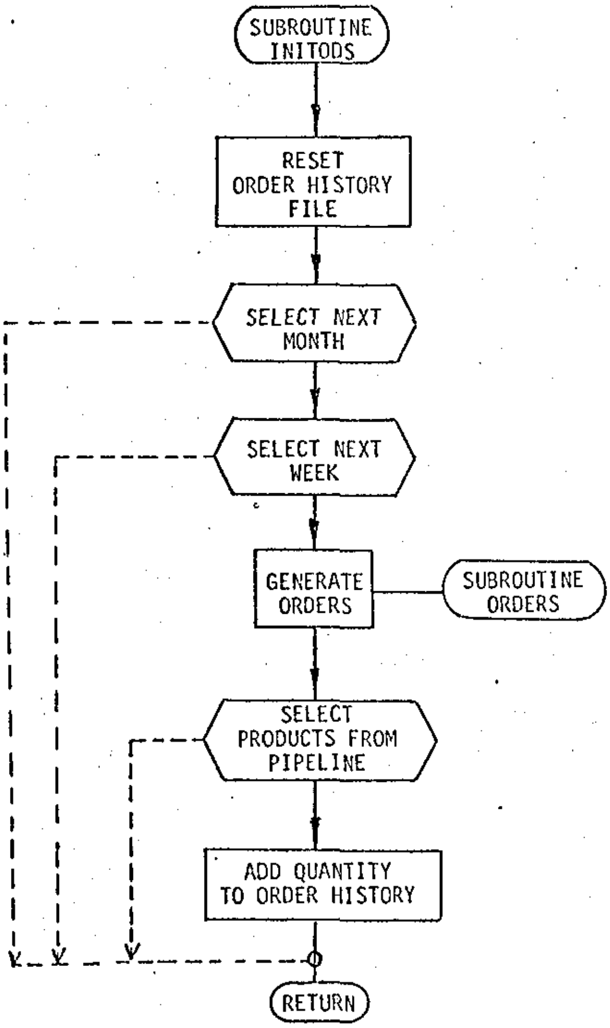
```
C
C      HSAMPLE 2
C
      SUBROUTINE HSAMPLE 2(J,VALUE,TABLE)
      INTEGER TABLE(2,2),VALUE
      CALL RANDOM(E,J)
      NUMBER=100*E
      K=0
   10 K=K+1
      IF(NUMBER.GT.TABLE(K,2))GO TO 10
      VALUE=TABLE(K,1)
      RETURN
      END
```

B13 - SUBROUTINE INITODS

To minimise the time taken to achieve a steady state condition, the start-up parameters have been selected, as far as possible, from the conditions selected for the main model logic.

Subroutine INITODS creates the order history file ORDHIST by running the order generator, subroutine ORDERS, for the equivalent of one year and summarising the orders received statistics by month. Thus, the basis for producing the orders received forecast, and subsequently the manufacturing plans, is consistent with the expected order input pattern.

It should be noted that the random number seeds are carried forward to the main model logic, thus selection of alternative seeds will change the start-up order history in detail.



Summarised Flow Chart - Subroutine Initods

```
C
C     INITODS
C
      SUBROUTINE INITODS(ORDHIST,TABLE5,TABLE6,TABLE7,ORDCOUNT,PIPELIN
     1E,ISEED4,ISEED5,ISEED6,ISEED7,AVGE4,CVARN4,IFILE,TABLE8,ISEED8,I
     2PRINT)
      INTEGER ORDHIST(5,12),TABLE5(7,2),TABLE6(7,2),TABLE7(7,2),ORDCOUN
     1T,PIPELINE(20,6,4),IFILE(25,23),TABLE8(2,2)
      DO 50 I=1,4
      DO 50 J=1,12
   50 ORDHIST(I,J)=0
      DO 100 N=1,12
      DO 100 M=1,4
      CALL ORDERS(TABLE5,TABLE6,TABLE7,ORDCOUNT,PIPELINE,ISEED4,ISEED5
     1,ISEED6,ISEED7,AVGE4,CVARN4,IFILE,TABLE8,ISEED8,IPRINT)
      DO 100 I=1,20
      DO 100 J=2,6
      K=PIPELINE(I,J,2)
      IF(K.EQ.0)GO TO 100
      ORDHIST(K,N)=ORDHIST(K,N)+PIPELINE(I,J,3)
  100 CONTINUE
      RETURN
      END
```

B14 - SUBROUTINE ISSWIP

Subroutine ISSWIP is the mechanism for issuing components from stock to work in process. Facilities are provided to select items from the allocation file ALLQ in first-in-first-out priority or by due date, and to present the resultant material movement in familiar pick list format if required.

ISSWIP selects items sequentially from the allocation file ALLQ. The priority rule to be selected is determined by ISORT, the value of which is pre-defined for each simulation experiment. If ISORT is set to due date priority, ALLQ will be sorted into date sequence; first-in-first-out priority is achieved by by-passing the sort logic. It should be noted that the sort is by due date within product. The priority by product is determined by relative position in the part number master file, IFILE.

The quantity to be moved to work in process is determined by selecting an item from ALLQ. Sub-assemblies are moved as individual batches as defined in ALLQ and products are grouped by totalling all batches with a common shop order number.

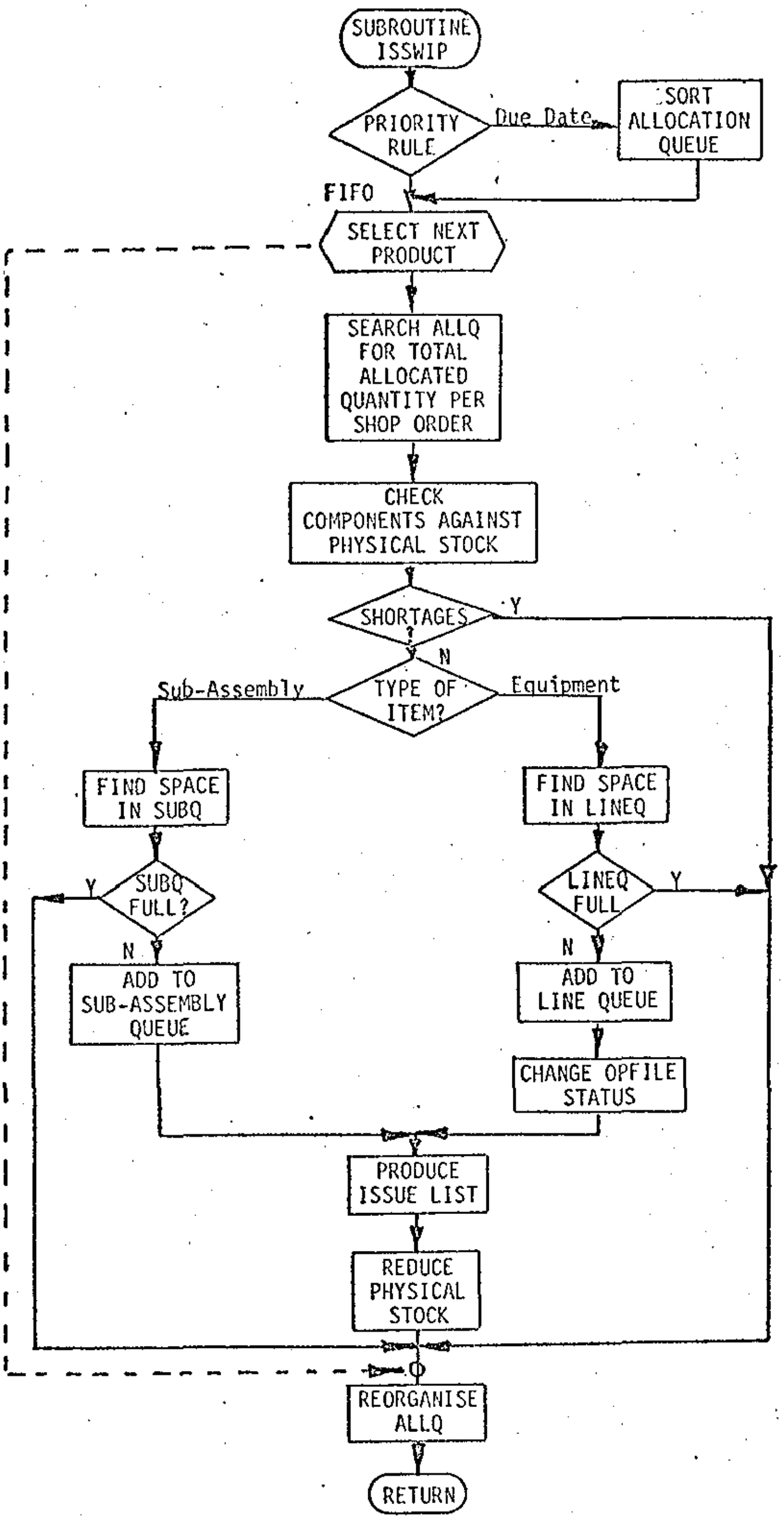
When the allocation quantity has been determined, each component required to produce the assembly is checked for material availability. Items coded as "do not issue" are stored temporarily for subsequent checking at the next lowest level. If any parts are short, the next product or sub-assembly is selected from ALLQ.

Sub-assembly requirements that can be met from stock will be transferred from the allocation file to work in process. This is achieved by creating a new record in SUBQ, increasing the work in process quantity in IFILE and removing the record from ALLQ.

Equipment requirements that can be met from stock are identified by the shop order number. Each batch is transferred to work in process by adding a record to LINEQ, incrementing the work in process record in IFILE by the batch quantity and removing the item from ALLQ. The status of the order in OPFILE is amended by moving the batch quantity from "in allocation" to "on-line". The cumulative quantity moved to work in process is incremented for subsequent use in the material issue procedure. This procedure avoids errors occurring if the volume of LINEQ is exceeded.

The total quantity moved for the product or sub-assembly is then processed by the issue list segment. If required, a listing of parts moved can be output in the form of a pick list. The physical stock and allocated stock of each component part is reduced by the quantity issued, including lower level components of "do not issue" assemblies.

The allocation file, ALLQ, is then consolidated by removing fully processed records.

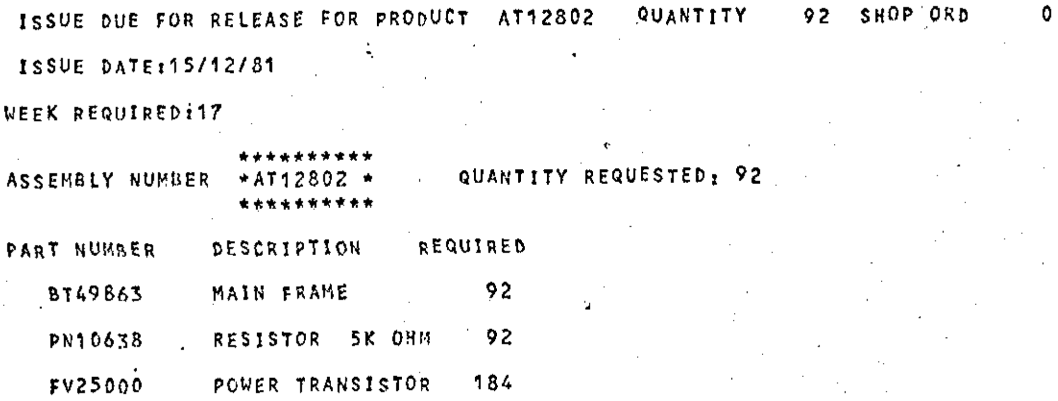


Summarised Flow Chart - Subroutine Isswip

```
C
C     ISSWIP
C
      SUBROUTINE ISSWIP(IFILE,OPFILE,ALLQ,LINEQ,AFILE,IPRINT,REFWEEK,
     1SUBQ,ISORT,DIAGFILE,RUNTIME)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23),OPFILE(125,5,5,10),ALLQ(12,50,6),LINEQ(5,50,
     15),REQD,MFSK,HOLD(5,2),QUANTITY,DATO,DATEREQD,REFWEEK,SUBQ(50,4),D
     2IAGFILE(10,2),RUNTIME
      IF(IPRINT.GT.1)GO TO 350
      WRITE(2,320)
  320 FORMAT(1H0,6X,'* * * *  ISSWIP  * * * *'//)
  350 CALL DATE(DATO)
C
C     SORT ALLOCATION QUEUE BY DUE DATE
C
      IF(ISORT.EQ.0)GO TO 3
      DO 2 I=1,12
      DO 2 J=1,49
      DO 2 K=J+1,50
      IF(ALLQ(I,K,4).EQ.0)GO TO 2
      IF(ALLQ(I,J,3).LE.ALLQ(I,K,3))GO TO 2
      DO 1 L=1,6
      IHOLD=ALLQ(I,J,L)
      ALLQ(I,J,L)=ALLQ(I,K,L)
      ALLQ(I,K,L)=IHOLD
    1 CONTINUE
    2 CONTINUE
C
C     SEARCH FOR ALLOCATIONS THAT ARE DUE FOR RELEASE
C
    3 DO 400 N=1,12
      IF(IFILE(N,11).GT.3)GO TO 400
      IF(IFILE(N,11).EQ.0)GO TO 400
      LEVEL=IFILE(N,11)
      INDEX=0
      DO 300 NP=1,50
      IF(ALLQ(N,NP,4).EQ.0)GO TO 300
      IF(ALLQ(N,NP,5).GT.0)GO TO 300
      GO TO(4,6,6),LEVEL
C
C     ESTABLISH ALLOCATION QUANTITY & SHOP ORDER NUMBER

    4 QUANTITY=0
      IMAX=ALLQ(N,NP,6)
       DO 5 L=NP,50
      IF(ALLQ(N,L,6).NE.IMAX)GO TO 5
      QUANTITY=QUANTITY+ALLQ(N,L,4)
    5 CONTINUE
      GO TO 7
    6 QUANTITY=ALLQ(N,NP,4)
      IMAX=0
    7 IF(IPRINT.GT.2)GO TO 9
      WRITE(2,8)AFILE(N,1),QUANTITY,IMAX
    8 FORMAT(1H0,6X,'ISSUE DUE FOR RELEASE FOR PRODUCT',2X,A8,2X,'QUANTI
     1TY',I6,2X,'SHOP ORD',I6)
    9 DATEREQD=ALLQ(N,NP,3)-4
C
C     CHECK WHETHER ISSUE CAN BE MADE
C
      NN=N
      K=0
```

```
   10 DO 60 I=1,9,2
      IF(IFILE(NN,I).EQ.0)GO TO 60
      IP=I+1
      REQD=QUANTITY*IFILE(NN,IP)
      L=IFILE(NN,I)
      IF(IFILE(L,15).EQ.1)GO TO 50
      IF(REQD.LE.IFILE(L,16))GO TO 60
      INDEX=1
      IF(IPRINT.GT.2)GO TO 60
      WRITE(2,20)AFILE(L,1),REQD,IFILE(L,16)
   20 FORMAT(1H0,6X,'SHORTAGE OCCURRED ON ITEM',2X,A8,' WHERE QUANTITY R
     1EQUIRED = ',I5,' PHYS STOCK = ',I5)
      GO TO 60
   50 K=K+1
      HOLD(K,1)=L
      HOLD(K,2)=REQD
   60 CONTINUE
      IF(K.EQ.0)GO TO 100
      NN=HOLD(K,1)
      QUANTITY=HOLD(K,2)
      K=K-1
      GO TO 10
  100 IF(INDEX.EQ.1)GO TO 400
C
C     MOVE STATUS TO W.I.P.
C
C
C     SUB-ASSEMBLIES
C
      GO TO(167,155,155),LEVEL
  155 DO 157 L=1,50
      IF(SUBQ(L,3).EQ.0)GO TO 163
  157 CONTINUE
      IF(IPRINT.GT.5)GO TO 205
      WRITE(2,160)AFILE(N,1)
  160 FORMAT(1H0,'EXCEEDED SUBQ SIZE FOR PRODUCT NO.',A8)
      GO TO 205
  163 SUBQ(L,1)=N
      SUBQ(L,2)=ALLQ(N,NP,3)
      SUBQ(L,3)=ALLQ(N,NP,4)
      SUBQ(L,4)=3
      IFILE(N,18)=IFILE(N,18)+ALLQ(N,NP,4)
      ALLQ(N,NP,4)=0
  165 CONTINUE
      GO TO 105
C
C     EQUIPMENTS
C
  167 QUANTITY=0
      DO 200 NR=1,50
      IF(ALLQ(N,NR,6).NE.IMAX)GO TO 200
  170 DO 175 L=1,50
      IF(LINEQ(N,L,4).EQ.0)GO TO 183
  175 CONTINUE
       IF(IPRINT.GT.5)GO TO 205
      WRITE(2,180)AFILE(N,1)
  180 FORMAT(1H0,'EXCEEDED LINE QUEUE SIZE FOR PRODUCT NO.',A8)
      GO TO 205
  183 JA=ALLQ(N,NR,1)
      JB=ALLQ(N,NR,2)
      JC=ALLQ(N,NR,3)
      IF(ALLQ(N,NR,1).LT.0)GO TO 187
      DO 184 KEYNO=1,125
      IF(OPFILE(KEYNO,JB,1,10).EQ.JA)GO TO 186
  184 CONTINUE
      GO TO  195
  186 DO 190 JJ=1,5
      IF(OPFILE(KEYNO,JB,JJ,3).EQ.JC)GO TO 188
  190 CONTINUE
      GO  TO 195
  188 OPFILE(KEYNO,JB,JJ,7)=ALLQ(N,NR,4)+OPFILE(KEYNO,JB,JJ,7)
      OPFILE(KEYNO,JB,JJ,6)=OPFILE(KEYNO,JB,JJ,6)-ALLQ(N,NR,4)
  187 QUANTITY=QUANTITY+ALLQ(N,NR,4)
      DO 189 M=1,4
  189 LINEQ(N,L,M)=ALLQ(N,NR,M)
      LINEQ(N,L,5)=3
      IFILE(N,18)=IFILE(N,18)+ALLQ(N,NR,4)
      ALLQ(N,NR,4)=0
      GO TO 200
  195 IF(IPRINT.GT.5)GO TO 200
      WRITE(2,250)JA,JB,JC,OPFILE(KEYNO,JB,JJ,3),REFWEEK
  250 FORMAT(1H0,6X,'NO ENTRY FOUND IN OPFILE FOR ORDER',I4, 'ITEM',I4,'
     1DUE WEEK',I4/6X,'ACTUAL WEEK ',I4,6X,'REFWEEK ',I4)
      IPRINT=1
      DO 255 IZ=1,10
  255 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
  200 CONTINUE
C
C     PRODUCE ISSUE LIST AND REDUCE PHYSICAL STOCK
C
  105 K=0
  110 IF(IPRINT.GT.3)GO TO 115
      WRITE(2,500)DATO,DATEREQD,AFILE(N,1),QUANTITY
  500 FORMAT(1H0,6X,'ISSUE DATE:',A8//6X,'WEEK REQUIRED:',I2//,23X,'****
     1******'/6X,'ASSEMBLY NUMBER  *',A8,'*',6X,'QUANTITY REQUESTED:',I3
     2/23X,'**********'//6X,'PART NUMBER',4X,'DESCRIPTION',4X,'REQUIRED'
     3)
  115 DO 150 I=1,9,2
      IF(IFILE(N,I).EQ.0)GO TO 150
      IP=I+1
      REQD=QUANTITY*IFILE(N,IP)
      L=IFILE(N,I)
      IF(IFILE(L,15).EQ.1)GO TO 130
      IFILE(L,16)=IFILE(L,16)-REQD
      IFILE(L,17)=IFILE(L,17)-REQD
      IF(IPRINT.GT.3)GO TO 150
      WRITE(2,120)(AFILE(L,J),J=1,3),REQD
  120 FORMAT(1H0,8X,A8,4X,2A8,I6)
      GO TO 150
  130 IF(IPRINT.GT.3)GO TO 145
      WRITE(2,140)AFILE(L,1)
  140 FORMAT(1H0,8X,A8,4X,'SEPARATE ISSUE LIST  * * * * ')
  145 K=K+1
      HOLD(K,1)=L
      HOLD(K,2)=REQD
  150 CONTINUE
      IF(K.EQ.0)GO TO 300
      N=HOLD(K,1)
      QUANTITY=HOLD(K,2)
      K=K-1
      GO TO 110
  300 CONTINUE
```

```
205 DO 220 K=1,49
    IF(ALLQ(N,K,4).GT.0)GO TO 220
    DO 210 M=K+1,50
    IF(ALLQ(N,M,4).GT.0)GO TO 215
210 CONTINUE
    GO TO 400
215 DO 218 L=1,6
    ALLQ(N,K,L)=ALLQ(N,M,L)
    ALLQ(N,M,L)=0
218 CONTINUE
220 CONTINUE
400 CONTINUE
    RETURN
    END
```



```
 ISSUE DUE FOR RELEASE FOR PRODUCT  AT12802   QUANTITY     92  SHOP ORD      0

 ISSUE DATE:15/12/81

WEEK REQUIRED:17

                     **********
ASSEMBLY NUMBER      *AT12802 *      QUANTITY REQUESTED: 92
                     **********

PART NUMBER     DESCRIPTION      REQUIRED

   BT49863      MAIN FRAME            92

   PN10638      RESISTOR  5K OHM      92

   FV25000      POWER TRANSISTOR     184
```

Sample Issue List

B15 - SUBROUTINE LIMIT

The subroutine QPLAN requires, as part of the decision process, constraints within which changes can be effected. These constraints, or limits, may be labour or material related and, dependent upon the time horizon, may be a maximum or a minimum parameter.

The labour constraint simulates the effect of increasing the planned requirement and represents the maximum plan in any one quarter with reference to the previous quarter's activity.

The labour related rules incorporated into LIMIT are:

- No increase in activity permissible in the current quarter.
- If the previous quarter was zero, a maximum of 250 is permissible.
- If the previous quarter up to 150, a maximum of 3 times the previous plan is permitted.
- If the previous quarter up to 500, a maximum of 2.5 times the previous plan is permitted.
- If the previous quarter up to 2000, a maximum of 2.0 times the previous plan is permitted.
- If the previous quarter more than 2000, a maximum of 1.5 times the previous plan is permitted.
- It is assumed that there are no labour constraints on reduction in planned requirements.

Material constraints have been calculated as a maximum and a minimum, and both are related to the lead time available before the change is required and the likely success in achieving the change within the ability of the suppliers to respond to the requests. It should be noted that the parameters chosen do not necessarily reflect the aggregate internal and external lead times (or response times), either in the model or the real world, but are similar to those currently used in the manual plan deriviation.

The rules are summarised in the table below:

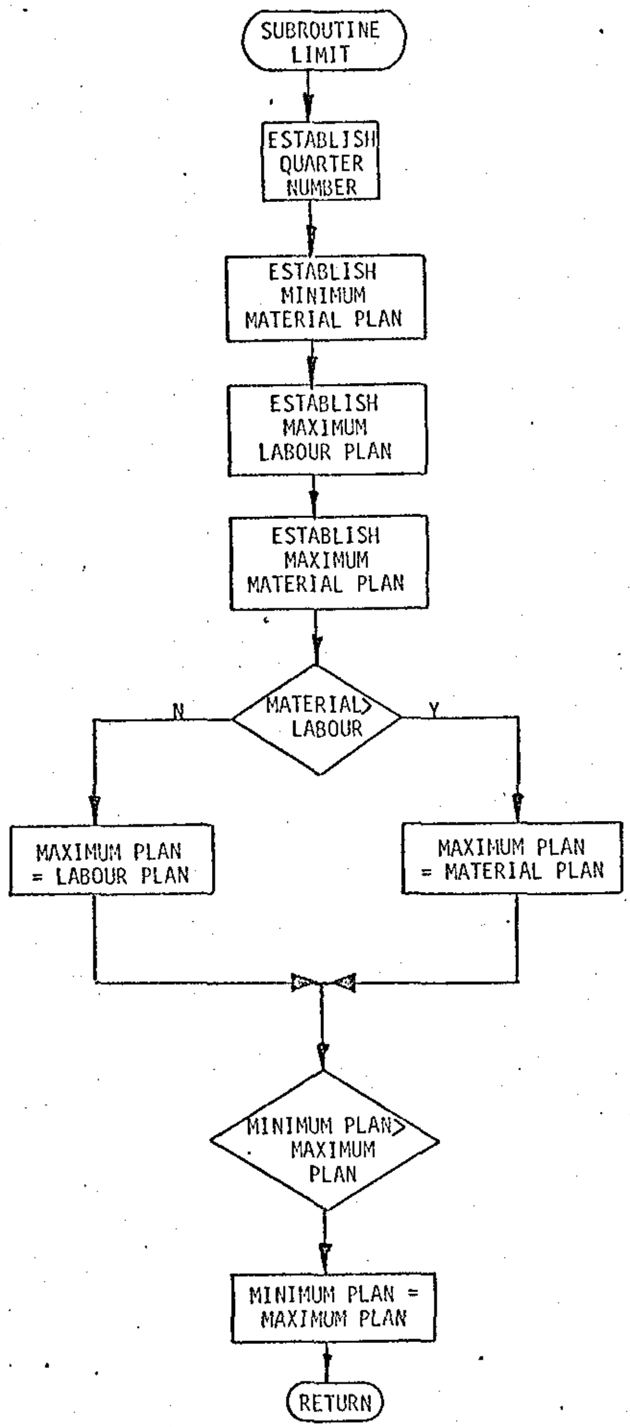
PERIOD	1	2	3	4
MAXIMUM PLAN	Px100%	Px100%	*Px150% or 150	No limit
MINIMUM PLAN	Px100%	Px100%	Px50%	0

* whichever is the higher

From period 4 onwards there is considered to be no material constraint (either maximum or minimum), thus the labour constraint becomes the overriding factor.

In arriving at the maximum plan, the lower of the labour or material constraint is used.

Although the labour constraint is strictly an "off-line" parameter, for simplicity the maximum and minimum are deemed to apply to the material, or on-line plan.


SUBROUTINE LIMIT
ESTABLISH QUARTER NUMBER
ESTABLISH MINIMUM MATERIAL PLAN
ESTABLISH MAXIMUM LABOUR PLAN
ESTABLISH MAXIMUM MATERIAL PLAN
MATERIAL> LABOUR
N
Y
MAXIMUM PLAN = LABOUR PLAN
MAXIMUM PLAN = MATERIAL PLAN
MINIMUM PLAN> MAXIMUM PLAN
MINIMUM PLAN = MAXIMUM PLAN
RETURN

Summarised Flow Chart - Subroutine Limit

```
C
C     LIMIT
C
      SUBROUTINE LIMIT(PLAN,QTR,*,MATPLN,PLNMAX,PLNMIN,CUMDIF)
      INTEGER PLAN,LABMAX,QTR,MATMAX,MATPLN,PLNMAX,PLNMIN,CUMDIF
C
C  SET MINIMUM LIMIT
C
      GO TO(230,10,20,30,40,40,40),QTR
   10 PLNMIN=MATPLN
      GO TO 50
   20 PLNMIN=MATPLN
      GO TO 50
   30 PLNMIN=MATPLN*0.5
      GO TO 50
   40 PLNMIN=0
C
C  SET LABOUR CONSTRAINT
C
      IF(QTR-2)45,45,50
   45 LABMAX=PLAN
      GO TO 140
   50 IF(PLAN)60,60,70
   60 LABMAX=250
      GO TO 140
   70 IF(PLAN-150)80,80,90
   80 LABMAX=PLAN*3
      IF(LABMAX-250)60,140,140
   90 IF(PLAN-500)100,100,110
  100 LABMAX=PLAN*2.5
      GO TO 140
  110 IF(PLAN-2000)120,120,130
  120 LABMAX=PLAN*2.0
      GO TO 140
  130 LABMAX=PLAN*1.5
C
C  SET MAXIMUM MATERIAL LIMITS
C
  140 GO TO(230,150,160,170,190,190,190),QTR
  150 MATMAX=MATPLN
      GO TO 200
  160 MATMAX=MATPLN*1.25+CUMDIF
      GO TO 200
  170 MATMAX=MATPLN*1.75
      IF(MATMAX-150)180,180,200
  180 MATMAX=150
      GO TO 200
  190 MATMAX=LABMAX
  200 IF(MATMAX-LABMAX)210,210,220
  210 PLNMAX=MATMAX
      GO TO 224
  220 PLNMAX=LABMAX
  224 IF(PLNMIN-PLNMAX)228,228,226
  226 PLNMIN=PLNMAX
  228 RETURN
  230 RETURN 1
      END
```

B16 - SUBROUTINE LOAD

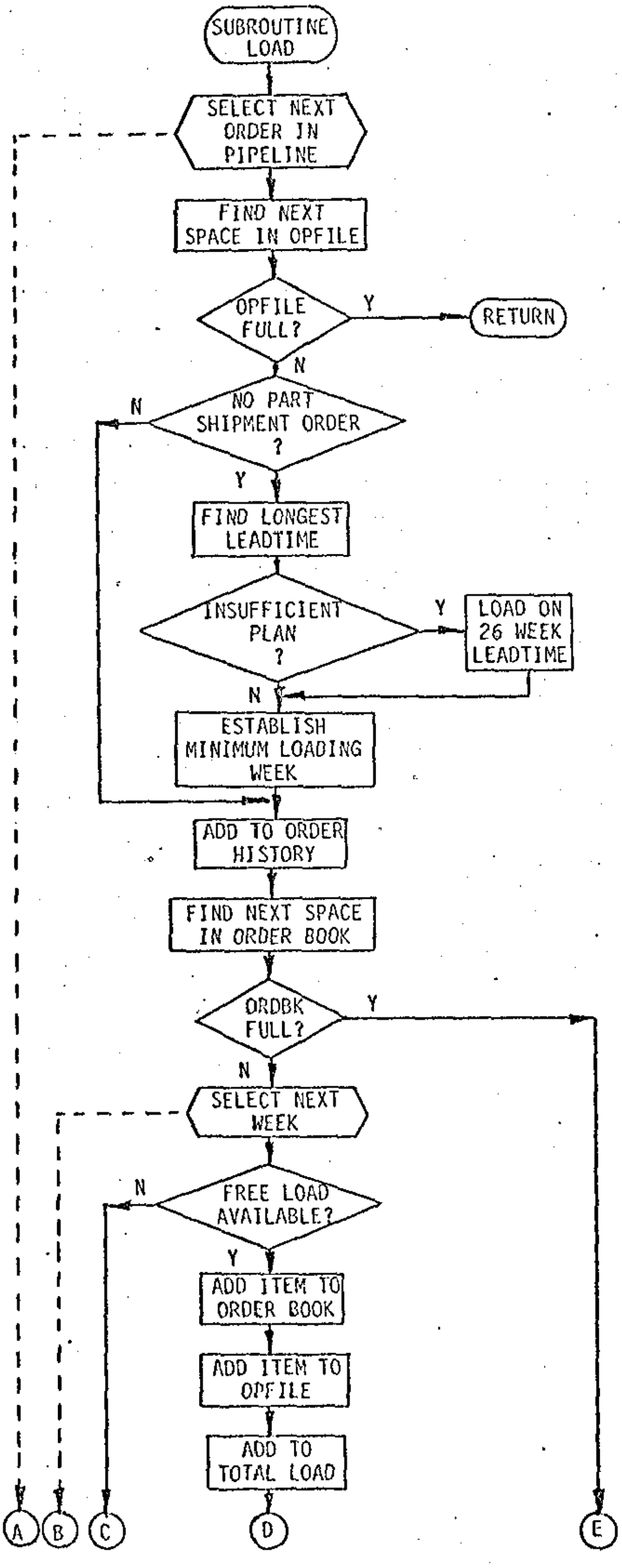
Customer orders generated by subroutine ORDERS are entered in file PIPELINE in preparation for order promising (assignment of due dates), also known as order loading. Subroutine LOAD performs the task of due date assignment and subsequently creates corresponding records in the order book, ORDBK and the orders placed file, OPFILE.

Orders are extracted sequentially from file PIPELINE and the next available space in OPFILE is assigned. The PIPELINE record will identify the order reference, the number of items and whether part shipment is permissible. For "no part shipment" orders, the longest delivery lead time is determined by searching for the item with the latest delivery date, the available capacity being the difference between the committed load as contained in file TOTAL and the delivery plan in DELPLAN. If insufficient capacity is available to support the order, a 26 week delivery lead time is selected on the assumption that the next re-planning cycle will accommodate the overload. Order line items are committed to the delivery plan by searching for the first "available to promise" quantity (difference between the delivery plan and total committed load) beyond the minimum loading date. The minimum loading date is either the minimum order book parameter (OCFMIN) for "part shipment" orders, or the maximum lead time determined as above for "no part shipment" orders.

A successful search will cause the order to be committed to the plan, in which case the total load for the appropriate week number will be incremented by the quantity loaded. The quantity selected is either the full item quantity or the available to promise, whichever is the smaller. If the full quantity cannot be loaded, the balance will be carried forward for loading in subsequent periods, up to a maximum of five periods in total. In the interests of file economy, quantities that cannot be accommodated over five periods cause the remainder of the order quantity to be truncated.

If insufficient delivery plan is available, a 26 week delivery lead time is selected for the full item quantity.

Each quantity loaded will cause a corresponding record to be created in the order book (ORDBK) for the appropriate product and week number, and the orders placed file (OPFILE). The delivery lead time achieved is registered in file LEADTM for subsequent analysis if required.



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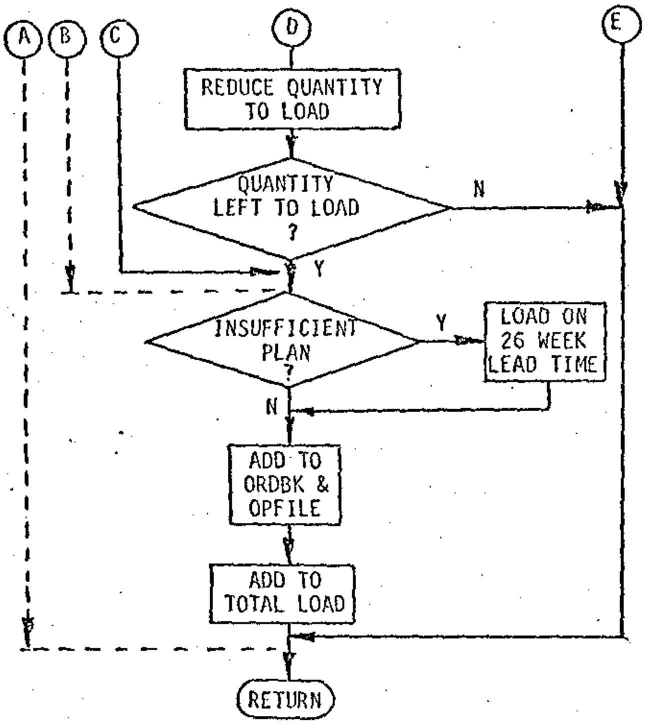


Summarised Flow Chart - Subroutine Load

```
C
C     LOAD
C
      SUBROUTINE LOAD(DELPLAN,OCFMIN,WEEK,TOTAL,PIPELINE,ORDBK,OPFILE,OR
     1DHIST,IPRINT,AFILE,IFILE,ORDCOUNT,REFWEEK,LEADTM)
      REAL AFILE(25,3)
      INTEGER DELPLAN( 5,52),OCFMIN,WEEK,TOTAL( 5,52),PIPELINE(20,6,4),O
     1RDBK( 5,52,20,5),OPFILE(125,5,5,10),ORDHIST( 5,12),IPRINT,ORDNO,IT
     2EMCOUNT,TYPE,QTY,ORDCOUNT,IFILE(25,23),REFWEEK,ACTWK,LEADTM(5,52)
      IF(IPRINT.GT.1)GO TO 7
      WRITE(2,5)
    5 FORMAT(1H0,6X,'* * * *  LOAD  * * * *'//)
    7 JZ=0
      N=WEEK+OCFMIN-1
   10 JZ=JZ+1
      IF(PIPELINE(JZ,1,1).EQ.0)GO TO 150
C
C     FIND NEXT SPACE IN OPFILE
C
      DO 13 KEYNO=1,125
      IF(OPFILE(KEYNO,1,1,10).EQ.0)GO TO 17
   13 CONTINUE
      IF(IPRINT.GT.5)GO TO 160
      WRITE(2,15)
   15 FORMAT(1H0,6X,'EXCEEDED OPFILE SIZE')
      GO TO 160
   17 ORDNO=PIPELINE(JZ,1,1)
      ITEMCOUNT=PIPELINE(JZ,1,3)
      IF(IPRINT.GT.2)GO TO 25
      WRITE(2,20)ORDNO
   20 FORMAT(1H0,12X,'ORDER NUMBER',I6,2X,'ITEM',6X,'PROD',2X,'QTY')
   25 IF=PIPELINE(JZ,1,2)
      MAXWEEK=1
      GO TO(35,26)IF
C
C     FIND LONGEST LEAD TIME FOR 'NO PART SHIPMENT'
C
   26 DO 30 J=1,ITEMCOUNT
      L=J+1
      TYPE=PIPELINE(JZ,L,2)
      DO 27 I=N,52
      IF(DELPLAN(TYPE,I).GT.TOTAL(TYPE,I))GO TO 29
   27 CONTINUE
C
C     IF DELIVERY PLAN IS INSUFFICIENT, ORDER IS LOADED ON 26 WEEK LEAD TIME
C
      MAXWEEK=WEEK+26
      GO TO 33
   29 IF(I.LE.MAXWEEK)GO TO 30
      MAXWEEK=I
   30 CONTINUE
   33 IF(IPRINT.GT.2)GO TO 35
      WRITE(2,1100)ORDNO,MAXWEEK
 1100 FORMAT(1H0,6X,'NO PART SHIPMENT FOR ORDER NUMBER',I5,6X,'LONGEST L
     1EAD TIME LOADED WEEK',I5)
   35 IF(MAXWEEK.GT.N)GO TO 39
      MAXWEEK=N
   39 DO 110 JM=1,ITEMCOUNT
      L=JM+1
      ITEM=PIPELINE(JZ,L,1)
      TYPE=PIPELINE(JZ,L,2)
      QTY=PIPELINE(JZ,L,3)
      IF(IPRINT.GT.2)GO TO 50
      WRITE(2,40)ITEM,AFILE(TYPE,1),QTY
   40 FORMAT(1H0,32X,I4,2X,A8,2X,I4)
   50 ORDHIST(TYPE,12)=ORDHIST(TYPE,12)+QTY
      M=0
      DO 100 I=MAXWEEK,52
      IF(QTY.LE.(DELPLAN(TYPE,I)-TOTAL(TYPE,I)))GO TO 80
      IF(DELPLAN(TYPE,I).LE.TOTAL(TYPE,I))GO TO 100
      NUMBER=DELPLAN(TYPE,I)-TOTAL(TYPE,I)
      GO TO 70
   80 NUMBER=QTY
   70 DO 60 J=1,20
      IF(ORDBK(TYPE,I,J,1).EQ.0)GO TO 90
   60 CONTINUE
      IF(IPRINT.GT.5)GO TO 100
      IZ=REFWEEK+I
      WRITE(2,65)AFILE(TYPE,1),IZ
   65 FORMAT(1H0,6X,'EXCEEDED ORDER BOOK SIZE FOR PRODUCT',2X,A8,2X,'IN
     1WEEK NUMBER',I6)
      GO TO 100
   90 QTY=QTY-NUMBER
   92 DO 95 M=1,5
      IF(OPFILE(KEYNO,ITEM,M,1).EQ.0)GO TO 99
   95 CONTINUE
      IF(IPRINT.GT.2)GO TO 110
      WRITE(2,400)
  400 FORMAT(1H0,6X,'NUMBER OF WEEKS EXCEEDS FIVE, QUANTITY TRUNCATED')
      GO TO 110
   99 ORDBK(TYPE,I,J,1)=ORDNO
      ORDBK(TYPE,I,J,2)=ITEM
      ORDBK(TYPE,I,J,3)=NUMBER
      ORDBK(TYPE,I,J,4)=0
      ORDBK(TYPE,I,J,5)=PIPELINE(JZ,1,2)
      ACTWK=REFWEEK+I
      OPFILE(KEYNO,ITEM,M,1)=TYPE
      OPFILE(KEYNO,ITEM,M,2)=NUMBER
      OPFILE(KEYNO,ITEM,M,3)=ACTWK
      OPFILE(KEYNO,ITEM,M,4)=NUMBER
      OPFILE(KEYNO,ITEM,M,10)=ORDNO
      LEADTM(TYPE,I-WEEK)=LEADTM(TYPE,I-WEEK)+NUMBER
      TOTAL(TYPE,I)=TOTAL(TYPE,I)+NUMBER
      IF(QTY.EQ.0)GO TO 110
  100 CONTINUE
      IF(IPRINT.GT.2)GO TO 101
      WRITE(2,600)AFILE(TYPE,1),ORDNO
  600 FORMAT(1H0,6X,'EXHAUSTED AVAILABLE DELIVERY PLAN FOR PRODUCT NUMBE
     1R',2X,A8/6X,'ORDER NUMBER ',I5,' LOADED ON 26 WEEK LEAD TIME')
C
C     IF DELIVERY PLAN IS INSUFFICIENT, ORDER LOADED ON 26 WEEK LEAD TIME
C
  101 JL=WEEK+26
      IF(M.EQ.5)GO TO 110
      M=M+1
  102 DO 103 J=1,20
      IF(ORDBK(TYPE,JL,J,1).EQ.0)GO TO 105
  103 CONTINUE
      IF(IPRINT.GT.5)GO TO 104
      WRITE(2,65)AFILE(TYPE,1),I
  104 JL=JL+1
      IF(JL.GT.52)GO TO 110
      GO TO 102
```

```
105 ORDBK(TYPE,JL,J,1)=ORDNO
    ORDBK(TYPE,JL,J,2)=ITEM
    ORDBK(TYPE,JL,J,3)=QTY
    ORDBK(TYPE,JL,J,4)=0
    ORDBK(TYPE,JL,J,5)=PIPELINE(JZ,1,2)
    ACTWK=REFWEEK+JL
    OPFILE(KEYNO,ITEM,M,1)=TYPE
    OPFILE(KEYNO,ITEM,M,2)=QTY
    OPFILE(KEYNO,ITEM,M,3)=ACTWK
    OPFILE(KEYNO,ITEM,M,4)=QTY
    OPFILE(KEYNO,ITEM,M,10)=ORDNO
    LEADTM(TYPE,JL-WEEK)=LEADTM(TYPE,JL-WEEK)+QTY
    TOTAL(TYPE,JL)=TOTAL(TYPE,JL)+QTY
110 CONTINUE
    GO TO 10
150 IF(IPRINT.GT.3)GO TO 160
    CALL ORDBKPRT(ORDBK,AFILE,IFILE,TOTAL,REFWEEK)
    CALL OPFPRT(OPFILE,AFILE)
160 RETURN
    END
```

```
        ORDER NUMBER     16  ITEM      PROD   QTY
    NO PART SHIPMENT FOR ORDER NUMBER   16       LONGEST LEAD TIME LOADED WEEK   14
                                         1   MF6AM 02     1
                                         2   MF6AM 02     5
                                         3   MF6AM 01    10
                                         4   AC15PU      25
                                         5   AC15PU       2
        ORDER NUMBER     17  ITEM      PROD   QTY
                                         1   MF6AM 01     5
                                         2   MF6AM 01    10
```

Sample Order Loading Report

B17 - SUBROUTINE LOADPLAN

Under ideal conditions, which implies that orders are received as forecast and deliveries take place according to plan, the delivery plan can be used as a basis for order promising. When conditions are less than ideal, it is often desirable to promise orders at a different level, to accommodate for example

- excess finished equipment stock
- insufficient finished equipment stock
- excessive overdue orders
- poor performance to plan

The latter is not addressed by the model since it is normally evident by either excessive overdue orders or insufficient finished equipment stock.

