



BIJLAGEN BIJ RAPPORT R73/7/D

G. J. VAN EIJK

Vloeistofmechanica

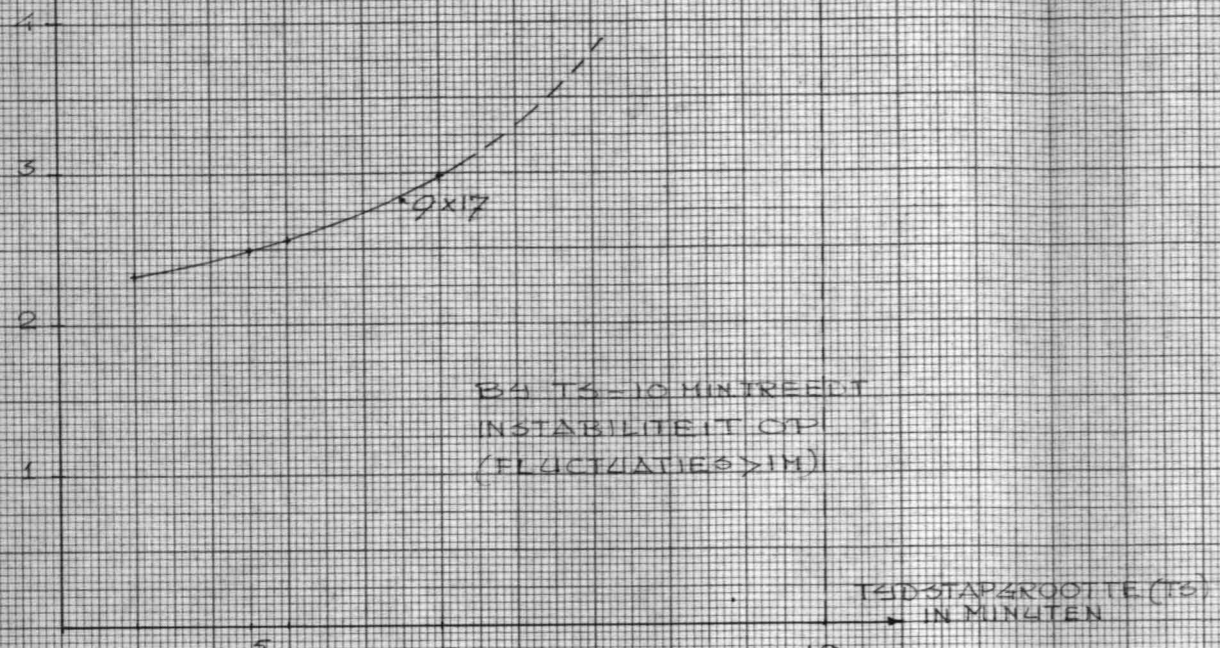
Afd. Weg- en Waterbouwkunde

Technische Hogeschool Delft

OVERZICHT VAN DE BIJLAGEN

- V.1. Diverse figuren betreffende de nauwkeurigheid in verband met tijdstap grootte, onderverdeling en rekentijd.
- VI.1. Stroomschema voor de programma's LM6A en LM6B (LM6).
- VI.2. Computer programma LM6 (7 pagina's)
- VI.3. Computer programma LM6A (8 pagina's)
- VI.4. Computer programma LM6B (8 pagina's)
- VIII.1A. Detail van zandblok bij lineaire stijging gedurende 15 minuten.
- VIII.1B. Detail van zandblok bij lineaire stijging bij time = 15 minuten.
- VIII.2. Vergelijking van de hoogte van het freatisch vlak in de tijd gedurende 1 uur.
- VIII.3. Vergelijking van de hoogte van het freatisch vlak in de tijd gedurende 15 minuten.
- VIII.4. Resultaten van het vrije oppervlak in het zandblok bij lineaire stijging.
- VIII.5. Resultaten van het vrije oppervlak per raai in de tijd bij lineaire stijging.
- VIII.6. Resultaten van het vrije oppervlak in het zandblok bij periodieke randvoorwaarde.
- VIII.7. Resultaten van het vrije oppervlak per raai in de tijd bij periodieke randvoorwaarde.

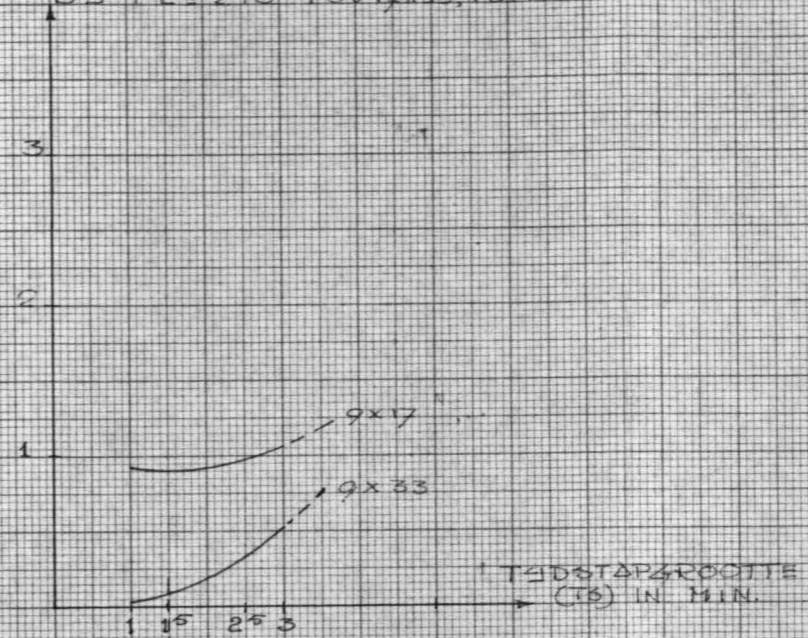
AFWIJ KING IN CM BIJ PL=225 TOV 9x33, TS=1^o MIN
TPV RAAD 8



