hydrodynamic efficiency. This limit was not reached in either of the column tests, but was reached in the rolling bottle tests. If the correlations are used within their quoted Reynolds number range, they should produce meaningful simulations.

* During the experimental testwork on the three agitation systems, dimensionless number correlations were proposed in order to link the mass transfer coefficient to the physical parameters of the system affecting the rate. All three of these correlations had the same form, namely

$$Sh = \frac{p}{\epsilon} Re^{q} \quad Sc^{0,33}$$

but the values of p and q differed for each system. Hence, these correlations are specific to a system, and, should it be required to study a different system, for example agitated tanks, these correlations may not be suitable.

* Implicit in the Reynolds number is the diameter of the carbon particles. The assumption was made that, if carbon is screened between two screens, the particle diameter will be the mean of the two aperture sizes. This is not the case in the real situation, as a particle size distribution occurs. It was also assumed that the granules were spherical, whereas, in fact, they are irregularly shaped. These assumptions could account for some of the difficulty in fitting the dimensionless number correlations. The limitation here is that the carbon was screened to produce the maximum number of size

fractions, and the assumption of the diameter being the mean aperture size was shown to hold during the correlation fitting. If the carbon is screened to wider size fractions, this assumption may no longer be valid, due to the size distribution.

5.3 RECOMMENDATIONS FOR FUTURE WORK

* The first recommendation follows from the limitation on the definition of the carbon diameter. In a real situation, carbon is used with a particle size distribution in which the smaller granules will have a greater rate of adsorption than the larger ones. The assumption that the particle diameter is the mean of the screen apertures would probably be incorrect in this case. Work is required to define the mass transfer coefficient in terms of the particle size distribution.

* It is known from other work that the pulp density affects the rate of adsorption. It has not yet been established if this is due to a decrease in mixing efficiency or to physical "blinding" of the carbon surface. Work is required to define the effect of the pulp density on the mass transfer coefficient.

* The rate expression and dimensionless correlations can be used to check experimental work on the activity of carbon. At present, samples of carbon are contacted with a gold solution and the

rate of depletion of gold measured. The knowledge developed during this project can be used to check the testwork and establish whether the activity of the carbon is being measured, and not the effect of its particle size distribution or the effect of the mixing conditions.

* The correlations developed hold only for the specific agitation systems studied. It is recommended that the work be extended to agitated tanks.

* It was established that the mechanism of adsorption changes from film diffusion control to intraparticle diffusion control when the carbon reaches 60 to 70 per cent of its equilibrium loading value. Further investigations should be undertaken to determine if the change of mechanism is also a factor in the degree of carbon loading to its maximum loading capacity.

APPENDIX A

RAW DATA FROM EXPERIMENTAL TESTWORK

TABLE A1: Interruption test

Solution	:	$KAu(CN)_2$ made up in borax buffer
Solution pH	:	9,8
Batch solution volume	:	20 ℓ
Type of carbon	:	Virgin G210 AS
Carbon size fraction	:	-2,0 mm +1,7 mm
Mass of carbon in column	:	8 g
Solution temperature	:	Ambient
Mode of flow	:	Up
Solution linear velocity	:	0,013 m s^{-1}
Bed expansion	:	20 per cent

Sample time h	Soln concn p.p.m	Sample time h	Soln concn p.p.m	Sample time h	Soln concn p.p.m	Sample time h	Soln concn p.p.m
0	4,53						
1,17	3,87	4,90	2,60	9,20	2,12	29,00	0,31
1,25	3,54	5,05	2,59	9,40	2,05	29,25	0,31
1,35	3,60	5,23	2,45	9,60	1,98	29,50	0,30
1,42	3,46	5,35	2,50	9,80	1,94	29,75	0,29
1,50	3,39	5,50	2,44	10,00	1,89	30,00	0,29
Interrupt 2 hours		Interrupt 2 hours		Interrupt 2 hours		Interrupt 2 hours	
3,50	3,41	7,50	2,44	12,00	1,88	32,00	0,29
3,58	3,48	7,65	2,33	12,20	1,83	32,25	0,28
3,67	3,43	7,80	2,25	12,40	1,80	32,50	0,27
3,75	3,41	7,95	2,19	12,60	1,72	32,75	0,25
3,83	3,34	8,10	2,16	12,80	1,70	33,00	0,25

TABLE A2: Equilibrium Tests

Solution:	:	$KAu(CN)_2$ in demineralized water
Solution pH:	:	11
Type of carbon	:	Virgin G210 AS, -2,0 mm +1,7 mm
Solution temperature	:	Ambient
Contacting vessel	:	2 litre rolling bottle at 11 r.p.m.