Subroutine LOADPLAN is used to modify the delivery plan derived from subroutine WEEKLYPLAN to reflect the above conditions.

On entering subroutine LOADPLAN, the modeller has the opportunity to by-pass the subroutine logic by setting ILOAD to zero. This will cause the delivery plan, DELPLAN, to be written directly into the loading plan, NETPLAN.

Setting ILOAD to "1" causes the delivery plan to be modified according to the level of overdue orders and excess stock. The overdue load is derived by searching the order book file, ORDBK, for the appropriate product for outstanding quantities which either have the overdue flag set or are overdue in the current quarter.

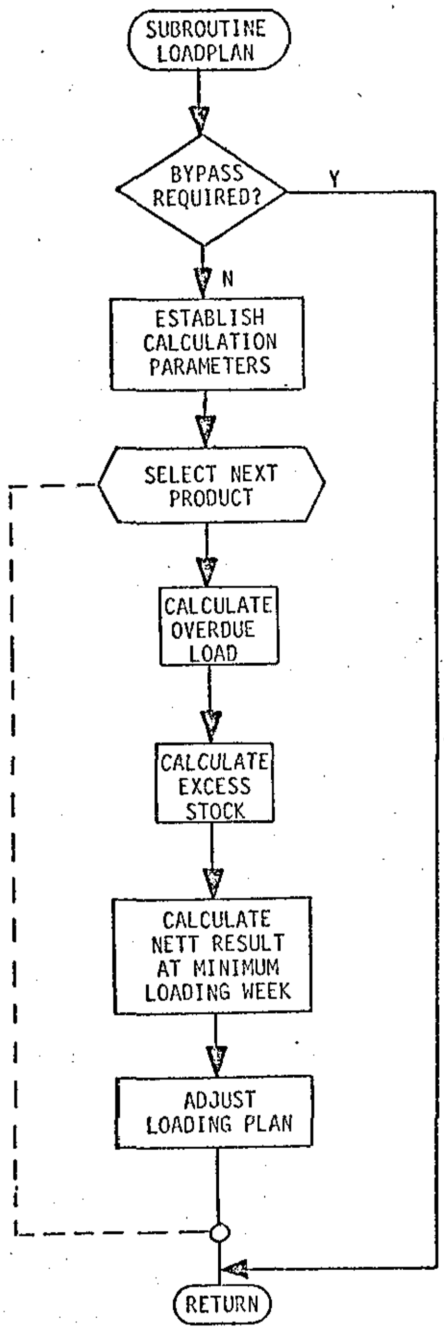
Excess stock is the difference between the actual free stock (physical stock less allocated stock) and one half of the maximum authorised stock, all of which are contained within IFILE.

The net result of the overdue orders and excess stock is projected to the minimum delivery lead time by comparing the difference between the delivery plan (DELPLAN) and the committed load (TOTAL) over the period.

The resultant quantity is then used to modify the delivery plan. A negative value indicates an overload condition and a positive value suggests excess capacity.

Overload conditions cause the loading plan to be reduced in the earliest available week after the minimum loading period, to a minimum determined by the existing committed load. Excess capacity is accommodated by increasing the loading plan by a factor of 15% beyond the minimum loading period until the excess capacity has been accounted for. This simulates the application of overtime working in the test departments (this condition is normally as a result of excess stock).

The resultant modified delivery plan is written into file NETPLAN for subsequent application in subroutine LOAD.



Summarised Flow Chart - Subroutine Loadplan

```
C
C     LOADPLAN
C
      SUBROUTINE LOADPLAN(DELPLAN,NETPLAN,IFILE,IPRINT,WEEK,OCFMIN,ORDBK
     1,AFILE,TOTAL)
      REAL AFILE(25,3)
      INTEGER DELPLAN( 5,52),NETPLAN( 5,52),IFILE(25,23),WEEK,OCFMIN,XST
     1OCK,ORDBK(5,52,20,5),TOTAL(5,52)
C
C    TO BYPASS LOADPLAN, SET ILOAD TO '0'
C
      ILOAD=1
      IF(IPRINT.GT.1)GO TO 2
      WRITE(2,1)
    1 FORMAT(1H0,6X,'* * * *  LOADPLAN  * * * *'//)
    2 IF(ILOAD.EQ.1)GO TO 4
      DO 3 I=1,5
      DO 3 J=1,52
      NETPLAN(I,J)=DELPLAN(I,J)
    3 CONTINUE
      GO TO 150
    4 N=WEEK+OCFMIN-1
      JA=WEEK
      JB=WEEK+19
      IF(IPRINT.GT.2)GO TO 5
      WRITE(2,200)
  200 FORMAT(1H0,6X,'PRODUCT',6X,'OVERDUES',6X,'EXCESS STOCK',6X,'NET LO
     1AD')
      WRITE(2,250)(J,J=JA,JB)
  250 FORMAT(1H0,28X,20I4)
C
C     CALCULATE OVERDUE LOAD
C
    5 DO 100 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 100
      NETLOAD=0
      DO 10 J=1,52
      DO 10 K=1,20
      IF(ORDBK(I,J,K,4).EQ.0)GO TO 10
      NETLOAD=NETLOAD-ORDBK(I,J,K,3)
   10 CONTINUE
      IF(WEEK.EQ.1)GO TO 30
      DO 20 J=1,WEEK-1
      NETPLAN(I,J)=0
      DO 20 K=1,15
      IF(ORDBK(I,J,K,4).EQ.1)GO TO 20
      NETLOAD=NETLOAD-ORDBK(I,J,K,3)
   20 CONTINUE
   30 IF(IPRINT.GT.2)GO TO 40
      WRITE(2,300)NETLOAD
  300 FORMAT(1H0,18X,I6)
C
C     CALCULATE EXCESS STOCK
C
   40 XSTOCK=IFILE(I,16)-IFILE(I,23)/2.0
      NETLOAD=NETLOAD+XSTOCK
C
C     CALCULATE LOAD DIFFERENCE AT OCFMIN
C
      DO 50 J=WEEK,N
      NETPLAN(I,J)=DELPLAN(I,J)
   50 NETLOAD=NETLOAD+DELPLAN(I,J)-TOTAL(I,J)
```

```
      IF(IPRINT.GT.2)GO TO 60
      WRITE(2,400)XSTOCK,NETLOAD
  400 FORMAT(1H+,35X,I6,10X,I6)
C
C     RESET LOADING PLAN
C
   60 IF(NETLOAD.LE.0)GO TO 80
      DO 70 J=N+1,52
      NETPLAN(I,J)=DELPLAN(I,J)*1.15
      NETLOAD=NETLOAD-NETPLAN(I,J)+DELPLAN(I,J)
      IF(NETLOAD.LE.0)GO TO 90
   70 CONTINUE
      GO TO 90
   80 DO 87 J=N+1,52
      IF((TOTAL(I,J)-DELPLAN(I,J)).GT.NETLOAD)GO TO 85
   83 NETPLAN(I,J)=DELPLAN(I,J)+NETLOAD
      GO TO 90
   85 NETPLAN(I,J)=TOTAL(I,J)
      NETLOAD=NETLOAD+DELPLAN(I,J)-TOTAL(I,J)
   87 CONTINUE
   90 IF(J.GT.51)GO TO 95
      DO 92 M=J+1,52
   92 NETPLAN(I,M)=DELPLAN(I,M)
   95 IF(IPRINT.GT.4)GO TO 100
      WRITE(2,500)AFILE(I,1),(DELPLAN(I,J),J=JA,JB),(NETPLAN(I,J),J=
     1JA,JB)
  500 FORMAT(1H0,6X,A8,5X,'DELPLAN',2X,20I4//20X,'NETPLAN',2X,20I4)
  100 CONTINUE
  150 RETURN
      END
```

B18 - SUBROUTINE MONTHEVENT

Subroutine MONTHEVENT controls the activities which are required to be executed each month, all of which are independent modules.

SUBPROG - establishes the sub-assembly manufacturing programme from the requirements data and modifiers(EBQ, stock levels).

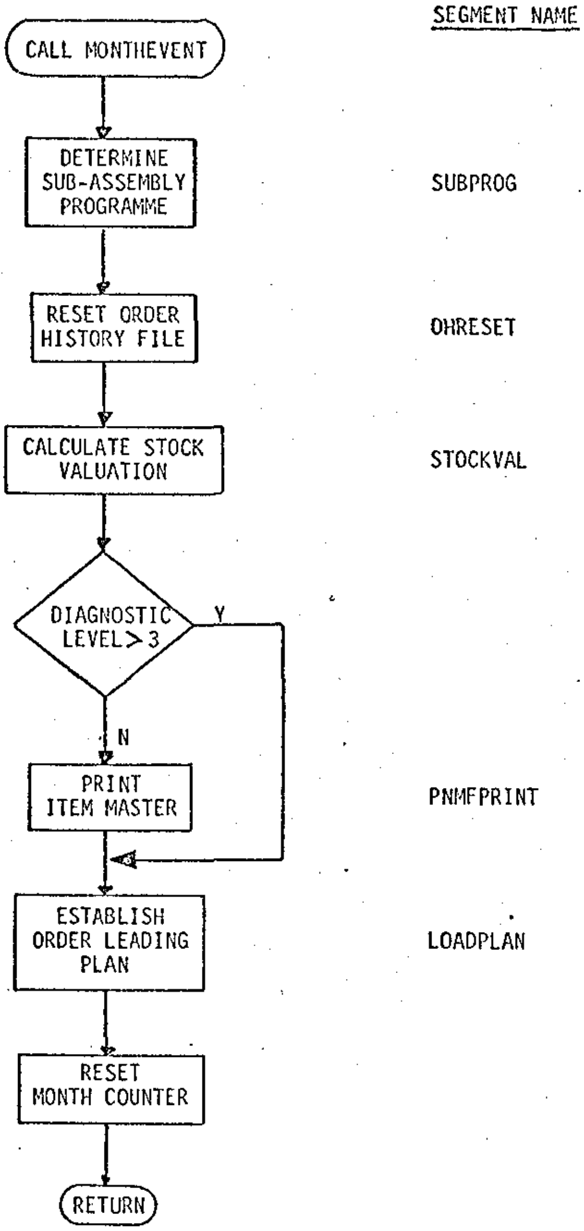
OHRESET - resets the orders received history file in preparation for the acceptance of new data.

STOCKVAL - calculates and displays the value of stock in each category.

PNMFPRINT - optional module displaying the status of the item master data.

LOADPLAN - establishes the plan to be used for order loading.

Two counters are maintained within subroutine MONTHEVENT; the first establishes the actual simulation month and the second resets the decremental counter which subsequently determines the time of activation of MONTHEVENT.



Summarised Flow Chart - Subroutine Monthevent

```
C
C     MONTHEVENT
C
      SUBROUTINE MONTHEVENT(AFILE,IFILE,REQFILE,SUBFILE,WEEK,ORDHIST,IPR
     1INT,TMONTH,MONTH,OPFILE,DELPLAN,NETPLAN,OCFMIN,ORDBK,ALLQ,TOTAL)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23),REQFILE(25,52),WEEK,SUBFILE(12,26),ORDHIST( 5
     1,12),OPFILE(125,5,5,10),DELPLAN(5,52),NETPLAN( 5,52),OCFMIN,ORDBK(
     25,52,20,5),ALLQ(12,50,6),TOTAL(5,52)
      IF(IPRINT.GT.1)GO TO 20
      WRITE(2,10)
   10 FORMAT(1H0,6X,'* * * *  MONTHEVENT   * * * *'//)
   20 CALL SUBPROG(REQFILE,WEEK,IFILE,IPRINT,SUBFILE,AFILE,ALLQ)
      CALL OHRESET(ORDHIST)
      CALL STOCKVAL(IFILE,MONTH,OPFILE)
      IF(IPRINT.GT.3)GO TO 40
      CALL PNMFPRINT(AFILE,IFILE)
   40 CALL LOADPLAN(DELPLAN,NETPLAN,IFILE,IPRINT,WEEK,OCFMIN,ORDBK,AFILE)
     1,TOTAL)
      TMONTH=4.0
      MONTH=MONTH+1
      RETURN
      END
```

B19 - SUBROUTINE NETTING

The subroutine NETTING is used to adjust, or "net", the requirements for each item for free stock and planned buffer (safety) stocks.

The requirements for the item are presented to the programme as a weekly plan over a 52 week horizon. The planned buffer stock is maintained on the PNMF in terms of weeks worth of stock and the opening value of free stock is also derived from the PNMF.

Each month, the planned level of buffer stock at the end of the month is calculated by summing the next "x" weeks of plan, where "x" is the number of weeks worth of buffer required. A net quantity is derived, being the difference between the previous buffer (or actual stock in the first period) and the revised buffer. The resultant net quantity is then offset against the gross requirements plan to provide a net requirements plan.

Two examples of the logic are shown below:

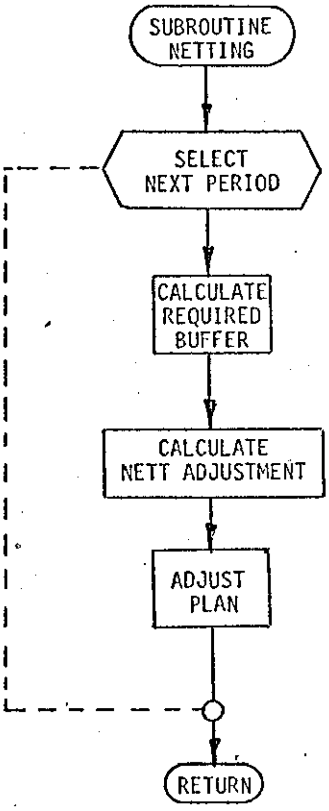
A

WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13
Gross Plan	10	10	10	10	10	10	10	10	10	15	15	15	15
Planned buffer (4weeks)					40				55				60*
Opening stock	20												
Net Value	+20				+15				+5				
Net Plan	30	10	10	10	25	10	10	10	15	15	15	15	

*Assumes constant 15 pw

B

WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13
Gross Plan	-	-	-	-	-	-	25	-	-	-	-	-	-
Planned Buffer	-	-	-	-	25	-	-	-	0	-	-	-	0
Opening Stock	5												
Net Value	+20				-25				0				
Net Plan	20	-	-	-	-	-	-	-	-	-	-	-	-



Summarised Flow Chart - Subroutine Netting

```
C
C     NETTING
C
      SUBROUTINE NETTING(BUFFERWKS,STOCK,WORKFILE)
      INTEGERBUFFERWKS,STOCK,NETQTY,OLDBUFFER,WORKFILE(52)
      OLDBUFFER=STOCK
      DO 100 I=1,49,4
      IF(BUFFERWKS.GT.0)GO TO 5
      BUFFER=0
      GO TO 30
C
C     CALCULATE BUFFER FOR NEXT PERIOD
C
    5 BUFFER=0
      J=I+BUFFERWKS-1
      DO 10 L=I+4,J+4
      IF(L.GT.52)GO TO 30
   10 BUFFER=BUFFER+WORKFILE(L)
C
C     CALCULATE NET MOVEMENT OF BUFFER STOCK
C
   30 NETQTY=BUFFER-OLDBUFFER
C
C     ADJUST PLAN
C
      J=I+3
      DO 60 K=I,J
      IF(WORKFILE(K)+NETQTY)40,50,50
   40 NETQTY=NETQTY+WORKFILE(K)
      WORKFILE(K)=0
      GO TO 60
   50 WORKFILE(K)=WORKFILE(K)+NETQTY
      NETQTY=0
   60 CONTINUE
      OLDBUFFER=BUFFER-NETQTY
  100 CONTINUE
      RETURN
      END
```

B20 - SUBROUTINE NORMAL

Subroutine NORMAL is a general purpose facility for generating normally distributed random variates. The subroutine is presented with the mean and co-efficient of variance of the normal distribution. A seed is also provided for use by the random number generator RANDOM.

The normal variate generator is based on the Central Limit Theorem, which states that the probability distribution of the sum of N independently and identically distributed random variates x_i with respective means μ_i and variances σ_i^2, as N becomes very large, approaches the normal distribution asymptotically. The resultant distribution has mean and variance:

$$\mu = \sum_{i=1}^{N} \mu_i$$

$$\sigma^2 = \sum_{i=1}^{N} \sigma_i^2$$

The probability density function f(x) for a normal distribution is given by;

$$f(x) = \frac{1}{\sigma_x \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x - \mu x}{\sigma_x}\right)^2} \quad \text{for } -\infty < x < \infty$$

If $\mu_x = o$ and $\sigma_x = 1$, the distribution function is known as the "standard normal distribution", with density function

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}z^2} \quad \text{for } -\infty < z < \infty$$

To convert a normal distribution into the standard form

$$z = \frac{x - \mu_x}{\sigma_x}$$

If we now consider the Central Limit Theorem, where $r_1, r_2 \ldots r_N$ are independent random variables each having the same probability distribution with expected value $E(r_i) = \Theta$ and variance $Var(r_i = \sigma^2$, then

$$\lim_{N \to \infty} P\left[a < \frac{\sum_{i=1}^{N} r_i - N\Theta}{\sqrt{N}\ \sigma} < b \right] = \frac{1}{\sqrt{2\pi}} \int_a^b e^{-\frac{1}{2}z^2} . dz$$

Where

$$E\left(\sum_{i=1}^{N} r_i\right) = N\Theta$$

$$Var\left(\sum_{i=1}^{N} r_i\right) = N\sigma^2$$

$$z = \frac{\sum_{i=1}^{N} r_i - N\Theta}{\sigma\sqrt{N}}$$

If we now consider the uniformly distributed random variate, the expected value and variance are given by

$$E(x) = \int_a^b \frac{1}{b - a} x . dx = \frac{a + b}{2}$$

$$Var(x) = \int_a^b \frac{(x - E(x))^2}{b - a} . dx = \frac{(b - a)^2}{12}$$

If we assume that the intervals a, b are o, 1 respectively, the sum of K uniformly distributed random variates r_1, r2....r_K (where r_i is defined over the interval $o \leqslant r_i \leqslant 1$).

$$\Theta = \frac{0 + 1}{2} = 1/2$$

$$\sigma = \frac{b - a}{\sqrt{12}} = \frac{1}{\sqrt{12}}$$

$$z = \frac{\sum_{i=1}^{K} r_i - \frac{K}{2}}{\sqrt{K/12}}$$

Since z is the standard normal deviate, then

$$\frac{x - \mu_x}{\sigma_x} = \frac{\sum_{i=1}^{K} r_i - \frac{K}{2}}{\sqrt{K/12}}$$

$$\text{or} \quad x = \sigma_x \left(\frac{12}{K}\right)^{1/2} \left(\sum_{i=1}^{K} r_i - \frac{K}{2}\right) + \mu_x$$

This now provides the basis for generating random normal variates given a series of K uniformly distributed random variates, and the defined mean (μ_x) and standard deviation (σ_x) of the desired normal distribution.

The larger the value of K, the more accurate is the result, especially at the distribution tails. However, a value of K = 12 simplifies the computation and provides reasonably accurate results up to three standard deviations.

Thus, if K = 12

$$x = \sigma_x \left(\sum_{i=1}^{12} r_i - 6\right) + \mu_x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

The construction of subroutine NORMAL is therefore straightforward. Given the definition of the normal distribution (σ_x, μ_x), twelve uniformly distributed random variates are derived from subroutine RANDOM. These are presented to equation (1) above, and the result "x" is returned to the calling programme.

```
C
C     NORMAL
C
      SUBROUTINE NORMAL(AVGE,X,J,CVARN)
      SUM=0.0
      SVAR=CVARN*AVGE
      DO 10 I=1,12
      CALL RANDOM(R,J)
   10 SUM=SUM+R
      X=SVAR*(SUM-6.0)+AVGE
      RETURN
      END
```

B21 - SUBROUTINE OFFLINE

The off-line point is taken to be the movement between the assembly work-in-progress queue to either test or stock, dependent upon the type of item. Sub-assemblies and equipment stock orders will be moved to stock; customer orders will move directly to the test work-in-progress queue.

Assembly work-in-progress queues are held in files LINEQ for equipments and SUBQ for sub-assemblies. Subroutine OFFLINE offers the facility to sort each queue into due date sequence or default to a first-in-first-out priority, in which case the sort segments are by-passed. Each queue represents a logically independent manufacturing department, and no interaction between each queue is assumed.

The sub-assembly queue, SUBQ, represents the work-in-progress in the sub-assembly department, the manufacturing capacity of which is determined by the gross quarterly capacity requirement calculation in sub-routine EBQ. The capacity is measured in total sub-assemblies per quarter and must first be converted into the equivalent rate per week.

Items are selected sequentially from the sub-assembly queue and compared with the available capacity. Items cannot be moved unless the timer is set at zero or less, recognising the minimum throughput time determined in STKALL. If sufficient capacity is available, the item quantity will be removed from the queue and the item physical stock is augmented in IFILE. The capacity balance is then reduced by the quantity moved and the next item selected from SUBQ. The process is continued until the capacity available for the week has been consumed or the work-in-progress queue is exhausted. SUBQ records which have been fully processed (zero quantity outstanding) are removed and the file consolidated.

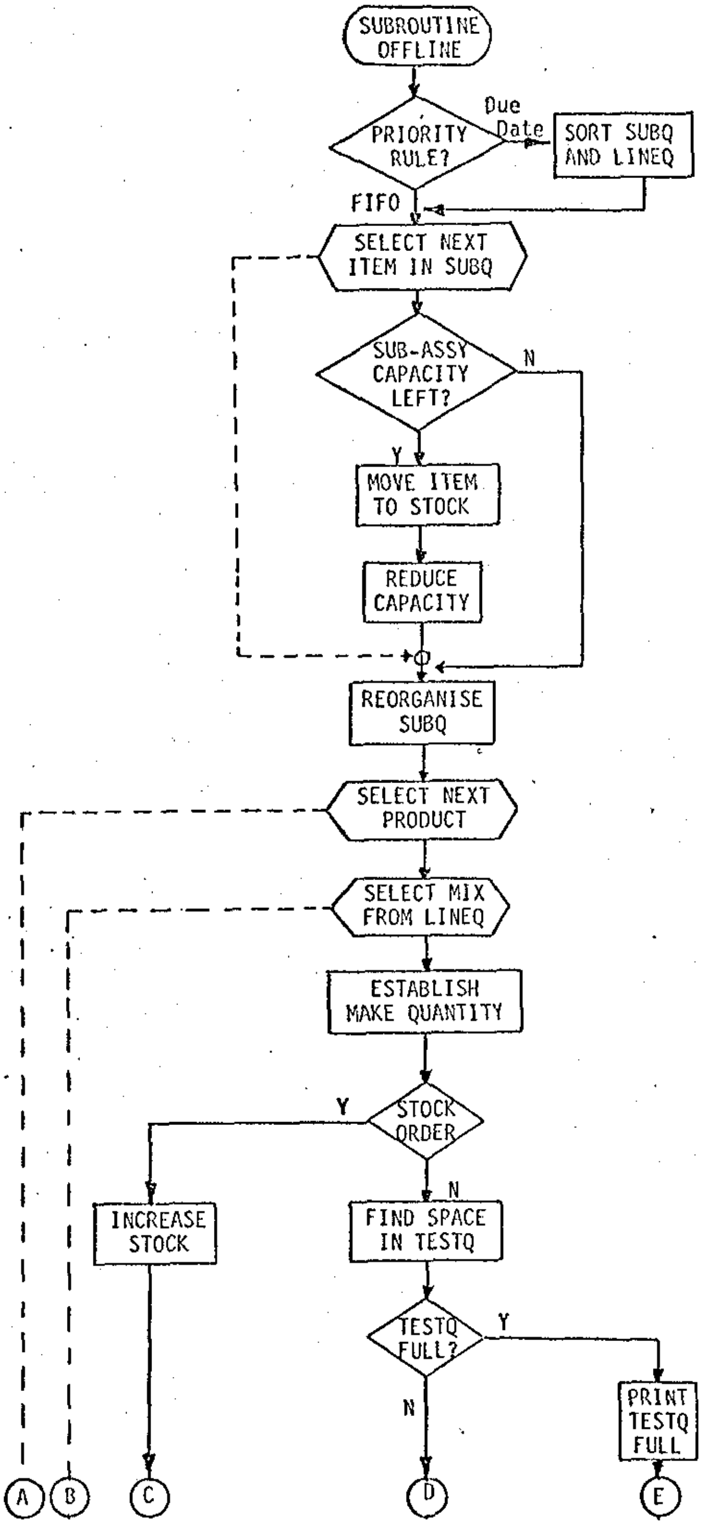
Equipments are selected from each product queue and matched against the manufacturing rate as defined by REQFILE for the appropriate week. The processing logic is dependent upon the

LINEQ record being either a stock order or a customer order. Stock orders will pass directly to stock on leaving LINEQ for subsequent allocation to customer orders in subroutine FESALL. Customer orders pass directly from LINEQ to the test work-in-progress, TESTQ.

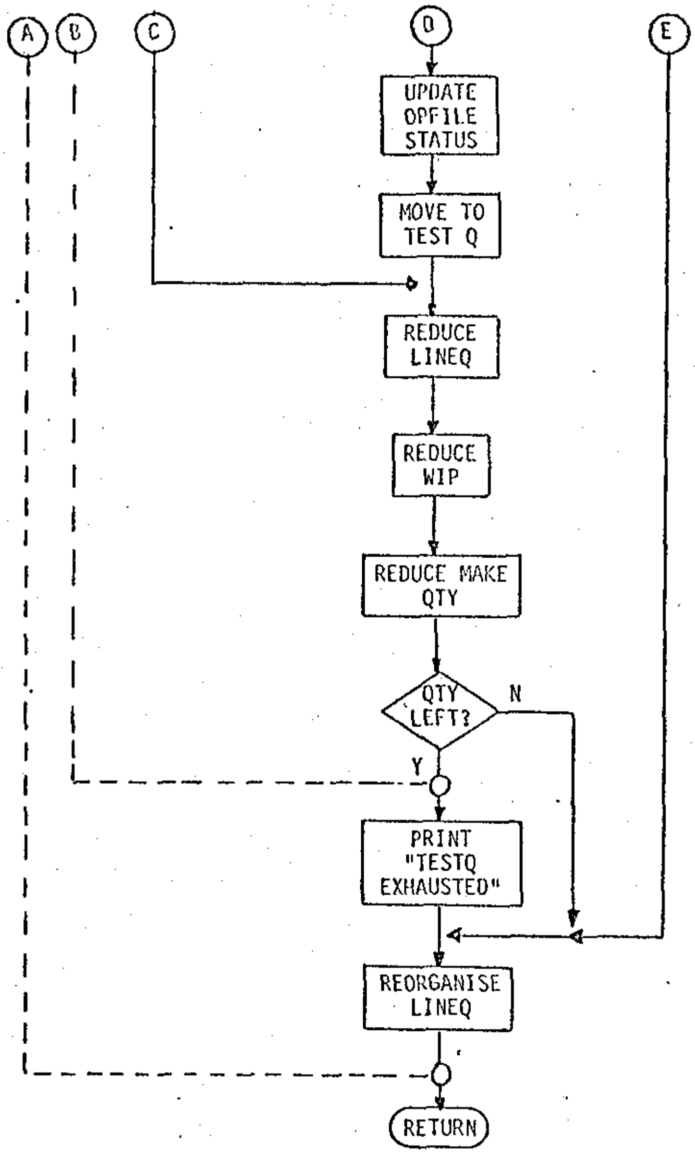
For each equipment type, LINEQ is accessed sequentially and the order records with the time set at zero or less are selected. The quantity moved for each order is the order line quantity or the balance to be moved off-line as defined by REQFILE for the appropriate week. The orders placed file, OPFILE, is searched to locate the corresponding order record, and a successful match will cause the status to change from "on-line" to "test". The LINEQ data will be transferred to the first available record in TESTQ for the appropriate product and the time set to the minimum throughput time in test.

Stock orders will by-pass the orders placed file transaction and will augment the physical stock record in IFILE instead of moving to TESTQ. Both stock and customer order will cause the line work-in-progress record in IFILE, the LINEQ record and the off-line plan balance in REQFILE to be decremented by the quantity moved.

Orders will continue to be selected from LINEQ until the off-line plan is consumed or the eligible work-in-progress is exhausted. LINEQ records which have been fully processed are removed and the file consolidated.


SUBROUTINE OFFLINE
PRIORITY RULE?
Due Date
SORT SUBQ AND LINEQ
FIFO
SELECT NEXT ITEM IN SUBQ
SUB-ASSY CAPACITY LEFT?
N
Y
MOVE ITEM TO STOCK
REDUCE CAPACITY
REORGANISE SUBQ
SELECT NEXT PRODUCT
SELECT MIX FROM LINEQ
ESTABLISH MAKE QUANTITY
STOCK ORDER
Y
N
INCREASE STOCK
FIND SPACE IN TESTQ
TESTQ FULL?
Y
N
PRINT TESTQ FULL
A
B
C
D
E

Cont. over.

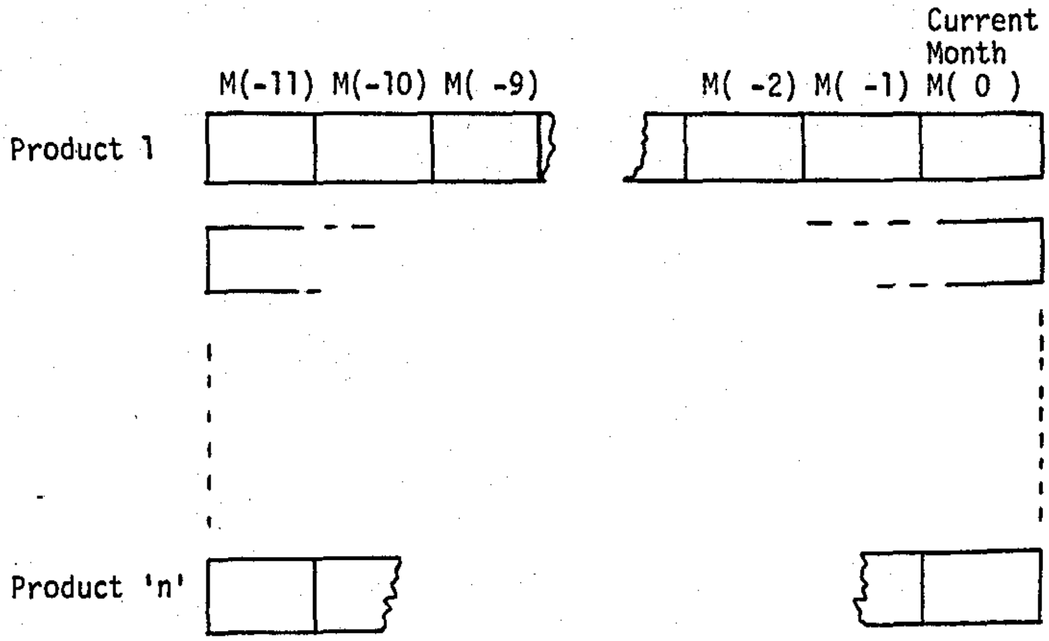


Summarised Flow Chart - Subroutine Off-line

```
C
C     OFFLINE
C
      SUBROUTINE OFFLINE(LINEQ,TESTQ,OPFILE,WEEK,REQFILE,IFILE,IPRINT,AF
     1ILE,REFWEEK,CAPACITY,ISORT,SUBQ,DIAGFILE,RUNTIME)
      REAL AFILE(25,3)
      INTEGER LINEQ(5,50,5),TESTQ(5,50,5),OPFILE(125,5,5,10),WEEK,REQFI
     1LE(25,52),IFILE(25,23),REFWEEK,CAPACITY,WKCAP,SUBQ(50,4),QTY,DI
     2AGFILE(10,2),RUNTIME
      WKCAP=CAPACITY/13.0
      IF(IPRINT.GT.1)GO TO 1
      WRITE(2,560)
  560 FORMAT(1H0,6X,'* * * *  OFFLINE  * * * *'//)
      WRITE(2,570)WKCAP
  570 FORMAT(1H0,6X,'WKCAP ='I6)
C
C     SORT SUB QUEUE
C
    1 IF(ISORT.EQ.0)GO TO 5
      DO 2 J=1,49
      DO 2 K=J+1,50
      IF(SUBQ(K,3).EQ.0)GO TO 2
      IF(SUBQ(J,2).LE.SUBQ(K,2))GO TO 2
      DO 2 L=1,4
      M=SUBQ(J,L)
      SUBQ(J,L)=SUBQ(K,L)
      SUBQ(K,L)=M
    2 CONTINUE
C
C     SORT LINE QUEUE
C
      DO 3 I=1,5
      DO 3 J=1,49
      DO 3 K=J+1,50
      IF(LINEQ(I,K,4).EQ.0)GO TO 3
      IF(LINEQ(I,J,3).LE.LINEQ(I,K,3))GO TO 3
      DO 3 L=1,5
      M=LINEQ(I,J,L)
      LINEQ(I,J,L)=LINEQ(I,K,L)
      LINEQ(I,K,L)=M
    3 CONTINUE
    5 IF(IPRINT.GT.3)GO TO 4
      CALL SQPRINT(SUBQ,WEEK,AFILE,REFWEEK)
      CALL LQPRINT(LINEQ,WEEK,AFILE,REFWEEK)
C
C     SEGMENT FOR SUB-ASSEMBLIES
C
    4 DO 18 J=1,50
      IF(WKCAP.LE.0)GO TO 19
      IF(SUBQ(J,3).EQ.0)GO TO 18
      IF(SUBQ(J,4).GT.0)GO TO 18
      IPROD=SUBQ(J,1)
      IF(SUBQ(J,3).GT.WKCAP)GO TO 12
      IQTY=SUBQ(J,3)
      GO TO 14
   12 IQTY=WKCAP
   14 WKCAP=WKCAP-IQTY
      SUBQ(J,3)=SUBQ(J,3)-IQTY
      IFILE(IPROD,16)=IFILE(IPROD,16)+IQTY
      IFILE(IPROD,18)=IFILE(IPROD,18)-IQTY
      IF(IPRINT.GT.1)GO TO 18
      WRITE(2,16)AFILE(IPROD,1),SUBQ(J,2),IQTY
   16 FORMAT(1H0,6X,'SUB-ASSEMBLY',2X,A8,2X,'DUE WEEK',I6,2X,
     1'QTY',I6,2X,'MOVED TO STOCK')
   18 CONTINUE
   19 DO 180 MM=1,49
      IF(SUBQ(MM,3).GT.0)GO TO 180
      DO 170 M=MM+1,50
      IF(SUBQ(M,3).GT.0)GO TO 175
  170 CONTINUE
      GO TO 10
 175   DO 181 N=1,4
      SUBQ(MM,N)=SUBQ(M,N)
      SUBQ(M,N)=0
 181   CONTINUE
  180 CONTINUE
   10 DO 200 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 200
C
C     SEGMENT FOR EQUIPMENTS
C
      IF(IPRINT.GT.1)GO TO 30
      WRITE(2,550)AFILE(I,1),REQFILE(I,WEEK)
  550 FORMAT(1H0,6X,'OFFLINE QUANTITY FOR',2X,A8,2X,'IS',I7)
   30 IF(REQFILE(I,WEEK).LE.0)GO TO 200
      DO 120 J=1,50
      IF(LINEQ(I,J,5).GT.0)GO TO 120
      IF(LINEQ(I,J,4).EQ.0)GO TO 120
      QTY=LINEQ(I,J,4)
      IF(LINEQ(I,J,4).LT.REQFILE(I,WEEK))GO TO 35
      QTY=REQFILE(I,WEEK)
   35 IF(LINEQ(I,J,1).LT.0)GO TO 100
C
C     SEGMENT FOR CUSTOMER ORDERS
C
      DO 40 K=1,50
      IF(TESTQ(I,K,4).EQ.0)GO TO 50
   40 CONTINUE
      IF(IPRINT.GT.5)GO TO 150
      WRITE(2,45)AFILE(I,1)
   45 FORMAT(1H0,6X,'EXCEEDED TEST QUEUE SIZE FOR PRODUCT NO.',2X,A8)
      GO TO 150
   50 JA=LINEQ(I,J,1)
      JB=LINEQ(I,J,2)
      JC=LINEQ(I,J,3)
      DO 55 KEYNO=1,125
      IF(OPFILE(KEYNO,JB,1,10).EQ.JA)GO TO 57
   55 CONTINUE
      GO TO 65
   57 DO 60 M=1,5
      IF(OPFILE(KEYNO,JB,M,3).EQ.JC)GO TO 80
   60 CONTINUE
   65 IF(IPRINT.GT.5) GO TO 120
      WRITE(2,70)JA,JB,JC,OPFILE(KEYNO,JB,M,3),REFWEEK
   70 FORMAT(1H0,6X,'INCOMPATIBLE DATA IN OPFILE FOR ORDER NO.',I4,' ITE
     1M NO.',I4,' DUE WEEK',I4/6X,'ACTUAL WEEK ',I4,6X,'REFWEEK ',I4)
      IPRINT=1
      DO 75 IZ=1,10
   75 DIAGFILE(IZ,2)=1
      RUNTIME=REFWEEK+WEEK+4
      GO TO 120
 80 DO 90 L=1,3
 90 TESTQ(I,K,L)=LINEQ(I,J,L)
    TESTQ(I,K,4)=QTY
    TESTQ(I,K,5)=3
    IFILE(I,19)=IFILE(I,19)+QTY
    OPFILE(KEYNO,JB,M,8)=OPFILE(KEYNO,JB,M,8)+QTY
    OPFILE(KEYNO,JB,M,7)=OPFILE(KEYNO,JB,M,7)-QTY
    GO TO 110
100 IFILE(I,16)=IFILE(I,16)+QTY
110 LINEQ(I,J,4)=LINEQ(I,J,4)-QTY
    IFILE(I,18)=IFILE(I,18)-QTY
    REQFILE(I,WEEK)=REQFILE(I,WEEK)-QTY
    IF(IPRINT.GT.3)GO TO 115
    WRITE(2,530)(LINEQ(I,J,K),K=1,3),QTY
530 FORMAT(1H0,6X,'ORDER',I5,2X,'ITEM',I5,2X,'DUE',I5,2X,'QTY',I5,
   12X,'MOVED OFF LINE')
115 IF(REQFILE(I,WEEK).LE.0)GO TO 150
120 CONTINUE
500 IF(IPRINT.GT.2)GO TO 150
    WRITE(2,510)AFILE(I,1)
510 FORMAT(1H0,6X,'EXHAUSTED ORDERS IN W.I.P. FOR PRODUCT',2X,A8)
150 DO 160 MM=1,49
    IF(LINEQ(I,MM,4).GT.0)GO TO 160
    DO 153 M=(MM+1),50
    IF(LINEQ(I,M,4).GT.0)GO TO 155
153 CONTINUE
    GO TO 200
155 DO 158 N=1,5
    LINEQ(I,MM,N)=LINEQ(I,M,N)
    LINEQ(I,M,N)=0
158 CONTINUE
160 CONTINUE
200 CONTINUE
    IF(IPRINT.GT.2)GO TO 250
    CALL TQPRINT(TESTQ,WEEK,AFILE,REFWEEK)
250 RETURN
    END
```

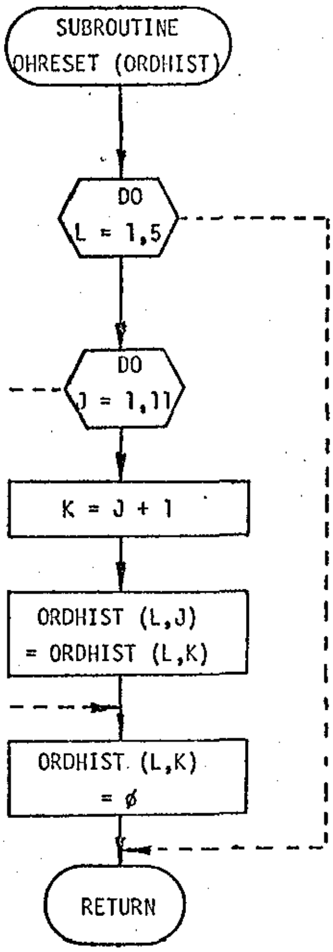
B22 SUBROUTINE OHRESET

Orders received history is maintained in file ORDHIRST, and is used to prepare the orders received forecast in subroutine FORECAST. ORDHIST is organised into twelve monthly buckets per product as shown below.