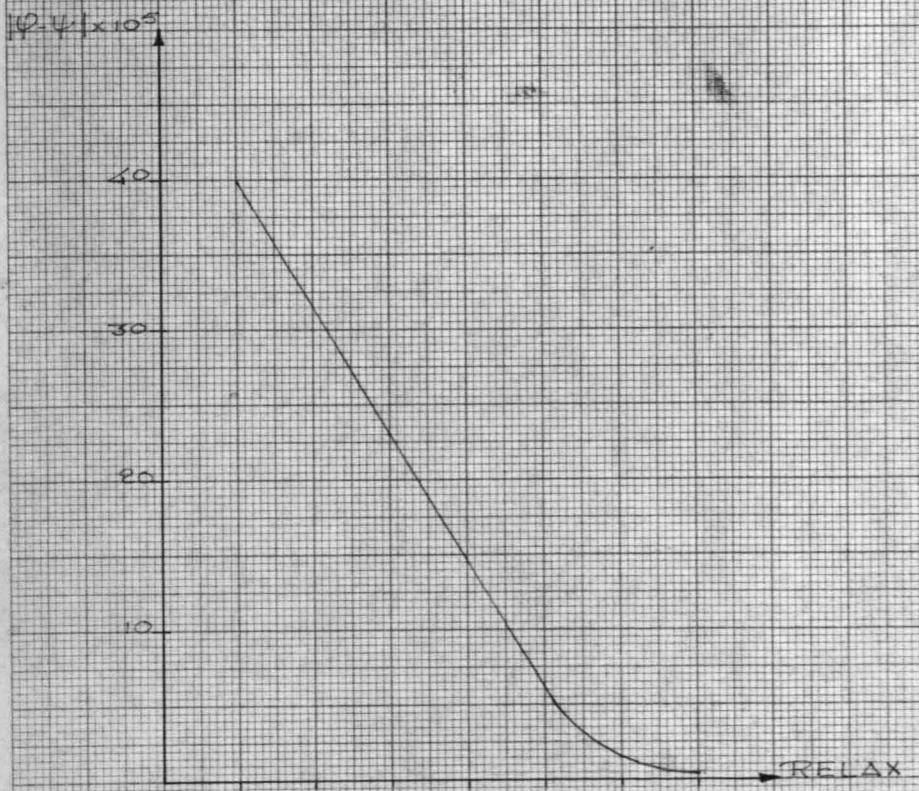
BIJ TS=10 MIN TREEDT
INSTABILITEIT OP
(FLUCTUATIES > IN)

FIGUUR V.5

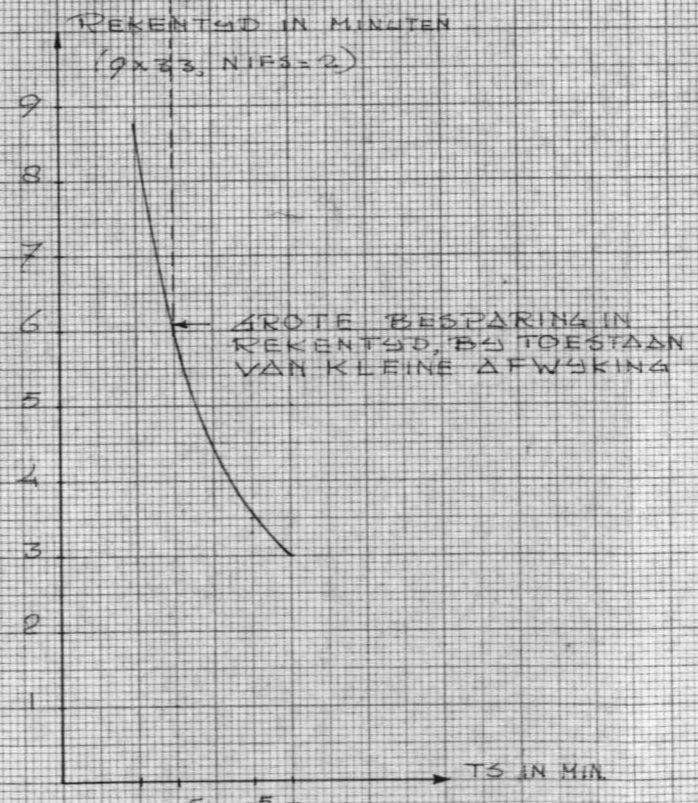
AFWIJ KING IN CM IN RAAD 8
BIJ PL=210 TOV 9x33, TS=1 MIN



FIGUUR V.6



FIGUUR V.7 GEBASEERD OP
RELEVENS ONTLEEND AAN
9x17, TS=3 MIN, TIME=0,1 (PL=210)



FIGUUR V.8

GROTE BESPARING IN
REKENTJD, BIJ TOESTAAN
VAN KLEINE AFWIJ KING

```

C      FINITE ELEMENT METHOD IN PLANE GROUNDWATER FLOW
C      PROGRAM 6, A. VERRUIJT, DELFT, HOLLAND, AUGUST 1971

```

```

C      *****
C      *
C      * NON-STEADY FLOW IN DAM *
C      *      PROGRAM  LM6      *
C      *
C      *****

```

```

C      THIS PROGRAM CALCULATES THE TRANSIENT POSITION OF THE
C      FREE SURFACE IN A DAM. THE DAM IS BASED UPON A HORIZONTAL
C      IMPERMEABLE LAYER. ITS LEFT AND RIGHT SIDE SLOPES ARE
C      STRAIGHT. THE WATER LEVEL AT THE RIGHT SIDE IS CONSTANT,
C      AND THE WATER LEVEL AT THE LEFT SIDE FLUCTUATES. THE DAM
C      IS COMPOSED OF A HOMOGENEOUS AND ISOTROPIC POROUS
C      MATERIAL.