Test	EQ 1-1	EQ 1-2	EQ 1-3	EQ 2-1	EQ 2-2	EQ 2-3
Solution buffer	NaOH	NaOH	NaOH	NaOH	NaOH	NaOH
Open to atmosphere	No	No	No	Yes	Yes	Yes
Mass of solution g	500	500	500	500	500	500
Mass of carbon g	0,077 3	0,239	0,696	0,064 7	0,397	0,724
Time - hours	Solution concentration - p.p.m.					
0	4,76	4,76	4,76	3,8	3,6	3,4
168	-	-	-	0,79	0,012	0,002
312	1,28	0,115	0,011	-	-	-
Time - hours	Carbon concentration - p.p.m.					
0	0	0	0	0	0	0
168	-	-	-	23 261	4 518	2 346
312	22 509	9 717	3 411	-	-	-

TABLE A2 (Cont.): Equilibrium tests

Solution	:	$KAu(CN)_2$ in demineralized water
Solution pH	:	9,8
Type of carbon	:	Virgin G210 AS -1,4 mm +1,18 mm
Solution temperature	:	Ambient
Contacting vessel	:	Rolling bottles

Test	EQ 4-1	EQ 4-2	EQ 4-3	EQ 4-4
Solution buffer	Borax	Borax	Borax	Borax
Open to atmosphere	Yes	Yes	Yes	Yes
Mass of solution g	500	500	500	1710
Mass of carbon g	0,0258	0,0932	0,1958	0,5065
Time - hours	Solution concentration - p.p.m.			
0	3,5	3,5	3,5	33
120	2,2	0,20	0,007	18
216	2,1	0,14	0,007	17,5
Time - hours	Carbon concentration - p.p.m.			
0	0	0	0	0
120	25 193	17 703	8 919	50 641
216	27 131	18 025	8 919	52 329

TABLE A3: Effect of mass ratio of carbon to solution on rate of adsorption

Solution	:	$KAu(CN)_2$ made up in borax buffer
Solution pH	:	9,8
Solution volume	:	500 ml
Type of carbon	:	Virgin G210 AS
Carbon size fraction	:	-2,0 mm +1,7 mm
Solution temperature	:	Ambient
Bottle	:	2 ℓ
Rolling bottle speed	:	11,1 r.p.m.

Test Mass of carbon, g	GA 0,0622	GB 0,1248	GC 0,2111	GD 0,3536	GE 0,6043
Time - hours	Solution concentration - p.p.m.				
0	4,32	4,26	4,28	4,28	4,40
0,5	4,16	3,88	3,80	3,23	2,83
1	4,08	3,68	3,10	2,63	1,98
1,5	4,00	3,29	2,71	2,07	1,44
2	3,70	3,22	2,37	1,64	1,04
3	-	-	-	1,13	0,60
3,25	3,49	2,65	1,88	-	-
4	3,33	2,44	1,53	-	-
6	3,10	1,94	1,10	0,38	0,078
Time - hours	Carbon concentration - mg kg^{-1}				
0	0	0	0	0	0
6	9807	9294	7484	5514	3576

TABLE A4: Fluidized bed mass transfer tests

Solution : $KAu(CN)_2$ made up in borax buffer
Solution pH : 9,8
Batch solution volume : 20 litres
Type of carbon : Virgin G210 AS
Solution temperature : Ambient
Mode of flow : Up