As orders are generated and entered into the order book in subroutine LOAD, the current month bucket in ORDHIST for the appropriate product is augmented by the order quantity.

At the end of each month the file is reset in subroutine OHRESET by shifting each entry in ORDHIST by one period. Values for month (-11) are removed from the file and the current month is cleared down in preparation for new orders received data.



Summarised Flow Chart - Subroutine Ohreset

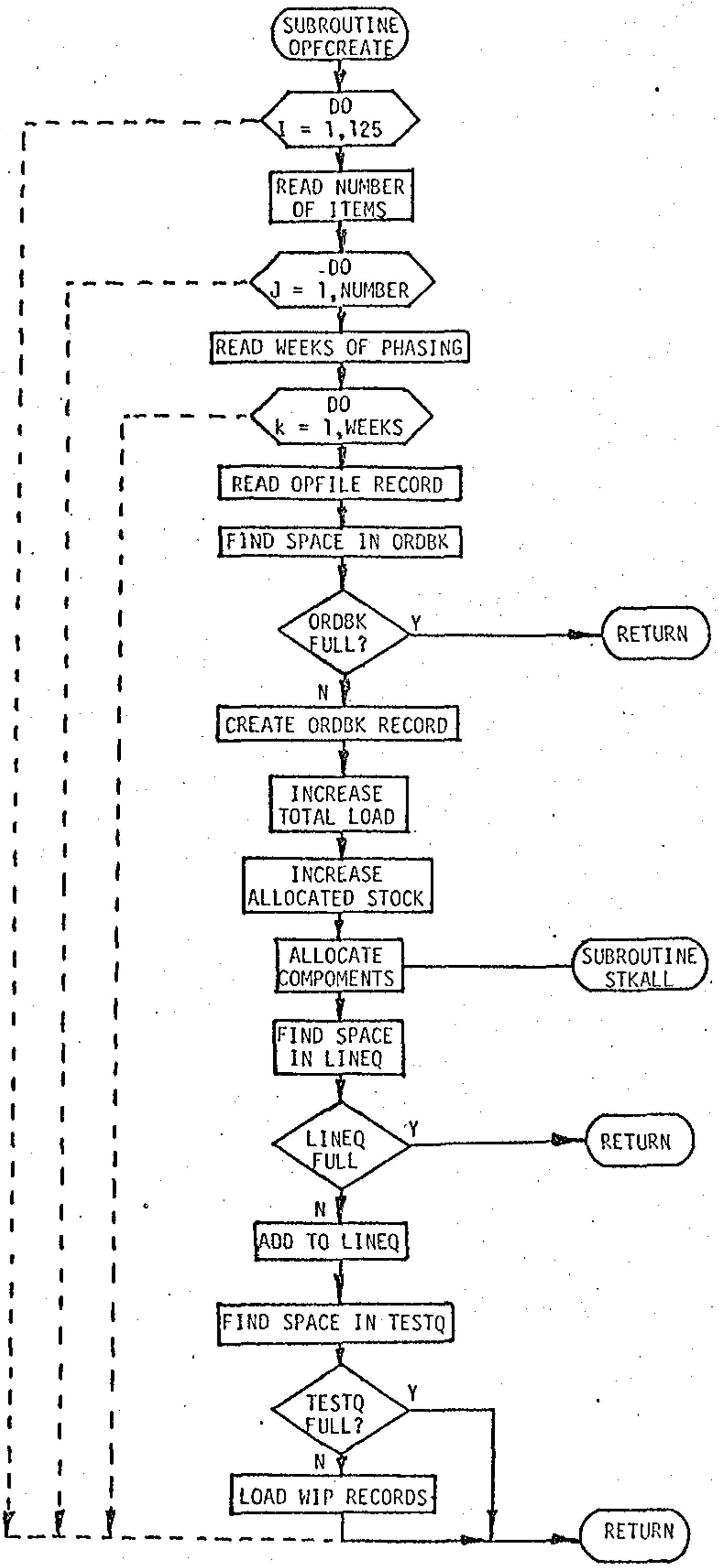
```
C
C     OHRESET
C
      SUBROUTINE OHRESET(ORDHIST)
      INTEGER ORDHIST( 5,12)
      DO 20 L=1,5
      DO 10 J=1,11
      K=J+1
   10 ORDHIST(L,J)=ORDHIST(L,K)
   20 ORDHIST(L,12)=0
      RETURN
      END
```

B23 - SUBROUTINE OPFCREATE

Subroutine OPFCREATE is used to create the initial conditions, where these are related to the orders placed file (OPFILE) records.

Customer order information is read from the source file and creates an OPFILE record, which subsequently is used to create a corresponding order book (ORDBK) record for the appropriate product. The total load in file TOTAL is incremented by the order quantity and items "to be allocated ex-stock" will increment the allocated stock filed in IFILE. Items shown "in allocation" status will cause the component stock to be allocated by making use of subroutine STKALL, which will also create a record in the allocation queue ALLQ. Items shown in "on-line" status will cause a record to be created in file LINEQ and items in "test" status will create a record in TESTQ.

When the source data file has been exhausted, the work in progress quantity for each product is derived by summing the quantities in LINEQ and TESTQ, and the totals are entered in IFILE. The sub-assembly work in progress, contained in file SUBQ is also totalled for entry in IFILE. SUBQ is initialised in the main STOCKMODEL segment.



Summarised Flow Chart - Sub-routine Opfcreate

```
C
C     OPFCREATE
C
      SUBROUTINE OPFCREATE(OPFILE,ORDBK,TOTAL,ALLQ,LINEQ,TESTQ,ORDCOUNT,
     1REFWEEK,IFILE,ISEED4,ICOUNT,ISHORT,IPRINT,AFILE,SUBQ)
      REAL AFILE(25,3)
      INTEGER OPFILE(125,5,5,10),ORDBK( 5,52,20,5),ORDNO,ITEMNO,DUE,QTY,
     1TOTAL( 5,52),ALLQ(12,50,6),LINEQ(5,50,5),TESTQ(5,50,5),ORDCOUNT
     2,PROD,REFWEEK,IFILE(25,23),SUBQ(50,4),ICOUNT(25),ISHORT(25)
      IF(IPRINT.GT.1)GO TO 5
      WRITE(2,3)
    3 FORMAT(1H0,6X,'* * * *  OPFCREATE  * * * *'//)
    5 REFWEEK =0
      ORDCOUNT=0
      DO 170 I=1,125
      READ(1,10)NUMBER,IPS
   10 FORMAT(2I5)
C
C     NUMBER=NUMBER OF ITEMS,NWKS=NUMBER OF WEEKS OF PHASING
C
      IF(NUMBER.EQ.0)GO TO 175
      DO 170 J=1,NUMBER
      READ(1,15)NWKS
   15 FORMAT(I5)
      DO 170 K=1,NWKS
      READ(1,20)(OPFILE(I,J,K,L),L=1,10)
   20 FORMAT(10I5)
      ORDNO=OPFILE(I,J,K,10)
      IF(ORDNO.LE.ORDCOUNT)GO TO 25
      ORDCOUNT=ORDNO
   25 ITEMNO=J
      QTY=OPFILE(I,J,K,2)-OPFILE(I,J,K,9)
      DUE=OPFILE(I,J,K,3)
      PROD=OPFILE(I,J,K,1)
C
C     FIND NEXT SPACE IN ORDER BOOK
C
      DO 30 M=1,20
      IF(ORDBK(PROD,DUE,M,1).EQ.0)GO TO 50
   30 CONTINUE
      IF(IPRINT.GT.5)GO TO 200
      WRITE(2,40)PROD
   40 FORMAT(1H0,6X,'ORDER BOOK SIZE EXCEEDED FOR PRODUCT NUMBER',I6,2X,
     1'DUE WEEK',I6)
      GO TO 200
   50 ORDBK(PROD,DUE,M,1)=ORDNO
      ORDBK(PROD,DUE,M,2)=ITEMNO
      ORDBK(PROD,DUE,M,3)=QTY
      ORDBK(PROD,DUE,M,4)=0
      ORDBK(PROD,DUE,M,5)=IPS
      TOTAL(PROD,DUE)=TOTAL(PROD,DUE)+QTY
      IF(OPFILE(I,J,K,5).EQ.0)GO TO 80
C
C      ALLOCATE COMPONENTS
C
      IFILE(PROD,17)=IFILE(PROD,17)+OPFILE(I,J,K,5)
   80 IF(OPFILE(I,J,K,6).EQ.0)GO TO 90
C
C     MOVE ITEM INTO ALLOCATION QUEUE AND RESERVE COMPONENTS
C
```

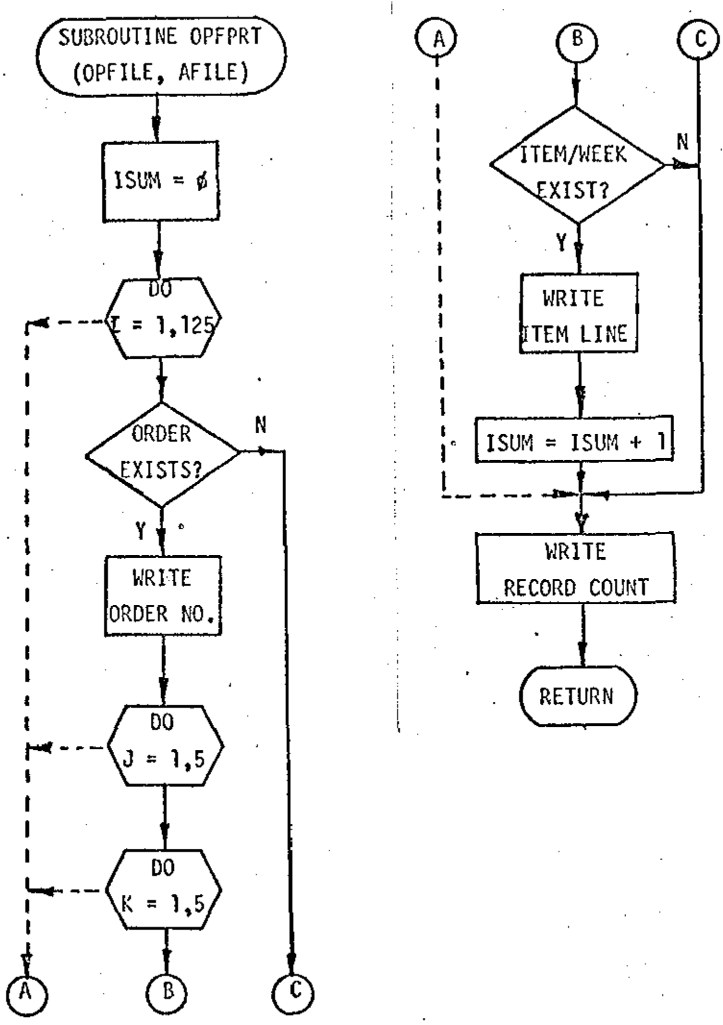
```
      NR=OPFILE(I,J,K,6)
      IMAX=0
      OUTPUT=0.0
      CALL STKALL(IFILE,    NR,PROD,ALLQ,ORDNO,ITEMNO,DUE, OUTPUT,ICOUNT
     1,ISHORT,IPRINT,IMAX,AFILE,&200)
   90 IF(OPFILE(I,J,K,7).EQ.0)GO TO 130
C
C     FIND NEXT SPACE IN LINE QUEUE
C
      DO 100 L=1,50
      IF(LINEQ(PROD,L,1).EQ.0)GO TO 120
  100 CONTINUE
      IF(IPRINT.GT.5)GO TO 200
      WRITE(2,110)PROD
  110 FORMAT(1H0,6X,'EXCEEDED LINE QUEUE FOR PRODUCT NUMBER',I6)
      GO TO 200
  120 LINEQ(PROD,L,1)=ORDNO
      LINEQ(PROD,L,2)=ITEMNO
      LINEQ(PROD,L,3)=DUE
      LINEQ(PROD,L,4)=OPFILE(I,J,K,7)
      LINEQ(PROD,L,5)=0
  130 IF(OPFILE(I,J,K,8).EQ.0)GO TO 170
C
C     FIND NEXT SPACE IN TEST QUEUE
C
      DO 140 L=1,50
      IF(TESTQ(PROD,L,1).EQ.0)GO TO 160
  140 CONTINUE
      IF(IPRINT.GT.5)GO TO 200
      WRITE(2,150)PROD
  150 FORMAT(1H0,6X,'EXCEEDED TEST QUEUE FOR PRODUCT NUMBER',I6)
      GO TO 200
  160 TESTQ(PROD,L,1)=ORDNO
      TESTQ(PROD,L,2)=ITEMNO
      TESTQ(PROD,L,3)=DUE
      TESTQ(PROD,L,4)=OPFILE(I,J,K,8)
      TESTQ(PROD,L,5)=0
  170 CONTINUE
C
C     LOAD WIP RECORDS
C
  175 DO 190 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 190
      IFILE(I,18)=0
      DO 180 J=1,50
      IFILE(I,18)=IFILE(I,18)*LINEQ(I,J,4)
  180 CONTINUE
      IFILE(I,19)=0
      DO 190 J=1,50
      IFILE(I,19)=IFILE(I,19)*TESTQ(I,J,4)
  190 CONTINUE
      DO 195 I=1,20
      IF(IFILE(I,11).EQ.2)GO TO 193
      IF(IFILE(I,11).NE.3)GO TO 195
  193 DO 195 J=1,50
      IF(SUBQ(J,1).NE.I)GO TO 195
      IFILE(I,18)=IFILE(I,18)*SUBQ(J,3)
  195 CONTINUE
  200 RETURN
      END
```

B24 - SUBROUTINE OPFPRT

Subroutine OPFPRT is used to display the contents of file OPFILE for diagnostic purposes. Orders are displayed in the sequence held in the file, which is quasi-random. Redundant entries which have been cleared down are not displayed.

Data is presented as week due within item number within order number, each line specifying the product type, ordered quantity, week due and status information.

A record count is displayed each time the subroutine is activated, to allow the modeller to remain within the file volume constraints of OPFILE.



Summarised Flow Chart - Subroutine Opfprt

```
C
C     OPFPRT
C
      SUBROUTINE OPFPRT(OPFILE,AFILE)
      REAL AFILE(25,3)
      INTEGER OPFILE(125,5,5,10)
      WRITE(2,200)
  200 FORMAT(1H0,6X,'ORDER FILE DETAIL',50X,'STATUS'//6X,'ORDER NUMBER
     1     ITEM     PRODUCT   QUANTITY   DUE DATE   OPEN EX-STK ALLN ON-LINE
     2TEST DESP.'/)
      ISUM=0
      DO 110 I=1,125
      IF(OPFILE(I,1,1,10).EQ.0)GO TO 110
      WRITE(2,210)OPFILE(I,1,1,10)
  210 FORMAT(1H ,10X,I5)
      ISUM=ISUM+1
      DO 110 J=1,5
      DO 110 K=1,5
      IF(OPFILE(I,J,K,1).EQ.0)GO TO 110
      WRITE(2,205)J
  205 FORMAT(1H+,22X,I3)
      N=OPFILE(I,J,K,1)
      WRITE(2,220)AFILE(N,1),(OPFILE(I,J,K,L),L=2,9)
  220 FORMAT(1H+,31X,A8,2I9,6I6/)
  110 CONTINUE
      WRITE(2,230)ISUM
  230 FORMAT(1H0,6X,'RECORD COUNT =',I6)
      RETURN
      END
```

```
 ORDER-FILE DETAIL                                                   STATUS

ORDER NUMBER       ITEM    PRODUCT  QUANTITY  DUE DATE   OPEN EX-STK ALLN ON-LINETEST DESP.

        24         1      MF6AM 03         4       26     0     4     0     0     0      0
                   1      MF6AM 03        21       27     0    21     0     0     0      0
                   2      MF6AM 02        34       26    34     0     0     0     0      0
                   2      MF6AM 02         9       27     9     0     0     0     0      0
                   2      MF6AM 02         7       28     7     0     0     0     0      0
                   3      MF6AM 02        33       28    33     0     0     0     0      0
                   3      MF6AM 02        17       29    17     0     0     0     0      0

         2         1      MF6AM 01        20       13     0     0     0     0     0     20
                   1      MF6AM 01        20       14     0     0     0     0     0     20
                   1      MF6AM 01        20       15     0     0     0     0     0     20
                   1      MF6AM 01        20       16     0     0     0     0    20      0
                   1      MF6AM 01        20       17     0     0     0     0    20      0

        18         1      MF6AM 02         2       25     0     0     2     0     0      0

        27         1      MF6AM 01        13       29    13     0     0     0     0      0
                   1      MF6AM 01        12       30    12     0     0     0     0      0
                   2      MF6AM 02        23       29    23     0     0     0     0      0
                   2      MF6AM 02        27       30    27     0     0     0     0      0
                   3      MF6AM 01        10       30    10     0     0     0     0      0
                   4      MF6AM 01         5       30     5     0     0     0     0      0
                   5      MF6AM 01         1       30     1     0     0     0     0      0

         5         1      MF6AM 03        25       17     0     0     0     0    25      0
                   2      MF6AM 01        50       14     0     0     0     0     0      0
                   2      MF6AM 01        50       15     0     0     0     0    42      8
                   3      MF6AM 01        50       16     0     0     0     0    50      0
                   3      MF6AM 01        25       17     0     0     0    25     0      0
                   4      MF6AM 02        10       17     0     0     0     0    10      0
                   5      AC15PU          20       16     0     0     0     0    20      0

        28         1      AC15PU          25       30    25     0     0     0     0      0
                   1      AC15PU          25       31    25     0     0     0     0      0
                   2      MF6AM 01        10       30    10     0     0     0     0      0
                   3      MF6AM 01         1       30     1     0     0     0     0      0
```

Sample Orders Placed File

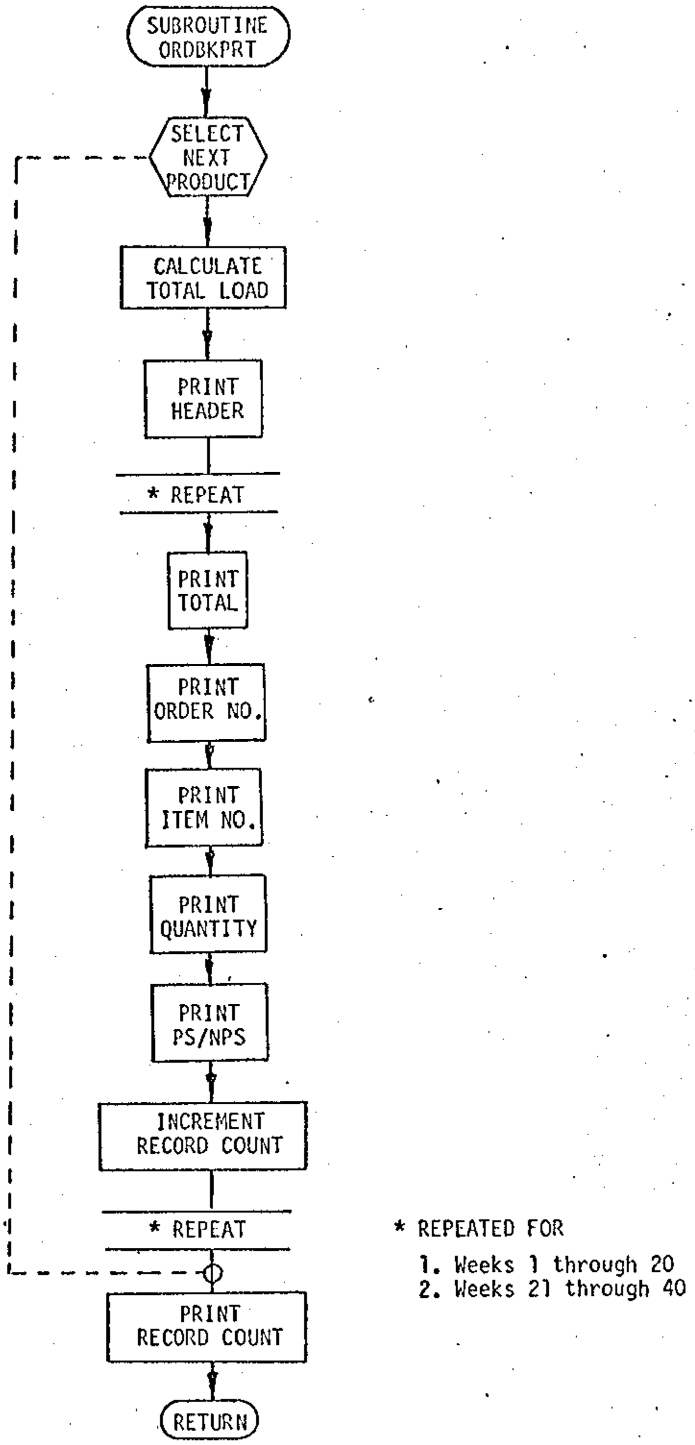
B25 - SUBROUTINE ORDBKPRT

Subroutine ORDBKPRT is used to display the content of the order book, ORDBK, for each product as a diagnostic tool.

The print format is arranged in product sequence and displays as total values the overdue load and the total order load. For due orders, the order number, item number and quantity outstanding are displayed, with an indicator signifying part shipment or no part shipment allowed.

The print format will accommodate up to 20 weeks of due orders. If live orders exist beyond this horizon a further 20 weeks horizon is displayed. Orders beyond 40 weeks are not considered in ORDBKPRT.

Each week in ORDBK can accommodate a maximum of fifteen entries. ORDBKPRT will suppress zero records, thus reducing the volume of printed output. A counter is contained within the subroutine to register the maximum record count, indicating to the modeller the proportion of file ORDBK utilised during each simulation run.



Summarised Flow Chart - Subroutine Ordbkprt

```
C
C     ORDBKPRT
C
      SUBROUTINE ORDBKPRT(ORDBK,AFILE,IFILE,TOTAL,REFWEEK)
      REAL AFILE(25,3)
      INTEGER ORDBK(5,52,20,5),IFILE(25,23),TOTAL(5,52),REFWEEK
      MAX2=0
      DO 100 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 100
      WRITE(2,10)AFILE(I,1)
   10 FORMAT(1H0,6X,'ORDER BOOK DETAIL FOR PRODUCT NUMBER',2X,A8)
      INDEX=0
      ISUM=0
      DO 20 J=1,52
      DO 20 K=1,20
      IF(ORDBK(I,J,K,4).EQ.0)GO TO 20
      ISUM=ISUM+ORDBK(I,J,K,3)
   20 CONTINUE
      L1=1
      L2=20
      M=REFWEEK+1
      N=REFWEEK+20
   30 WRITE(2,50)(J,J=M,N)
   50 FORMAT(1H0,6X,'WEEK',4X,'O/D',2X,20I4)
      WRITE(2,53)ISUM,(TOTAL(I,J),J=L1,L2)
   53 FORMAT(1H0,6X,'LOAD',3X,I4,2X,20I4)
      MAX1=0
      DO 90 K=1,20
      DO 55 J=L1,L2
      IF(ORDBK(I,J,K,4).EQ.1)GO TO 55
      IF(ORDBK(I,J,K,1).GT.0)GO TO 57
   55 CONTINUE
      GO TO 90
   57 WRITE(2,60)(ORDBK(I,J,K,1),J=L1,L2)
   60 FORMAT(1H0,6X,'ORD,NO,',6X,20I4)
      WRITE(2,70)(ORDBK(I,J,K,2),J=L1,L2)
   70 FORMAT(1H ,6X,'ITEM',9X,20I4)
      WRITE(2,80)       (ORDBK(I,J,K,3),J=L1,L2)
   80 FORMAT(1H ,6X,'QTY',10X,20I4)
      WRITE(2,85)(ORDBK(I,J,K,5),J=L1,L2)
   85 FORMAT(1H ,6X,'1=PS,2=NPS',3X,20I4)
      MAX1=MAX1+1
   90 CONTINUE
      IF(MAX1.LT.MAX2)GO TO 92
      MAX2=MAX1
   92 IF(INDEX.EQ.1) GOTO 100
      DO 95 J=21,40
      DO 95 K=1,20
      IF(ORDBK(I,J,K,4).EQ.1)GO TO 95
      IF(ORDBK(I,J,K,3).EQ.0)GO TO 95
      M=REFWEEK+21
      N=REFWEEK+40
      ISUM=0
      L1=21
      L2=40
      INDEX=1
      GO TO 30
   95 CONTINUE
  100 CONTINUE
      WRITE(2,110)MAX2
  110 FORMAT(1H0,6X,'MAXIMUM RECORD COUNT =',I6)
      RETURN
      END
```

```
ORDER BOOK DETAIL FOR PRODUCT NUMBER  MF6AM 02

WEEK      O/D    14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33

LOAD        0     0    0    0   10   35   35   35   25    0   34    7   34   34   40   40   40   40   40   40   21

ORD,NO.           0    9    0    5   14   14   14   14    0   31   35   18   24   16   24   24   27   30   35   39
ITEM              0    2    0    4    1    1    1    1    0    1    2    1    2    1    2    3    2    2    2    1
QTY              .0    0    0   10   25   25   25   25    0   10    7    2   34    1    7   17   27   14   11   21
1=PS:2=NPS        0    2    0    1    1    1    1    1    0    2    2    2    2    2    2    2    2    2    2    2

ORD,NO.           9    0    0   14   15   15   15    0    0   35    0   35    0   16   24   27   29   35   39    0
ITEM              2    0    0    1    1    1    1    0    0    2    0    2    0    2    3    2    3    2    1    0
QTY               0    0    0    0   10   10   10    0    0   24    0   32    0    5   33   23    2   26   29    0
1=PS:2=NPS        2    0    0    1    1    1    1    0    0    2    0    2    0    2    2    2    2    2    2    0

ORD,NO.           0    0    0    0    0    0    0    0    0    0    0    0    0   21    0    0   30    0    0    0
ITEM              0    0    0    0    0    0    0    0    0    0    0    0    0    2    0    0    2    0    0    0
QTY               0    0    0    0    0    0    0    0    0    0    0    0    0   25    0    0   11    0    0    0
1=PS;2=NPS        0    0    0    0    0    0    0    0    0    0    0    0    0    2    0    0    2    0    0    0

ORD,NO.           0    0    0    0    0    0    0    0    0    0    0    0    0   24    0    0    0    0    0    0
ITEM              0    0    0    0    0    0    0    0    0    0    0    0    0    2    0    0    0    0    0    0
QTY               0    0    0    0    0    0    0    0    0    0    0    0    0    9    0    0    0    0    0    0
1=PS:2=NPS        0    0    0    0    0    0    0    0    0    0    0    0    0    2    0    0    0    0    0    0
```

Sample Product Order Book

B26 - SUBROUTINE ORDERS

Subroutine ORDERS simulates the arrival of customer orders into the order processing pipeline. The structure and profile of orders generated is a reasonable approximation to the pattern observed in the real world.

The subroutine makes use of five sampling profiles, determining

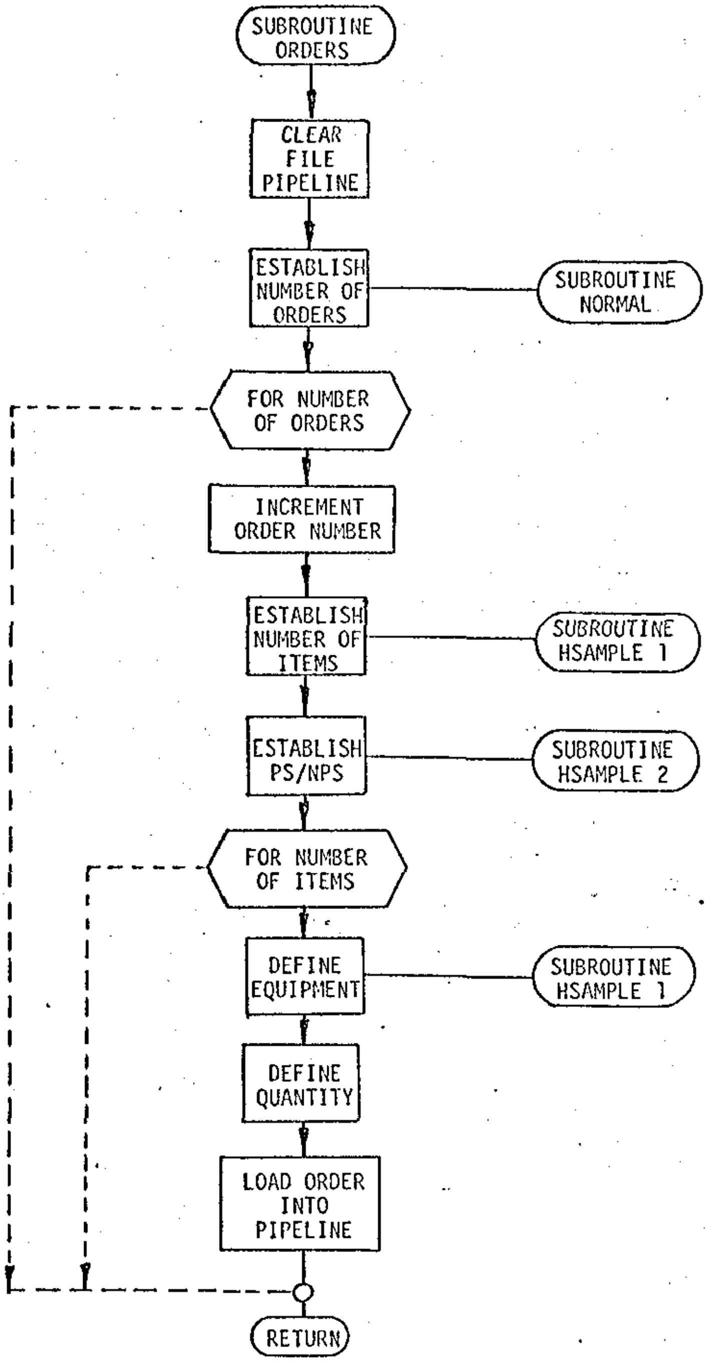
- the number of orders to be generated in each period (simulated week)
- the number of order lines
- the product applicable to each order line
- the quantity of each product
- whether part shipment is permissible

The orders pipeline file, PIPELINE, is cleared down to accept new orders and the number of new orders is determined by sampling from a normal distribution in subroutine NORMAL. The mean and coefficient of variation of the distribution may be modified by the modeller, but it should be noted that a mean in excess of 5.0 may cause file volumes to be exceeded.

For each new order, the number of items is established by sampling from the frequency histogram contained in TABLE 5, using subroutine HSAMPLE 1. The "part shipment" or "no part shipment" condition is determined by sampling from TABLE 8 in subroutine HSAMPLE 2.

Two further frequency histograms are sampled for each order item line; the product to be selected and the quantity required. Both use HSAMPLE 1 and the parameters from TABLE 6 and TABLE 7 respectively. The quantity for each product is extended by the unit cost contained in IFILE to arrive at an approximate sales value for later analysis if required.

The resultant customer order profile is entered as a new record in the file PIPELINE for subsequent order loading.



Summarised Flow Chart - Subroutine Orders

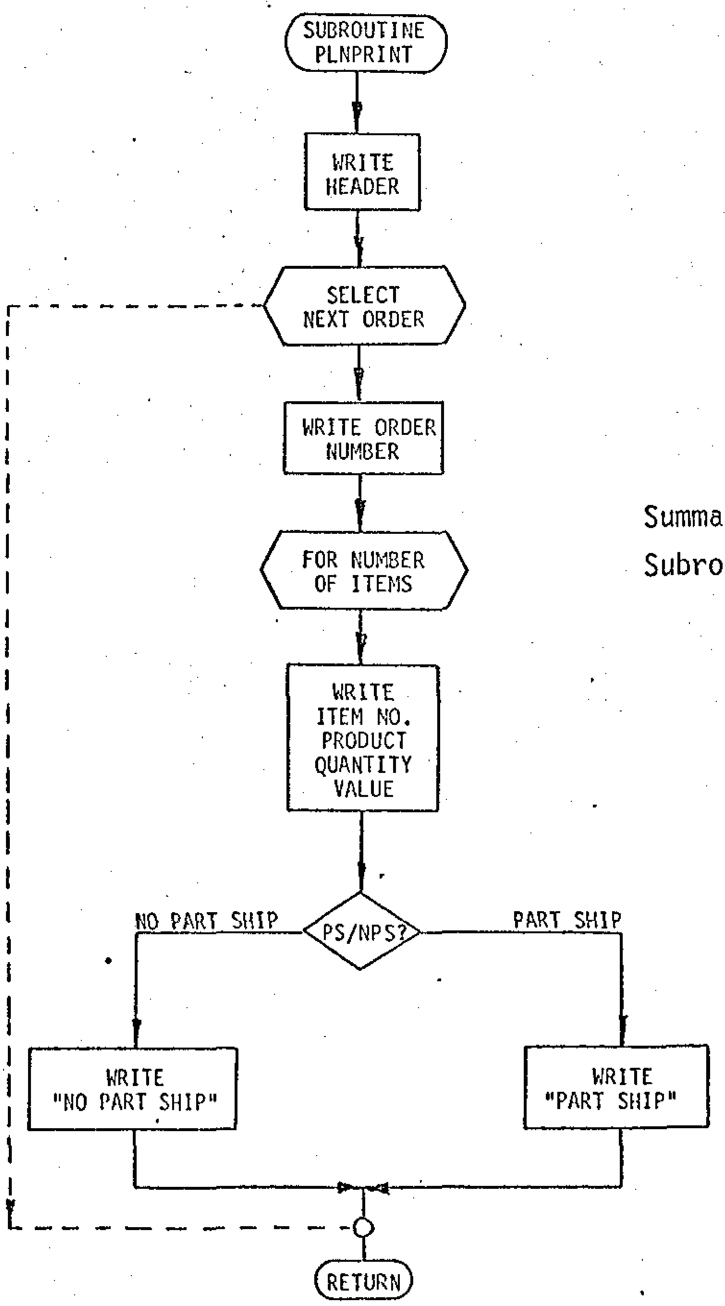
```
C
C     ORDERS
C
      SUBROUTINE ORDERS(TABLE5,TABLE6,TABLE7,ORDCOUNT,PIPELINE,ISEED4,IS
     1EED5,ISEED6,ISEED7,AVGE4,CVARN4,IFILE,TABLE8,ISEED8,IPRINT)
      INTEGER PIPELINE(20,6,4),TABLE5(7,2),TABLE6(7,2),TABLE7(7,2),ORDCO
     1UNT,PROD,QTY,IFILE(25,23),TABLE8(2,2)
C
C     CLEAR PIPELINE
C
      DO 5 I=1,20
      DO 5 J=1,6
      DO 5 K=1,4
    5 PIPELINE(I,J,K)=0
C
C     SET NUMBER OF ORDERS
C
      CALL NORMAL(AVGE4,X,ISEED4,CVARN4)
      IF(X.GE.0.0)GO TO 10
      X=0.0
   10 IF(X.LE.20.0)GO TO 20
      X=20.0
   20 NUMBER=NINT(X)
      IF(IPRINT.GT.1)GO TO 30
      WRITE(2,500)ISEED4,X,NUMBER
  500 FORMAT(1H0,6X,I10,6X,F10.5,6X,I10)
   30 DO 40 K=1,NUMBER
      ORDCOUNT=ORDCOUNT+1
C
C     DEFINE ORDER CONTENT . . . . . . . NUMBER OF ITEMS
C
      CALL HSAMPLE 1(ISEED5,ITEMCOUNT,TABLE5)
      PIPELINE(K,1,1)=ORDCOUNT
C
C     ESTABLISH WHETHER PART SHIP OR NOT
C
      CALL HSAMPLE 2(ISEED8,NO,TABLE8)
      PIPELINE(K,1,2)=NO
      PIPELINE(K,1,3)=ITEMCOUNT
      DO 40 I=1,ITEMCOUNT
      L=I+1
C
C     DEFINE EQUIPMENT AND QUANTITY
C
      CALL HSAMPLE 1(ISEED6,PROD,TABLE6)
      CALL HSAMPLE 1(ISEED7,QTY,TABLE7)
      PIPELINE(K,L,1)=I
      PIPELINE(K,L,2)=PROD
      PIPELINE(K,L,3)=QTY
      PIPELINE(K,L,4)=1.7*(IFILE(PROD,13)*1.2+IFILE(PROD,14)*3.5)*QTY
   40 CONTINUE
      RETURN
      END
```

B27 - SUBROUTINE PLNPRT

Subroutine PLNPRT is used to display the contents of the orders to be loaded pipeline, PIPELINE, for diagnostic use.