```

```

0001 REAL LA
0002 INTEGER CT,ST,TY,TR,TT,TL,TR
0003 DIMENSION CO(400,2),ST(800,3),TY(400),PE(800)
0004 DIMENSION CT(400,12),P(400,12),LA(400)
0005 DIMENSION PHI(400),PSI(400),Q(20),H(20)
0006 DIMENSION NO(3),X(3),Y(3),B(3),C(3),AA(3,3)
0007 DIMENSION BAS(20,2),TOP(20,2),TB(20),TT(20),PB(20),PT(20)
0008 DIMENSION POS(20),SLOPE(20)
0009 READ(5,1) AL,AR
0010 1 FORMAT(2F6.2)

```

```

C      AL IS ANGLE OF LEFT SIDE SLOPE, IN DEGREES.
C      AR IS ANGLE OF RIGHT SIDE SLOPE, IN DEGREES.
C      BOTH ANGLES TAKEN WITH RESPECT TO THE HORIZONTAL
C      BASE, IN COUNTERCLOCKWISE DIRECTION FROM THE
C      ZERO DIRECTION WHICH POINTS TOWARD THE RIGHT.

```

```

0011 READ(5,2) NR,NC
0012 2 FORMAT(2I3)
C      NR IS NUMBER OF ROWS OF NODES.
C      NC IS NUMBER OF COLUMNS OF NODES.

```

```

0013 READ(5,3) W,PERM,BETA,HH
0014 3 FORMAT(4F12.6)
C      W IS LENGTH OF HORIZONTAL BASE OF DAM.
C      PERM IS COEFFICIENT OF PERMEABILITY.
C      BETA IS EFFECTIVE POROSITY.
C      HH IS ORIGINAL HEIGHT OF WATER TABLE.

```

```

0015 READ(5,4) MAXIT,NTS,NIFS,RELAX,TS
0016 4 FORMAT(3I6,2F12.6)
C      MAXIT IS NUMBER OF ITERATIONS IN NUMERICAL SOLUTION
C      (FOR INSTANCE MAXIT=NR+NC).
C      NTS IS NUMBER OF TIME STEPS.
C      NIFS IS NUMBER OF ITERATIONS IN CALCULATION OF NEW

```

C POSITION OF FREE SURFACE (FOR INSTANCE NIFS=2).
 C RELAX IS OVER-RELAXATION FACTOR (FOR INSTANCE RFLAX=1.1).
 C TS IS TIME STEP.
 C TO ENSURE STABILITY TS MUST BE SMALL ENOUGH. A POSSIBLE
 C UPPER BOUND IS $BETA*(DELTA X**2)/(2*PERM*HH)$, WHERE
 C DELTAX IS THE SMALLEST ELEMENT SIZE NEAR THE FREE
 C SURFACE.

```

0017 KLM=0
0018 ITS=0
0019 TIME=0.0
0020 PI=3.141592654
0021 AL=AL*PI/180
0022 AR=AR*PI/180
0023 DW=W/(NC-1)
0024 DO 5 I=1,NC
0025 BAS(I,1)=(I-1)*DW
0026 BAS(I,2)=0.0
0027 TB(I)=1
0028 5 PB(I)=HH
0029 TB(1)=2
0030 TB(NC)=2
0031 A1=HH*COS(AL)/SIN(AL)
0032 A2=W+HH*COS(AR)/SIN(AR)
0033 DW=(A2-A1)/(NC-1)
0034 DO 6 I=1,NC
0035 TOP(I,1)=A1+(I-1)*DW
0036 TOP(I,2)=HH
0037 TT(I)=2
0038 6 PT(I)=HH
0039 TL=2
0040 TR=2
0041 PL=HH
0042 PR=HH
0043 NOD=NR*NC
0044 NEL=2*(NR-1)*(NC-1)

```

C CALCULATION OF STRUCTURE OF ELEMENTS,ST.

```

0045 L=NC-1
0046 LL=NR-1
0047 DO 30 I=1,L
0048 II=(I-1)*NR+1
0049 DO 30 J=1,LL
0050 JJ=2*(I-1)*LL+2*J-1
0051 JJJ=JJ+1
0052 III=II+J
0053 ST(JJ,1)=III-1
0054 ST(JJ,2)=III+NR-1
0055 ST(JJ,3)=III+NR
0056 ST(JJJ,1)=III-1

```

```

0057      ST(JJJ,2)=III+NR
0058      ST(JJJ,3)=III
0059      30 CONTINUE
          C      END CALCULATION ST.
          C      CALCULATION OF INCLINATION OF COLUMNS.
0060      DO 31 I=1,NC
0061      A1=TOP(I,2)-BAS(I,2)
0062      A2=TOP(I,1)-BAS(I,1)
0063      SLOPE(I)=A2/A1
0064      31 CONTINUE
          C      END CALCULATION INCLINATION OF COLUMNS.
          C      CALCULATION OF TY AND PE.
0065      DO 50 I=1,NOD
0066      50 TY(I)=0
0067      DO 51 I=1,NR
0068      TY(I)=TL
0069      51 TY(NOD+1-I)=TR
0070      DO 52 I=1,NC
0071      J=(I-1)*NR
0072      TY(J+1)=TB(I)
0073      52 TY(J+NR)=TT(I)
0074      DO 53 I=1,NEL
0075      53 PE(I)=PERM
          C      END CALCULATION TY AND PE.
          C      CALCULATION OF NODAL CONTACTS,CT.
          C      CT(I,1)=I, CT(I,J), I=1,...,NOD, J=2,...,CT(I,12) ARE
          C      THE NODAL NUMBERS OF THE NODES THAT ARE IN ONE
          C      ELEMENT WITH NODE I.
0076      DO 280 I=1,NOD
0077      CT(I,1)=I
0078      CT(I,12)=1
0079      K=1
0080      J=1
0081      281 IF(J.GT.NEL) GOTO 280
0082      DO 282 II=1,3
0083      IF(ST(J,II).EQ.I) GOTO 283
0084      282 CONTINUE
0085      GOTO 284
0086      283 DO 285 II=1,3
0087      JJ=ST(J,II)
0088      DO 286 L=1,K
0089      IF(CT(I,L).EQ.JJ) GOTO 285
0090      286 CONTINUE
0091      K=K+1
0092      CT(I,K)=JJ
0093      CT(I,12)=K
0094      285 CONTINUE
0095      284 J=J+1