Test		EA	EB		EC	ED		EE	EF
Mass of carbon g		7,948	7,948		7,948	7,948		7,676	7,676
Solution flowrate $l\ h^{-1}$		28,57	11,80		19,29	15,0		21,18	14,07
Soln linear velocity $m\ s^{-1}$		0,0229	0,0095		0,0155	0,0120		0,0170	0,0113
Carbon size fraction mm		-2,36	-2,36		-2,36	-2,36		-2,0	-2,0
		+2,0	+2,0		+2,0	+2,0		+1,7	+1,[illegible]
	Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.	
	0	4,21	4,59	0	3,62	3,34	0	3,71	3,64
	0,5	3,91	4,27	0,5	3,42	3,40	0,5	3,38	3,30
	1	3,53	3,51	1	3,16	3,10	1	3,06	3,12
	2	2,99	3,37	2	2,74	2,84	2,75	2,28	2,43
	3	2,55	2,96	3,22	2,36	2,43	3,8	1,97	2,15
	4	2,29	2,65	4,2	2,10	2,18	4,92	1,71	1,88
	6,33	1,68	2,00	6,42	1,71	1,76	6,83	1,34	1,54
	24	0,25	0,36	[illegible],17	0,36	0,39	24,83	0,24	0,32
	Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$	
	0	0	0	0	0	0	0	0	0
	24	9965	10 644	23,17	8203	7423	24,83	9041	8650

TABLE A4 (Continued)

Test		EG	EH		EI	EJ		EK	EL
Mass of carbon g		7,728	7,728		7,676	7,728		7,948	7,948
Solution flowrate $l\ h^{-1}$		21,18	14,06		15,6	18,9		11,16	11,4
Soln linear velocity $m\ s^{-1}$		0,0170	0,0113		0,0125	0,0152		0,0090	0,0091
Carbon size fraction mm		-1,7	-1,7		-2,0	-1,7		-2,36	-2,36
		+1,4	+1,4		+1,7	+1,4		+2,0	+2,0
	Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.	
	0	3,58	3,52	0	3,46	3,45	0	4,07	4,07
	0,5	3,24	3,18	0,5	3,18	3,13	0,5	3,73	3,75
	1	2,88	2,93	1	2,91	2,83	1	3,50	3,44
	2,05	2,45	2,46	2	2,53	2,35	1,5	3,30	3,22
	3,25	2,03	2,07	3	2,19	2,00	2,75	2,79	2,58
	5,38	1,48	1,56	3,92	1,97	1,75	5	2,19	1,92
	6,92	1,12	1,19	6,2	1,49	1,32	7,17	1,84	-
	23,0	0,22	0,29	24,92	0,31	0,17	24	0,76	0,33
	Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn. $mg\ kg^{-1}$	
	0	0	0	0	0	0	0	0	0
	23,0	8695	8359	24,92	8207	8488	24	8329	9411

TABLE A4 (Continued)

Test		EM	EN
Mass of carbon g		7,728	7,728
Solution flowrate $l\ h^{-1}$		22,68	19,32
Soln linear velocity $m\ s^{-1}$		0,0182	0,0155
Carbon size fraction mm		-1,7 +1,4	-1,7 +1,4
	Time hours	Soln concn p.p.m.	
	0	4,14	4,12
	0,5	3,71	3,69
	1	3,38	3,30
	2	2,73	2,71
	4,42	1,82	1,84
	6,92	1,31	1,32
	24,90	0,25	0,25
	Time hours	Carbon concn $mg\ kg^{-1}$	
	0	0	0
	24,90	10 067	10 015

TABLE A5: Fixed bed mass transfer tests

Solution	:	$KAu(CN)_2$ made up in borax buffer
Solution pH	:	9,8
Batch solution volume	:	20 litres
Type of carbon	:	Virgin G210 AS
Solution temperature	:	Ambient
Mode of flow	:	Down

Test		FA	FB		FC	FD		FE	FF
Mass of carbon g		7,676	7,676		7,948	7,948		7,728	7,728
Solution flowrate $l\ h^{-1}$		15,78	21,24		15,78	21,24		16,2	20,4
Soln linear velocity $m\ s^{-1}$		0,0127	0,0170		0,0127	0,0170		0,0130	0,0164
Carbon size fraction mm		-2,0	-2,0		-2,36	-2,36		-1,7	-1,7
		+1,7	+1,7		+2,0	+2,0		+1,4	+1,4
	Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.	
	0	3,96	3,98	0	4,01	4,00	0	4,06	4,01
	0,5	3,46	3,39	0,5	3,49	3,44	0,5	3,46	3,38
	1	3,00	2,91	1	3,06	2,95	1	2,98	2,77
	2	2,40	2,37	2	2,46	2,30	2	2,30	2 23
	3,25	2,02	1,95	3	1,92	1,76	3	1,92	1,80
	6	1,30	1,21	6	1,28	1,12	6	1,20	1,10
	23,67	0,31	0,29	24	0,26	0,18	24	0,23	0,21
	Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$	
	0	0	0	0	0	0	0	0	0
	23,67	9510	9614	24	9436	9612	24	9912	9834