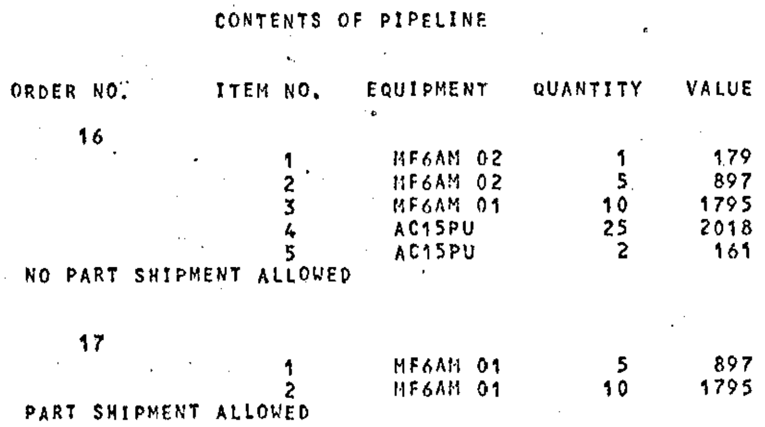
PLNPRT will display all new orders generated by subroutine ORDERS prior to loading in subroutine LOAD. Only active records containing new order numbers are displayed.

For each order number, PLNPRT will indicate each comprising item number and details of the products and quantities selected. The value is also displayed if further analysis is required by the modeller. Each order entry is accompanied by a statement signifying whether or not part shipment is permissible.



Summarised Flow Chart - Subroutine Plnprt

```
C
C     PLNPRINT
C
      SUBROUTINE PLNPRINT(PIPELINE,AFILE)
      REAL AFILE(25,3)
      INTEGER PIPELINE(20,6,4)
      WRITE(2,10)
   10 FORMAT(1H0,20X,'CONTENTS OF PIPELINE',///6X,'ORDER NO.',6X,'ITEM N
     1O.',3X,'EQUIPMENT',3X,'QUANTITY',3X,'VALUE')
      N=1
   20 WRITE(2,30)PIPELINE(N,1,1)
   30 FORMAT(1H0,9X,I3)
      DO 40 I=1,PIPELINE(N,1,3)
      L=I+1
      K=PIPELINE(N,L,2)
   40 WRITE(2,50)PIPELINE(N,L,1),AFILE(K,1),(PIPELINE(N,L,J),J=3,4)
   50 FORMAT(1H ,23X,I3,7X,A8,6X,I3,3X,I6)
      ICHECK=PIPELINE(N,1,2)
      GO TO(60,80)ICHECK
   60 WRITE(2,70)
   70 FORMAT(1H ,6X,'PART SHIPMENT ALLOWED'/)
      GO TO 95
   80 WRITE(2,90)
   90 FORMAT(1H ,6X,'NO PART SHIPMENT ALLOWED'/)
   95 N=N+1
      IF(PIPELINE(N,1,1).NE.0)GO TO 20
  100 RETURN
      END
```



```
                     CONTENTS OF PIPELINE


      ORDER NO.      ITEM NO.   EQUIPMENT   QUANTITY   VALUE

         16
                         1      MF6AM 02        1        179
                         2      MF6AM 02        5        897
                         3      MF6AM 01       10       1795
                         4      AC15PU         25       2018
                         5      AC15PU          2        161
       NO PART SHIPMENT ALLOWED


         17
                         1      MF6AM 01        5        897
                         2      MF6AM 01       10       1795
       PART SHIPMENT ALLOWED
```

Sample Pipeline Contents Report

B28 - SUBROUTINE PNMFCREATE

The subroutine PNMFCREATE is the means of loading data into the master files. The master data is held within two files; AFILE, which is a real array and IFILE, an integer array.

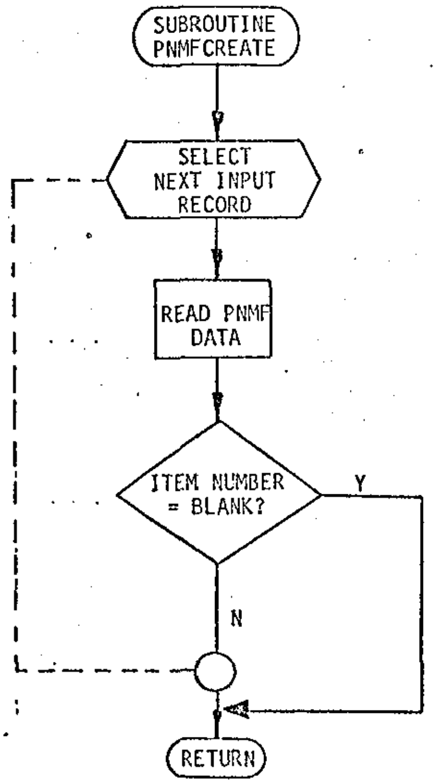
The data which is read into the master files is of three types:

a) Fixed data, including structure relationships, cost data, operational parameters and descriptive information.

b) Semi-variable parameters, which may be defined prior to each simulation experiment (egs. Lead time, buffer level).

c) Variable data, including stock and work-in-progress status, input as initial conditions.

The file detail is defined more fully in the file descriptions for AFILE and IFILE.



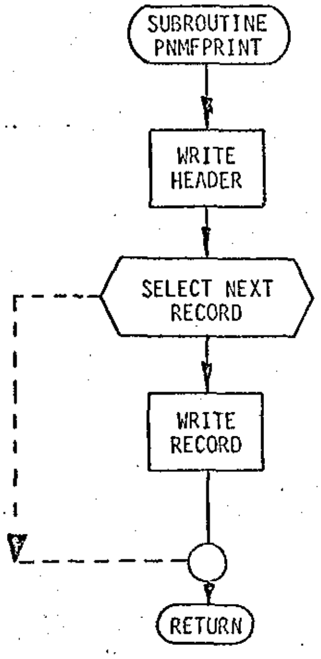
Summarised Flow Chart - Subroutine Pnmfcreate

```
C
C     PNMFCREATE
C
      SUBROUTINE PNMFCREATE(AFILE,IFILE)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23)
      DATA BLANK/'        '/
      DO 30 I=1,25
      DO 10 J=1,23
   10 IFILE(I,J)=0
      READ(1,20)(AFILE(I,J),J=1,3),(IFILE(I,J),J=1,16)
   20 FORMAT(3A8,15I2,I4)
      CALL COMP8(AFILE(I,1),BLANK,ITEST)
      GO TO (40,30),ITEST
   30 CONTINUE
   40 RETURN
      END
```

B29 - SUBROUTINE PNMFPRINT

The subroutine PNMFPRINT is used to format and present the detail contained within the master data files AFILE and IFILE.

The master data will usually be printed at the commencement of a simulation experiment to indicate the initial conditions pertaining to each master item.



Summarised Flow Chart - Subroutine Pnmfprint

```
C
C     PNMFPRINT
C
      SUBROUTINE PNMFPRINT(AFILE,IFILE)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23)
      WRITE(2,10)
   10 FORMAT(1H1,7X,'PART NO.   DESCRIPTION AD QY AD QY AD QY AD QY AD Q
     1Y LE LD MT LB IS PHYS ALLD LINE TEST DU EBQ CY AFS'/64X,'TM CT CT
     2CD STCK STCK WIP  WIP  WK      TM MAX')
      DO 20 I=1,25
   20 WRITE(2,30)I,(AFILE(I,J),J=1,3),(IFILE(I,J),J=1,23)
   30 FORMAT(1H0,1X,I2,2X,3A8,15I3,4I5,I3,I4,I3,I4)
      RETURN
      END
```

Sample Part Number Master File

	PART NO.	DESCRIPTION	AD	QY	AD	QY	AD	QY	AD	QY	AD	QY	LE	LD	MT	LB	IS	PHYS	ALLD	LINE	TEST	BU	EBQ	CY	AFS
														TM	CT	CT	CD	STCK	STCK	WIP	WIP	WK		TM	MAX
1	MF6AM 01	RADIOTELEPHONE	5	1	6	1	19	1	11	1	12	1	1	2	53	12	1	48	169	260	164	4	0	0	334
2	MF6AM 02	RADIOTELEPHONE	5	1	7	1	19	1	11	1	12	1	1	2	53	12	1	30	147	155	81	4	0	0	154
3	MF6AM 03	RADIOTELEPHONE	5	1	8	1	19	1	11	1	12	1	1	2	53	12	1	63	56	55	43	4	0	0	145
4	AC15PU	POWER UNIT	23	1	9	1	15	1	17	1	14	1	1	2	25	5	1	0	0	88	26	4	0	0	114
5	AT12345	L.F. ASSEMBLY	11	2	14	1	21	1	0	0	0	0	2	3	25	5	2	786	262	828	0	4	160	1	0
6	AT12347	R.F. ASSEMBLY	13	1	18	1	22	2	0	0	0	0	2	3	25	4	2	732	136	350	0	4	185	2	0
7	AT12801	R.F. ASSEMBLY	13	1	15	1	22	2	0	0	0	0	2	3	25	4	2	67	80	136	0	4	100	2	0
8	AT12802	R.F. ASSEMBLY	13	1	16	1	22	2	0	0	0	0	2	3	25	4	2	99	46	112	0	4	92	3	0
9	AT27896	P.C.B. ASSY.	14	2	17	1	10	1	0	0	0	0	2	4	12	2	2	133	0	242	0	4	122	4	0
10	AT22000	P.C.B. ASSY. SI	20	1	17	3	0	0	0	0	0	0	3	4	9	1	1	0	0	0	0	0	130	7	0
11	RW69873	SCREW 10MM M2	0	0	0	0	0	0	0	0	0	0	4	10	1	0	2	6444	262	0	0	8	0	0	0
12	RU10034	NUT M2	0	0	0	0	0	0	0	0	0	0	4	10	1	0	2	1224	262	0	0	8	0	0	0
13	BT49863	MAIN FRAME	0	0	0	0	0	0	0	0	0	0	4	20	18	0	2	1830	192	0	0	8	0	0	0
14	PP42906	CAPACITOR 100P	0	0	0	0	0	0	0	0	0	0	4	15	1	0	2	2404	0	0	0	8	0	0	0
15	PN50006	RESISTOR 110 OHM	0	0	0	0	0	0	0	0	0	0	4	12	1	0	2	612	100	0	0	8	0	0	0
16	PN10638	RESISTOR 5K OHM	0	0	0	0	0	0	0	0	0	0	4	12	1	0	2	103	92	0	0	8	0	0	0
17	PN10639	RESISTOR 10K OHM	0	0	0	0	0	0	0	0	0	0	4	12	1	0	2	1240	0	0	0	8	0	0	0
18	PN56043	RESISTOR 22K OHM	0	0	0	0	0	0	0	0	0	0	4	12	1	0	2	1448	0	0	0	8	0	0	0
19	PN69746	RESISTOR 100 OHM	0	0	0	0	0	0	0	0	0	0	4	12	1	0	2	1334	262	0	0	8	0	0	0
20	ET12345	BOARD BLANK	0	0	0	0	0	0	0	0	0	0	4	16	6	0	2	418	0	0	0	8	0	0	0
21	FU10000	INTEGRATED CCT.	0	0	0	0	0	0	0	0	0	0	4	18	22	0	2	1696	0	0	0	8	0	0	0
22	FV25000	POWER TRANSISTOR	0	0	0	0	0	0	0	0	0	0	4	16	3	0	2	3410	384	0	0	8	0	0	0
23	FS66000	SOCKET	0	0	0	0	0	0	0	0	0	0	4	14	10	0	2	252	0	0	0	8	0	0	0

B30 - SUBROUTINE QPLAN

The subroutine QPLAN simulates the deriviation of a production plan from the orders received forecast, known order book and stock status.

The programme is recalculated at quarterly intervals and is stated in 13 week periods. The programme is derived by reference to a number of pre-defined parameters, specifically;

a) the maximum authorised stock, or the level of finished equipment that is permitted to be held in stock in unallocated (or "free") status. The level of stock is re-assessed, within the Company, each 6 months, therefore, the model is expected to reflect this review within the logic. It should be noted that contention between the maximum authorised stock and other parameters may cause a plan which is temporarily in excess of the authorised level.

The opening stock is derived from the PNMF record for the product.

b) work-in-progress, which is considered to be the work-in-progress prior to the off-line point (thus excluding any test work-in-progress). The level of planned work-in-progress is derived from the manufacturing lead time as stated on the PNMF. The logic within the model will attempt to correct any difference between the actual opening work-in-progress and the nominal level and thereafter maintain the nominal level as defined by the lead time.

c) recommended running rate, or the weekly planned capacity of the product. The rates will normally reflect the resource in labour and plant to fully utilise a working week, although, for simplification, an assumption has been made in the model as an approximation to reality.

It is further assumed that:

(i) the rate cannot be changed within a period;
(ii) any rate change will be immediate (a step function);
(iii) all periods are a full 13 weeks with no adjustment for actual working days due to holidays.

d) minimum order book, which is the least number of orders that can be supported in the order book at a given capacity level. Typically, due to crystal lead times, this tends to be 6 weeks on a frequency conscious product and 4 weeks on a non-frequency conscious product.

e) nominal order book, or the number of weeks worth of orders (on average) that is set by policy to maintain a reasonable working backlog of work. Since there is no feedback from the final aggregate plan for all products which reflects variances against budgetted output or capacity, this parameter is often pre-defined in practice to offer some degree of control over the level of the plan in response to a variable orders received forecast.

The variables which are used in the calculation include:

a) opening work-in-progress as defined above, from the PNMF;

b) opening stock as defined above, also from the PNMF;

c) previous material plan, which is carried forward from the previous quarter's material plan for the product;

d) current order load, or the phased order book for the product adjusted in time to reflect the demand at the off-line point. (The plan makes no allowance for abnormal test work-in-progress). The "brought forward" figure represents delinquent performance, or overdue products (at the off-line point).

Using the relationship discussed in the main report narrative, namely:

- Orders carried forward = orders brought forward + orders received forecast - production to be allocated
- Closing stock = opening stock + off-line plan - production to be allocated
- Closing work-in-progress = opening work-in-progress + material plan - off-line plan.

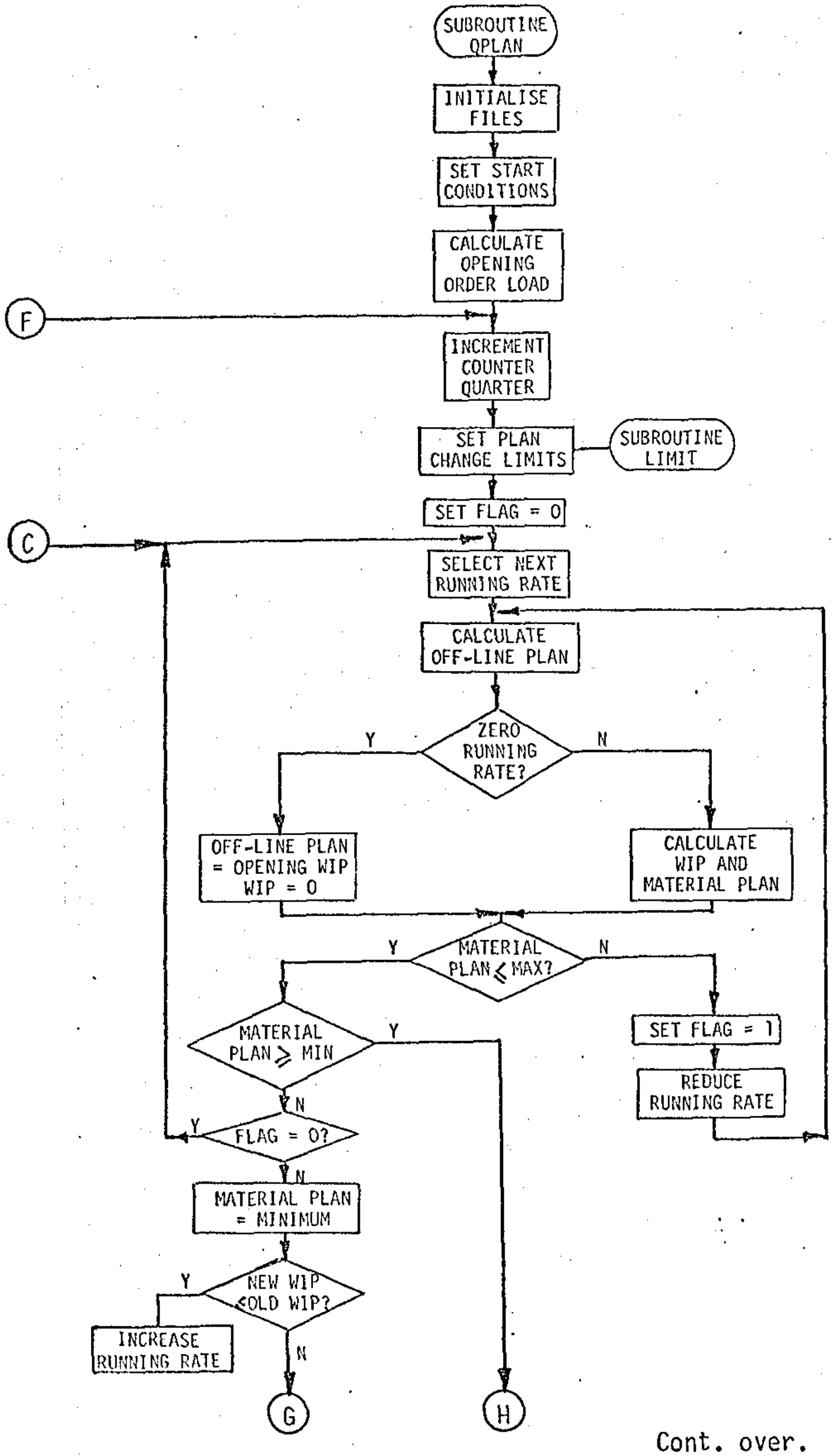
The forward projection may be derived for the three reference plans:

- production to be allocated, which is used for order loading
- off-line plan, the plan against which main equipment shop schedules are geared
- material plan, the input to the purchasing and material scheduling routines.

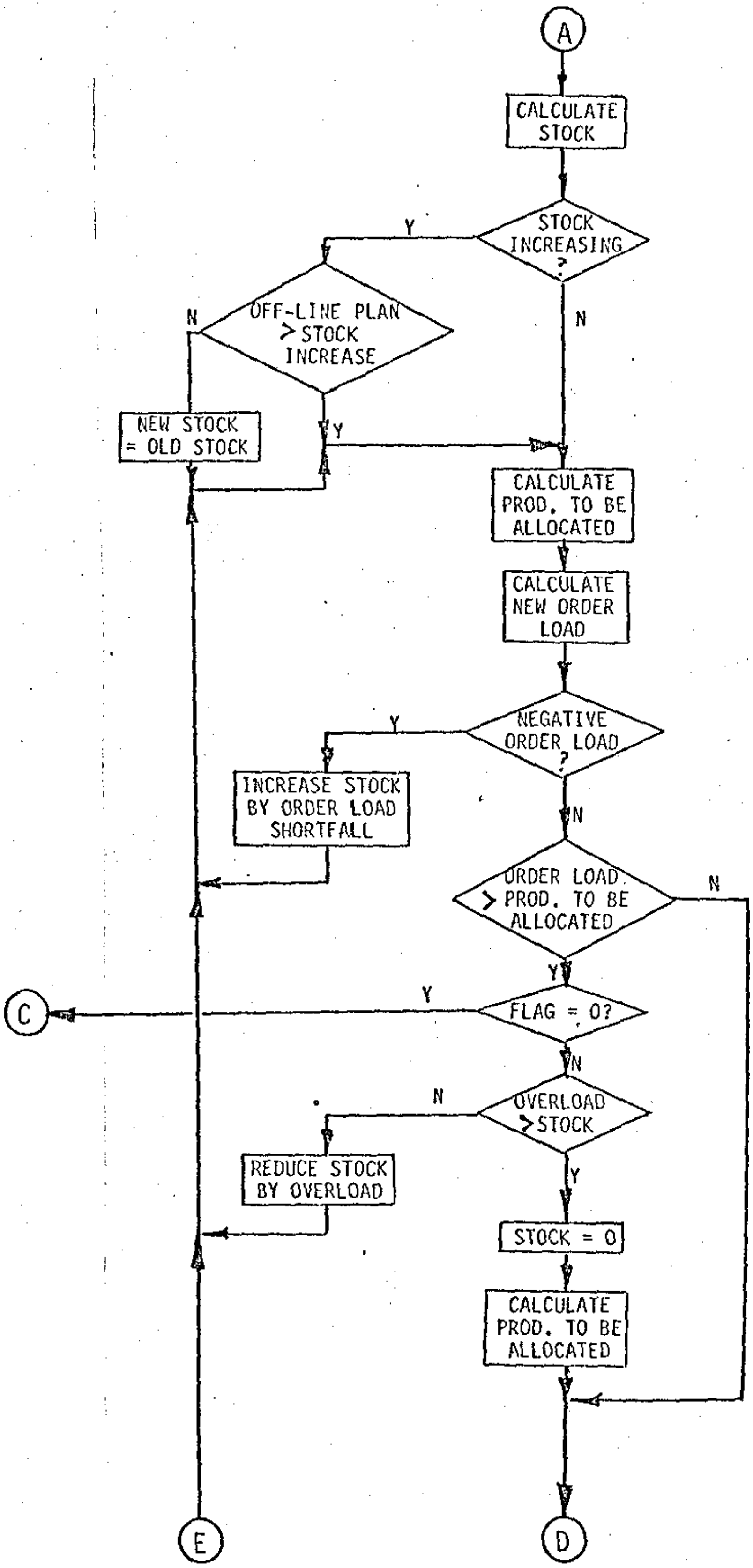
The logic in developing the plan has been kept as simple as possible without destroying, as far as possible, the reality of the simulation. Thus, no facility has been included to regress to a previous period where the line running rate is changed, to avoid frequent rate changes. In practice this situation does not arise because the plan is derived manually and the planner is able to view the complete planning horizon as the decisions are made. Further, simple rules have been incorporated to reflect critical situations, for example, a sudden change in forecast which results in a temporary overstock or excess work-in-progress.

In the real world the planner may use some judgement in terms of a trade-off between stock of finished equipments, sub-assemblies or components.

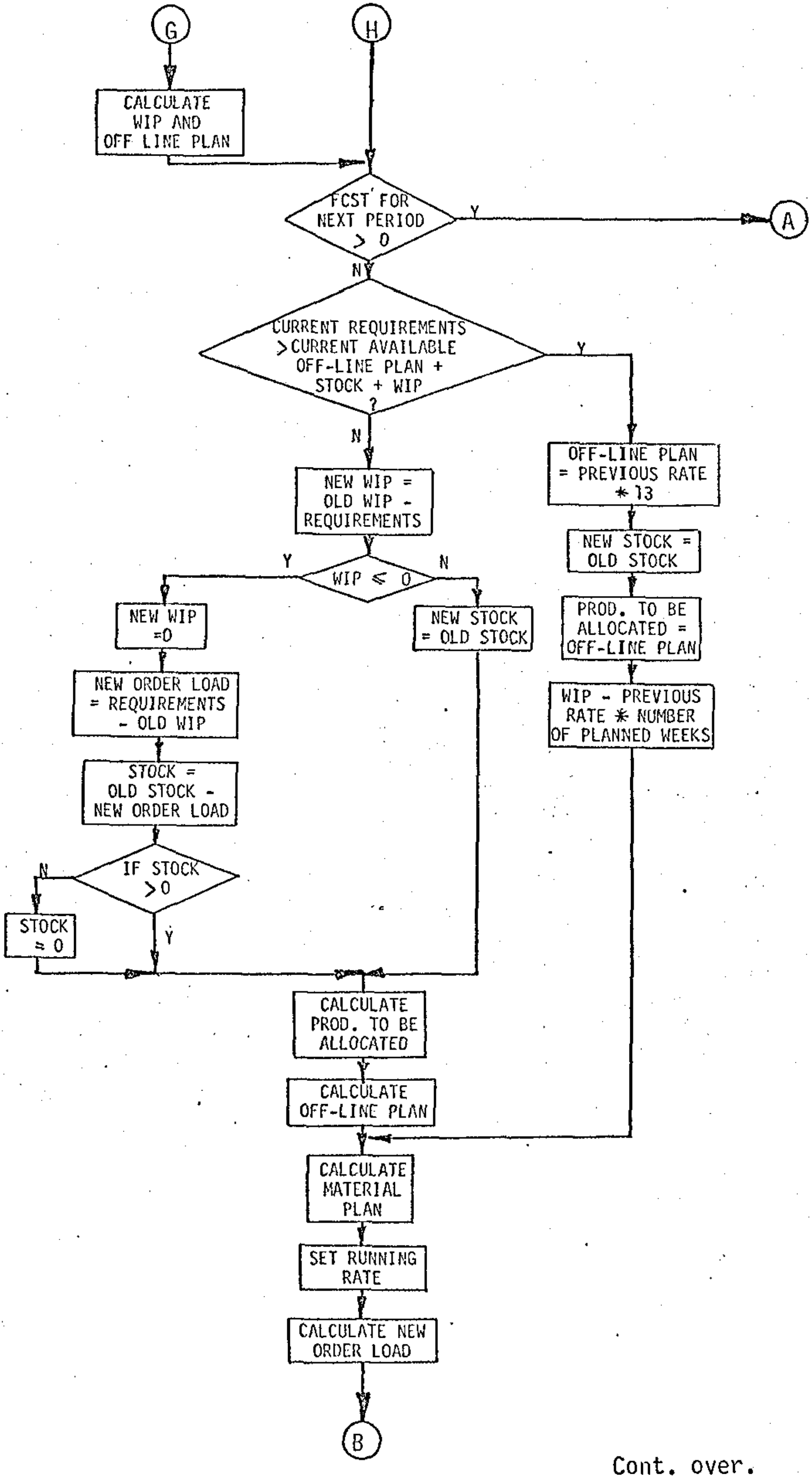
The module QPLAN makes use of a secondary module LIMIT, which defines the constraints within which any changes to a plan may be made.


SUBROUTINE QPLAN
INITIALISE FILES
SET START CONDITIONS
CALCULATE OPENING ORDER LOAD
F
INCREMENT COUNTER QUARTER
SET PLAN CHANGE LIMITS
SUBROUTINE LIMIT
SET FLAG = 0
C
SELECT NEXT RUNNING RATE
CALCULATE OFF-LINE PLAN
ZERO RUNNING RATE?
Y
N
OFF-LINE PLAN = OPENING WIP WIP = 0
CALCULATE WIP AND MATERIAL PLAN
MATERIAL PLAN ≤ MAX?
Y
N
MATERIAL PLAN ≥ MIN
Y
N
SET FLAG = 1
REDUCE RUNNING RATE
FLAG = 0?
Y
N
MATERIAL PLAN = MINIMUM
NEW WIP <OLD WIP?
Y
N
INCREASE RUNNING RATE
G
H

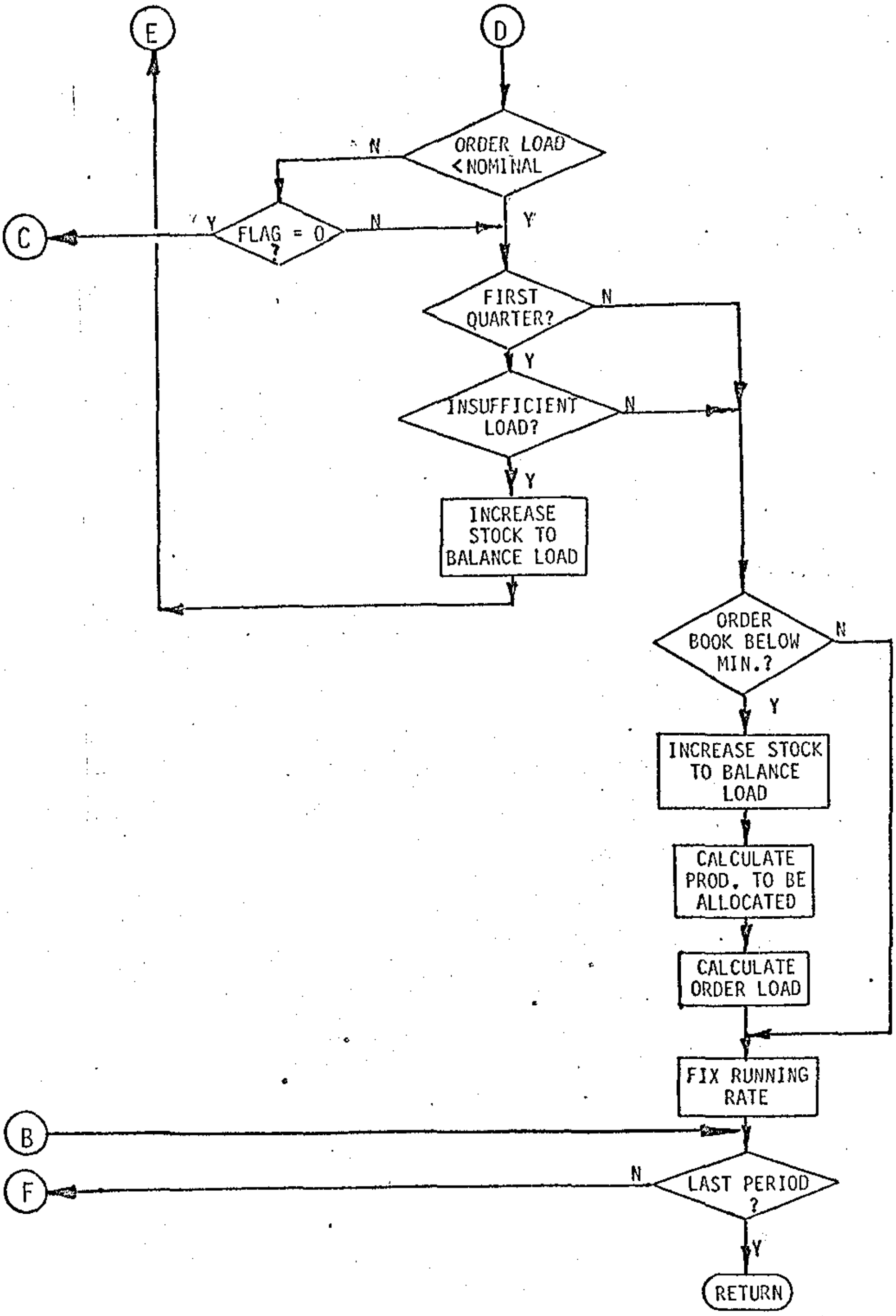
Cont. over.


A
CALCULATE STOCK
STOCK INCREASING ?
Y
N
OFF-LINE PLAN > STOCK INCREASE
N
Y
NEW STOCK = OLD STOCK
CALCULATE PROD. TO BE ALLOCATED
CALCULATE NEW ORDER LOAD
NEGATIVE ORDER LOAD ?
Y
N
INCREASE STOCK BY ORDER LOAD SHORTFALL
ORDER LOAD > PROD. TO BE ALLOCATED
N
Y
FLAG = 0?
Y
N
C
OVERLOAD > STOCK
N
Y
REDUCE STOCK BY OVERLOAD
STOCK = 0
CALCULATE PROD. TO BE ALLOCATED
E
D

Cont. over.


G
H
CALCULATE WIP AND OFF LINE PLAN
FCST FOR NEXT PERIOD > 0
Y
A
N
CURRENT REQUIREMENTS >CURRENT AVAILABLE OFF-LINE PLAN + STOCK + WIP ?
Y
N
OFF-LINE PLAN = PREVIOUS RATE * 13
NEW STOCK = OLD STOCK
PROD. TO BE ALLOCATED = OFF-LINE PLAN
WIP - PREVIOUS RATE * NUMBER OF PLANNED WEEKS
NEW WIP = OLD WIP - REQUIREMENTS
WIP ≤ 0
Y
N
NEW WIP =0
NEW STOCK = OLD STOCK
NEW ORDER LOAD = REQUIREMENTS - OLD WIP
STOCK = OLD STOCK - NEW ORDER LOAD
IF STOCK >0
N
Y
STOCK = 0
CALCULATE PROD. TO BE ALLOCATED
CALCULATE OFF-LINE PLAN
CALCULATE MATERIAL PLAN
SET RUNNING RATE
CALCULATE NEW ORDER LOAD
B

Cont. over.