```

```
0096          GOTO 281
0097          280 CONTINUE
C           END CALCULATION CT.
C           CALCULATION OF COORDINATES OF NODES, CO.
0098          41 DO 40 I=1,NC
0099             A1=BAS(I,1)
0100             A2=BAS(I,2)
0101             B1=TOP(I,1)-A1
0102             B2=TOP(I,2)-A2
0103             II=(I-1)*NR
0104             DO 40 J=1, NR
0105                 III=II+J
0106                 AJ=J-1
0107                 AN=NR-1
0108                 AJN=AJ/AN
0109                 CO(III,1)=A1+AJN*B1
0110                 CO(III,2)=A2+AJN*B2
0111             40 CONTINUE
C           END CALCULATION CO.
C           CALCULATION OF PHI IN FIRST ESTIMATION.
0112             DO 54 I=1,NC
0113                 A1=TOP(I,2)
0114                 II=(I-1)*NR
0115                 DO 54 J=1, NR
0116                     54 PHI(II+J)=A1
0117                     DO 55 J=1, NR
0118                         55 PHI(J)=PL
0119                     PHI(NR)=CO(NR,2)
C           END CALCULATION PHI.
C           CALCULATION OF INITIAL VALUES OF MATRIX AND LOAD VECTOR.
0120             DO 290 I=1, NOD
0121                 LA(I)=0.0
0122                 DO 290 J=1, 12
0123                     290 P(I,J)=0.0
C           END CALCULATION INITIAL VALUES.
C           CALCULATION OF MATRIX COEFFICIENTS.
0124             DO 320 I=1, NEL
0125                 DO 330 J=1, 3
0126                     330 NO(J)=ST(I,J)
0127                     DO 340 K=1, 3
0128                         J=NO(K)
0129                         X(K)=CO(J,1)
0130                     340 Y(K)=CO(J,2)
0131                         B(1)=Y(2)-Y(3)
0132                         B(2)=Y(3)-Y(1)
0133                         B(3)=Y(1)-Y(2)
0134                         C(1)=X(3)-X(2)
0135                         C(2)=X(1)-X(3)
```



```

0136      C(3)=X(2)-X(1)
0137      D=X(J)*B(1)+X(2)*B(2)+X(3)*B(3)
0138      DDD=2*ABS(D)
0139      D=PE(I)/DDD
0140      DO 350 J=1,3
0141      DO 350 K=1,3
0142      350 AA(J,K)=(B(J)*B(K)+C(J)*C(K))*D
0143      DO 360 J=1,3
0144      JJ=NO(J)
0145      II=CT(JJ,12)
0146      DO 370 K=1,II
0147      DO 380 L=1,3
0148      IF(NO(L).EQ.CT(JJ,K)) GOTO 390
0149      GOTO 380
0150      390 P(JJ,K)=P(JJ,K)+AA(J,L)
0151      GOTO 370
0152      380 CONTINUE
0153      370 CONTINUE
0154      360 CONTINUE
0155      320 CONTINUE
      C      END CALCULATION MATRIX COEFFICIENTS.
      C      GAUSS-SEIDEL ITERATION.
0156      IT=0
0157      510 DO 520 I=1,NOD
0158      IF(TY(I).GT.1) GOTO 520
0159      CC=LA(I)
0160      II=CT(I,12)
0161      DO 530 J=2,II
0162      530 CC=CC-P(I,J)*PHI(CT(I,J))
0163      CC=CC/P(I,1)
0164      CC=PHI(I)-CC
0165      PHI(I)=PHI(I)-RELAX*CC
0166      520 CONTINUE
0167      IT=IT+1
0168      IF(MAXIT-IT) 540,550,510
0169      550 CONTINUE
0170      GOTO 510
0171      540 CONTINUE
      C      END GAUSS-SEIDEL ITERATION.
      C      CALCULATION OF NODAL FLOWS.
0172      DO 401 I=1,NC
0173      K=I*NR
0174      Q(I)=0.0
0175      L=CT(K,12)
0176      DO 401 J=1,L
0177      401 Q(I)=Q(I)-P(K,J)*PHT(CT(K,J))
      C      END CALCULATION NODAL FLOWS.
      C      CALCULATION OF APPARENT EVAPORATION.

```

```

0178      DW=(TOP(2,1)-TOP(1,1))/2
0179      H(1)=Q(1)/DW
0180      L=NC-1
0181      DO 402 I=2,L
0182          DW=(TOP(I+1,1)-TOP(I-1,1))/2
0183      402  H(I)=Q(I)/DW
0184          DW=(TOP(NC,1)-TOP(L,1))/2
0185          H(NC)=Q(NC)/DW
0186      DO 403 J=1,10
0187          A1=(TOP(2,1)-TOP(1,1))/6
0188          H(1)=(Q(1)/A1-H(2))/2
0189      DO 404 I=2,L
0190          A1=(TOP(I+1,1)-TOP(I,1))/6
0191          A2=(TOP(I,1)-TOP(I-1,1))/6
0192          A3=A1+A2
0193      404  H(I)=(Q(I)-A1*H(I+1)-A2*H(I-1))/(2*A3)
0194          A1=(TOP(NC,1)-TOP(L,1))/6
0195      403  H(NC)=(Q(NC)/A1-H(L))/2
C      END CALCULATION H.
C      ITERATION OF POSITION OF FREE SURFACE.
0196      II=NC-1
0197      KLM=KLM+1
0198      IF(KLM.GT.1) GOTO 406
0199      DO 405 I=1,NC
0200      405  POS(I)=TOP(I,2)
0201      406  IF(KLM.EQ.NIFS) GOTO 408
0202          DO 407 I=2,II
0203      407  TOP(I,2)=POS(I)+TS*H(I)/(2*BETA)
0204          TOP(1,2)=(POS(1)+PL)/2
0205          GOTO 410
0206      408  CONTINUE
0207          DO 409 I=2,II
0208      409  TOP(I,2)=POS(I)+TS*H(I)/BETA
0209          TOP(1,2)=PL
0210          KLM=0
0211      410  CONTINUE
0212          DO 411 I=1,NC
0213      411  TOP(I,1)=BAS(I,1)+(TOP(I,2)-BAS(I,2))*SLOPE(I)
C      END ITERATION POSITION FREE SURFACE.
0214      IF(KLM.GT.0) GOTO 41
C      OUTPUT FREE SURFACE.
0215      IF(ITS.GT.0) GOTO 610
0216      WRITE(6,601)
0217      601  FORMAT(1H1,' FINITE ELEMENT METHOD')
0218      WRITE(6,602)
0219      602  FORMAT(1H , ' PROGRAM LM6')
0220      610  WRITE(6,603) TIME
0221      603  FORMAT(1H1,' TIME =',F12.6)