TABLE A5 (Continued)

Test		FG	FH		FI	FJ
Mass of carbon g		7,948	7,676		7,676	7,728
Solution flowrate $l\ h^{-1}$		11,7	11,4		21,6	19,8
Soln linear velocity $m\ s^{-1}$		0,0094	0,0091		0,0173	0,0159
Carbon size fraction mm		-2,36 +2,0	-2,0 +1,7		-2,0 +1,7	-1,7 +1,4
	Time h	Soln concn p.p.m.		Time h	Soln concn p.p.m.	
	0	4,12	4,07	0	4,35	4,30
	0,58	3,56	3,60	0,5	3,63	3,58
	1	3,26	3,24	1	3,05	3,10
	2	2,77	2,64	2	2,38	2,48
	3	2,38	2,20	3	1,91	2,06
	6,5	1,54	1,39	6,66	1,08	1,22
	24	0,38	0,33	24	0,24	0,30
	Time h	Carbon concn $mg\ kg^{-1}$		Time h	Carbon concn $mg\ kg^{-1}$	
	0	0	0	0	0	0
	24	9411	9744	24	10 708	10 351

TABLE A6: Two-litre rolling bottle batch adsorption tests at various rolling speeds

TESTS A

Solution	: $KAu(CN)_2$ in demineralized water
Solution pH	: 11,3
Volume of solution	: 0,5 litre
Type of carbon	: Virgin G210 AS
Carbon size fraction	: +1,7 mm -2,0 mm
Mass of carbon	: 0,000 77 kg
Solution temperature	: Ambient
Bottle	: 2 litre (diameter 13 cm, length 16cm)

Test Rolling bottle speed r.p.m.	AE 8,2	AC 20,8	AI 38,1	AA 61,9	AG 89,1
Time, hours	Solution concentration, mg l^{-1}				
0	4,65	4,62	4,86	4,89	4,57
0,5	3,24	2,85	2,85	2,56	2,53
1	2,11	1,80	1,23	1,40	1,37
1,5	1,41	1,10	0,94	0,74	0,72
2	0,93	0,67	0,61	0,41	0,43
3	0,38	0,23	0,25	0,19	0,11
4	0,12	0,086	0,11	0,053	0,037
7	0,020	0,012	0,009	0,007	0,010
Time, hours	Carbon concentration, mg kg^{-1}				
0	0	0	0	0	0
7	3005	2997	3154	3175	2965

TABLE A6 (Continued) Five-litre rolling bottle batch adsorption tests at various rolling speeds.

TESTS A

Solution	:	$KAu(CN)_2$ in demineralized water
Solution pH	:	11,3
Volume of solution	:	0,5 litre
Type of carbon	:	Virgin G210 AS
Carbon size fraction	:	+1,7 mm -2,0 mm
Mass of carbon	:	0,000 77 kg
Solution temperature	:	Ambient
Bottle	:	5 litre (diameter 18 cm, length 20cm)

Test Rolling bottle speed r.p.m.	AF 6,7	AD 15,5	A[illegible] 28,0	[illegible]B 46,0	AH 69,2
Time, hours	Solution concentration, mg l^{-1}				
0	4,65	4,62	4,86	4,89	4,57
0,5	3,35	3,02	2,83	2,39	2,41
1	2,31	2,05	1,30	1,25	1,28
1,5	1,68	1,34	0,99	0,68	0,61
2	1,15	0,89	0,64	0,34	0,34
3	0,59	0,38	0,27	0,09	0,072
4	0,28	0,12	0,010	0,031	0,025
7	0,029	0,011	0,005	0,004	0,006
Time, hours	Carbon concentration, mg kg^{-1}				
0	0	0	0	0	0
7	3005	2997	3157	3177	2967