Summarised Flow Chart - Subroutine Qplan

```
C
C     QPLAN
C
      SUBROUTINE QPLAN(ORF,COL,FES,WIP,IONP,R,AFSMAX,OCFMIN,OCFNOM,ONP,P
     1A,OCF,OFP,RR,*,IFILE,REQFILE,IPRINT,MODE,EQUBUFR)
      INTEGER ORF(10,7),COL(10,7),FES(10,7),WIP(10,7),IONP(10,7),R(10,10
     1),AFSMAX(10),OCFMIN,OCFNOM,ONP(10,7),PA(10,10),FLAG,OCF(10,7),OFP(
     210,7),RR(10,11),ONPMAX,ONPMIN,IFILE(25,23),REQFILE(25,52),CUMDIF,
     3EQUBUFR
C
C     RESET REQUIREMENTS FILES
C
      DO 5 I=1,25
      DO 5 J=1,52
    5 REQFILE(I,J)=0
      DO 200 L=1,10
      IF(IFILE(L,11).NE.1)GO TO 200
C
C     SET START CONDITIONS
C
      CUMDIF=0
      DO 10 I=1,7
   10 IONP(L,I)=ONP(L,I)
      FES(L,1)=IFILE(L,16)
      WIP(L,1)=IFILE(L,18)
      OFP(L,1)=IONP(L,1)
      IF(MODE.NE.3)GO TO 12
      IFILE(L,23)=0
      GO TO 19
   12 K=0
      DO 15 J=2,5
   15 K=K+ORF(L,J)
      IFILE(L,23)=K*EQUBUFR/52.0
C
C     SET FIRST QUARTER LOAD AND CALCULATE OPENING ORDERS
C
   19 AFSMAX(L)=IFILE(L,23)
      COL(L,2)=COL(L,2)*COL(L,1)
      OCF(L,1)=0
      DO 20 I=2,7
   20 OCF(L,1)=OCF(L,1)+COL(L,I)
C
C     RESET QUARTER COUNTER
C
      N=1
   30 N=N+1
      NN=N-1
      NP=N+1
      IF(NP.LE.7)GO TO 40
      NP=7
C
C     SET PLAN CHANGE CONSTRAINTS
C
   40 CALL LIMIT(OFP(L,NN),N,&170,IONP(L,N),ONPMAX,ONPMIN,CUMDIF)
      IF(IPRINT.GT.1)GO TO 55
      WRITE(2,50)L,N,ONPMAX,ONPMIN
   50 FORMAT(1H0,6X,'PRODUCT = ',I5,6X,'PERIOD = ',I5,6X,'ONPMAX = ',I5,
     16X,'ONPMIN = ',I5)
   55 FLAG=0
```

```
C
C     CALCULATE INITIAL OFF-LINE PLAN
C
      J=0
   60 J=J+1
      IF(J.LE.10)GO TO 70
      J=J-1
      GO TO 101
   70 OFP(L,N)=R(L,J)*13.0
C
C     CHECK FOR ZERO RUNNING RATE
C
      IF(R(L,J).GT.0)GO TO 80
      OFP(L,N)=WIP(L,NN)
      WIP(L,N)=0
      ONP(L,N)=0
      GO TO 90
C
C     CALCULATE NOMINAL W.I.P. AND ON-LINE PLAN
C
   80 WIP(L,N)=IFILE(L,12)*R(L,J)
      ONP(L,N)=OFP(L,N)-WIP(L,NN)+WIP(L,N)
C
C     CHECK AGAINST MATERIAL PLAN CONSTRAINTS
C
   90 IF(ONP(L,N).LE.ONPMAX)GO TO 100
      FLAG=1
      IF(J.EQ.1)GO TO 100
      J=J-1
      GO TO 70
C
C     FLAG IS SET TO 1 WHEN MAXIMUM MATERIAL PLAN IS REACHED
C
  100 IF(ONP(L,N).GE.ONPMIN) GO TO 101
      IF(FLAG.EQ.0) GO TO 60
      ONP(L,N)=ONPMIN
      IF(WIP(L,NN).GT.WIP(L,N))GO TO 102
       J=J+1
  102 WIP(L,N)=IFILE(L,12)*R(L,J)
      OFP(L,N)=ONP(L,N)+WIP(L,NN)-WIP(L,N)
C
C     CHECK FOR ZERO FORWARD REQUIREMENT
C
  101 IF(ORF(L,NP).GT.0)GO TO 110
      IF((OCF(L,NN)+ORF(L,N)).GT.(RR(L,NN)*13+FES(L,NN)+WIP(L,NN)))GO TO
     1 107
       WIP(L,N)=WIP(L,NN)-OCF(L,NN)-ORF(L,N)
       IF(WIP(L,N).LE.0)GO TO 103
       FES(L,N)=FES(L,NN)
       GO TO 105
  103  WIP(L,N)=0
       OCF(L,N)=OCF(L,NN)+ORF(L,N)-WIP(L,NN)
       FES(L,N)=FES(L,NN)-OCF(L,N)
       IF(FES(L,N).GT.0)GO TO 105
       FES(L,N)=0
  105  PA(L,N)=OCF(L,NN)+ORF(L,N)
       OFP(L,N)=PA(L,N)+FES(L,N)-FES(L,NN)
       GO TO 109
  107  OFP(L,N)=RR(L,NN)*13
       FES(L,N)=FES(L,NN)
       PA(L,N)=OFP(L,N)
       WIP(L,N)=RR(L,NN)*IFILE(L,12)
  109 ONP(L,N)=OFP(L,N)+WIP(L,N)-WIP(L,NN)
      RR(L,N)=RR(L,NN)
      OCF(L,N)=OCF(L,NN)+ORF(L,N)-PA(L,N)
      GO TO 162
C
C     CALCULATE STOCK AND PRODUCTION TO BE ALLOCATED
C
  110 FES(L,N)=IFILE(L,23)/2.0
C
C     IS STOCK INCREASING
C
      IF(FES(L,N).LE.FES(L,NN))GO TO 120
      IF(OFP(L,N).GT.(FES(L,N)-FES(L,NN)))GO TO 120
      FES(L,N)=FES(L,NN)
  120 PA(L,N)=OFP(L,N)-FES(L,N)+FES(L,NN)
      OCF(L,N)=OCF(L,NN)+ORF(L,N)-PA(L,N)
      IF(OCF(L,N))124,126,126
  124 FES(L,N)=FES(L,N)-OCF(L,N)
      GO TO 120
C
C     CHECK FOR OVERLOAD
C
  126 IF(COL(L,N).LE.PA(L,N))GO TO 140
      IF(FLAG.EQ.0)GO TO 60
      IF((COL(L,N)-PA(L,N)).GT.FES(L,N))GO TO 130
      FES(L,N)=FES(L,N)-COL(L,N)+PA(L,N)
      GO TO 120
  130 FES(L,N)=0
      PA(L,N)=OFP(L,N)+FES(L,NN)
C
C     CHECK FOR INCREASING ORDER BOOK
C
  140 IF(OCF(L,N).LT.OCFNOM*R(L,J))GO TO 150
      IF(FLAG.EQ.0)GO TO 60
C
C     CHECK FOR 1ST QUARTER UNDERLOAD
C
  150 IF(N.GT.2)GO TO 155
      IF(PA(L,N).LE.COL(L,N)+IFIX(ORF(L,N)*(13-OCFMIN)/13.0))GO TO 155
      FES(L,N)=FES(L,N)+PA(L,N)-COL(L,N)-IFIX(ORF(L,N)*(13-OCFMIN)/13.0)
      GO TO 120
C
C     CHECK FOR MINIMUM ORDER BOOK
C
  155 IF(OCF(L,N).GT.OCFMIN*ORF(L,NP)/13.0)GO TO 160
      FES(L,N)=FES(L,N)+OCFMIN*ORF(L,NP)/13.0-OCF(L,N)
      PA(L,N)=OFP(L,N)-FES(L,N)+FES(L,NN)
      OCF(L,N)=OCF(L,NN)+ORF(L,N)-PA(L,N)
  160 RR(L,N)=R(L,J)
  162 IF(N.GT.3)GO TO 165
      CUMDIF=CUMDIF+IONP(L,N)-ONP(L,N)
  165 IF(N.LT.7)GO TO 30
  200 CONTINUE
      RETURN
  170 RETURN 1
      END
```

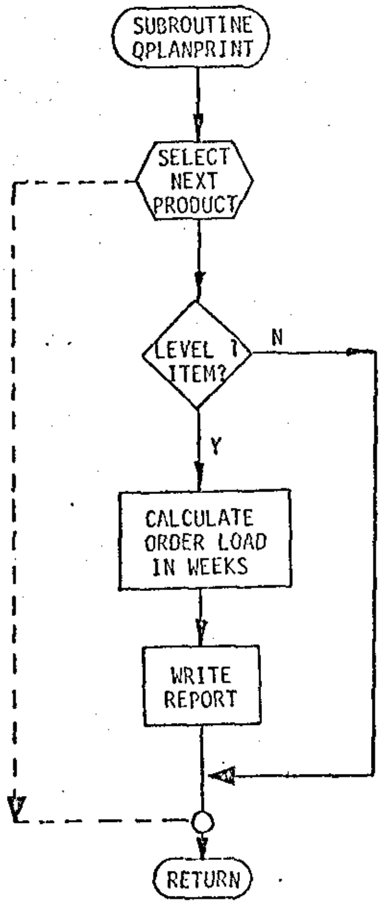
B31 - SUBROUTINE QPLANPRINT

The subroutine QPLANPRINT serves two purposes:

a) to portray the new quarterly production plans resulting from the subroutine QPLAN;

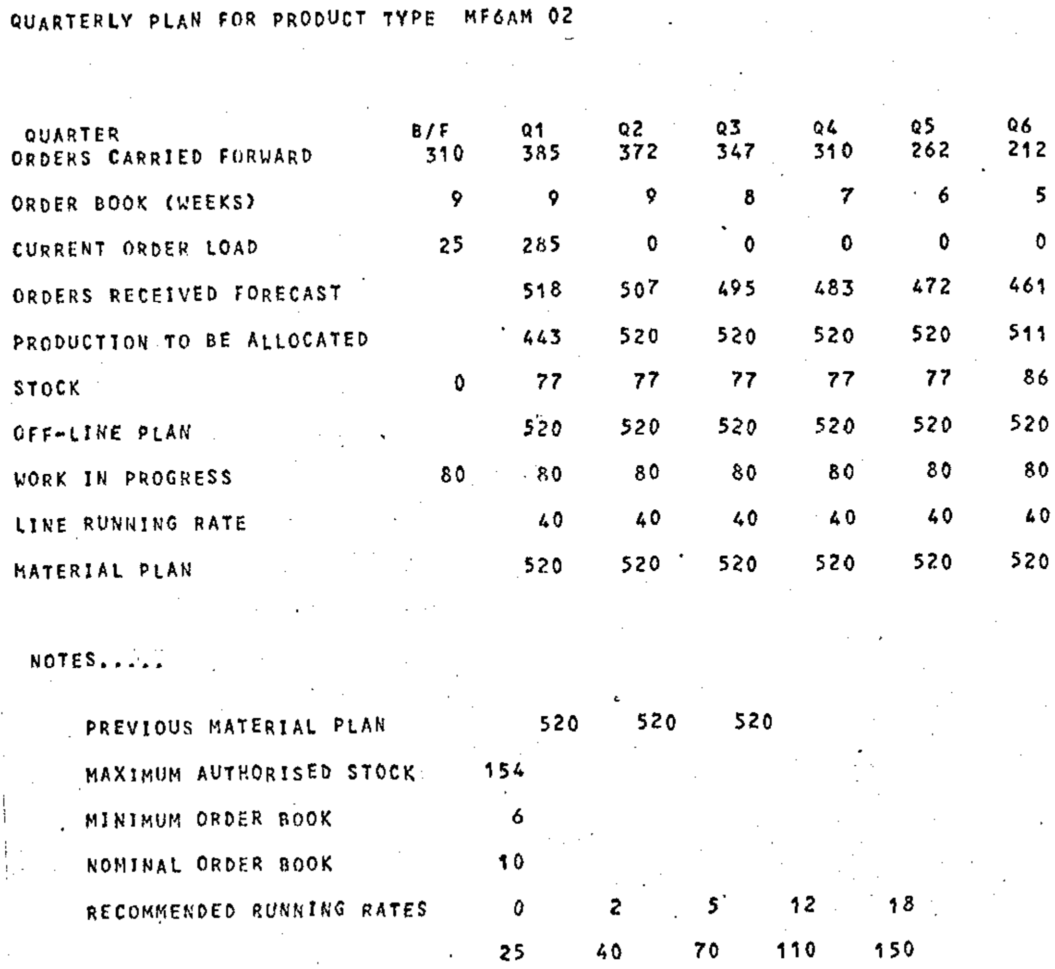
b) to present the information in a readily readable form, which includes a calculation of the actual order load in weeks. This data is not required as part of the model logic, but completes the plan presentation format as used within the Company and permits diagnostic analyses.

In addition to the presentation of the quarterly based file contents, QPLANPRINT also identifies the parameters applicable to the quarterly plan calculation.



Summarised Flow Chart - Subroutine Qplanprint

```
C
C     QPLANPRINT
C
      SUBROUTINE QPLANPRINT(ORF,COL,FES,WIP,IONP,R,AFSMAX,OCFMIN,OCFNOM,
     1ONP,PA,OCF,OFP,RR,AFILE,IFILE)
      REAL AFILE(25,3)
      INTEGER ORF(10,7),COL(10,7),FES(10,7),WIP(10,7),IONP(10,7),R(10,10
     1),AFSMAX(10),OCFMIN,OCFNOM,ONP(10,7),PA(10,10),OCF(10,7),OFP(10,7)
     2,RR(10,11),PASUM,OCFWKS(7),IFILE(25,23)
      DO 100 K=1,10
      IF(IFILE(K,11).NE.1)GO TO 100
      WRITE(2,30)AFILE(K,1)
   30 FORMAT(1H1,////6X,'QUARTERLY PLAN FOR PRODUCT TYPE',2X,1A8///)
C
C     CALCULATE WEEKS WORTH OF ORDERS CARRIED FORWARD
C
      COL(K,2)=COL(K,2)-COL(K,1)
      DO 80 N=1,7
      I=N
      PASUM=0
   40 I=I+1
      IF(I.LE.7)GO TO 50
      PA(K,I)=PA(K,I-1)
   50 PASUM=PASUM+PA(K,I)
      IF(OCF(K,N).LE.PASUM)GO TO 60
      IF(I.LT.10)GO TO 40
      PASUM=OCF(K,N)
      GO TO 70
   60 PASUM=PASUM-PA(K,I)
   70 IF(PA(K,I).GT.0)GO TO 75
      M=1
      GO TO 80
   75 M=PA(K,I)
   80 OCFWKS(N)=(I-N-1)*13+(OCF(K,N)-PASUM)*13/M
C
C     WRITE REPORT
C
      WRITE(2,310)(OCF(K,I),I=1,7),(OCFWKS(I),I=1,7),(COL(K,I),I=1,7),(O
     1RF(K,I),I=2,7),(PA(K,I),I=2,7),(FES(K,I),I=1,7),(OFP(K,I),I=2,7),(
     2WIP(K,I),I=1,7),(RR(K,I),I=2,7),(ONP(K,I),I=2,7)
  310 FORMAT(1H0,6X,'QUARTER',21X,'B/F',5X,'Q1',5X,'Q2',5X,'Q3',5X,'Q4',
     15X,'Q5',5X,'Q6'/6X,'ORDERS CARRIED FORWARD',4X,7I7//6X,'ORDER BOOK
     2 (WEEKS)',8X,7I7//6X,'CURRENT ORDER LOAD',8X,7I7//6X,'ORDERS RECEI
     3VED FORECAST',9X,6I7//6X,'PRODUCTION TO BE ALLOCATED',7X,6I7//6X,'
     4STOCK',21X,7I7//6X,'OFF-LINE PLAN',20X,6I7//6X,'WORK IN PROGRESS',
     510X,7I7//6X,'LINE RUNNING RATE',16X,6I7//6X,'MATERIAL PLAN',20X,6I
     67//)
      WRITE(2,320)(IONP(K,J),J=2,4),AFSMAX(K),OCFMIN,OCFNOM,(R(K,J),J=1,
     110)
  320 FORMAT(1H0,6X,'NOTES....'///11X,'PREVIOUS MATERIAL PLAN',7X,3I7//
     111X,'MAXIMUM AUTHORISED STOCK',I8//11X,'MINIMUM ORDER BOOK',7X,I7/
     2/11X,'NOMINAL ORDER BOOK',7X,I7//11X,'RECOMMENDED RUNNING RATES',5
     3I7//36X,5I7)
  100 CONTINUE
      RETURN
      END
```



QUARTERLY PLAN FOR PRODUCT TYPE MF6AM 02

QUARTER	B/F	Q1	Q2	Q3	Q4	Q5	Q6
ORDERS CARRIED FORWARD	310	385	372	347	310	262	212
ORDER BOOK (WEEKS)	9	9	9	8	7	6	5
CURRENT ORDER LOAD	25	285	0	0	0	0	0
ORDERS RECEIVED FORECAST		518	507	495	483	472	461
PRODUCTION TO BE ALLOCATED		443	520	520	520	520	511
STOCK	0	77	77	77	77	77	86
OFF-LINE PLAN		520	520	520	520	520	520
WORK IN PROGRESS	80	80	80	80	80	80	80
LINE RUNNING RATE		40	40	40	40	40	40
MATERIAL PLAN		520	520	520	520	520	520

NOTES.....

PREVIOUS MATERIAL PLAN		520	520	520		
MAXIMUM AUTHORISED STOCK	154					
MINIMUM ORDER BOOK	6					
NOMINAL ORDER BOOK	10					
RECOMMENDED RUNNING RATES	0	2	5	12	18	
	25	40	70	110	150	

Sample Product Quarterly Plan

B32 - SUBROUTINE QTREVENTS

Subroutine QTREVENTS controls the sequence of the quarterly activities, the majority of which are dependent modules.

a) Dependent modules

QTRRESET - resets the planning and execution files in preparation for the next quarterly cycle.

FORECAST - calculates the quarterly orders received forecast from the order received history.

QPLAN - establishes a new quarterly plan in response to the new orders received forecast.

QPLANPRINT - optional module permitting the result of the planning process to be examined.

WEEKLYPLAN - converts the time base from quarterly to weekly planning data.

EXPLODE - generates nett requirements for lower level parts by using the product structure relationships.

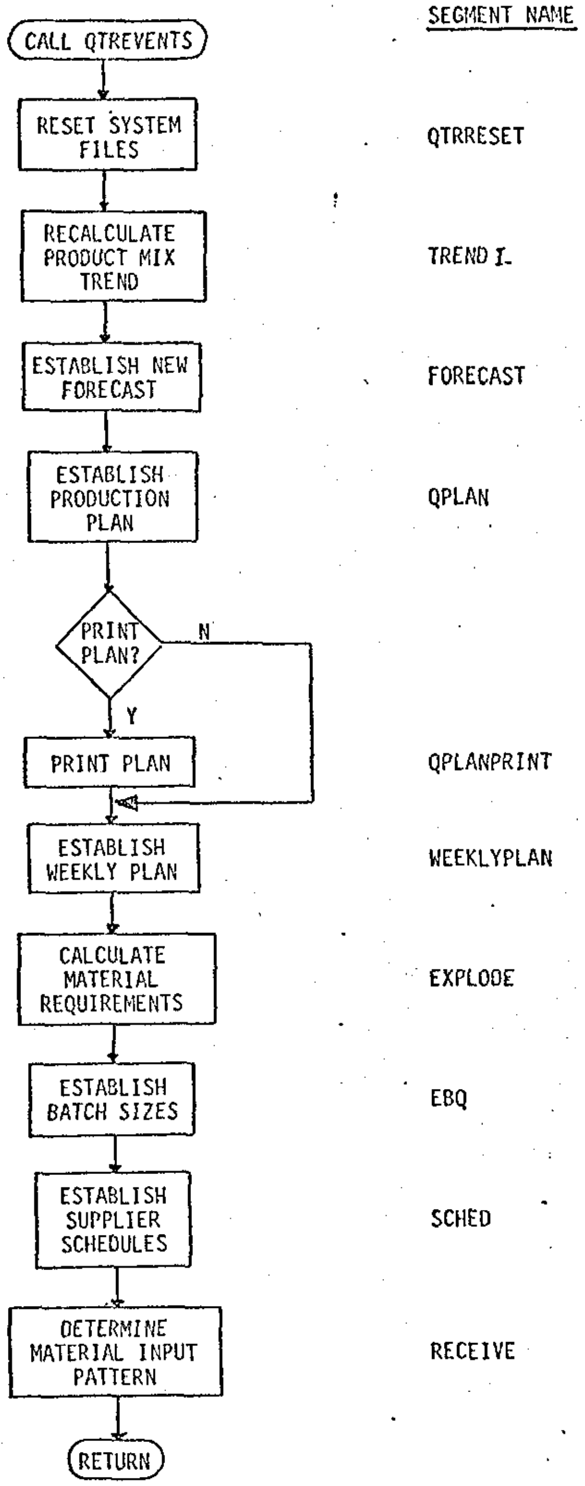
SCHED - establishes the supplier schedule for component items.

RECEIVE - determines the actual input pattern of material against the planned supplier schedule.

b) Independent modules

TRENDI - modifies the product mix data when orders received trends are introduced into the model.

EBQ - calculates the "economic batch quantity" to be used in the sub-assembly programme determination.



Summarised Flow Chart - Subroutine Qtrevents

```
C
C     QTREVENTS
C
      SUBROUTINE QTREVENTS(ORDHIST,AFILE,IFILE,IPRINT,COL,ONP,R,RESPONSE
     1,ISEED1,TABLE1,ISEED2,TABLE2,OCFMIN,OCFNOM,SCHEDULE,INPUT,OPFILE,O
     2RDBK,TOTAL,WEEK,REFWEEK,TQTR,EXFILE,REQFILE,DELPLAN,NETPLAN,ICOUNT
     3,ISHORT,CAPACITY,UTIL,LEADTM,TREND,TABLE6,PRODMIX,ALLQ,MODE,EQUPER
     4F,ITEMPERF,ORDPERF,EQUBUFR)
      REAL AFILE(25,3),TREND(7),PRODMIX(7)
      INTEGER IFILE(25,23),ORDHIST( 5,12),ORF(10,7),COL(10,7),FES(10,7),
     1WIP(10,7),IONP(10,7),R(10,10),AFSMAX(10),OCFMIN,OCFNOM,ONP(10,7),P
     2A(10,10),OCF(10,7),OFP(10,7),RR(10,11),REQFILE(25,52),DELPLAN( 5,5
     32),CAPACITY,  RESPONSE,TABLE1(7,2),TABLE2(7,2),ISEED1,ISEED2,SCHED
     4ULE(25,13),INPUT(25,52),OPFILE(125,5,5,10),ORDBK( 5,52,20,5),TOTAL
     5(5,52),WEEK,REFWEEK,EXFILE(25,52),NETPLAN(5,52),LEADTM(5,52),TABLE
     66(7,2),ALLQ(12,50,6),EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(2,30)
     7,ICOUNT(25),ISHORT(25),EQUBUFR
      IF(IPRINT.GT.1)GO TO 5
      WRITE(2,3)
    3 FORMAT(1H0,6X,'* * * *  QTREVENTS  * * * *'//)
    5 CALL QTRRESET(OPFILE,ORDBK,TOTAL,WEEK,REFWEEK,TQTR,EXFILE,IFILE,AF
     1ILE,COL,SCHEDULE,INPUT,NETPLAN,ONP,OFP,IPRINT,ICOUNT,ISHORT,LEADTM
     2,EQUPERF,ITEMPERF,ORDPERF)
      CALL TRENDI(TABLE6,PRODMIX,TREND,IPRINT)
      CALL FORECAST(ORDHIST,ORF,IPRINT,AFILE,IFILE)
      CALL QPLAN(ORF,COL,FES,WIP,IONP,R,AFSMAX,OCFMIN,OCFNOM,ONP,PA,OCF,
     1OFP,RR,&100,IFILE,REQFILE,IPRINT,MODE,EQUBUFR)
      IF(IPRINT.GT.5)GO TO 10
      CALL QPLANPRINT(ORF,COL,FES,WIP,IONP,R,AFSMAX,OCFMIN,OCFNOM,ONP,PA
     1,OCF,OFP,RR,AFILE,IFILE)
   10 CALL WEEKLYPLAN(OFP,REQFILE,IFILE,PA,DELPLAN,IPRINT,AFILE)
      CALL EXPLODE(AFILE,IFILE,REQFILE,IPRINT,ALLQ)
      CALL EBQ(REQFILE,IFILE,IPRINT,AFILE,CAPACITY,UTIL)
      CALL SCHED(REQFILE,SCHEDULE,RESPONSE,IFILE,AFILE,IPRINT)
      CALL RECEIVE(SCHEDULE,INPUT,ISEED1,TABLE1,ISEED2,TABLE2,IFILE,IPRI
     1NT,RESPONSE,AFILE)
  100 RETURN
      END
```

B33 - SUBROUTINE QTRRESET

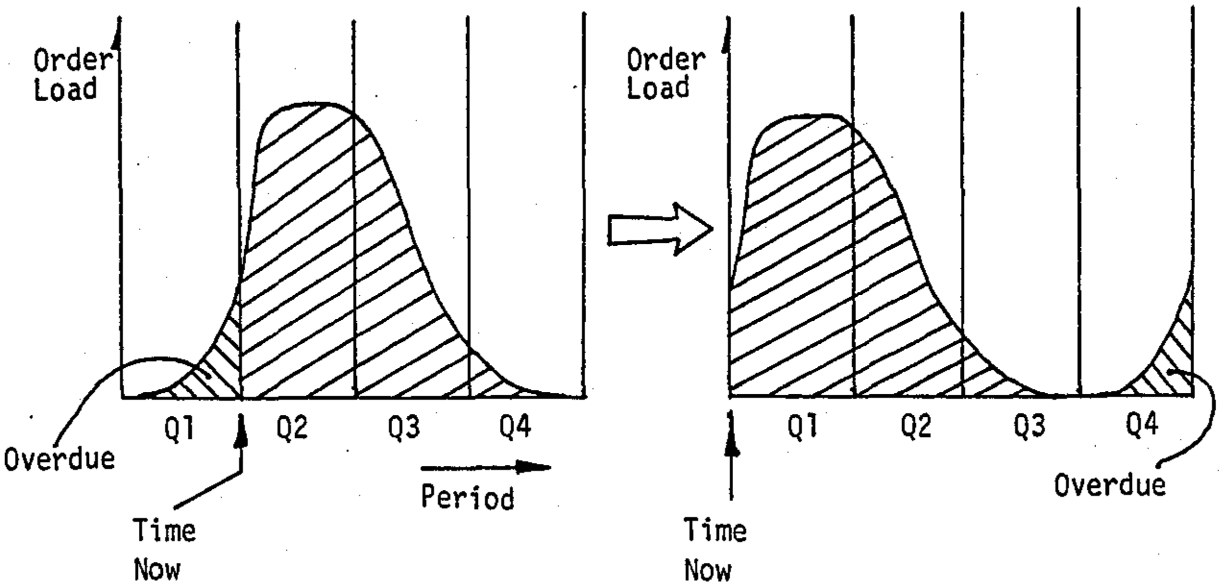
The prime planning files are reset each quarter by subroutine QTRRESET, thus limiting the amount of redundant file space in the model. QTRRESET also initialises a number of files and parameters used for performance measurement and diagnostic analysis.

The quarter counter is reset to 13.0 weeks and the component service level status variables are initialised in preparation for the next quarterly cycle. For the first simulation cycle only, the off-line plan, OFP, is loaded with the material on-line plan, ONP. The parameter REFWEEK is incremented by 13 weeks, indicating the last week number of the previous quarterly period.

The following files are then reset as indicated.

a) ORDBK

The equipment order book cannot be simply advanced by thirteen weeks, since the overdue orders are still required to be serviced. In the interests of file economy, these records are transferred to the "tail end" of the file and identified with an "overdue" flag as shown.



Resetting ORDBK

b) ONP

The material plan, which is carried forward to QPLAN as a plan constraint, is reset by moving the data forward by one period.

c) TOTAL, NETPLAN, INPUT, EXFILE

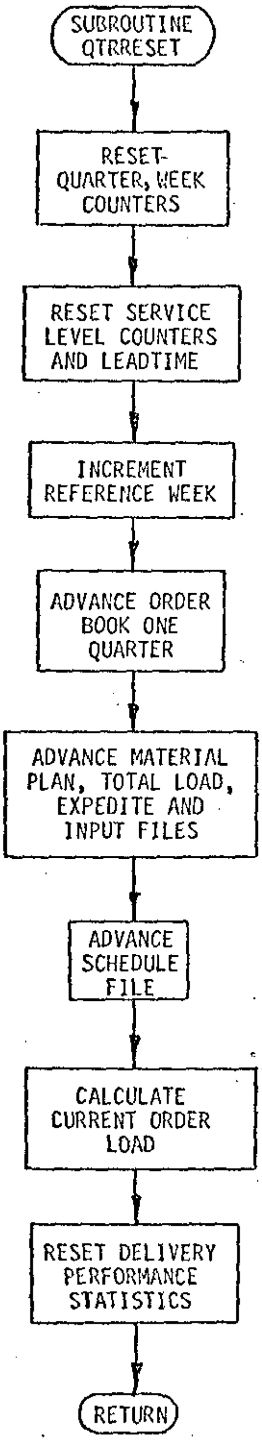
The total load, loading plan, material input and expedite files are each organised into 52 weekly periods. In each case the overdue periods are discarded and the file contents advanced by 13 periods.

d) SCHEDULE

The schedule file contains twelve monthly periods plus a gross overdue, or arrears, value. The residue of the current quarter is added to the arrears total and the file advanced in three periods increments.

e) The current order load is derived by searching ORDBK for undelivered quantities and loading these into the file COL for subsequent use by subroutine QPLAN.

f) The files containing order performance statistics are cleared down in preparation for the next quarterly cycle.


SUBROUTINE QTRRESET
RESET QUARTER, WEEK COUNTERS
RESET SERVICE LEVEL COUNTERS AND LEADTIME
INCREMENT REFERENCE WEEK
ADVANCE ORDER BOOK ONE QUARTER
ADVANCE MATERIAL PLAN, TOTAL LOAD, EXPEDITE AND INPUT FILES
ADVANCE SCHEDULE FILE
CALCULATE CURRENT ORDER LOAD
RESET DELIVERY PERFORMANCE STATISTICS
RETURN

Summarised Flow Chart - Sub-routine Qtrreset

```
C
C     QTRRESET
C
      SUBROUTINE QTRRESET(OPFILE,ORDBK,TOTAL,WEEK,REFWEEK,TQTR,  EXFILE,
     1IFILE,AFILE,COL,SCHEDULE,INPUT,NETPLAN,ONP,OFP,IPRINT,ICOUNT,ISHOR
     2T,LEADTM,EQUPERF,ITEMPERF,ORDPERF)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23),OPFILE(125,5,5,10),ORDBK( 5,52,20,5),TOTAL( 5
     1,52),WEEK,  EXFILE(25,52),COL(10,7),REFWEEK,SCHEDULE(25,13),INPUT(
     225,52),NETPLAN(5,52),OFP(10,7),ONP(10,7),IHOLD(5),LEADTM(5,52),EQU
     3PERF(10,30),ITEMPERF(10,30),ORDPERF(2,30),ICOUNT(25),ISHORT(25)
      IF(IPRINT.GT.1)GO TO 3
      WRITE(2,1)
    1 FORMAT(1H0,6X,'* * * *  QTRRESET  * * * *'//)
    3 TQTR=13.0
      WEEK=1
      DO 2 I=1,25
      ICOUNT(I)=1
    2 ISHORT(I)=0
      DO 4 I=1,5
      DO 4 J=1,52
    4 LEADTM(I,J)=0
      IF(REFWEEK.GT.0) GO TO 5
      DO 243 N=1,5
      DO 243 J=1,7
  243 OFP(N,J)=ONP(N,J)
    5 REFWEEK=REFWEEK+13
C
C     RESET ORDER BOOK
C
      DO 80 I=1,5
      IF(IFILE(I,11).GT.1)GO TO 80
      DO 80 MA=1,13
      MF=MA+39
      MG=MA+26
      DO 80 MD=1,20
      DO 50 ME=1,5
   50 IHOLD(ME)=ORDBK(I,MA,MD,ME)
      DO 60 MB=MA,MG,13
      MC=MB+13
      DO 60 ME=1,5
      ORDBK(I,MB,MD,ME)=ORDBK(I,MC,MD,ME)
   60 CONTINUE
      DO 70 ME=1,5
   70 ORDBK(I,MF,MD,ME)=IHOLD(ME)
      IF(ORDBK(I,MF,MD,3).EQ.0)GO TO 80
      ORDBK(I,MF,MD,4)=1
   80 CONTINUE
C
C     RESET ON LINE PLAN
C
      DO 120 I=1,10
      DO 120 J=1,6
      K=J+1
  120 ONP(I,J)=ONP(I,K)
C
C     RESET TOTAL LOAD,EXPEDITE FILE AND INPUT FILE
C
      DO 174 I=1,5
      DO 170 J=1,39
      K=J+13
      NETPLAN(I,J)=NETPLAN(I,K)
  170 TOTAL(I,J)=TOTAL(I,K)
      DO 172 J=40,52
      NETPLAN(I,J)=0
  172 TOTAL(I,J)=0
  174 CONTINUE
      IF(IPRINT.GT.3)GO TO 175
      WRITE(2,110)REFWEEK
  110 FORMAT(1H1,6X,'FILES RESET AT END OF QUARTER'//6X,'REFWEEK=',I4)
      CALL ORDBKPRT(ORDBK,AFILE,IFILE,TOTAL,REFWEEK)
  175 IF(IPRINT.GT.4)GO TO 179
      WRITE(2,176)
  176 FORMAT(1H0,6X,'EXPEDITING FREQUENCY'/)
      DO 178 I=1,25
      IF(IFILE(I,11).NE.4)GO TO 178
      WRITE(2,177)AFILE(I,1),(INPUT(I,J),J=1,20),(EXFILE(I,J),J=1,20)
  177 FORMAT(1H ,6X,A8,20I5/14X,20I5)
  178 CONTINUE
  179 DO 190 I=1,25
      IF(IFILE(I,11).NE.4)GO TO 190
      DO 180 J=1,39
      K=J+13
      INPUT(I,J)=INPUT(I,K)
  180 EXFILE(I,J)=EXFILE(I,K)
      DO 183 J=40,52
      INPUT(I,J)=0
      EXFILE(I,J)=0
  183 CONTINUE
C
C     RESET SCHEDULE FILE
C
      DO 185 J=2,4
  185 SCHEDULE(I,1)=SCHEDULE(I,1)+SCHEDULE(I,J)
      DO 186 L=2,10
      K=L+3
  186 SCHEDULE(I,L)=SCHEDULE(I,K)
      IF(IPRINT.GT.3)GO TO 190
      WRITE(2,187)AFILE(I,1),(INPUT(I,J),J=1,20),(EXFILE(I,J),J=1,20),(S
     1CHEDULE(I,J),J=1,13)
  187 FORMAT(1H0,6X,'PRODUCT...',A8//6X,'INPUT',8X,20I5//6X,'EXFILE',7
     1X,20I5//6X,'SCHEDULE',13I5)
  190 CONTINUE
C
C     CALCULATE CURRENT ORDER LOAD
C
  200 IF(IPRINT.GT.3)GO TO 205
      WRITE(2,203)(J,J=1,6)
  203 FORMAT(1H0/6X,'CURRENT ORDER LOAD',2X,'O/D',3X,6(3X,'Q',I1))
  205 DO 250 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 250
      COL(I,1)=0
      DO 210 L=1,52
      DO 210 M=1,20
      IF(ORDBK(I,L,M,4).EQ.0)GO TO 210
      COL(I,1)=COL(I,1)+ORDBK(I,L,M,3)
  210 CONTINUE
      DO 230 J=2,5
      COL(I,J)=0
      K=(J-1)*13
      N=K-12
      DO 230 L=N,K
      DO 230 M=1,20
      IF(ORDBK(I,L,M,4).EQ.1) GO TO 230
      COL(I,J)=COL(I,J)+ORDBK(I,L,M,3)
  230 CONTINUE
      IF(IPRINT.GT.3)GO TO 250
      WRITE(2,220)AFILE(I,1),(COL(I,J),J=1,7)
  220 FORMAT(1H0,10X,A8,6X,I5,3X,6I5)
  250 CONTINUE
C
C     RESTT DELIVERY PERFORMANCE STATISTICS
C
      DO 260 I=1,10
      DO 260 J=1,30
      EQUPERF(I,J)=0
      ITEMPERF(I,J)=0
  260 CONTINUE
      DO 270 I=1,2
      DO 270 J=1,30
      ORDPERF(I,J)=0
  270 CONTINUE
      RETURN
      END
```

B34 - SUBROUTINE RANDOM

The generation of pseudo-random number streams is required to support the various sampling tables and distributions accessed by the model.

Two factors were considered when selecting a suitable pseudo-random number generator design:

- the generator should be capable of accepting an external seed, which could be returned for future use. This facilitates the identification of a unique stream of seeds with a particular sampling facility.
- the generator should be capable of accepting negative seeds if antithetic sequences are required.

The design chosen is a multiplicative congruential method as described by Naylor et al (1966). The model is designed to run on an ICL1904S computer, which is a 24 bit word machine.

The number of bits available for number definition is 23.

The modulus, $m = 2^b$, where b is the number of binary digits (bits) in a word. This $m = 2^b = 2^{24}$

The value of "a" which is relatively prime to "m" is given by the congruence relation

$$a \equiv \pm 3 \pmod 8$$

which may be expressed as

$$a = 8t \pm 3$$

where "t" is any positive integer. "t" should be chosen to give "a" close to $2^{b/2}$, or 2048 (for a 24 bit machine). Hence a value of 2048 - 3 = 2045 was selected.

A starting value n_o (the seed) is selected, which should be relatively prime to 2^b, a condition which is satisfied by any odd number.

The product an_o will consist of 2b bits, the lower-order "b" bits representing n_1. This value is returned as a seed for subsequent use. The subroutine returns r_1, which is a uniformly distributed variate defined on the unit interval, where $r_1 = n_1/2^b = n_1/2^{23}$

The subroutine will produce a series of random variates $r_1 \ldots r_n$ which will repeat after $2^{b-2} = 2097152$ numbers.

The subroutine depends upon the standard FORTRAN compiler logic, where an integer multiplication instruction automatically discards the high order b bits. The compiler "XFAT" will not normally allow this condition (which results in the overflow register being set), thus an error trap has been introduced to suppress an error exit on overflow condition. The error condition is re-established on leaving the sub-routine.

The subroutine is based on an IBM library program modified to comply with the above parameter definitions. A sequence to accommodate negative seeds has been included to provide the facility of antithetic streams.

The output of the pseudo-random generator has not been tested by any of the standard statistical methods. Sequences of numbers have been visually checked as a uniform distribution and after application in a random normal deviate generator. Both instances provide acceptable results in the context of the model. If a rigourous analysis of results is required, including meaningful tests of significance, appropriate statistical tests must be applied.

```
C
C     RANDOM
C
      SUBROUTINE RANDOM(E,J)
      EXTERNAL OVER
      CALL FTRAP(OVER)
      IF(J)60,40,10
   10 J=2045*J
      IF(J)20,40,30
   20 J=J+8388607+1
   30 E=J/8388608.0
      CALL FRESET
      RETURN
   40 WRITE(2,50)
   50 FORMAT(1H0,6X,'ZERO RANDOM STREAM')
      STOP
   60 J=2045*J
      IF(J)80,40,70
   70 J=J-8388607-1
   80 E=1.0+J/8388608.0
      CALL FRESET
      RETURN
      END
```

```
C
C      ERROR TRAP
C
     ERROR TRAP
     SUBROUTINE OVER(I)
     IF(I.EQ.50)GO TO 100
     WRITE(2,10)I
  10 FORMAT(1H0,6X,'EXECUTION ERROR =',I3)
     PAUSE EE
 100 RETURN
     END
```

B35 - SUBROUTINE RECEIVE

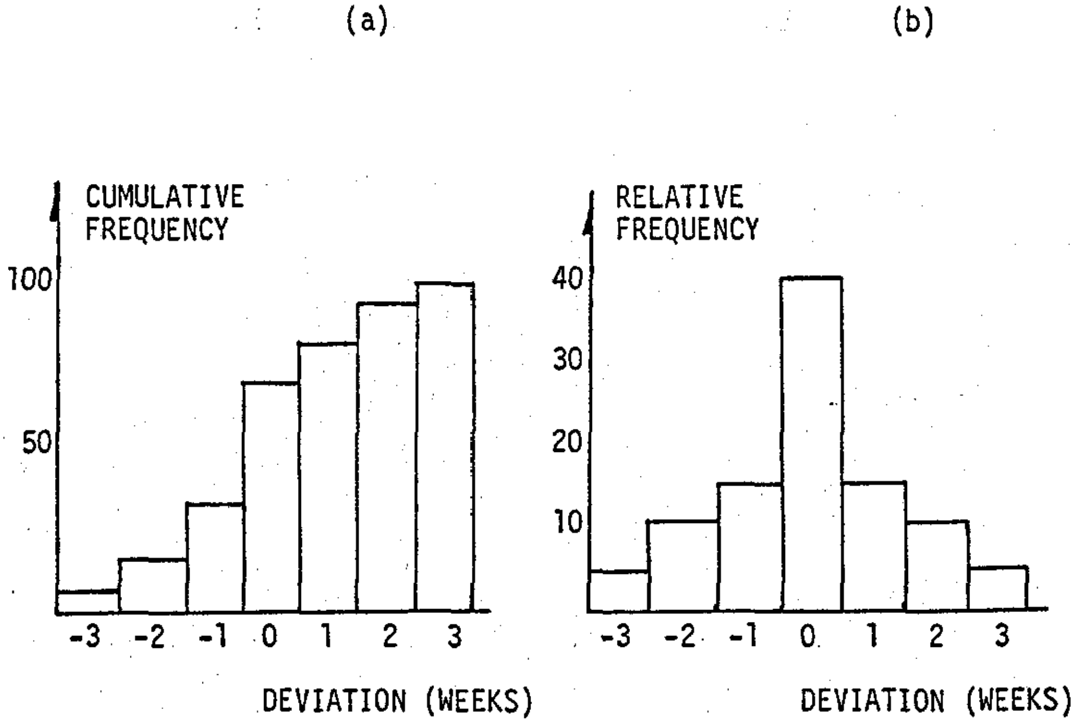
The schedules of planned deliveries from the supplier are established in subroutine SCHED and maintained in monthly buckets in file SCHEDULE. The actual deliveries will tend to conform to a pattern around the planned receipt date. Subroutine RECEIVE establishes the deviation from the planned receipt date and creates a new file, INPUT, which contains the weekly programme of actual material receipts.

The schedule response time, which is the period during which no changes may be made to the supplier schedule, is also applied to the input file. This ensures that the two files, SCHEDULE and INPUT are consistent. The response time is stored in months for use in SCHED and is converted to an equivalent weekly value for use in RECEIVE.

The schedule of supplier deliveries is maintained in SCHEDULE as a series of monthly quantities due in the last week of the month. Subroutine RECEIVE determines, for each scheduled receipt, the actual delivery week. Two sampling tables are used to determine the spread around the scheduled date; the first is applicable to normal deliveries beyond the schedule response time, and the second is applicable to "arrears" to schedule.