```

0222 WRITE(6,604)
0223 604 FORMAT(1H , ' POSITION OF FREE SURFACE')
0224 DO 605 I=1,NC
0225 WRITE(6,606) TOP(I,1),TOP(I,2)
0226 606 FORMAT(3H , 2F12.6)
0227 605 CONTINUE
C END OUTPUT.
C TIME STEP.
C IN THIS PROGRAM THE WATER LEVEL AT THE LEFT SIDE SLOPE
C OF THE DAM, WHICH IS DENOTED BY PL, DECREASES BY HH/20
C IN EACH TIME STEP. FOR OTHER TYPES OF FLUCTUATIONS THIS
C PART OF THE PROGRAM MUST BE ADJUSTED.
0228 PL=PL-HH/20
0229 TIME=TIME+TS
0230 ITS=ITS+1
0231 IF(ITS.LT.NTS) GOTO 41
0232 STOP
0233 END

```

C      FINITE ELEMENT METHOD IN PLANE GROUNDWATER FLOW
C      PROGRAM G, A. VERRUIJT, DELFT, HOLLAND, AUGUST 1971
C
C      *****
C      *
C      * NON-STEADY FLOW IN DAM *
C      * PROGRAM LM6 A. *
C      *
C      *****
C
C      THIS PROGRAM CALCULATES THE TRANSIENT POSITION OF THE
C      FREE SURFACE IN A DAM. THE DAM IS BASED UPON A HORIZONTAL
C      IMPERMEABLE LAYER. ITS LEFT AND RIGHT SIDE SLOPES ARE
C      STRAIGHT. THE WATER LEVEL AT THE RIGHT SIDE IS CONSTANT,
C      AND THE WATER LEVEL AT THE LEFT SIDE FLUCTUATES. THE DAM
C      IS COMPOSED OF A HOMOGENEOUS AND ISOTROPIC POROUS
C      MATERIAL.
C      IN THIS PROGRAM LM6 A SOME ADDITIONS ARE MADE TO THE
C      PROGRAM LM6 BY G.J. VAN EIJK
0001 REAL LA
0002      1 INTEGER CT,ST,TY,TB,TT,TL,TR
0003      DIMENSION CO(297,2),ST(512,3),TY(297),PE(512)
0004      DIMENSION CT(297,8),P(297,8),LA(297)
0005      DIMENSION PHI(297),PSI(297),Q(33),H(33)
0006      DIMENSION NO(3),X(3),Y(3),B(3),C(3),AA(3,3)
0007      DIMENSION BAS(33,2),TOP(33,2),TB(33),TT(33),PB(33),PT(33)
0008      DIMENSION POS(33),SLOPE(33),FS1(33),FS2(33),Q1(33),Q2(33)
0009      DIMENSION H1(33),H2(33)
0010      READ(5,1) AL,AR
0011      1 FORMAT(2F6.2)
C      AL IS ANGLE OF LEFT SIDE SLOPE, IN DEGREES.
C      AR IS ANGLE OF RIGHT SIDE SLOPE, IN DEGREES,
C      BOTH ANGLES TAKEN WITH RESPECT TO THE HORIZONTAL
C      BASE, IN COUNTERCLOCKWISE DIRECTION FROM THE
C      ZERO DIRECTION WHICH POINTS TOWARD THE RIGHT.
0012      READ(5,2) NR,NC
0013      2 FORMAT(2I3)
C      NR IS NUMBER OF ROWS OF NODES.
C      NC IS NUMBER OF COLUMNS OF NODES
0014      READ(5,3) W,PERM,BETA,HH
0015      3 FORMAT(4F12.6)
C      W IS LENGTH OF HORIZONTAL BASE OF DAM
C      PERM IS COEFFICIENT OF PERMEABILITY
C      BETA IS EFFECTIVE POROSITY.
C      HH IS ORIGINAL HEIGHT OF WATER TABLE
0016      READ(5,4) MAXIT,NTS,NIFS,RELAX,TS,EIS
0017      4 FORMAT(3I6,2F12.6,F12.8)
C      MAXIT IS NUMBER OF ITERATIONS IN NUMERICAL SOLUTION

```

N.B.