APPENDIX B

PROGRAM TO CALCULATE THE MASS TRANSFER COEFFICIENT FROM BATCH TEST DATA

```
C PROGRAM TO CALCULATE THE VALUE OF THE MASS TRANSFER COEFFICIENT
C FROM BATCH TEST DATA
C
C THE DIFFERENTIAL EQUATION DESCRIBING THE SOLUTION CONCENTRATION
C IS SOLVED VIA A RUNGE KUTTE NUMERICAL METHOD FOR A SPECIFIED
C VALUE OF THE TRANSFER COEFFICIENT . THE SUM OF SQUARES OF THE
C OBSERVED DATA MINUS THE PREDICTED DATA IS THEN CALCULATED .
C A GOLDEN SECTION SEARCH NUMERICAL TECHNIQUE IS USED TO OBTAIN
C THE MINIMUM SUM OF SQUARES AND HENCE THE TRANSFER COEFFICIENT .
C
C DEFINE VARIABLES TO DOUBLE PRECISION
      DOUBLE PRECISION A1,A2,A3,A4,FB,LL,UL,TL,DR,SS,CON,S0,C0
      DOUBLE PRECISION RC1,RC2,SSQ1,SSQ2,SCO(20),TIM(20),SP(6000)
      DOUBLE PRECISION RC,SSQ,DD1,DD2,DD3,LLL,UUL,SCH
C TYPE PROGRAM TO SCREEN
      TYPE '*******************************************************'
      TYPE '******  DETERMINATION OF KL FROM A BATCH TEST  ******'
      TYPE '*******************************************************'
      TYPE ' '
C RECIEVE OPERATING PARAMETERS FROM SUBROUTINE
      CALL DATAIN(A1,A2,A3,A4,FB,S0,C0)
C OBTAIN DATA FOR PROGRAM
      TYPE ''
      TYPE '*******************************************************'
      TYPE '*****    DATA FOR DETERMINING VALUE OF KL     ********'
      TYPE '*******************************************************'
      TYPE ''
      ACCEPT 'THE LOWER LIMIT OF THE TRANSFER COEFF     M/HR ',LL
      ACCEPT 'THE UPPER LIMIT OF THE TRANSFER COEFF     M/HR ',UL
      ACCEPT 'THE ERROR LIMIT OF THE TRANSFER COEFF     M/HR ',TL
      ACCEPT 'THE DURATION OF THE RUN                     HR ',DR
      ACCEPT 'THE STEP SIZE OF THE ITTERATION             HR ',SS
C DATA FILES
      TYPE ' '
      TYPE '*******************************************************'
      TYPE '****            DATA            FILES          *******'
      TYPE '*******************************************************'
      TYPE ' '
      CALL IAFO1(17,'EXPERIMENTAL DATA FILE  : $')
      CALL IAFO1(18,'TRENDVIEW    DATA FILE  : $')
      CALL IAFO1(19,'DATA OUTPUT       FILE  : $')
C READ IN EXPERIMENTAL DATA
      READ FREE (17) N
      DO 10 I=1,N
      READ FREE (17) TIM(I),SCO(I)
      T=TIM(I)
      S=SCO(I)
      WRITE FREE (18) T,S,'&'
 10   CONTINUE
C STORE LIMTS
      LLL=LL
      UUL=UL
C CALCULATE GOLDEN SECTION CONSTANT
      CON=(3-SQRT(5))/2
C CALCULATE THE NUMBER OF LOOPS FOR DESIRED ERROR
      L=(ALOG(TL/(UL-LL))/ALOG(1-CON))+1
C ERROR MESSAGES
      DD1=UL-LL
      IF (DD1.LE.TL) GO TO 1
```

```
      GO TO 2
 1    TYPE ' '
      TYPE '***********************************************************'
      TYPE '**  WARNING  ******  TOLERANCE LEVEL TO LARGE  ***'
      TYPE '***********************************************************'
 2    IF (LL.GE.UL) GO TO 3
      GO TO 4
 3    TYPE ' '
      TYPE '************************************************************'