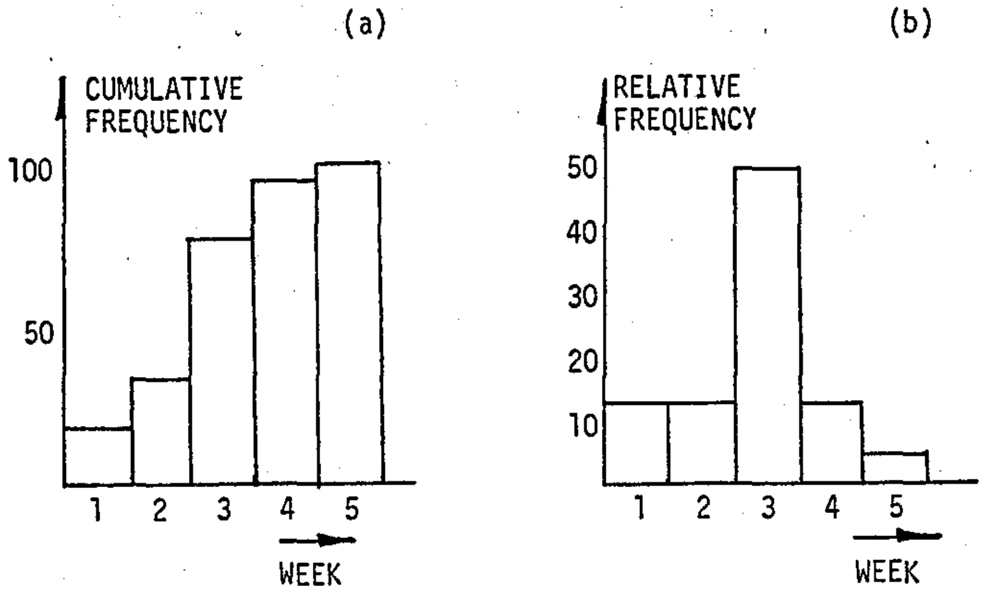
The file INPUT is re-created each quarter following establishment of the file SCHEDULE in subroutine SCHED. All data in file INPUT is cleared down beyond the schedule response time and the data within the response period is carried forward. No further changes to the data currently within this period are permissible.

File SCHEDULE is interrogated for finite scheduled receipts. The actual receipt date of the batch is determined by sampling from TABLE 1, which is a frequency histogram defining the deviation from the planned date and is of the form shown in (a). The relative frequency for each interval is shown in (b).



Thus, the actual delivery date is equally distributed around the planned date with a maximum deviation of 3 weeks. The scheduled batch is assumed to be delivered in one shipment, thus the scheduled quantity may be loaded into the appropriate week in file INPUT.

Within the schedule response time, the gross value of schedule receipts is compared to the actual input batches in file INPUT for the same period to arrive at a net value. This net value is treated as a schedule arrear. Arrears inputs augment the normal receipt batches, the receipt dates being derived by sampling from TABLE 2. TABLE 2 is a cumulative frequency histogram defining the actual delivery week as shown below.



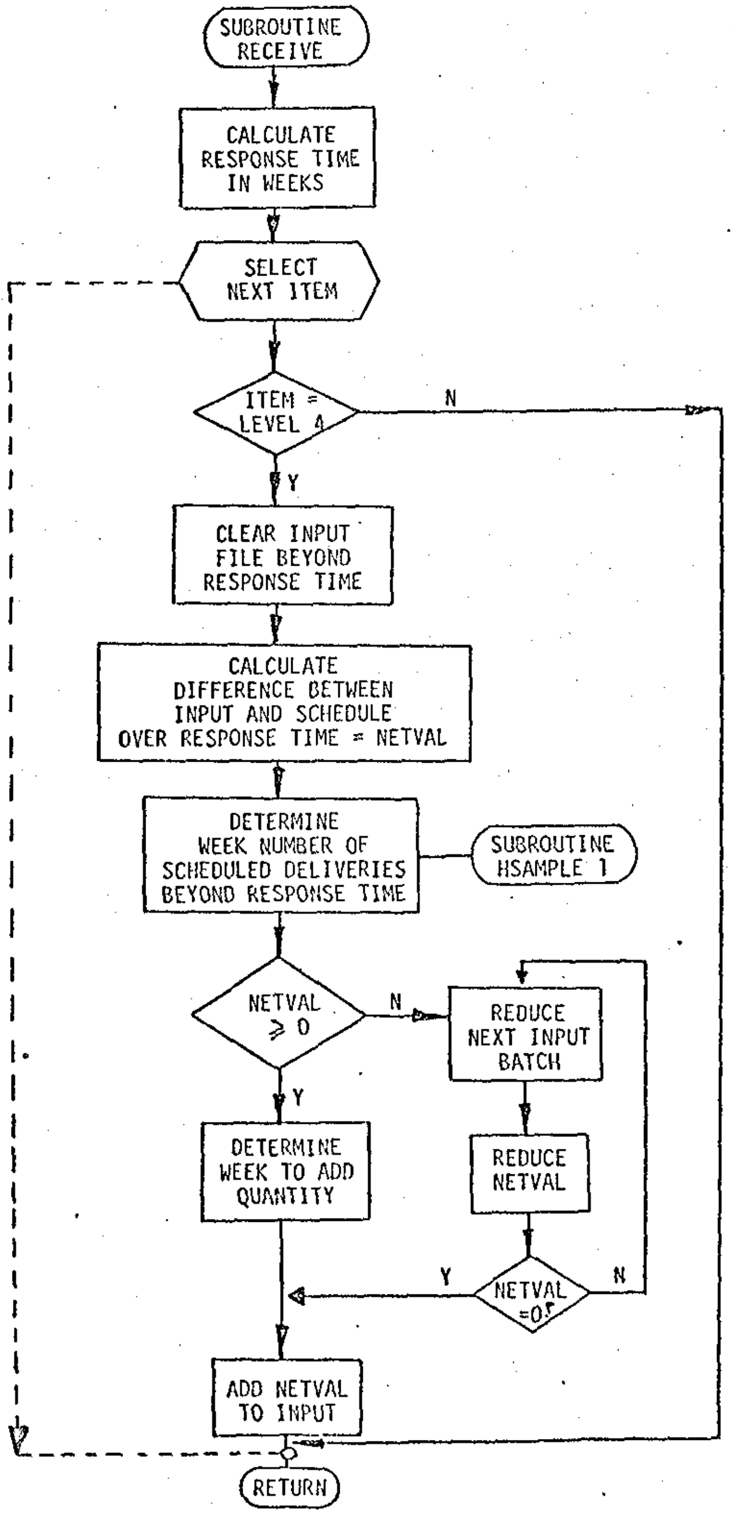
File INPUT is, therefore, created from three elements:

a) Previous INPUT data, within the response period;

b) Arrears to schedule, being the difference between the schedule batches and the actual input within the response period;

c) Normal schedule receipts beyond the response period.

Summarised Flow Chart - Subroutine Receive


SUBROUTINE RECEIVE
CALCULATE RESPONSE TIME IN WEEKS
SELECT NEXT ITEM
ITEM = LEVEL 4
N
Y
CLEAR INPUT FILE BEYOND RESPONSE TIME
CALCULATE DIFFERENCE BETWEEN INPUT AND SCHEDULE OVER RESPONSE TIME = NETVAL
DETERMINE WEEK NUMBER OF SCHEDULED DELIVERIES BEYOND RESPONSE TIME
SUBROUTINE HSAMPLE 1
NETVAL ≥ 0
N
Y
REDUCE NEXT INPUT BATCH
REDUCE NETVAL
DETERMINE WEEK TO ADD QUANTITY
NETVAL =0
Y
N
ADD NETVAL TO INPUT
RETURN

```
C
C     RECEIVE
C
      SUBROUTINE RECEIVE(SCHEDULE,INPUT,ISEED1,TABLE1,ISEED2,TABLE2,IFIL
     1E,IPRINT,RESPONSE,AFILE)
C
C     FIRST BUCKET OF SCHEDULE IS ARREARS
C     EIGHT WEEKS OF INPUT IS FIXED
C
      REAL AFILE(25,3)
      INTEGER INPUT(25,52),SCHEDULE(25,13),TABLE1(7,2),TABLE2(7,2),IFILE
     1(25,23),RESPONSE
      IF(IPRINT.GT.1)GO TO 400
      WRITE(2,420)
  420 FORMAT(1H0,6X,'* * * *  RECEIVE  * * * *'//)
  400 M=RESPONSE*4
      IF(IPRINT.GT.3)GO TO 1
      WRITE(2,200)
  200 FORMAT(1H0///6X,'MATERIAL INPUT')
    1 DO 70 N=1,25
      IF(IFILE(N,11).NE.4)GO TO 70
      DO 5 J=M+1,52
    5 INPUT(N,J)=0
      NETVAL=0
      DO 10 J=1,RESPONSE+1
   10 NETVAL=NETVAL+SCHEDULE(N,J)
      DO 15 J=1,M
   15 NETVAL=NETVAL-INPUT(N,J)
      IF(IPRINT.GT.1)GO TO 16
      WRITE(2,100)NETVAL
  100 FORMAT(1H0,6X,'NETVAL= ',I6)
   16 DO 30 J=RESPONSE+2,13
      K=4*(J-1)-3
      IF(SCHEDULE(N,J).EQ.0)GO TO 30
      NUMBER=0
      IF(ISEED1.EQ.0)GO TO 20
      CALL HSAMPLE 1(ISEED1,NUMBER,TABLE1)
      IF((K+NUMBER).LE.52)GO TO 20
      NUMBER=52-K
   20 INPUT(N,K+NUMBER)=INPUT(N,K+NUMBER)+SCHEDULE(N,J)
   30 CONTINUE
      IF(NETVAL)40,65,35
   35 NUMBER=2
      IF(ISEED2.EQ.0)GO TO 37
      CALL HSAMPLE 1(ISEED2,NUMBER,TABLE2)
   37 I=NUMBER+M
      GO TO 60
   40 DO 50 I=M+1,52
      IF(INPUT(N,I).GE.IABS(NETVAL))GO TO 60
      NETVAL=NETVAL+INPUT(N,I)
   50 INPUT(N,I)=0
      IF(I.GT.52) GOTO 65
   60 INPUT(N,I)=INPUT(N,I)+NETVAL
   65 IF(IPRINT.GT.3)GO TO 70
      WRITE(2,300)AFILE(N,1),(INPUT(N,J),J=1,40)
  300 FORMAT(1H0,6X,A8,2X,20I5//16X,20I5)
   70 CONTINUE
      RETURN
      END
```

B36 - SUBROUTINE SCHED

The subroutine SCHED converts the requirements plan for a purchased part into a monthly "call-off" schedule for the supplier.

The prime input to the subroutine is the net requirement for the part, which is presented to the program in weekly detail. The previous call-off schedule is used as a reference, with any backlog appearing as a single "arrears" value. Early deliveries will appear as a negative arrear to schedule.

The existing scheduling system logic employs an eight week "frozen period", or schedule response time, during which the previous schedule is maintained. Any prospective change to the schedule thus applies immediately beyond the fixed period.

In practice, any changes required during the fixed period and any significant changes beyond the fixed period, would be discussed between the Purchasing Department and the supplier and a schedule revision is agreed. The final schedule is input to the system and is used to monitor supplier performance. No formal procedure is present to feed back the revised information and evaluate the implications on the plan.

The simulation model uses an input parameter to determine the response time before schedule changes are effected and assumes that:

a) the "frozen" period is inviolable;

b) no manual intervention may take place;

c) purchase order cover is available to support the required call-off schedule.

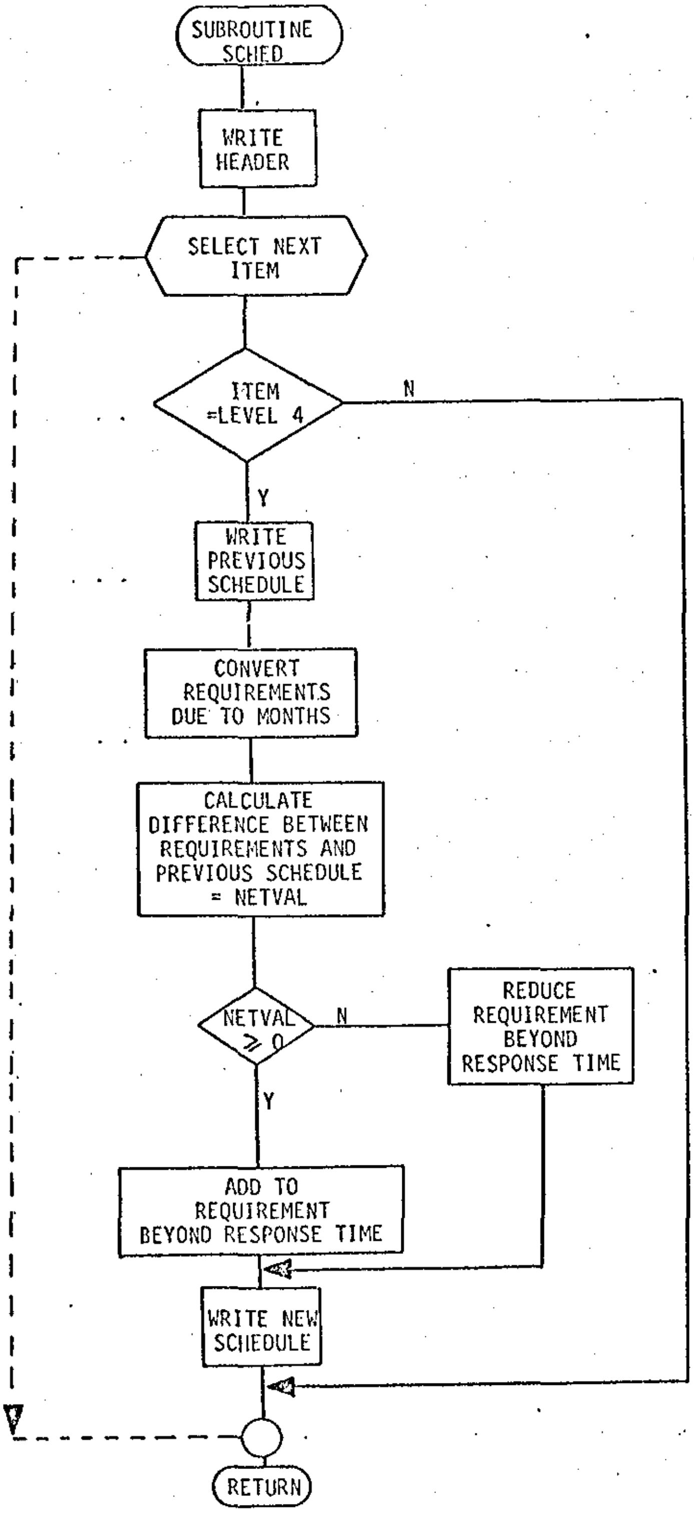
The final schedule returned to the model will thus reflect:

(i) the previous schedule arrears;

(ii) the first "x" call-offs of the previous schedule, where x is the response time in months;

(iii) the following new requirement in monthly periods based on the net requirements.

Summarised Flow Chart - Subroutine Sched


SUBROUTINE SCHED
WRITE HEADER
SELECT NEXT ITEM
ITEM =LEVEL 4
N
Y
WRITE PREVIOUS SCHEDULE
CONVERT REQUIREMENTS DUE TO MONTHS
CALCULATE DIFFERENCE BETWEEN REQUIREMENTS AND PREVIOUS SCHEDULE = NETVAL
NETVAL ≥ 0
N
REDUCE REQUIREMENT BEYOND RESPONSE TIME
Y
ADD TO REQUIREMENT BEYOND RESPONSE TIME
WRITE NEW SCHEDULE
RETURN

```
C
C     SCHED
C
      SUBROUTINE SCHED(REQFILE,SCHEDULE,RESPONSE,IFILE,AFILE,IPRINT)
      REAL AFILE(25,3)
      INTEGER NETPLAN(12),OLDSCHED(13),SCHEDULE(25,13),RESPONSE,REQFILE(
     125,52),IFILE(25,23)
C
C     NOTE THAT FIRST PERIOD OF SCHEDULE IS ARREARS
C
      IF(IPRINT.GT.1)GO TO 400
      WRITE(2,420)
  420 FORMAT(1H0,6X,'* * * *  SCHED  * * * *'//)
  400 IF(IPRINT.GT.3)GO TO 1
      WRITE(2,150)(J,J=1,12)
  150 FORMAT(1H0//6X,'COMPONENT SCHEDULES'//16X,'ARREARS',12I8)
    1 DO 70 N=1,25
      IF(IFILE(N,11).NE.4)GO TO 70
      IF(IPRINT.GT.3)GO TO 2
      WRITE(2,250)AFILE(N,1),(SCHEDULE(N,J),J=1,13)
  250 FORMAT(1H0/6X,'PART NUMBER',2X,A8//6X,'OLD SCHED',I8,2X,12I8)
    2 DO 3 J=1,13
    3 OLDSCHED(J)=SCHEDULE(N,J)
      DO 5 J=1,12
      NETPLAN(J)=0
      M=4*J-3
      DO 5 K=M,M+3
    5 NETPLAN(J)=NETPLAN(J)+REQFILE(N,K)
      SCHEDULE(N,1)=OLDSCHED(1)
      NETVAL=OLDSCHED(1)
      IF(RESPONSE.EQ.0)GO TO 20
      DO 10 J=2,RESPONSE+1
      IF(J.GT.12)GO TO 70
      NETVAL=NETVAL+OLDSCHED(J)-NETPLAN(J-1)
   10 SCHEDULE(N,J)=OLDSCHED(J)
   20 K=RESPONSE
   30 K=K+1
      IF(NETVAL.GT.NETPLAN(K))GO TO 40
      SCHEDULE(N,K+1)=NETPLAN(K)-NETVAL
      GO TO 50
   40 NETVAL=NETVAL-NETPLAN(K)
      SCHEDULE(N,K+1)=0
      IF(K.LT.12)GO TO 30
   50 IF(K.GE.12)GO TO 70
      DO 60 L=K+1,11
   60 SCHEDULE(N,L+1)=NETPLAN(L)
      IF(IPRINT.GT.3)GO TO 70
      WRITE(2,350)(SCHEDULE(N,J),J=1,13)
  350 FORMAT(1H0/6X,'NEW SCHED',I8,2X,12I8)
   70 CONTINUE
   80 RETURN
      END
```

B37 - SUBROUTINE STKALL

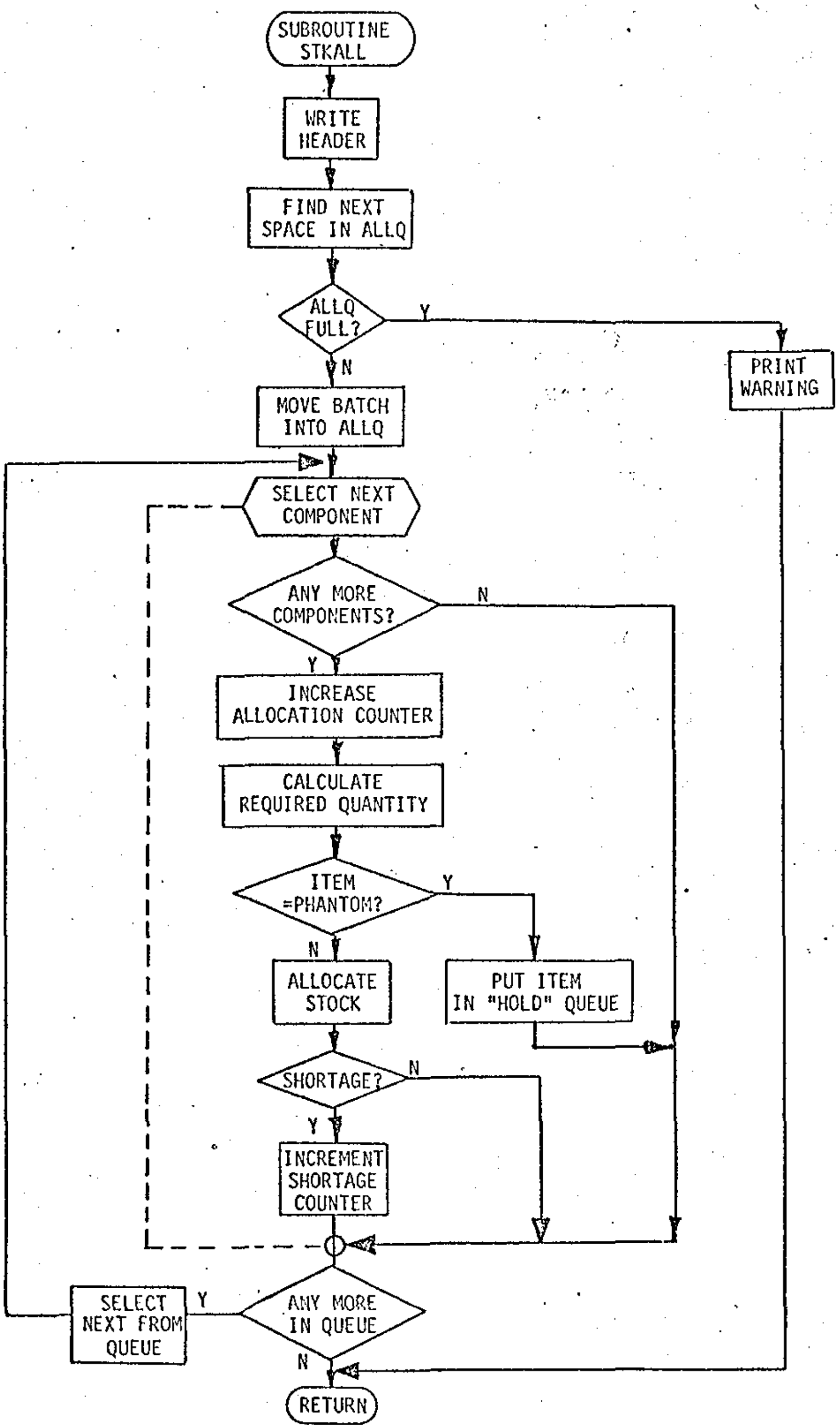
Orders which have been selected in subroutine ALLOCATE are moved from "open" to "allocation" status in file OPFILE and have their component requirements allocated against stock. This is performed by subroutine STKALL.

Entry into the subroutine is followed by a check that a free record is available in the allocate queue, ALLQ, for the required product. If the file is full, control is returned to the calling programme.

The allocation queue record is created by writing into the next available space the order number, item number, due date and quantity. The minimum lead time that the order must remain in ALLQ for material preparation is determined by a random normal deviate derived from the calling program. The shop order number, which links quantities of the same product, is also derived from the calling programme.

For each product requirement entering the subroutine, the components are allocated by extending the quantity required by the component relationships contained within IFILE. The allocation procedure consists of incrementing the "allocated stock" field in IFILE for each component by the gross requirement. Each requirement will increment a "required" counter, ICOUNT, and each shortage encountered (where allocated stock exceeds physical stocks) will increment the "shortage" counter, ISHORT. These status variables are subsequently used for service level reporting.

Where a non-stocked item (identified as "not to be issued" in IFILE) is encountered, a further level of allocation is performed on the components of the non-stocked item.



Summarised Flow Chart - Subroutine Stkall

```
C
C      STKALL
C
       SUBROUTINE STKALL(IFILE,QUANTITY,N,ALLQ,ORDNO,ITEMNO,DDATE, OUTPUT
      1,ICOUNT,ISHORT,IPRINT,IMAX,AFILE,*)
       REAL AFILE(25,3)
       INTEGER QUANTITY,IFILE(25,23),REQD,HOLD(7,2),ALLQ(12,50,6),
      1DDATE,ORDNO,ICOUNT(25),ISHORT(25)
       IF(IPRINT.GT.1)GO TO 3
       WRITE(2,1)
     1 FORMAT(1H0,6X,'* * * *  STKALL  * * * *'//)
     3 K=0
       IF(IPRINT.GT.1)GO TO 5
       WRITE(2,200)ORDNO,ITEMNO,DDATE,QUANTITY
   200 FORMAT(1H0,6X,'ORDNO= ',I6,2X,'ITEMNO= ',I6,2X,'DDATE= ',I6,2X,'QU
      1ANTITY= ',I6)
C
C     FIND NEXT SPACE IN QUEUE
C
     5 DO 10 J=1,50
       IF(ALLQ(N,J,4).EQ.0)GO TO 30
    10 CONTINUE
       IF(IPRINT.GT.5)GO TO 140
       WRITE(2,20)AFILE(N,1)
    20 FORMAT(1H0,6X,'EXCEEDED ALLOCATION QUEUE SIZE FOR PRODUCT NO.',2X,
      1A8)
       GO TO 140
C
C     MOVE ITEM INTO ALLOCATION QUEUE
C
    30 ALLQ(N,J,1)=ORDNO
       ALLQ(N,J,2)=ITEMNO
       ALLQ(N,J,3)=DDATE
       ALLQ(N,J,4)=QUANTITY
    35 ALLQ(N,J,5)=NINT(OUTPUT)
       ALLQ(N,J,6)=IMAX
       IF (IPRINT.GT.2)GO TO 40
       WRITE(2,38)AFILE(N,1),(ALLQ(N,J,M),M=1,6)
    38 FORMAT(1H0,6X,'ITEM ADDED TO ALLQ FOR PRODUCT',2X,A8//6X,'ORDNO',I
      16,2X,'ITEMNO',I6,2X,'DDATE',I6,2X,'QUANTITY',I6,2X,'TIME',I6,2X,'S
      2HOP ORD.',I6)
C
C     ALLOCATE COMPONENTS
C
    40 DO 110 J=1,9,2
       IF(IFILE(N,J).EQ.0)GO TO 110
       L=IFILE(N,J)
       ICOUNT(L)=ICOUNT(L)+1
       IP=J+1
       REQD=QUANTITY*IFILE(N,IP)
       IF(IFILE(L,15).EQ.1)GO TO 50
       IFILE(L,17)=IFILE(L,17)+REQD
       IF(IFILE(L,16).GE.IFILE(L,17))GO TO 110
       ISHORT(L)=ISHORT(L)+1
       GO TO 110
    50 K=K+1
       HOLD(K,1)=L
       HOLD(K,2)=REQD
   110 CONTINUE
       IF(K.EQ.0)GO TO 120
      N=HOLD(K,1)
      QUANTITY=HOLD(K,2)
      K=K-1
      GO TO 40
  120 RETURN
  140 RETURN 1
      END
```

B38 - SUBROUTINE STOCKVAL

One of the key performance measures required of the model is to monitor the investment in inventory. The evaluation of inventory across the various production stages is executed within the subroutine STOCKVAL.

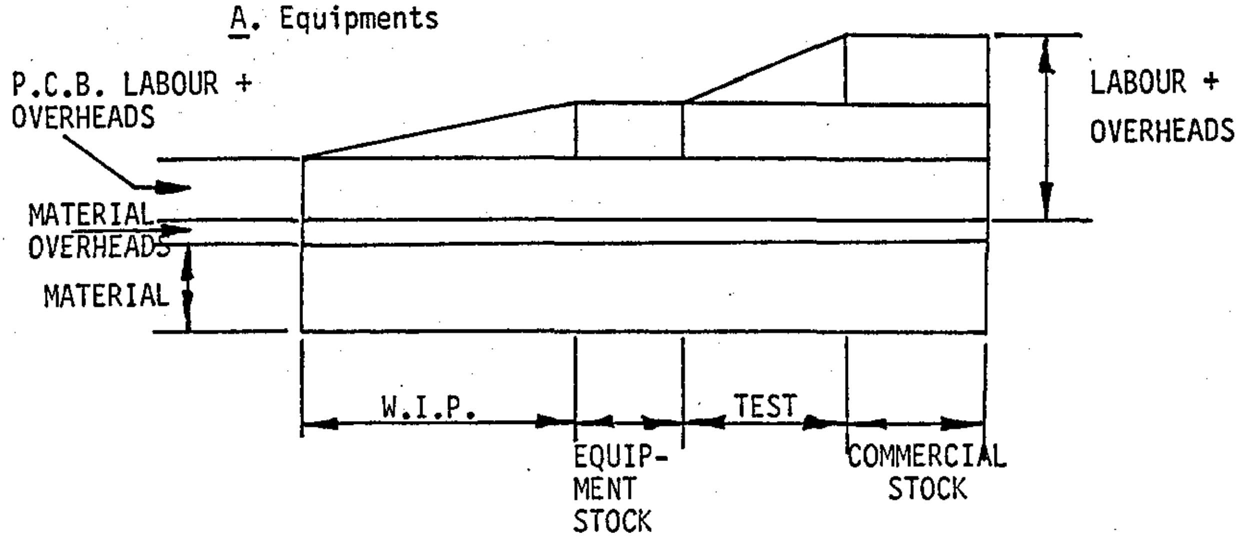
Each product standard cost comprises four elements; direct material, material overheads, direct labour and labour overheads. The overhead rates selected are fairly representative of the composition of a typical product. Material overheads are applied (or recovered) at the point of issue to work in progress at a rate of 20% of the standard cost of material. Labour overheads are applied at the point of transfer to stock (or finished goods warehouse) at a rate of 250% of direct labour.

Values held in IFILE are prime costs only, nett of overhead elements. At each level of assembly, the accumulated value of prime costs, including the labour content for completion of the assembly as a stockable item, is held. If "M" is the accumulated value of direct material and "L" is the corresponding value of direct labour, the total standard cost, "S", for the assembly is

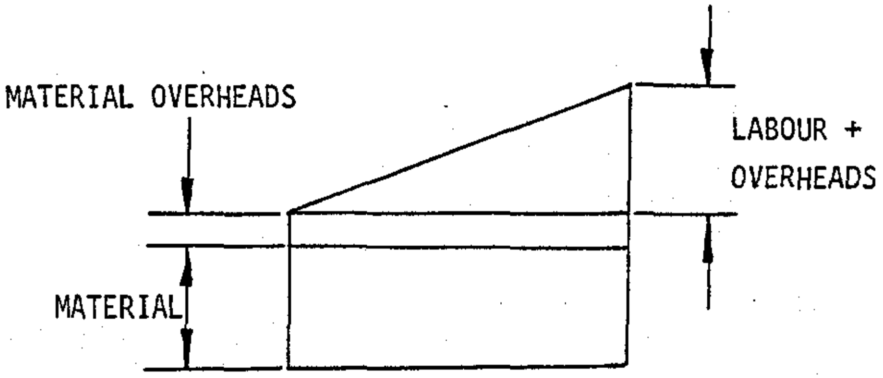
$$S = 1.2M + 3.5L \qquad (1)$$

Figures A/B below illustrate the assumptions used to arrive at a reasonable approximation of the added value as the production process advances.

A. Equipments



B. Sub-assemblies



The formulae used to value each category of inventory are derived from the above profiles.

COMPONENTS

The value of stock is taken as the standard cost of material less any material overhead contribution. The total stock value is the product of the standard cost and the physical stock for each component item.

SUB-ASSEMBLIES

Sub-assemblies held in stock are assumed to be fully completed including assembly and test labour. Thus, the standard value of each item is given by the relationship in (1) above.

As sub-assemblies progress through work in progress, labour is assumed to be applied to the material linearly. The standard value is therefore given by the relationship

$$S = 1.2M + 1.75L \qquad (2)$$

EQUIPMENT

Equipment is valued at four levels. Stock which is ready for despatch (commercial stock) is valued at the full standard cost as given in (1) above.

Equipment in final test is assumed to have accumulated 95% of the total labour effort, giving a standard value of

$$S = 1.2M + 3.3L \qquad (3)$$

Equipment held in finished product stock is normally nett of final test labour, and has been assumed to have accumulated 85% of the labour value. Thus, finished equipment stock is valued as

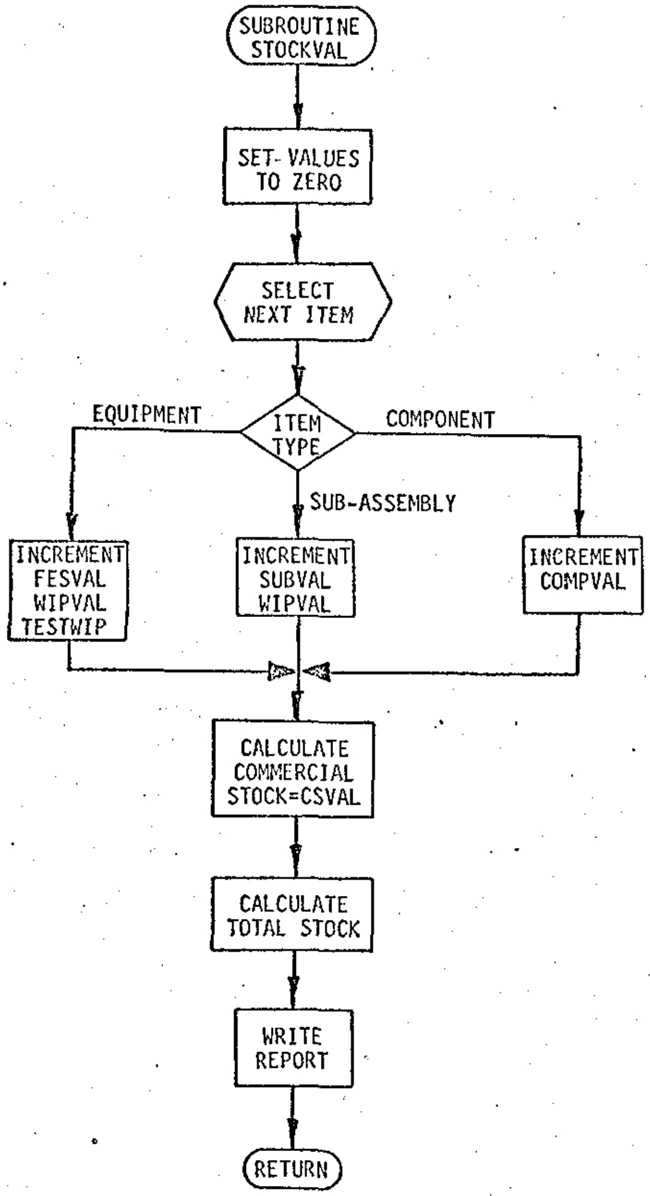
$$S = 1.2M + 3.0L \qquad (4)$$

Equipment in the product assembly stage will have accumulated the labour value of the comprising sub-assemblies plus a proportion of the final assembly labour. This is assumed to be 70% of the full labour content, giving a standard value of

$$S = 1.2M + 2.5L \qquad (5)$$

All values except commercial stock are derived from the item master record IFILE. Commercial stock is determined by scanning the product record in the orders placed file OPFILE and summing the items in "despatch" status.

The sum of each of the above stock categories indicates the total inventory investment for the period.



Summarised Flow Chart - Sub-routine Stockval

```
C
C     STOCKVAL
C
      SUBROUTINE STOCKVAL(IFILE,MONTH,OPFILE)
      INTEGER COMPVAL,WIPVAL,SUBVAL,FESVAL,IFILE(25,23),TOTVAL,CSVAL,OPF
     1ILE(125,5,5,10),TESTWIP
      CSVAL=0
      COMPVAL=0
      WIPVAL=0
      SUBVAL=0
      FESVAL=0
      TESTWIP=0
      DO 100 I=1,25
      IF=IFILE(I,11)
      GO TO (10,20,20,30),IF
   10 FESVAL=FESVAL+IFILE(I,16)*(IFILE(I,13)*1.2+IFILE(I,14)*3.0)
      WIPVAL=WIPVAL+IFILE(I,18)*(IFILE(I,13)*1.2+IFILE(I,14)*2.5)
      TESTWIP=TESTWIP+IFILE(I,19)*(IFILE(I,13)*1.2+IFILE(I,14)*3.3)
      GO TO 100
   20 SUBVAL=SUBVAL+IFILE(I,16)*(IFILE(I,13)*1.2+IFILE(I,14)*3.5)
      WIPVAL=WIPVAL+IFILE(I,18)*(IFILE(I,13)*1.2+IFILE(I,14)*2.5)
      GO TO 100
   30 COMPVAL=COMPVAL+IFILE(I,16)*IFILE(I,13)
  100 CONTINUE
      DO 150 I=1,125
      DO 150 J=1,5
      DO 150 K=1,5
      IF(OPFILE(I,J,K,9).EQ.0)GO TO 150
      L=OPFILE(I,J,K,1)
      CSVAL=CSVAL+OPFILE(I,J,K,9)*(IFILE(L,13)*1.2 +IFILE(L,14)*3.5)
  150 CONTINUE
      TOTVAL=COMPVAL+SUBVAL+WIPVAL+FESVAL+CSVAL+TESTWIP
      WRITE(2,200)MONTH,COMPVAL,SUBVAL,WIPVAL,FESVAL,TESTWIP,CSVAL,TOTVA
     1L
  200 FORMAT(1H0,///6X,'STOCK VALUES FOR MONTH',I5//12X,'COMPONENTS = £'
     1,I6//8X,'SUB-ASSEMBLIES = £',I6//6X,'WORK IN PROGRESS = £',I6//7X,
     2'EQUIPMENT STOCK = £',I6//11X,'TEST W.I.P. = £',I6//6X,'COMMERCIAL
     3 STOCK = £',I6///15X,'TOTAL STOCK VALUE = £',I8////)
      RETURN
      END
```

B39 - SUBROUTINE SUBPROG

The requirement for sub-assemblies is derived each quarter from the requirements calculation contained in subroutine EXPLODE. Since the recalculation is executed infrequently, some mechanism is required to review and modify the sub-assembly schedule according to the actual demand pattern and stock profile. This re-balancing is performed in subroutine SUBPROG.

The role of SUBPROG is twofold; to convert the requirements into "economic batch quantities" and to adjust the programme for unbalanced buffer stocks.