- | = TOEVOEGING T.O.V. LM6
- | = WYZIGING " " "

C (FOR INSTANCE MAXIT=NR+NC).
 C NIS IS NUMBER OF TIME STEPS
 C NIFS IS NUMBER OF ITERATIONS IN CALCULATION OF NEW
 C POSITION OF FREE SURFACE (FOR INSTANCE NIFS=2).
 C RELAX IS OVER-RELAXATION FACTOR (FOR INSTANCE RELAX=1.1)
 C TS IS TIME STEP.
 C EIS IS ALLOWABLE VALUE OF THE DIFFERENCE BETWEEN THE VALUE
 C PSI AND PHI
 C TO ENSURE STABILITY TS MUST BE SMALL ENOUGH. A POSSIBLE
 C UPPER BOUND IS $BETA*(DELTA**2)/(2*PERM*HH)$, WHERE
 C DELTAX IS THE SMALLEST ELEMENT SIZE NEAR THE FREE
 C SURFACE

```

0018 KLM=0
0019 ITS=0
0020 TIME=0.0
0021 PI=3.141592654
0022 AL=AL*PI/180
0023 AR=AR*PI/180
0024 DW=W/(NC-1)
0025 DO 5 I=1,NC
0026 BAS(I,1)=(I-1)*DW
0027 BAS(I,2)=0.0
0028 TB(1)=1
0029 5 PB(1)=HH
0030 TB(1)=2
0031 TB(NC)=2
0032 A1=HH*COS(AL)/SIN(AL)
0033 A2=W+HH*COS(AR)/SIN(AR)
0034 DW=(A2-A1)/(NC-1)
0035 DO 6 I=1,NC
0036 TOP(I,1)=A1+(I-1)*DW
0037 TOP(I,2)=HH
0038 TI(1)=2
0039 6 PI(1)=HH
0040 TL=2
0041 TR=2
0042 PL=HH
0043 PR=HH
0044 NUJ=NP*NC
0045 NEL=2*(NR-1)*(NC-1)

```

C CALCULATION OF STRUCTURE OF ELEMENTS, ST:

```

0046 L=NC-1
0047 LL=NR-1
0048 DO 30 I=1,L
0049 I1=(I-1)*NR+1
0050 DO 30 J=1,LL
0051 JJ=2*(I-1)*LL+2*J-1
0052 JJJ=JJ+1

```

```

0053      III=II+J
0054      SI(JJ,1)=III-1
0055      SI(JJ,2)=III+NR-1
0056      SI(JJ,3)=III+NR
0057      SJ(JJJ,1)=III-1
0058      SJ(JJJ,2)=III+NR
0059      SJ(JJJ,3)=III
0060      30 CONTINUE
          C      END CALCULATION ST
          C      CALCULATION OF INCLINATION OF COLUMNS
0061      DO 31 I=1,NC
0062      A1=TOP(I,2)-BAS(I,2)
0063      A2=TOP(I,1)-BAS(I,1)
0064      SLOPE(I)=A2/A1
0065      31 CONTINUE
          C      END CALCULATION INCLINATION OF COLUMNS
          C      CALCULATION OF TY AND PEc
0066      DO 50 I=1,MOD
0067      50 TY(I)=0
0068      DO 51 I=1,NR
0069      TY(I)=TL
0070      51 TY(MOD+1-I)=TR
0071      DO 52 I=1,NC
0072      J=(I-1)*NR
0073      TY(J+1)=TB(I)
0074      52 TY(J+NR)=TT(I)
0075      DO 53 I=1,NEL
0076      53 PE(I)=PERM
          C      END CALCULATION TY AND PE
          C      CALCULATION OF NODAL CONTACTS,CT
          C1      CT(I,1)=I, CT(I,J), I=1, ,MOD, J=2, ,CT(I,8) ARE
          C1      THE NODAL NUMBERS OF THE NODES THAT ARE IN ONE
          C      ELEMENT WITH NODE I
0077      DO 280 I=1,MOD
0078      CT(I,1)=I
0079      CT(I,8)=1
0080      K=1
0081      J=1
0082      281 IF(J GT NEL) GOTO 280
0083      DO 282 II=1,3
0084      IF(SI(J,II) EQ I) GOTO 283
0085      282 CONTINUE
0086      GOTO 284
0087      283 DO 285 II=1,3
0088      JJ=SI(J,II)
0089      DO 286 L=1,K
0090      IF(CT(I,L) EQ JJ) GOTO 285
0091      286 CONTINUE

```

```

0092      X=K+1
0093      CT(I,K)=JJ
0094      CT(L,8)=K
0095      285 CONTINUE
0096      284 J=J+1
0097      GOTO 281
0098      280 CONTINUE
      C      END CALCULATION CT.
      C      CALCULATION OF COORDINATES OF NODES,CO
0099      41 DO 43 I=1,NC
0100      A1=BAS(I,1)
0101      A2=BAS(I,2)
0102      B1=TOP(I,1)-A1
0103      B2=TOP(I,2)-A2
0104      I1=(I-1)*NR
0105      DO 40 J=1,NR
0106      I1I=I1+J
0107      AJ=J-1
0108      AN=NR-1
0109      AJN=AJ/AN
0110      CO(I1I,1)=A1+AJN*B1
0111      CO(I1I,2)=A2+AJN*B2
0112      40 CONTINUE
      C      END CALCULATION CO.
      C      CALCULATION OF PHI IN FIRST ESTIMATION
0113      DO 54 J=1,NC
0114      A1=TOP(I,2)
0115      I1=(I-1)*NR
0116      DO 54 J=1,NR
0117      54 PHI(I1+J)=A1
0118      DO 55 J=1,NR
0119      55 PHI(J)=PL
0120      PHI(NR)=CO(NR,2)
      C      END CALCULATION PHI.
      C      CALCULATION OF INITIAL VALUES OF MATRIX AND LOAD VECTOR
0121      DO 290 I=1,NOD
0122      LA(I)=0.0
0123      DO 290 J=1,8
0124      290 P(I,J)=0.0
      C      END CALCULATION INITIAL VALUES
      C      CALCULATION OF MATRIX COEFFICIENTS:
0125      DO 320 I=1,NEL
0126      DO 330 J=1,3
0127      330 NO(J)=ST(I,J)
0128      DO 340 K=1,3
0129      J=NO(K)
0130      X(K)=CO(J,1)
0131      340 Y(K)=CO(J,2)