      TYPE '**  WARNING  *******  LIMITS ARE NOT ACCEPTABLE  **'
      TYPE '************************************************************'
 4    CONTINUE
C CALCULATE INITIAL GUESS VALUES OF THE TRANSFER COEFFICIENTS
      RC1=LL+CON*(UL-LL)
      RC2=UL-CON*(UL-LL)
C CALCULATE CORESPONDING SUM OF SQUARES
      M=DR/SS
      SCH=S0
      DO 30 I=1,M
      CALL RUNKUT(A1,A2,A3,A4,SS,SCH,RC1,FB)
      SP(I)=SCH
 30   CONTINUE
      CALL DETSSQ(SCO,N,SSQ1,TIM,SP,SS,S0)
      SCH=S0
      DO 40 I=1,M
      CALL RUNKUT(A1,A2,A3,A4,SS,SCH,RC2,FB)
      SP(I)=SCH
 40   CONTINUE
      CALL DETSSQ(SCO,N,SSQ2,TIM,SP,SS,S0)
C USE GOLDEN SECTION TO OBTAIN MINUMUM SUM OF SQUARES
      DO 20 J=1,L
      IF (SSQ1.LT.SSQ2) GO TO 22
      GO TO 24
 22   UL=RC2
      RC2=RC1
      SSQ2=SSQ1
      RC1=LL+CON*(UL-LL)
      SCH=S0
      DO 32 I=1,M
      CALL RUNKUT(A1,A2,A3,A4,SS,SCH,RC1,FB)
      SP(I)=SCH
 32   CONTINUE
      CALL DETSSQ(SCO,N,SSQ1,TIM,SP,SS,S0)
      GO TO 20
 24   LL=RC1
      RC1=RC2
      SSQ1=SSQ2
      RC2=UL-CON*(UL-LL)
      SCH=S0
      DO 42 I=1,M
      CALL RUNKUT(A1,A2,A3,A4,SS,SCH,RC2,FB)
      SP(I)=SCH
 42   CONTINUE
      CALL DETSSQ(SCO,N,SSQ2,TIM,SP,SS,S0)
 20   CONTINUE
C OUTPUT ANSWERS
      SSQ=(SSQ1+SSQ2)/2
      RC=(RC1+RC2)/2
      TYPE ' '
```

```
      TYPE'THE LOWER LIMIT OF THE SUM OF SQUARES  ',SSQ1
      TYPE'THE UPPER LIMIT OF THE SUK OF SQUARES  ',SSQ2
      TYPE ' '
      TYPE'THE AVERAGE      OF THE SUM OF SQUARES  ',SSQ
      TYPE ' '
      TYPE ' '
      TYPE 'THE LOWER VALUE OF THE TRANSFER COEFF ',RC1
      TYPE 'THE UPPER VALUE OF THE TRANSFER COEFF ',RC2
      TYPE ' '
      TYPE 'THE AVERAGE      OF THE TRANSFER COEFF ',RC
      TYPE ' '
      TYPE ' '
      WRITE FREE (19) ' '
      WRITE FREE (19)'THE LOWER LIMIT OF THE SUM OF SQUARES  ',SSQ1
      WRITE FREE (19)'THE UPPER LIMIT OF THE SUM OF SQUARES  ',SSQ2
      WRITE FREE (19) ' '
      WRITE FREE (19)'THE AVERAGE      OF THE SUM OF SQUARES  ',SSQ
      WRITE FREE (19) ' '
      WRITE FREE (19) ' '
      WRITE FREE (19) 'THE LOWER VALUE OF THE TRANSFER COEFF ',RC1
      WRITE FREE (19) 'THE UPPER VALUE OF THE TRANSFER COEFF ',RC2
      WRITE FREE (19) ' '
      WRITE FREE (19) 'THE AVERAGE      OF THE TRANSFER COEFF ',RC
      WRITE FREE (19) ' '
      WRITE FREE (19) ' '
C WARNING MESSAGES
      DD2=RC+TL
      DD3=RC-TL
      IF (DD2.GE.UUL) GO TO 75
      GO TO 76
 75   TYPE '****************************************************'
      TYPE '**  WARNING  ****  UPPER LIMIT TO SMALL    **********'
      TYPE '****************************************************'
 76   IF (DD3.LE.LLL) GO TO 77
      GO TO 78
 77   TYPE '****************************************************'
      TYPE '**  WARNING  ***  LOWER LIMIT TO LARGE     **********'
      TYPE '****************************************************'
 78   CONTINUE
C END
      STOP
      END
```