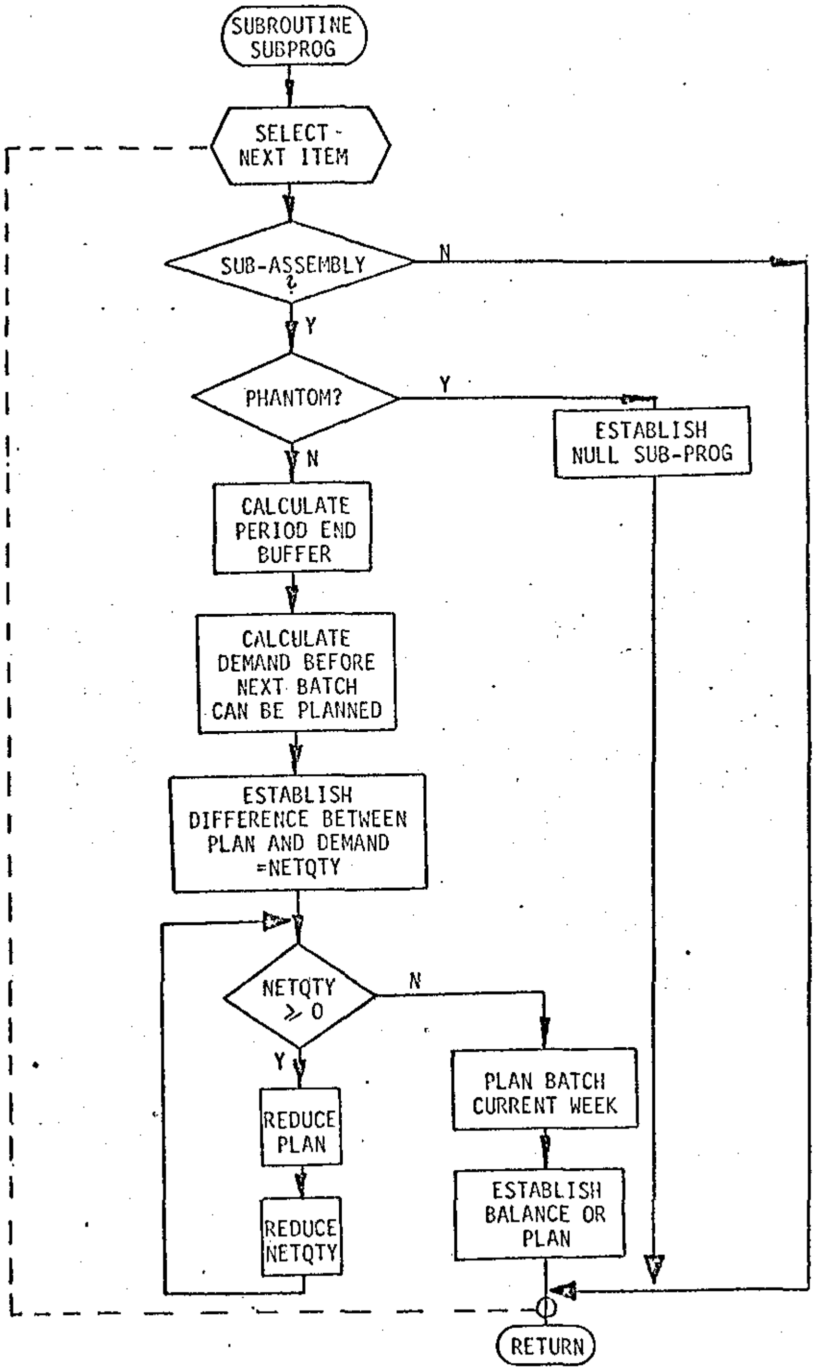
The required buffer at the end of the current period, which is determined by the manufacturing lead time, is calculated as the gross requirements extended by the number of weeks of planned buffer. The latter is a prime experimental parameter.

The net result at the end of the period is derived by comparing total requirements (planned buffer, gross demand, allocated stock) with the total available stock (physical stock, work in progress, quantity in allocation).

The nett quantity, if positive, will cause requirements to be deleted until the excess has been consumed. A negative nett quantity will cause a batch to be planned in the current period.

For the period beyond the modified zone, batches are planned according to the frequency and batch size contained in file IFILE.

The resultant file, SUBFILE, is used to plan the manufacture of sub-assembly batches, initiated by subroutine ALLOCATE.


SUBROUTINE SUBPROG
SELECT NEXT ITEM
SUB-ASSEMBLY ?
N
Y
PHANTOM?
Y
ESTABLISH NULL SUB-PROG
N
CALCULATE PERIOD END BUFFER
CALCULATE DEMAND BEFORE NEXT BATCH CAN BE PLANNED
ESTABLISH DIFFERENCE BETWEEN PLAN AND DEMAND =NETQTY
NETQTY ≥ 0
N
Y
REDUCE PLAN
REDUCE NETQTY
PLAN BATCH CURRENT WEEK
ESTABLISH BALANCE OR PLAN
RETURN

Summarised Flow Chart - Subroutine Subprog

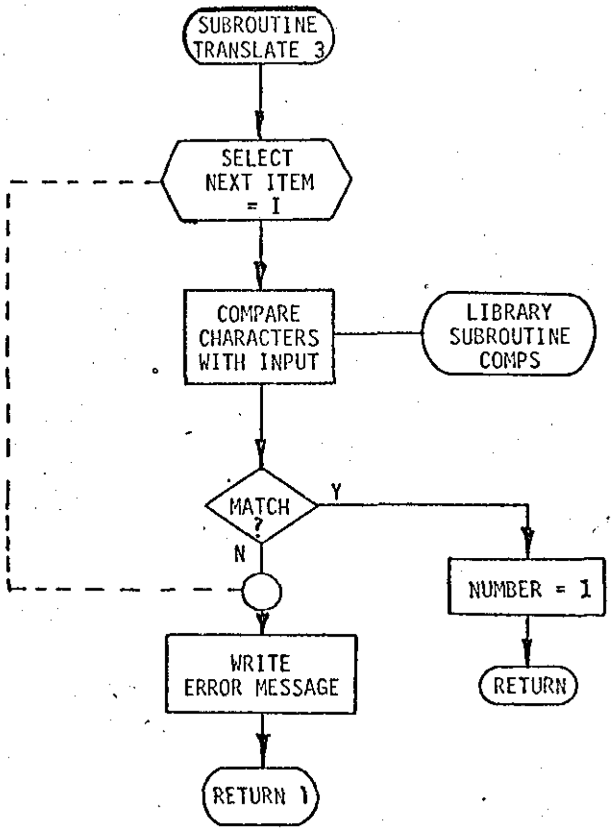
```
C
C     SUBPROG
C
      SUBROUTINE SUBPROG(REQFILE,WEEK,IFILE,IPRINT,SUBFILE,AFILE,ALLQ)
      REAL AFILE(25,3)
      INTEGER REQFILE(25,52),IFILE(25,23),WEEK,SUBFILE(12,26),BUFFER,DEM
     1AND,ALLQ(12,50,6),ALLQTY
      IF(IPRINT.GT.4)GO TO 1
      WRITE(2,205)
  205 FORMAT(1H0,6X,'SUB-ASSEMBLY PROGRAMMES')
    1 DO 50 I=1,12
      IF(IFILE(I,11).EQ.2.OR.IFILE(I,11).EQ.3)GO TO 5
      GO TO 50
    5 IF(IFILE(I,15).NE.1)GO TO 2
      DO 6 J=1,26
    6 SUBFILE(I,J)=0
      GO TO 110
C
C     FIND QUANTITY IN ALLOCATION
C
    2 ALLQTY=0
      DO 3 J=1,50
    3 ALLQTY=ALLQTY+ALLQ(I,J,4)
C
C     CALCULATE BUFFER AT PERIOD END
C
      BUFFER=0
      IF(IPRINT.GT.1)GO TO 7
      WRITE(2,200)AFILE(I,1)
  200 FORMAT(1H0,6X,'I =',2X,A8)
    7 K=IFILE(I,20)+WEEK+IFILE(I,12)+1
      IF(IPRINT.GT.1)GO TO 9
      WRITE(2,201)K
  201 FORMAT(1H0,6X,'K =',I4)
    9 IF(K.GT.52)GO TO 50
      L=WEEK+IFILE(I,12)+2
      DO 10 J=L,K
   10 BUFFER=BUFFER+REQFILE(I,J)
C
C     CALCULATE DEMAND BEFORE NEXT BATCH CAN BE ALLOCATED AND MADE
C
   15 DEMAND=0
      M=WEEK+IFILE(I,12)+1
      IF(M.GT.52)GO TO 50
      DO 20 L=WEEK,M
   20 DEMAND=DEMAND+REQFILE(I,L)
      IF(IPRINT.GT.1)GO TO 25
      WRITE(2,203)DEMAND,BUFFER,ALLQTY
  203 FORMAT(1H0,6X,'DEMAND =',I6,2X,'BUFFER =',I6,2X,'ALLQTY =',I6)
C
C     CALCULATE BATCH SIZE AND TIMING
C
   25 L=WEEK+12
      IF(L.LE.26)GO TO 30
      L=26
   30 DO 40 J=WEEK,L
   40 SUBFILE(I,J)=0
      NETQTY=IFILE(I,16)-IFILE(I,17)-BUFFER+IFILE(I,18)-DEMAND+ALLQTY
      IF(IPRINT.GT.1)GO TO 45
      WRITE(2,204)NETQTY
  204 FORMAT(1H0,6X,'NETQTY =',I6)
```

```
 45 N=IFILE(I,22)
    J=WEEK
    IF(NETQTY.LT.0)GO TO 60
    DO 70 J=WEEK,L
    IF(REQFILE(I,J).GE.NETQTY)GO TO 60
    NETQTY=NETQTY-REQFILE(I,J)
    SUBFILE(I,J)=0
 70 CONTINUE
    GO TO 110
 60 SUBFILE(I,J)=IFILE(I,21)
    K=J+N
    IF(IPRINT.GT.1)GO TO 95
 90 WRITE(2,500)K,L,N
500 FORMAT(1H0,6X,'K= ',I4,' L=',I4,' N=',I4)
 95 DO 100 J=K,L,N
    IF(K.GT.26)GO TO 110
100 SUBFILE(I,J)=IFILE(I,21)
110 IF(IPRINT.GT.4)GO TO 50
    WRITE(2,600)AFILE(I,1),(SUBFILE(I,J),J=1,20)
600 FORMAT(1H0,6X,A8,2X,20I5)
 50 CONTINUE
    RETURN
    END
```

B40 - SUBROUTINE TRANSLATE 3

An essential ingredient in the design of the model was to make communication both to and from the model as simple as possible. The facility has been provided to define part number data in alpha-numeric code rather than restricting the modeller to numeric only coding, thus allowing the use of familiar code references and simplifying the diagnostic routine interpretation, where code numbers could easily be confused with parameters and variable data. The only constraint in code numbering is that the field length is restricted to eight characters.

The subroutine accepts a real word from the calling programme, and compares each of the eight characters with the type code contained within AFILE by use of library subroutine COMP8. If a successful match is made, the logical position of the AFILE entry is returned as the equivalent numeric parameters defining the code number.



Summarised Flow Chart - Subroutine Translate 3

```
C
C     TRANSLATE 3
C
      SUBROUTINE TRANSLATE 3(AFILE,TYPE,NUMBER,*)
      REAL AFILE(25,3),TYPE
      DO 10 I=1,25
      CALL COMP8(TYPE,AFILE(I,1),ITEST)
      GO TO (30,10)ITEST
   10 CONTINUE
      WRITE(2,20)TYPE
   20 FORMAT(1H0,6X,A8,'IS AN INVALID PART NUMBER')
      RETURN 1
   30 NUMBER = I
      RETURN
      END
```

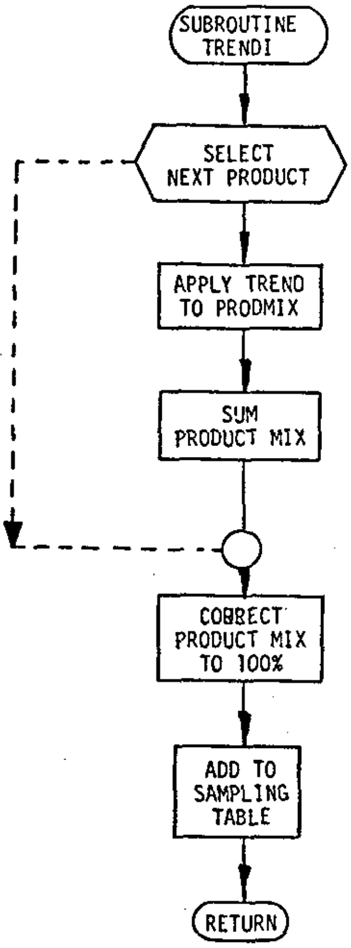
B41 - SUBROUTINE TRENDI

Subroutine TRENDI introduces a trend factor into the product mix sampling histogram. Thus, the behaviour of the model under conditions of sales growth and decay may be observed. Since the subroutine modifies only the probability that a particular product will be selected and not its quantity, the overall business volume is not influenced.

The product mix parameters available to the customer order generator, subroutine ORDERS, are held in the integer file TABLE 6. The initial values of product mix are derived from TABLE 6 and then translated into the real file PRODMIX for subsequent processing.

Trend parameters may be maintained independently for each product and are located in file TREND. The trend values represent the per unit increase (or decrease for negative trend values) in product mix value per period. Subroutine TRENDI is activated in the processing of subroutine QTREVENTS, thus each period represents a three month interval.

The direct application of trend modifiers to the file PRODMIX will normally result in a difference between the sum of the product components and the original scale of 0 - 100. Each component is therefore modified back to this scale and the cumulative mix results loaded into file TABLE 6.



Summarised Flow Chart - Subroutine Trendi

```
C
C      TRENDI
C
       SUBROUTINE TRENDI(TABLE6,PRODMIX,TREND,IPRINT)
       REAL PRODMIX(7),TREND(7)
       INTEGER TABLE6(7,2)
       SUM=0.0
       DO 50 I=1,7
       PRODMIX(I)=PRODMIX(I)*(1+TREND(I))
       SUM=SUM+PRODMIX(I)
   50  CONTINUE
       IF(IPRINT.GT.3)GO TO 65
       WRITE(2,60)(PRODMIX(I),I=1,7)
   60  FORMAT(1H0,6X,'PRODMIX WITH TREND'/10X,7F7.2)
       IF(IPRINT.GT.1)GO TO 65
       WRITE(2,63)SUM
   63  FORMAT(1H0,6X,'SUM =',F7.2)
   65  Z=0
       DO 70 I=1,7
       Z=Z+(PRODMIX(I)*100.0/SUM)
   70  TABLE6(I,2)=NINT(Z)
       IF(IPRINT.GT.3)GO TO 90
       WRITE(2,80)(TABLE6(I,1),I=1,7),(TABLE6(I,2),I=1,7)
   80  FORMAT(1H0,6X,'REVISED TABLE'//10X,7I6/10X,7I6///)
   90  RETURN
       END
```

B42 - SUBROUTINE WEEKEVENT

Subroutine WEEKEVENT sequences the weekly activities and links the data transfer between segments. The sequence of each segment within the subroutine is critical to the system performance and integrity, since it must follow, as closely as possible, the real world.

The subroutine simulates the nett effect of a week's worth of activities. No facility is provided to simulate a shorter time interval since such an approach would substantially reduce the computational efficiency and would provide little benefit. The main disadvantage is that no more than one activity may take place on a specific order in one week.

The first activity each period is the generation of a new batch of customer orders, which are filed in the orders pipeline. File PIPELINE may optionally be printed for diagnostic purposes.

Orders are extracted from the pipeline and loaded against the delivery plan in subroutine LOAD.

Components which are short to allocation are expedited in subroutine EXPEDITE and material receipts are simulated by subroutine ARRIVAL.

Customer orders which are still in unplanned status are selected for allocation against free equipment stock or for make to order in subroutine ALLOCATE. Subroutine ALLOCATE will subsequently cause components to be reserved and the order to be entered into the allocation queue in subroutine STKALL, together with stock replenishment orders as required to complete a batch. Orders selected for allocation against stock will be moved into "ex-stock" status for subsequent transfer into the test queue, using subroutine FESALL, as the due date approaches.

Orders in the allocation queue are moved into assembly work-in-progress by subroutine ISSWIP when all of the components are available, making allowance for the component picking lead time.

Orders which have completed the assembly process are moved out of the assembly queue in subroutine OFFLINE. Stock orders will update finished equipment stock in preparation for allocation in subroutine FESALL. Customer orders are moved directly to the test work-in-progress queue.

Subroutine FESALL selects orders in "ex-stock" status and compares the quantity required with the physical stock of finished equipment. Orders are subsequently moved into the test work-in-progress queue if stock exists.

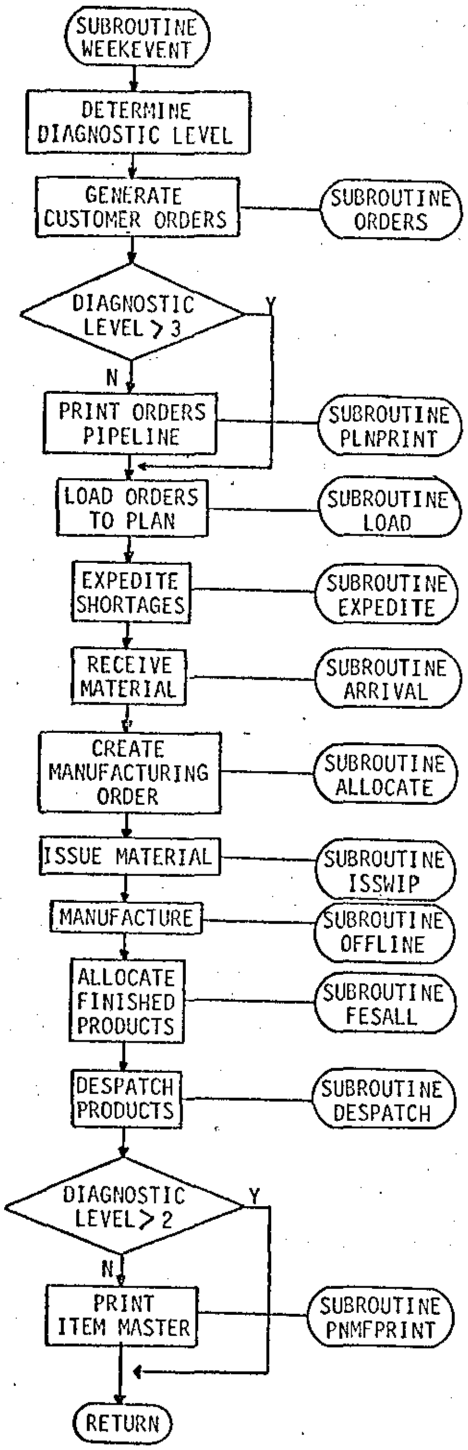
Subroutine DESPATCH selects orders from the test work-in-progress queue according to the priority rules selected and transfers the products to "despatch" status. Items transferred are analysed by subroutine DELPERF which will:

a) determine whether the order, or part order may be despatched, according to the part shipment rules;

b) update the delivery performance statistics.

Items which do not satisfy the part shipment rules remain in "despatch" status until the part shipment rules are satisfied.

The status of stock in the item master file may optionally be displayed at the end of each weekly cycle.



Summarised Flow Chart - Subroutine Weekevent

```
C
C     WEEKEVENT
C
      SUBROUTINE WEEKEVENT(AFILE,IFILE,TABLE3,TABLE5,TABLE6,TABLE7,TABLE
     111,AVGE4,CVARN4,AVGE9,CVARN9,AVGE10,ISEED3,ISEED4,ISEED5,ISEED6,IS
     2EED7,ISEED8,ISEED9,ISEED10,ISEED11,ISEED12,TABLE8,AVGE12,CVARN12,C
     3VARN10,ORDCOUNT,PIPELINE,DELPLAN,OCFMIN,WEEK,TOTAL,ORDBK,OPFILE,OR
     4DHIST,INPUT,EXFILE,SCHEDULE,REQFILE,ALLQ,LINEQ,TESTQ,SUBFILE,EQUPE
     5RF,ITEMPERF,ORDPERF,NETPLAN,REFWEEK,IPRINT,ICOUNT,ISHORT,CAPACITY,
     6LEADTM,ISORT,SUBQ,DIAGFILE,MODE,RUNTIME)
      REAL AFILE(25,3)
      INTEGER IFILE(25,23),TABLE3(7,2),TABLE5(7,2),TABLE6(7,2),TABLE7(7,
     12),TABLE8(2,2),TABLE11(2,2),ORDCOUNT,PIPELINE(20,6,4),DELPLAN(5,52
     2),OCFMIN,WEEK,TOTAL(5,52),ORDBK(5,52,20,5),OPFILE(125,5,5,10),ORDH
     3IST(5,12),INPUT(25,52),EXFILE(25,52),SCHEDULE(25,13),REQFILE(25,52
     4),STKORD(20),ALLQ(12,50,6),LINEQ(5,50,5),TESTQ(5,50,5),SUBFILE(12
     55,26),EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(2,30),NETPLAN(5,52),RE
     6FWEEK,CAPACITY,LEADTM(5,52),SUBQ(50,4),DIAGFILE(10,2),RUNTIME,ICOU
     7NT(25),ISHORT(25)
      DO 5 I=1,10
      IF(DIAGFILE(I,1).GT.(REFWEEK+WEEK))GO TO 7
    5 CONTINUE
    7 IPRINT=DIAGFILE(I-1,2)
      IF(IPRINT.GT.1)GO TO 30
      WRITE(2,10)
   10 FORMAT(1H0,6X,'* * * *  WEEKEVENT  * * * *'//)
   30 CALL ORDERS(TABLE5,TABLE6,TABLE7,ORDCOUNT,PIPELINE,ISEED4,ISEED5,I
     1SEED6,ISEED7,AVGE4,CVARN4,IFILE,TABLE8,ISEED8,IPRINT)
      IF(IPRINT.GT.3)GO TO 40
      CALL PLNPRINT(PIPELINE,AFILE)
   40 CALL LOAD(NETPLAN,OCFMIN,WEEK,TOTAL,PIPELINE,ORDBK,OPFILE,ORDHIST,
     1IPRINT,AFILE,IFILE,ORDCOUNT,REFWEEK,LEADTM)
      CALL EXPEDITE(IFILE,WEEK,INPUT,ISEED3,TABLE3,IPRINT,EXFILE,AFILE)
      CALL ARRIVAL(SCHEDULE,INPUT,IFILE,WEEK,IPRINT,AVGE9,CVARN9,AVGE10,
     1CVARN10,ISEED9,ISEED10,ISEED11,TABLE11,AFILE)
      CALL ALLOCATE(IFILE,REQFILE,ORDBK,STKORD,WEEK,OPFILE,ISEED12,ALLQ,
     1ICOUNT,ISHORT,SUBFILE,AVGE12,CVARN12,REFWEEK,IPRINT,AFILE,DIAGFILE
     2,MODE,RUNTIME,LINEQ)
      CALL ISSWIP(IFILE,OPFILE,ALLQ,LINEQ,AFILE,IPRINT,REFWEEK,SUBQ,
     1ISORT,DIAGFILE,RUNTIME)
      CALL OFFLINE(LINEQ,TESTQ,OPFILE,WEEK,REQFILE,IFILE,IPRINT,AFILE,RE
     1FWEEK,CAPACITY,ISORT,SUBQ,DIAGFILE,RUNTIME)
      CALL FESALL(ORDBK,OPFILE,WEEK,IFILE,AFILE,IPRINT,REFWEEK,TESTQ,DIA
     1GFILE,RUNTIME)
      CALL DESPATCH(TESTQ,OPFILE,WEEK,DELPLAN,IFILE,ORDBK,EQUPERF,ITEMPE
     1RF,ORDPERF,TOTAL,IPRINT,AFILE,REFWEEK,ISORT,DIAGFILE,RUNTIME)
      IF(IPRINT.GT.2)GO TO 20
      CALL PNMFPRINT(AFILE,IFILE)
   20 RETURN
      END
```

B43 - SUBROUTINE WEEKLYPLAN

The timebase for the prime plan recalculation is three-monthly (quarterly) periods. This time period is too coarse for detail factory scheduling, for which purpose the plan is expanded into weekly "buckets" or time periods.

Subroutine WEEKLYPLAN performs this task at two levels, following a common logic.

- the off-line plan, OFP, is translated into a weekly plan in REQFILE
- the production to be allocated, PA, is translated into a delivery plan, DELPLAN.

In practice, the computer logic within the Purchasing and Scheduling sub-system will cause the quarterly data to be divided by thirteen and this provides an equivalent weekly plan.

The facility is available to modify the suggested plan by a manual override where it is desirable to reflect significant changes in planned activity through the period, or to more clearly define batch produced equipments.

The subroutine WEEKLYPLAN combines the two requirements into one operation.

Input to the subroutine is the quarterly plan derived from subroutine QPLAN. Based on the magnitude of the quarterly requirements, the decision is then made on the frequency of manufacture according to the table below.

QUARTERLY REQUIREMENT (x)	FREQUENCY OF MANUFACTURE		
	1	3	13
$x \leqslant 50$	✓		
$50 < x \leqslant 150$		✓	
$150 \leqslant x$			✓

The programme will divide the quarterly requirement by the frequency of manufacture and schedule the resultant batch to the first week of the sub-period.

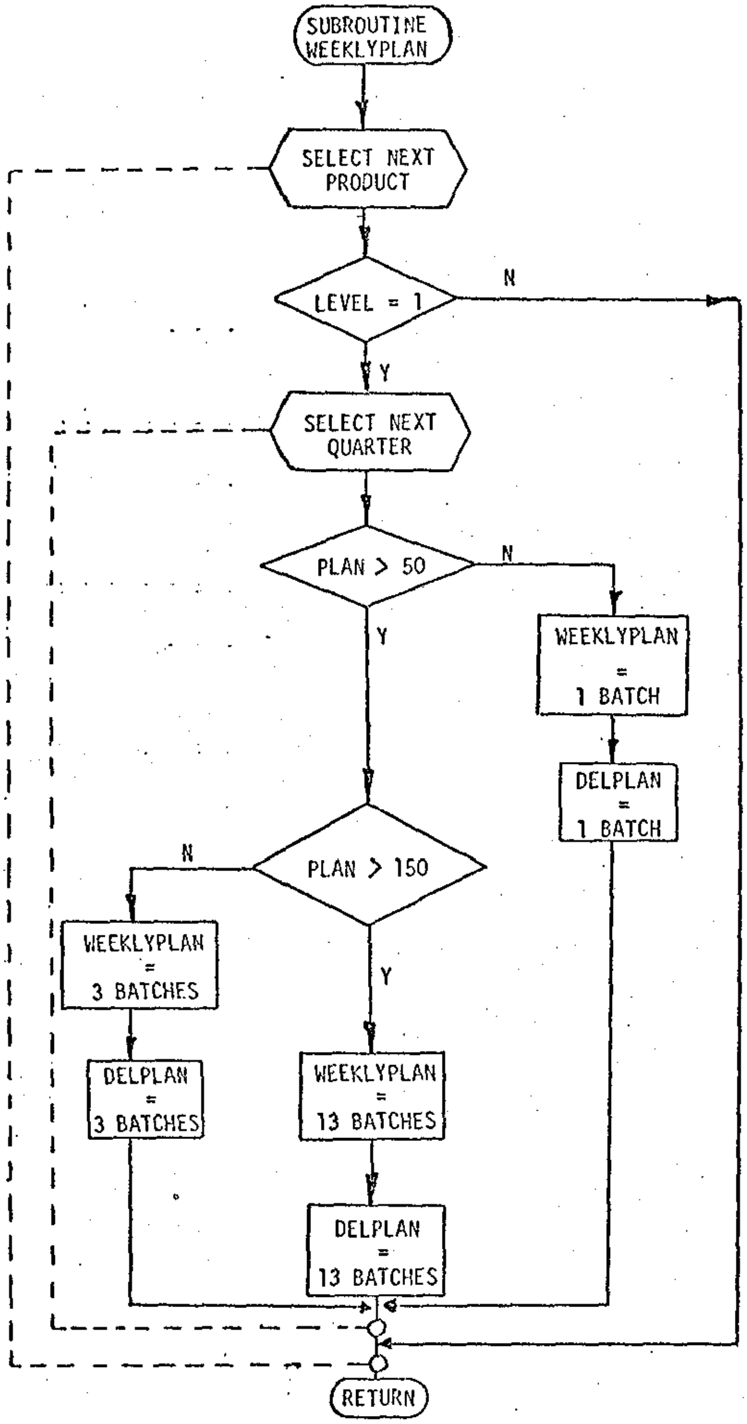
Thus, a requirement of 40 equipments will be scheduled in its entirety for the first week of the quarter; and a requirement of 120 equipments will be split into three equal batches of 40 (one a month) scheduled for the first week of each month. It should be noted that, since the quarter does not conveniently divide by 3, the months are defined as commencing in weeks 1, 6 and 10 of each quarter.

The resultant weekly plan for the equipment is held in an array which defines the forward requirements over a 52 week planning horizon.

Two assumptions have been made to avoid over-complication of the logic, neither of which will have a significant effect on the operation of the model.

a) No account is taken of the actual number of working days in each quarter, thus each quarter is assumed to comprise 13 equal weeks.

b) No attempt is made to even out the loading of batched products. In practice, such a policy would cause an uneven capacity profile throughout the quarter, but this is not considered to be a major consideration in the small sub-set of products involved in the experiments.



Summarised Flow Chart - Subroutine Weeklyplan

```
C
C     WEEKLYPLAN
C
      SUBROUTINE WEEKLYPLAN(OFP,REQFILE,IFILE,PA,DELPLAN,IPRINT,AFILE)
      REAL AFILE(25,3)
      INTEGER OFP(10,7),REQFILE(25,52),IFILE(25,23),PA(10,10),DELPLAN( 5
     1,52)
      DO 60 K=1,5
      IF(IFILE(K,11).NE.1)GO TO 60
      M=1
      N=13
      DO 30 I=2,5
      DO 20 J=M,N
      IF(OFP(K,I).GT.50)GO TO 10
      REQFILE(K,J)=OFP(K,I)
      DELPLAN(K,J+2)=PA(K,I)
      GO TO 25
   10 IF(OFP(K,I).GT.150)GO TO 18
      DO 15 L=J,J+9,4
      DELPLAN(K,L+2)=PA(K,I)/3.0
   15 REQFILE(K,L)=OFP(K,I)/3.0
      GO TO 25
   18 DELPLAN(K,J)=PA(K,I)/13.0
   20 REQFILE(K,J)=OFP(K,I)/13.0
   25 M=M+13
      N=N+13
   30 CONTINUE
      IF(IPRINT.GT.3)GO TO 60
      WRITE(2,50)AFILE(K,1),(REQFILE(K,J),J=1,52),(DELPLAN(K,J),J=1,52)
   50 FORMAT(1H0///6X,'OFF-LINE PLAN FOR PRODUCT REF.  ',A8//6X,26I4//6X
     1,26I4//6X,'DELIVERY PLAN'//6X,26I4//6X,26I4)
   60 CONTINUE
      RETURN
      END
```

B44 - SUBROUTINE WEEKPRINT

Subroutine WEEKPRINT is one of the prime output segments, and is used to calculate and display statistics relating to service level and delivery performance.

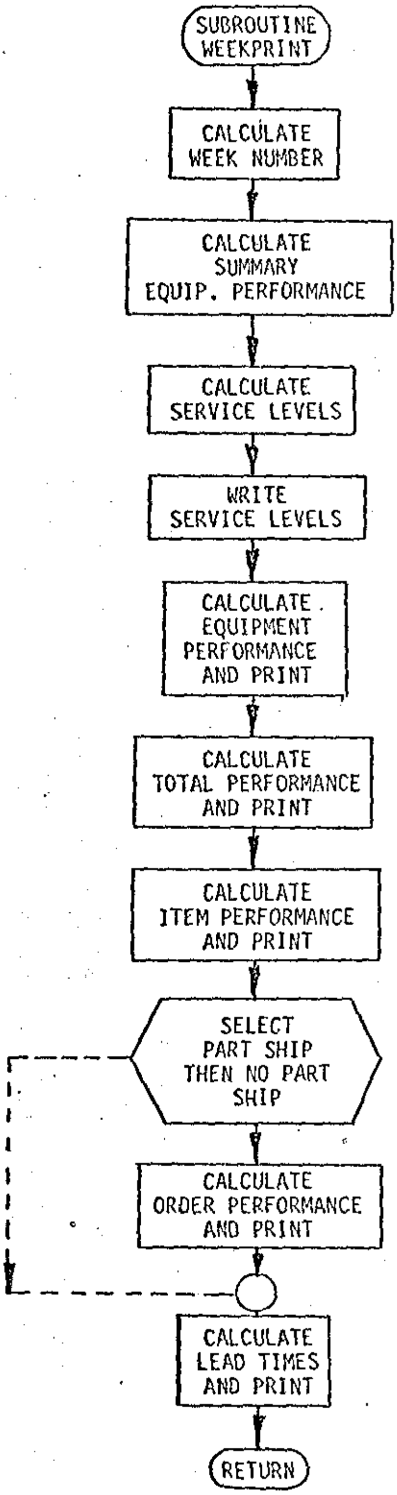
The subroutine will be activated either weekly or quarterly, dependent upon the diagnostic level selected. The data files and status variables analysed by WEEKPRINT are initialised by subroutine QTRRESET, following the quarterly activation.

Component service level is defined as the number of times an item can be supplied from stock as a ratio of the number of times requested. Service level statistics are maintained and presented both by individual item number and as a total for all items, to permit further detailed analysis against the item usage (i.e. common part or specific to an product type).

Delivery performance statistics are maintained in subroutine DELPERF at three levels; equipment, item and order. Data is contained within frequency histograms which relate the delivery date achieved with the number of instances. Delivery performance is calculated and presented in two alternative modes; proportion delivered on or before the due date, or the average lateness. The raw histogram data is available for further analysis if required.

Equipment performance is presented by product type and in total for all equipments; item performance is by product type only. Order performance is presented separately for "part shipment" and "no part shipment" orders.

A further measure of customer satisfaction, the quoted delivery lead time, is also maintained in histogram form for further analysis if required.


SUBROUTINE WEEKPRINT
CALCULATE WEEK NUMBER
CALCULATE SUMMARY EQUIP. PERFORMANCE
CALCULATE SERVICE LEVELS
WRITE SERVICE LEVELS
CALCULATE EQUIPMENT PERFORMANCE AND PRINT
CALCULATE TOTAL PERFORMANCE AND PRINT
CALCULATE ITEM PERFORMANCE AND PRINT
SELECT PART SHIP THEN NO PART SHIP
CALCULATE ORDER PERFORMANCE AND PRINT
CALCULATE LEAD TIMES AND PRINT
RETURN