```

```

0132      B(1)=Y(2)-Y(3)
0133      B(2)=Y(3)-Y(1)
0134      B(3)=Y(1)-Y(2)
0135      C(1)=X(3)-X(2)
0136      C(2)=X(1)-X(3)
0137      C(3)=X(2)-X(1)
0138      D=X(1)*B(1)+X(2)*B(2)+X(3)*B(3)
0139      DDD=2*ABS(D)
0140      J=P(1)/DDD
0141      DO 350 J=1,3
0142      DO 350 K=1,3
0143      350 AA(J,K)=(B(J)*B(K)+C(J)*C(K))*D
0144      DO 360 J=1,3
0145      JJ=NO(J)
0146      II=CT(JJ,8)
0147      DO 370 K=1,II
0148      DO 380 L=1,3
0149      IF(NO(L).EQ.CT(JJ,K)) GOTO 390
0150      GOTO 380
0151      390 P(JJ,K)=P(JJ,K)+AA(J,L)
0152      GOTO 370
0153      380 CONTINUE
0154      370 CONTINUE
0155      360 CONTINUE
0156      320 CONTINUE
C      END CALCULATION MATRIX COEFFICIENTS.
C      GAUSS-SEIDEL ITERATION.
0157      IT=0
0158      RELAX=1.7
0159      K=1
0160      510 DO 520 I=1,NOD
0161      IF(IY(I).GT.1) GOTO 520
0162      CC=LA(I)
0163      II=CT(I,8)
0164      DO 530 J=2,II
0165      530 CC=CC-P(I,J)*PHI(CT(I,J))
0166      CC=CC/P(I,1)
0167      CC=PHI(I)-CC
0168      PHI(I)=PHI(I)-RELAX*CC
0169      520 CONTINUE
0170      IT=IT+1
0171      IF (IT.EQ.20 ) RELAX=1.0
0172      L=5*K
0173      M=L+1
0174      IF(IT.EQ.M) GOTO 540
0175      IF(IT.EQ.L) GOTO 550
0176      GOTO 510
0177      550 DO 551 I=1,NOD

```



```

0178      PSI(1)=PHI(1)
0179      551 CONTINUE
0180      GOTO 510
0181      540 DIG=0.0
0182      DO 552 I=1,NOD
0183      DI=ABS(PHI(I)-PSI(I))
0184      IF(DI.GT.DIG)DIG=DI
0185      552 CONTINUE
0186      IF(DIG.LE.EPS) GOTO 553
0187      IF(17.GT.MAXIT) GOTO 553
0188      K=K+1
0189      GOTO 510
0190      553 IF(KLM.EQ.0) DIG1=DIG
0191      IF(KLM.EQ.1) DIG2=DIG
C      END GAUSS-SEIDEL ITERATION
C      CALCULATION OF NODAL FLOWS.
0192      DO 401 I=1,NC
0193      K=I+NR
0194      Q(I)=0.0
0195      L=CT(K,8)
0196      DO 401 J=1,L
0197      Q(I)=Q(I)-P(K,J)*PHI(CT(K,J))
0198      401 CONTINUE
0199      DO 415 I=1,NC
0200      IF(KLM.EQ.0) Q1(I)=Q(I)
0201      IF(KLM.EQ.1) Q2(I)=Q(I)
0202      415 CONTINUE
C      END CALCULATION NODAL FLOWS
C      CALCULATION OF APPARENT EVAPORATION.
0203      DW=(TOP(2,1)-TOP(1,1))/2
0204      H(1)=Q(1)/DW
0205      L=NC-1
0206      DO 402 I=2,L
0207      DW=(TOP(I+1,1)-TOP(I-1,1))/2
0208      402 H(I)=Q(I)/DW
0209      DW=(TOP(NC,1)-TOP(L,1))/2
0210      H(NC)=Q(NC)/DW
0211      DO 403 J=1,10
0212      A1=(TOP(2,1)-TOP(1,1))/6
0213      H(1)=(Q(1)/A1-H(2))/2
0214      DO 404 I=2,L
0215      A1=(TOP(I+1,1)-TOP(I,1))/6
0216      A2=(TOP(I,1)-TOP(I-1,1))/6
0217      A3=A1+A2
0218      404 H(I)=(Q(I)-A1*H(I+1)-A2*H(I-1))/(2*A3)
0219      A1=(TOP(NC,1)-TOP(L,1))/6
0220      H(NC)=(Q(NC)/A1-H(L))/2
0221      403 CONTINUE

```

```

0222      DO 416 I=1,NC
0223      IF(KLM.EQ.0) H1(I)=H(I)
0224      IF(KLM.EQ.1) H2(I)=H(I)
0225      416 CONTINUE
      C
      C
      C
      C
0226      II=NC-1
0227      KLM=KLM+1
0228      IF(KLM.GT.1) GOTO 406
0229      DO 405 I=1,NC
0230      405 POS(I)=TOP(I,2)
0231      406 IF(KLM.EQ.NIFS) GOTO 408
0232      DO 407 I=2,II
0233      407 TOP(I,2)=POS(I)+TS*H(I)/(2*BETA)
0234      TOP(1,2)=(POS(1)+PL)/2
0235      DO 414 I=1,NC
0236      GOTO (412,413),KLM
0237      412 FS1(I)=TOP(I,2)
0238      413 FS2(I)=TOP(I,2)
0239      414 CONTINUE
0240      GOTO 410
0241      408 CONTINUE
0242      DO 409 I=2,II
0243      409 TOP(I,2)=POS(I)+TS*H(I)/BETA
0244      TOP(1,2)=PL
0245      KLM=0
0246      410 CONTINUE
0247      DO 411 I=1,NC
0248      411 TOP(I,1)=BAS(I,1)+(TOP(I,2)-BAS(I,2))*SLOPE(I)
      C
0249      IF(KLM.GT.0) GOTO 41
      C
0250      IF(IYS.GT.0) GOTO 610
0251      WRITE(6,601)
0252      601 FORMAT(1H,' FINITE ELEMENT METHOD')
0253      WRITE(6,602)
0254      602 FORMAT(1H,' PROGRAM LM6')
0255      610 WRITE(6,603) TIME
0256      603 FORMAT(1H,' TIME =',F12.6)
0257      WRITE(6,604)
0258      604 FORMAT(1H,' NODAL FLOWS AND APPARENT EVAPORATION Q1 Q2 Q
0259      DO 605 I=1,NC
0260      WRITE(6,606) Q1(I),Q2(I),Q(I),H1(I),H2(I),H(I)
0261      606 FORMAT(1H,' 6F12.6)
0262      605 CONTINUE
0263      WRITE(6,611)
0264      611 FORMAT(1H,' FIRST SECOND AND DEFINITE POSITION OF FREE
0265      DO 613 I=1,NC
      SURFACE }