Summarised Flow Chart - Subroutine Weekprint

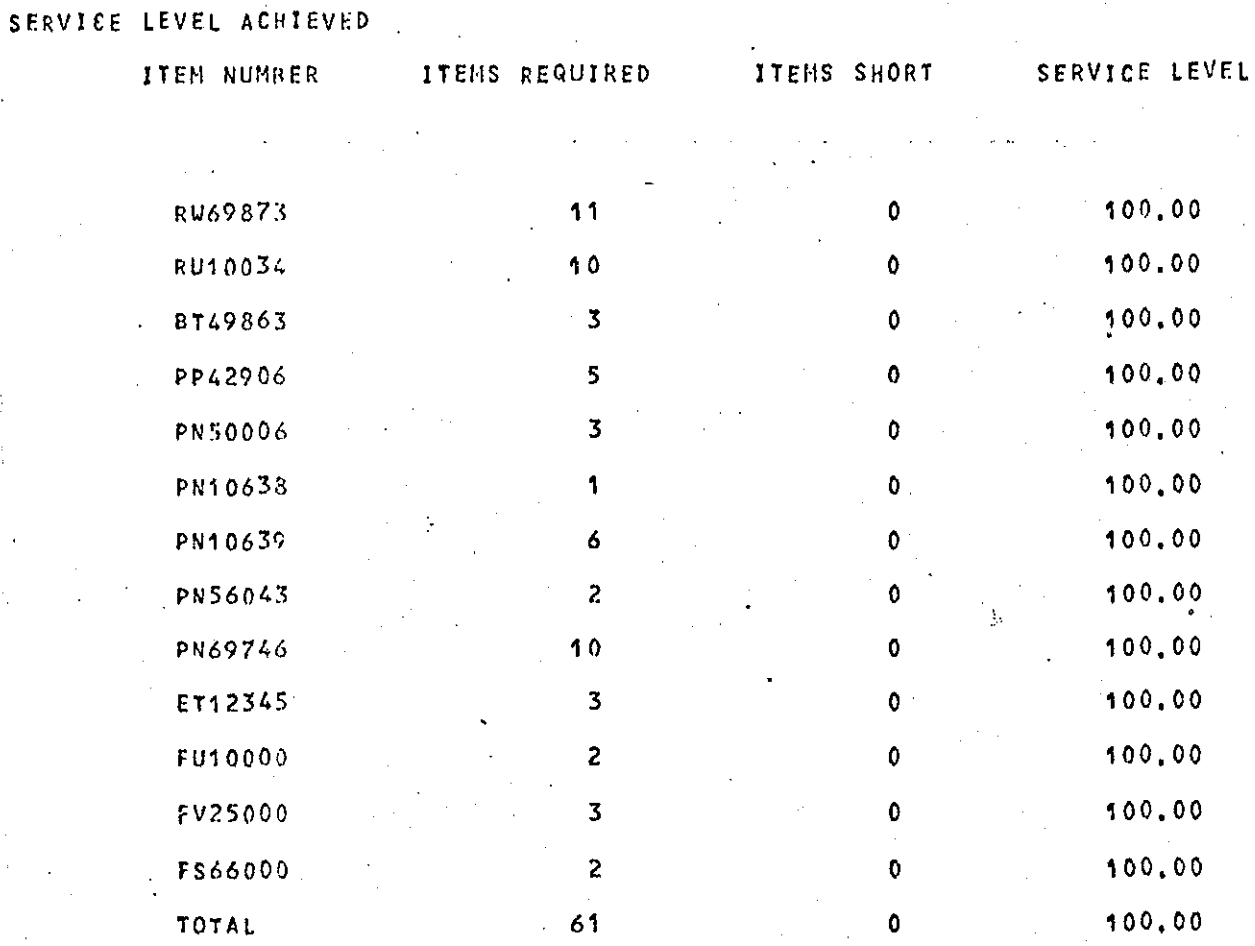
```
C
C     WEEKPRINT
C
      SUBROUTINE WEEKPRINT(ICOUNT,ISHORT,EQUPERF,ITEMPERF,ORDPERF,IFILE,
     1AFILE,REFWEEK,WEEK,LEADTM)
      REAL AFILE(25,3)
      INTEGER EQUPERF(10,30),ITEMPERF(10,30),ORDPERF(2,30),KK(30),IFILE(
     125,23),REFWEEK,WEEK,LEADTM(5,52),TOTPERF(30),ICOUNT(25),ISHORT(25)
      I=REFWEEK+WEEK
      WRITE(2,10)I
   10 FORMAT(1H0,6X,'* * * * SUMMARY FOR WEEK',I6,'  * * * *'//)
      DO 5 J=1,30
      TOTPERF(J)=0
      DO 5 I=1,10
      TOTPERF(J)=TOTPERF(J)+EQUPERF(I,J)
    5 CONTINUE
      ICTOT=0
      ISTOT=0
      WRITE(2,90)
   90 FORMAT(1H0//2X,'SERVICE LEVEL ACHIEVED'//10X,'ITEM NUMBER',6X,
     1'ITEMS REQUIRED',6X,'ITEMS SHORT',6X,'SERVICE LEVEL')
      DO 50 I=1,25
      IF(IFILE(I,11).NE.4)GO TO 50
      ICTOT=ICTOT+ICOUNT(I)
      ISTOT=ISTOT+ISHORT(I)
      SERV=100*FLOAT(ICOUNT(I)-ISHORT(I))/FLOAT(ICOUNT(I))
      WRITE(2,40)AFILE(I,1),ICOUNT(I),ISHORT(I),SERV
   40 FORMAT(1H0,11X,A8,12X,I6,12X,I6,12X,F6.2)
   50 CONTINUE
      SERV=100*FLOAT(ICTOT-ISTOT)/FLOAT(ICTOT)
      WRITE(2,60)ICTOT,ISTOT,SERV
   60 FORMAT(1H0,11X,'TOTAL',15X,I6,12X,I6,12X,F6.2)
      KK(1)=-20
      DO 130 J=1,29
  130 KK(J+1)=KK(J)+1
      WRITE(2,200)(KK(J),J=1,30)
  200 FORMAT(1H0//6X,'DELIVERY PERFORMANCE'//30I4//6X,'EQUIPMENT')
      DO 180 I=1,10
      IF(IFILE(I,11).NE.1)GO TO 180
      SUM1=0.0
      SUM2=0.0
      SUM3=0.0
      SUM4=0.0
      SUM5=0.0
      DO 140 J=1,30
  140 SUM1=SUM1+EQUPERF(I,J)
      IF(SUM1.EQ.0.0)GO TO 175
      DO 150 J=21,30
  150 SUM2=SUM2+EQUPERF(I,J)
      SUM2=SUM2*100.0/SUM1
      DO 160 J=18,30
  160 SUM3=SUM3+EQUPERF(I,J)
      SUM3=SUM3*100.0/SUM1
      DO 170 J=15,30
  170 SUM4=SUM4+EQUPERF(I,J)
      SUM4=SUM4*100.0/SUM1
      DO 173 J=1,30
  173 SUM5=SUM5+EQUPERF(I,J)*J
      SUM5=21.0-SUM5/SUM1
```

```
175 WRITE(2,500)AFILE(I,1)
500 FORMAT(1H0,6X,A8)
    WRITE(2,600)SUM2,SUM3,SUM4,SUM5
600 FORMAT(1H+,30X,'ON OR BEFORE=',F6.2,'%  WITHIN 3 WEEKS=',F6.2,
   1'%  WITHIN 6 WEEKS=',F6.2,'%  LATENESS=',F6.2)
    WRITE(2,700)(EQUPERF(I,J),J=1,30)
700 FORMAT(1H0,30I4/)
180 CONTINUE
    SUM1=0.0
    SUM2=0.0
    SUM3=0.0
    SUM4=0.0
    SUM5=0.0
    DO 185 J=1,30
185 SUM1=SUM1+TOTPERF(J)
    IF(SUM1.EQ.0.0)GO TO 195
    DO 187 J=21,30
187 SUM2=SUM2+TOTPERF(J)
    SUM2=SUM2*100.0/SUM1
    DO 189 J=18,30
189 SUM3=SUM3+TOTPERF(J)
    SUM3=SUM3*100.0/SUM1
    DO 191 J=15,30
191 SUM4=SUM4+TOTPERF(J)
    SUM4=SUM4*100.0/SUM1
    DO 193 J=1,30
193 SUM5=SUM5+TOTPERF(J)*J
    SUM5=21.0-SUM5/SUM1
195 WRITE(2,197)
197 FORMAT(1H0,6X,'TOTAL')
    WRITE(2,600)SUM2,SUM3,SUM4,SUM5
    WRITE(2,700)(TOTPERF(J),J=1,30)
    WRITE(2,800)
800 FORMAT(1H0,6X,'ITEM')
    DO 280 I=1,10
    IF(IFILE(I,11).NE.1)GO TO 280
    SUM1=0.0
    SUM2=0.0
    SUM3=0.0
    SUM4=0.0
    SUM5=0.0
    DO 240 J=1,30
240 SUM1=SUM1+ITEMPERF(I,J)
    IF(SUM1.EQ.0.0)GO TO 275
    DO 250 J=21,30
250 SUM2=SUM2+ITEMPERF(I,J)
    SUM2=SUM2*100.0/SUM1
    DO 260 J=18,30
260 SUM3=SUM3+ITEMPERF(I,J)
    SUM3=SUM3*100.0/SUM1
    DO 270 J=15,30
270 SUM4=SUM4+ITEMPERF(I,J)
    SUM4=SUM4*100.0/SUM1
    DO 273 J=1,30
273 SUM5=SUM5+ITEMPERF(I,J)*J
    SUM5=21.0-SUM5/SUM1
275 WRITE(2,500)AFILE(I,1)
    WRITE(2,600)SUM2,SUM3,SUM4,SUM5
    WRITE(2,700)(ITEMPERF(I,J),J=1,30)
280 CONTINUE
```

```
      WRITE(2,900)
  900 FORMAT(1H0,6X,'ORDERS')
      DO 390 I=1,2
      SUM1=0.0
      SUM2=0.0
      SUM3=0.0
      SUM4=0.0
      SUM5=0.0
      DO 340 J=1,30
  340 SUM1=SUM1+ORDPERF(I,J)
      IF(SUM1.EQ.0.0)GO TO 371
      DO 350 J=21,30
  350 SUM2=SUM2+ORDPERF(I,J)
      SUM2=SUM2*100.0/SUM1
      DO 360 J=18,30
  360 SUM3=SUM3+ORDPERF(I,J)
      SUM3=SUM3*100.0/SUM1
      DO 370 J=15,30
  370 SUM4=SUM4+ORDPERF(I,J)
      SUM4=SUM4*100.0/SUM1
      DO 373 J=1,30
  373 SUM5=SUM5+ORDPERF(I,J)*J
      SUM5=21.0-SUM5/SUM1
  371 GO TO(372,376),I
  372 WRITE(2,374)
  374 FORMAT(1H0,6X,'PART SHIP')
      GO TO 380
  376 WRITE(2,378)
  378 FORMAT(1H0,6X,'NO PART SHIP')
  380 WRITE(2,600)SUM2,SUM3,SUM4,SUM5
      WRITE(2,700)(ORDPERF(I,J),J=1,30)
  390 CONTINUE
      WRITE(2,450)(J,J=1,52)
  450 FORMAT(1H0//6X,'LEAD TIME ACHIEVED'/2(/5X,26I4))
      DO 490 I=1,5
      IF(IFILE(I,11).NE.1)GO TO 490
      WRITE(2,470)AFILE(I,1),(LEADTM(I,J),J=1,52)
  470 FORMAT(1H0,6X,A8/2(/5X,26I4))
  490 CONTINUE
      RETURN
      END
      FINISH
****
```

```
     DELIVERY PERFORMANCE
-20 -19 -18 -17 -16 -15 -14 -13 -12 -11 -10  -9  -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9
     EQUIPMENT
      MF6AM 01                  ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.37
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  84 140   0   0   0   0   0   0   0   0   0   0

      MF6AM 02                  ON OR BEFORE= 12.50%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.06
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  23  96  17   0   0   0   0   0   0   0   0   0

      MF6AM 03                  ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.82
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5  46  17   0   0   0   0   0   0   0   0   0   0

      AC15PU                    ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.17
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  12  60   0   0   0   0   0   0   0   0   0   0

      TOTAL                     ON OR BEFORE=  3.40%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.32
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5 165 313  17   0   0   0   0   0   0   0   0   0

      ITEM
      MF6AM 01                  ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.50
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   3   0   0   0   0   0   0   0   0   0   0

      MF6AM 02                  ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.14
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   6   0   0   0   0   0   0   0   0   0   0

      MF6AM 03                  ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  3.00
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0

      AC15PU                    ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  2.00
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   0   0   0   0   0   0   0   0   0   0   0

      ORDERS
      PART SHIP                 ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=100.00%  WITHIN 6 WEEKS=100.00%  LATENESS=  1.75
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   4   3   0   0   0   0   0   0   0   0   0   0

      NO PART SHIP              ON OR BEFORE=  0.00%  WITHIN 3 WEEKS=  0.00%  WITHIN 6 WEEKS=  0.00%  LATENESS=  0.00
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

Sample Delivery Performance Report



```
SERVICE LEVEL ACHIEVED
        ITEM NUMBER       ITEMS REQUIRED       ITEMS SHORT       SERVICE LEVEL


          RW69873                   11                 0              100.00
          RU10034                   10                 0              100.00
          BT49863                    3                 0              100.00
          PP42906                    5                 0              100.00
          PN50006                    3                 0              100.00
          PN10638                    1                 0              100.00
          PN10639                    6                 0              100.00
          PN56043                    2                 0              100.00
          PN69746                   10                 0              100.00
          ET12345                    3                 0              100.00
          FU10000                    2                 0              100.00
          FV25000                    3                 0              100.00
          FS66000                    2                 0              100.00
          TOTAL                     61                 0              100.00
```

Sample Component Service Level Report

APPENDIX C

FILE DESCRIPTIONS

Each file required by the simulation model is defined for ease of maintenance and analysis. The definition comprises the following information.

File Description: Briefly describes the content and use of the file.

File Content: The name of the file as used in the simulation program, and the definitions of the use of each array subscript.

File Size: The dimensions of the file.

File Type: The file will contain either integer or real (floating point) values.

Program Segments: The subroutines which contain the file. This information is required if the file sizes require modification.

Special Notes: Any important information concerning the structure, content or use of the file.

File Name: AFILE

File Description: Item Master File (Part)

Contains descriptive (text) part of the Item Master Record, used mainly for ease of communication between the modeller and the system.

File content: AFILE (a, b)
a = file address
b = 1 item number (up to 8 alpha-numeric characters)
2} item description (up to 16 alpha-
3} numeric characters)

File size: AFILE (25,3) = 75

File type: Real

Program Segments: STOCKMODEL, ALLOCATE, AQPRINT, ARRIVAL, DESPATCH, EBQ, EXPLODE, FESALL, FORECAST, ISSWIP, LOAD, LOADPLAN, LQPRINT, MONTHEVENT, OFFLINE, OPFCREATE, OPFPRT, ORDBKPRT, PLNPRINT, QPLANPRINT, QTREVENTS, QRTRESET, PNMFCREATE, PNMFPRINT, RECEIVE, SCHED, SQPRINT, STKALL, SUBPROG, TQPRINT, TRANSLATE 3, WEEKEVENT, WEEKLYPLAN, WEEKPRINT

Special Notes: File contains static data which is created prior to program execution and is not modified in any way during the simulation run.

The internal system logic will refer to items by a numeric key, which is equivalent to the address of the item in AFILE.

File Name: AFSMAX

File Description: Maximum authorised stock

Contains the maximum permissible finished equipment stock level per product.

File Content: AFSMAX (a)

a = product key/quantity

File Size: AFSMAX (10) = 10

File Type: Integer

Program Segements: QPLAN, QPLANPRINT

Special Notes: Used to convey data between QPLAN and QPLANPRINT for presentation of parameters.

File Name: ALLQ

File Description: Allocation queue

Contains a queue of requirements which have been allocated to stock pending release of parts to work in progress.

File content: ALLQ (a, b, c)

a = Product key
b = Position in file
c = 1 .... Order number
2 .... Item number
3 .... Due date
4 .... Quantity
5 .... Timer
6 .... Shop order number

File Size: ALLQ (12, 50, 6) = 3600

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, AQPRINT, ISSWIP, MONTHEVENT, OPFCREATE, QTREVENTS, WEEKEVENT

Special Notes: File is organised into a number of separate queues, one for each assembly number, each containing a sequence of material issue requirements. The file will be accessed sequentially, thus permitting a choice of priority rules; sorted by due date (utilising a sort pre-processor) or "first in first out". After processing, the file is always consolidated, and new entries are added to the tail of the file.

File Name: COL

File Description: Current order load

Contains the nett order load at the commencement of a quarterly period.

File Content: COL (a, b)

a = product key
b = 1 .... quantity overdue
2-7 .. quantity due in periods 1-6

File Size: COL (10, 7) = 70

File Type: Integer

Program Segments: STOCKMODEL, QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: DELPLAN

File Description: Delivery plan

Plan of proposed deliveries from the factory to the commercial warehouse, used for order promising and relief of test work in progress.

File Content: DELPLAN (a, b)

a = Product key
b = 1-52 .... Plan quantity per period

File Size: DELPLAN (5, 52) = 260

File Type: Integer

Program Segments: STOCKMODEL, DESPATCH, LOAD, LOADPLAN, MONTHEVENT, QTREVENTS, WEEKEVENT, WEEKLYPLAN

Special Notes: File is organised into weekly buckets, each containing the planned delivery quantity for the period. The file is reset each quarter by replacing the planned quantities such that the first bucket is the current period.

File Name: DIAGFILE

File Description: Diagnostic Selector

Contains instructions which set the level of diagnostic output for each simulation run.

File Content: DIAGFILE (a, b)

a = position in file
b = 1 .... week number (actual)
2 .... diagnostic level

File size: DIAGFILE (10, 2) = 20

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, DESPATCH, FESALL, ISSWIP, OFFLINE, WEEKEVENT

Special Notes: The use of DIAGFILE permits the resetting of the diagnostic level at any week number during the simulation run, thus permitting a detailed analysis of a particular time frame during the run.

The file is organised as follows:

Week No	1	14	20	22	60	999	0	0	0	0
Diag level	1	5	2	4	6	0	0	0	0	0

The above example will set the level to '1' for the initial conditions and then reset to '5' for periods 14 - 19 inclusive. The level will then revert to '1' for periods 20/21, reset to '4' for periods 22 to 59 and '6' to the end of the run.

File Name: EQUPERF

File Description: Equipment performance

Contains statistics relating to the delivery performance achievement at equipment level.

File Content: EQUPERF (a, b)

a = product key
b = 1 - 30 .... frequency histogram over the range -20 to +9.

File Size: EQUPERF (10, 30) = 300

File Type: Integer

Program Segments: STOCKMODEL, DELPERF, DESPATCH, WEEKEVENT, WEEKPRINT

Special Notes: File is organised as a frequency histogram, for each product, containing 30 intervals. Each product batch despatched augments the appropriate interval by the batch quantity. Delays over the range -20 to +9 weeks are converted to the file range 1 to 30 as data is captured, and re-converted to represent the correct delay factor for subsequent analysis.

File Name: EXFILE

File Description: Expedite tag

Contains a counter in each week that an item has been subject to expediting action.

File Content: EXFILE (a, b)

a = product key
b = 1-52 .... weekly buckets containing expedite action counter

File Size: EXFILE (25, 52) = 1300

File Type: Integer

Program Segments: STOCKMODEL, EXPEDITE, WEEKEVENT

Special Notes: File is reset to zero each quarter. The appropriate weekly bucket is incremented each time that a receipt batch is subject to expediting action, thus providing a measure of the expediting effort required.

File Name: FES

File Description: Finished Equipment Stock

Contains the planned level of finished equipment stock per quarterly period.

File Content: FES (a, b)

a = product key
b = 1 .... opening stock (actual)
2-7 .. planned closing stock for periods 1 to 6

File Size: FES (10, 7) = 70

File Type: Integer

Program Segments: QPLAN, QPLANPRINT

Special Notes: None

File Name: HOLD (also IHOLD)

File Description: Temporary workfile

Workfile used to store the item number and quantity of lower level assemblies during material explosion sequencies.

File Content: HOLD (a, b)

a = position in file
b = 1 .... Item number
2 .... Quantity

File Size: HOLD (5, 2) = 10

File Type: Integer

Program Segments: ISSWIP, STKALL

Special Notes: File is only required where the lower level part is classified as issue code (1), which means that the assembly should not be planned as a stocked part, but should be broken down to its constituent parts, i.e. a phantom assembly.

File Name: IFILE

File Description: Item Master File (part)

Contains data related to the item number.

File Content: IFILE (a, b)

a = product key

b =	1	.... Location of 1st component	
	2	.... Quantity of 1st component	
	3	.... Location of 2nd component	
	4	.... Quantity of 2nd component	
	5	.... Location of 3rd component	
	6	.... Quantity of 3rd component	
	7	.... Location of 4th component	
	8	.... Quantity of 4th component	
	9	.... Location of 5th component	
	10	.... Quantity of 5th component	
	11	.... Low Level code (1 - 4)	
	12	.... Lead Time	
	13	.... Material Cost	Cost Data
	14	.... Labour Cost	
	15	.... Issue Code (1 = normal 2 = do not breakdown)	
	16	.... Physical Stock	Stock Status
	17	.... Allocated Stock	
	18	.... Work in progress (assembly)	
	19	.... Work in progress (test)	
	20	.... Buffer in Weeks	Planning Parameters
	21	.... Economic Batch Quantity	
	22	.... Cycle Time between Batches	
	23	.... Maximum Authorised Stock	

File Size: IFILE (25, 23)

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, ARRIVAL, DESPATCH, EBQ, EXPEDITE, FESALL, FORECAST, INITODS, ISSWIP, LOAD, LOADPLAN, OFFLINE, OFFCREATE, ORDBKPRT, ORDERS, QPLAN, QPLANPRINT, QTREVENTS, QTRRESET, PNMFCREATE, PNMFPRINT, RECEIVE, SCHED, STKALL, STOCKVAL, WEEKEVENT, WEEKLYPLAN, WEEKPRINT

Special Notes: File contains a number of segments relating to the item. Static data includes the product structure relationships, cost data and planning parameters. The stock status segment contains dynamic data relating to stores and work in progress stocks.

File Name: INPUT

File Description: Weekly material input.

Contains a schedule of the actual material receipts.

File Content: INPUT (a, b)
a = product key
b = 1-52 .... Material input per period

File Size: INPUT (25, 52) = 1300

File Type: Integer

Program Segments: STOCKMODEL, ARRIVAL, EXPEDITE, QTREVENTS, QTRRESET, RECEIVE, WEEKEVENT.

Special Notes: The file is reset each quarter by advancing each data element by thirteen weeks.

Data in INPUT is periodically created within QTREVENTS by subroutine RECEIVE. The contents of INPUT may be modified in one of two ways;

- batches may be advanced in time as a result of expediting action (subroutine EXPEDITE).
- reject quantities (subroutine ARRIVAL) will be re-scheduled to a later period.

File Name: IONP

File Description: Initial On-line plan

Contains the on-line (material) plan prior to the quarterly plan regeneration.

File Content: IONP (a, b)

a = product key
b = 1-6 .. on-line plan for periods -1 to 5 inclusive.
7 .... not used

File Size: IONP (10, 7) = 70

File Type: Integer

Program Segments: QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: ITEMPERF

File Description: Item performance.

Contains statistics relating to the delivery performance achievements at order line level.

File Content: ITEMPERF (a, b)

a = product key
b = 1-30 .... frequency histogram over the range -20 to +9

File Size: ITEMPERF (10,30) = 300

File Type: Integer

Program Segments: STOCKMODEL, DELPERF, DESPATCH, WEEKEVENT, WEEKPRINT.

Special Notes: File is organised as a frequency histogram for each product, containing 30 intervals. Each completed item line will augment the appropriate interval by one.

File Name: LEADTM

File Description: Lead time

Contains data for compiling a frequency histogram of quoted delivery lead time for each product.

File Content: LEADTM (a, b)

a = product key
b = 1-52 .... frequency of achieving each value

File Size: LEADTM (5, 52) = 260

File Type: Integer

Program Segments: STOCKMODEL, LOAD, QTREVENTS, QTRRESET, WEEKEVENTS, WEEKPRINT.

Special Notes: As each order is loaded, the delivery lead time bucket for the appropriate product is augmented by the quantity loaded.

File Name: LINEQ

File Description: Assembly Work in Progress

Contains a queue of customer and stock orders for each product type at the main assembly location.

File Content: LINEQ (a, b, c)

a = Product key
b = Position in file
c = 1 .... order number
2 .... item number
3 .... due date
4 .... quantity
5 .... timer

File Size: LINEQ (5, 50, 5) = 1250

File Type: Integer

Program Segments: STOCKMODEL, WEEKEVENT, ALLOCATE, ISSWIP, OFFLINE

Special Notes: File is organised into a separate queue for each product type (sub-assemblies are located in SUBQ).

New entries to the file are always placed at the end of the queue. Two priority rules may be utilised; "first in first out", or by due date - in which case a sort routine is activated. After processing the file is consolidated by removing fully processed records.

File Name: NETPLAN

File Description: Order loading plan.

Contains the order loading plan for each product type.

File Content: NETPLAN (a, b)

a = product key
b = 1-52 .... Weekly order loading plan

File Size: NETPLAN (5, 52) = 260

File Type: Integer

Program Segments: STOCKMODEL, LOADPLAN, MONTHEVENT, QTREVENT, QTRRESET, WEEKEVENT.

Special Notes: The gross delivery plan is contained in file DELPLAN. The net delivery plan is derived from the gross delivery plan with modifications reflecting the level of overdue products and the difference between the planned and actual stock levels. The resultant plan is loaded into NETPLAN and used as the basis for order promising.

File Name: OCF

File Description: Orders carried forward

Contains the customer order load per period for each product.

File Content: OCF (a, b)

a. = product key
b = 1 .... overdue load
2-7 .. forward load for periods 1 to 6 inclusive

File Size: OCF (10, 7) = 70

Program Segments: QPLAN, QPLANPRINT, QTREVENTS

File Type: Integer

Special Notes: None

File Name: OCFWKS

File Description: Workfile

Contains the orders carried forward (order load) in equivalent weeks worth of production.

File Content: OCFWKS (a)

a = 1-7 .. gross load in weeks for each period

File Size: OCFWKS (7) = 7

File Type: Integer

Program Segments: QPLANPRINT

Special Notes: Used to present information on the equivalent weeks worth of order load for each period in QPLANPRINT.

File Name: OFP

File Description: Off-line Plan

Contains off-line (assembly) plan for each product.

File Content: OFP (a, b)

a = product key
b = 1 .... not used
2-7 .. off line plan for periods 1 to 6 inclusive

File Size: OFP (10, 7) = 70

File Type: Integer

Program Segments: QPLAN, QPLANPRINT, QTREVENTS, WEEKLYPLAN.

Special Notes: None

File Name: OLDSCHED

File Description: Workfile

Temporary file used to retain the previous schedule when formulating a new supplier schedule.

File Content: OLDSCHED (a)

a = 1 .... schedule arrears
2-13.. monthly call-off

File Size: OLDSCHED (13) = 13

File Type: Integer

Program Segments: SCHED

Special Notes: None

File Name: ONP

File Description: On-line plan

Contains the on-line (material) plan for each product.

File Content: ONP (a, b)

a = product key
b = 1 .... not used
2-7 .. On-line plan for periods 1 to 6 inclusive.

File Size: ONP (10, 7) = 70

File Type: Integer

Program Segments: STOCKMODEL, QPLAN, QPLANPRINT, QTREVENTS, QTRRESET

Special Notes: None

File Name: OPFILE

File Description: Orders placed file

Contains detail of each customer order, including data relating to *product requirement, due dates and state of completion.*

File Content: OPFILE (a, b, c, d)

a = file address
b = item number (up to 5)
c = delivery phasing (up to 5 batches per item)
d = 1 .... product type
2 .... quantity required (total)
3 .... week due (actual)
4 .... quantity unallocated
5 .... quantity to be taken from stock
6 .... quantity in an allocation
7 .... quantity on-line
8 .... quantity in test
9 .... quantity in despatch
10 .... order number

File Size: OPFILE (125, 5, 5, 10) = 31250

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, DELPERF, DESPATCH, FESALL, ISSWIP, LOAD, MONTHEVENTS, OFFLINE, OPFCREATE, OPFPRINT, QTREVENTS, QTRRESET, STOCKVAL, WEEKEVENT.

Special Notes: OPFILE contains all live (i.e. not fully despatched) customer orders and is organised in a quasi-random sequence. Early orders will tend to be sequential, later additions will be inserted in the first available free position. Thus, the file will tend to have a high occupancy at the head, thus improving processing time.

The file is organised into two partitions; static data describing the order content (products, quantities, due dates) and dynamic data reflecting the state of completion of the order (status information).

Orders are removed from the file and the position is made available for new orders when the final delivery of all item lines has been made.

File Name: ORDBK

File Description: Order Book

Contains a summary of the orders due per period for each product.

File Content: ORDBK (a, b, c, d)

a = product key
b = week due (relative)
c = position in file
d = 1 .... order number
2 .... item number
3 .... quantity outstanding
4 .... 0 = due
1 = overdue
5 .... 1 = part shipment permissible
2 = no part shipment

File Size: ORDBK (5, 52, 15, 5) = 19500

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, DELPERF, DESPATCH, FESALL, LOAD, LOADPLAN, MONTHEVENT, OPFCREATE, ORDBKPRT, QTREVENTS, QTRRESET, WEEKEVENT

Special Notes: The file is reset each quarter by avancing each data element by thirteen weeks. Orders with quantities outstanding in the first thirteen weeks prior to re-setting are overdue. To reduce file space, overdue orders are "tagged" and re-located at the tail of the file. Thus, an order which was originally located in period 8 and would normally be relocated to (8 - 13) = -5 is placed in period (39 + 8) = 47.

Orders are removed from the file when all item lines have been despatched.

File Name:	ORDHIST
File Description:	Order History

Contains monthly orders received history for use in forecasting.

File Content:	ORDHIST (a, b)
	a = product key b = 1-12 .... monthly orders received volume
File Size:	ORDHIST (5, 12) = 60
File Type:	Integer
Program Segments:	STOCKMODEL, FORECAST, LOAD, MONTHEVENT, OHRESET, QTREVENTS, WEEKEVENT.
Special Notes:	File is reset each month by advancing each data elements by one period and clearing the final period. Orders received data is captured from sub-routine LOAD and augments the final period in ORDHIST.

File Name: ORDPERF

File Description: Order performance.

Contains statistics relating to the delivery performance achievement at complete order level.

File Content: ORDPERF (a, b)

a = 1 .... part shipment order
2 .... no part shipment order
b = 1-30.. frequency histogram over the range -20 to +9

File Size: ORDPERF (2, 30) = 60

File Type: Integer

Program Segments: STOCKMODEL, DELPERF, DESPATCH, WEEKEVENT, WEEKPRINT

Special Notes: File contains two parts, part shipment order and no part shipment order statistics, each containing 30 intervals.

For part shipment orders, despatch of every item line on an order with a common due date will increment the appropriate interval by one. For no part shipment, all item lines on an order must be completely despatched for the file interval to be incremented. Delays over the range -20 to +9 weeks are converted to the range 1 to 30 as data is captured and reconverted to represent the correct delay factor for subsequent analysis.

File Name: ORF

File Description: Orders received forecast

Contains orders received forecast consolidated into quarterly buckets.

File Content: ORF (a, b)

a = product key
b = 1 .... not used
2-7 .. forecast for periods 1 to 6

File Size: ORF (10, 7) = 70

File Type: Integer

Program Segments: FORECAST, QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: PA

File Description: Production to be allocated.

Contains the planned allocation of equipments from assembly or stock into test.

File Content: PA (a, b)

a = product key
b = 1 .... not used
2-7 .. production to be allocated for periods 1 to 6 inclusive
8-10.. contains duplicate of period 6.

File Size: PA (10, 10) = 100

File Type: Integer

Program Segments: QPLAN, QPLANPRINT, QTREVENTS, WEEKLYPLAN

Special Notes: For planning purposes, the test load is assumed constant, therefore the production to be allocated may be considered as the equivalent of the delivery plan.

The content of periods 8 through 10 is used for data presentation purposes in QPLANPRINT.

File Name: PIPELINE

File Description: Orders Pipeline

Contains orders received from the order generator pending order promising (loading).

File Content: PIPELINE (a, b, c)

```
a  =  position in file
b  =  1 .... order header
              c = 1 .... order number
                  2 .... 1 = part shipment permissible
                         2 = no part shipment
                  3 .... number of items
      2-6 ...Item detail
              c = 1 .... item number
                  2 .... product type
                  3 .... quantity
                  4 .... value
```

File Size: PIPELINE (20, 6, 4) = 480

File Type: Integer

Program Segments: STOCKMODEL, INITODS, LOAD, ORDERS, WEEKEVENT

Special Notes: Temporary file used to organise orders introduced by the order generator in preparation for the order promising (order loading) process. When orders have been successfully loaded, order detail is transferred to OPFILE and summarised in ORDBK.

File Name: PRODMIX

File Description: Product Mix

Contains product mix data modified for trend prior to updating the product mix table (Table 6).

File Content: PRODMIX (a)

a = product key/data

File Size: PRODMIX (7) = 7

File Type: Real

Program Segments: STOCKMODEL, QTREVENTS, TRENDI

Special Notes: The file is intitially loaded from Table 6 with the starting mix values. Subsequent application of trend will modify PRODMIX values, which must be corrected to the range 0 - 100 before updating Table 6.

File Name: R

File Description: Recommended production rates

Contains a sequence of fixed production rates for each product.

File Content: R (a, b)

a = product key
b = 1-10 .... Series of rates (units/week) in ascending order

File Size: R (10, 10) = 100

File Type: Integer

Program Segments: STOCKMODEL, QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: REQFILE

File Description: Requirements File

Contains the weekly gross requirements for each item.

File Content: REQFILE (a, b)

a = product key
b = 1-52 .... weekly requirements

File Size: REQFILE (25, 52) = 1300

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, EBQ, EXPLODE, OFFLINE, QPLAN, QTREVENTS, SCHED, SUBPROG, WEEKEVENT, WEEKLYPLAN

Special Notes: File is recreated each quarter as a result of the quarterly planning and requirements calculations routines.

File Name: RR

File Description: Running Rate

Contains the selected production rate per period for each product.

File Content: RR (a, b)

```
a  =  product key
b  =  1 .... not used
      2-7 .. production rate for periods 1 to
             6 inclusive
      8-11 . not used
```

File Size: RR (10, 11) = 110

File Type: Integer

Program Segments: QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: SCHEDULE

File Description: Supplier Schedule

Contains monthly delivery requirements from the supplier, including a gross arrears value.

File Content: SCHEDULE (a, b)

a = item key

b = 1 .... arrears value

2-13.. monthly requirements for periods 1-12

File Size: SCHEDULE (25, 13) = 325

File Type: Integer

Program Segments: STOCKMODEL, ARRIVAL, QTREVENTS, RECEIVE, SCHED, WEEKEVENT

Special Notes: SCHEDULE contains the gross monthly delivery requirements from the supplier and includes a simple gross value for the outstanding arrears. Actual deliveries against the schedule are derived from subroutines RECEIVE and located in file INPUT.

File Name: STKORD

File Description: Stock Order Number

Contains the last stock order number allocated for each item type.

File Content: STKORD (a)

a = item key/last order number assigned

File Size: STKORD (20) = 20

File Type: Integer

Program Segments: ALLOCATE, WEEKEVENT

Special Notes: None

File Name: SUBFILE

File Description: Sub-assembly Programme

Contains the sub-assembly programme derived from the requirements file and incorporating economic batch rules.

File Content: SUBFILE (a, b)

a = item type
b = 1-26.... weekly sub-assembly programme

File Size: SUBFILE (12, 26) = 312

File Type: Integer

Program Segments: STOCKMODEL, ALLOCATE, MONTHEVENT, SUBPROG, WEEKEVENT

Special Notes: SUBFILE contains the schedule of sub-assembly deliveries to stock and is the basis for material allocation and subsequent manufacture. The schedule is derived from REQFILE and is modified to take account of economic batch rules, buffer stock and shortages.

File Name: SUBQ

File Description: Sub-assembly Queue

Contains a queue of sub-assembly orders in manufacture.

File Content: SUBQ (a, b)

a = position in file
b = 1 .... part number
2 .... due date (actual)
3 .... quantity
4 .... timer

File Size: SUBQ (50, 4) = 200

File Type: Integer

Program Segments: STOCKMODEL, ISSWIP, OFFLINE, OPFCREATE, SQPRINT, WEEKEVENT

Special Notes: File SUBQ represents the queue of work in the sub-assembly manufacturing department. The queue contains a mixture of sub-assembly types and may be organised in "first-in-first-out" or due date priority by utilising a sort pre-processor. The file is consolidated after all order completions have been processed in subroutine OFFLINE.

File Name: TABLE 1
TABLE 2
TABLE 3
TABLE 5
TABLE 6
TABLE 7
TABLE 8
TABLE 11

File Description: Sampling Tables

Contains histogram definition for use in sampling routines.

File Content: Table (a, b)

a = position in file
b = 1 .... parameters
2 .... cumulative frequency

File Size: TABLE (7, 2) = 14 (for TABLE 1 through TABLE 7)
TABLE (2, 2) = 4 (for TABLE 8, TABLE 11)

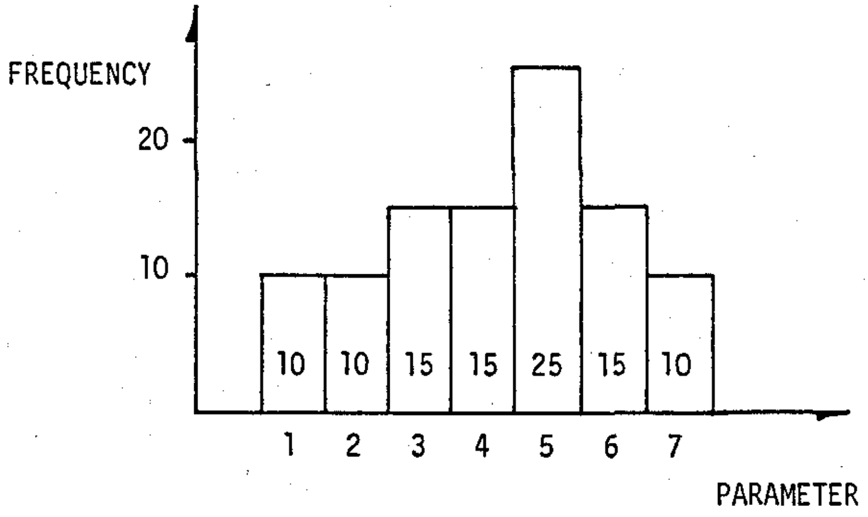
File Type: Integer

Program Segments: TABLE 1 - STOCKMODEL, QTREVENTS, RECEIVE
TABLE 2 - STOCKMODEL, QTREVENTS, RECEIVE
TABLE 3 - STOCKMODEL, EXPEDITE, WEEKEVENT
TABLE 5 - STOCKMODEL, INITODS, ORDERS, WEEKEVENT
TABLE 6 - STOCKMODEL, INITODS, ORDERS, QTREVENTS, TRENDI, WEEKEVENTS
TABLE 7 - STOCKMODEL, INITODS, ORDERS, WEEKEVENT
TABLE 8 - STOCKMODEL, INITODS, ORDERS, WEEKEVENT
TABLE 11 - STOCKMODEL, ARRIVAL, WEEKEVENT

Special Notes: Files (TABLES) contain static data which is predefined for each simulation run. The histograms held in each table are cumulative over the range 0-100. The general format is as below:

Parameter	1	2	3	4	5	6	7
Cum. freq.	10	20	35	50	75	90	100

This equates to a frequency histogram as depicted below:



File content is as follows:

TABLE 1 = Normal input - profile of material deliveries around the scheduled receipt date.

TABLE 2 = Arrears input - profile of schedule arrears receipts.

TABLE 3 = Expedited input - profile of the relative success of expediting action.

TABLE 5 = Number of items on the customer order.

TABLE 6 = Product type of selected item on order.

TABLE 7 = Quantity of product per line item on order.

TABLE 8 = Part ship/no part ship indicator.

TABLE 11 = Reject input - profile of reschedule for material rejects.

File Name: TESTQ

File Description: Test Queue

Contains a queue of products which have been moved into the test department pending despatch.

File Content: TESTQ (a, b, c)

a = product key
b = position in file
c = 1 .... order number
2 .... item number
3 .... due date
4 .... quantity
5 .... timer

File Size: TESTQ (5, 50, 5) = 1250

File Type: Integer

Program Segments: STOCKMODEL, DESPATCH, FESALL, OFFLINE, OFFCREATE, TQPRINT, WEEKEVENT

Special Notes: File is organised into a separate queue per product, each representing a manufacturing resource area.

New entries will be added to the tail of the file and the file is accessed sequentially from the head. Thus, the implicit priority sequence is "first-in-first-out". The file may be sorted by due date (utilising a sort pre-processor) if a due date priority is required.

File Name: TOTAL

File Description: Total Load

Contains the gross order load per week for each product.

File Content: TOTAL (a, b)

a = product key

b = 1-52 .... order load per period

File Size: TOTAL (5, 52) = 260

File Type: Integer

Program Segments: STOCKMODEL, DESPATCH, LOAD, OPFCREATE, QTREVENTS, QTRRESET, WEEKEVENT

Special Notes: File is augmented as orders are loaded in subroutine LOAD and decreased as orders are moved into despatch in subroutine DESPATCH.

File Name: TREND

File Description: Trend Data

Contains the order mix trend for each product.

File Content: TREND (a)

a = product key/data

File Size: TREND (7) = 7

File Type: Real

Program Segments: STOCKMODEL, QTREVENTS, TRENDI

Special Notes: The file contains a parameter for each product, used to modify the product mix ratios in the order generator sampling routines. Thus the relative proportion of the total orders received for each product may be changed without affecting the overall gross volume. The trend data is the per unit increase (or decrease) per quarter.

File Name: WIP

File Description: Work in Progress

Contains planned level of assembly work in progress per quarterly period.

File Content: WIP (a, b)

a = product key
b = 1 .... opening w.i.p. (actual)
2-7 .. planned closing w.i.p. for periods 1 to 6.

File Size: WIP (10, 7) = 70

File Type: Integer

Program Segments: QPLAN, QPLANPRINT, QTREVENTS

Special Notes: None

File Name: WORKFILE

File Description: Workfile

Contains transient information used in the plan explosion netting process.

File Content: WORKFILE (a)

a = value per period

File Size: WORKFILE (52) = 52

File Type: Integer

Program Segments: EXPLODE

Special Notes: None.

APPENDIX D

DATA DICTIONARY

The data dictionary describes the variables contained within the program segments as an aid to maintenance and program modification.

DATA DICTIONARY

ACTWK	Actual week (simulated)
ALLQTY	Quantity in allocation status
AVAIL	Calculated available stock
AVGE	Average
BUFFER	Calculated buffer level
BUFFERWKS	Weeks worth of buffer
CAP/CAPACITY	Capacity
COMPVAL	Component value
COMPBUFR	Component buffer level (planned) in weeks
CSVAL	Commercial stock value
CUMDIF	Cumulative difference between new and previous material plans
CVARN	Co-efficient of variance
DATO	Actual calendar date
DATEREQD	Date required
DDATE	Due date
DELAY	Delay between current week and due date
DEMAND	Calculated period demand
DUE (DATE)	Due date (general application)
EQUBUFR	Equipment buffer level (planned) in weeks
FESVAL	Finished equipment stock value
FLAG	Indicator used in quarterly planning process
ICOUNT	Number of items required
IPRINT	Print key set by diagnostic file
ISEEDI-12	Random number seeds
ISHORT	Sort key, used to determine priority rules
ITEMCOUNT	Number of order item lines
ITEMNO	Order line item number
MODE	Planning mode (order, stock, mixed)
OCFMIN	Minimum value of orders carried forward, expressed in weeks
OLDBUFFER	Previous buffer level
ORDCOUNT	Counter indicating the next available customer order reference
ORDNO	Customer order number

PASUM	Sum of production to be allocated
PCBBUFR	Printed circuit board buffer level (planned) in weeks
PROD	Product key
QTY	Quantity (general application)
REFWEEK	Reference week, used to derive the simulated calendar week (or actual week)
REJECT	Quantity of rejected batch
REQD	Quantity required
RESPONSE	Schedule response time in months
RUNTIME	Runtime for each experiment in simulated weeks
SHORT	Calculated component shortage
STOCK	Opening stock
SUBVAL	Sub-assembly value
TESTWIP	Test work in progress value
TIME	Not used
TOTVAL	Total value
TYPE	Product key
VALUE	Value selected from histogram
WEEK	Simulation week, relative to first period - reset each quarter
WIP	Work in progress
WIPVAL	Work in progress value (assembly)
WKCAP	Weekly capacity (derived from quarterly value)
XSTOCK	Excess stock