```

```

0266 WRITE(6,612) FS1(I),FS2(I),TOP(I,1),TOP(I,2)
0267 612 FORMAT(1H ,4F12.6)
0268 613 CONTINUE
0269 WRITE (6,607) IT
0270 6L7 FORMAT(1H0,'AFTER',I5 , ' ITERATIONS THE DIFFERENCE IN THE
0271 WRITE (6,608) VALUES
0272 608 FORMAT(1H , 'OF PHI IS APPROXIMATELY')
0273 WRITE (6,609) DIG1 ,DIG2 ,DIG
0274 609 FORMAT(1H , 3F12.8)
C END OUTPUT.
C TIME STEP
C IN THIS PROGRAM THE WATER LEVEL AT THE LEFT SIDE SLOPE
C OF THE DAM, WHICH IS DENOTED BY PL, INCREASES BY HH/120
C IN EACH TIME STEP, FOR OTHER TYPES OF FLUCTUATIONS THIS
C PART OF THE PROGRAM MUST BE ADJUSTED.
0275 PL=PL+HH/120
0276 TIME=TIME+TS
0277 ITS=ITS+1
0278 IF(ITS.LT.NTS) GO TO 41
0279 STOP
0280 END

```

```

C FINITE ELEMENT METHOD IN PLANE GROUNDWATER FLOW
C PROGRAM G, A. VERRUIJT, DELFT, HOLLAND, AUGUST 1971
C
C *****
C *
C * NON-STEADY FLOW IN DAM *
C * PROGRAM LM6 B *
C *
C *****
C
C THIS PROGRAM CALCULATES THE TRANSIENT POSITION OF THE
C FREE SURFACE IN A DAM. THE DAM IS BASED UPON A HORIZONTAL
C IMPERMEABLE LAYER. ITS LEFT AND RIGHT SIDE SLOPES ARE
C STRAIGHT. THE WATER LEVEL AT THE RIGHT SIDE IS CONSTANT,
C AND THE WATER LEVEL AT THE LEFT SIDE FLUCTUATES. THE DAM
C IS COMPOSED OF A HOMOGENEOUS AND ISOTROPIC POROUS
C MATERIAL.
C IN THIS PROGRAM LM6 B SOME ADDITIONS ARE MADE TO THE
C PROGRAM LM6 BY G. J. VAN EIJK
C THE DIFFERENCE WITH THE PROGRAM LM6A IS THE POSSIBILITY
C TO START FROM A PERMANENT CONDITION, WHILE THE POSITION OF
C THE FREE SURFACE IS GIVEN BY FOR EXAMPLE A DUPUIT PARABOLA
0001 REAL LA
0002 INTEGER CT,ST,TY,TB,TT,TL,TR
0003 DIMENSION CO(297,2),ST(512,3),TY(297),PE(512)
0004 DIMENSION CT(297,8),P(297,8),LA(297)
0005 DIMENSION PHI(297),PSI(297),Q(33),H(33)
0006 DIMENSION NO(3),X(3),Y(3),B(3),C(3),AA(3,3)
0007 DIMENSION BAS(33,2),TOP(33,2),TB(33),TT(33),PB(33),PT(33)
0008 DIMENSION POS(33),SLOPE(33),FS1(33),Q1(33),HI(33)
0009 DIMENSION FSP(33)
0010 READ(5,1) AL,AR
0011 1 FORMAT(2F6.2)
C AL IS ANGLE OF LEFT SIDE SLOPE, IN DEGREES.
C AR IS ANGLE OF RIGHT SIDE SLOPE, IN DEGREES.
C BOTH ANGLES TAKEN WITH RESPECT TO THE HORIZONTAL
C BASE, IN COUNTERCLOCKWISE DIRECTION FROM THE
C ZERO DIRECTION WHICH POINTS TOWARD THE RIGHT.
0012 READ(5,2) NR,NC
0013 2 FORMAT(2I3)
C NR IS NUMBER OF ROWS OF NODES.
C NC IS NUMBER OF COLUMNS OF NODES.
0014 READ(5,3) W,PERM,BETA,HH
0015 3 FORMAT(4F12.6)
C W IS LENGTH OF HORIZONTAL BASE OF DAM.
C PERM IS COEFFICIENT OF PERMEABILITY.
C BETA IS EFFECTIVE POROSITY.
C HH IS ORIGINAL HEIGHT OF WATER TABLE.
    
```

N.B.

= TOEVOEGING TOV LM6

= WYZIENING " " "

```

016      | READ(5,4) MAXIT,NTS,NIFS,RELAX,TS,EIS
017      | 4 FORMAT(3I6,2F12.6,F12.8)
      C   | MAXIT IS NUMBER OF ITERATIONS IN NUMERICAL SOLUTION
      C   | (FOR INSTANCE MAXIT=NR+NC).
      C   | NTS IS NUMBER OF TIME STEPS.
      C   | NIFS IS NUMBER OF ITERATIONS IN CALCULATION OF NEW
      C   | POSITION OF FREE SURFACE (FOR INSTANCE NIFS=2).
      C   | RELAX IS OVER-RELAXATION FACTOR (FOR INSTANCE RELAX=1.1).
      C   | TS IS TIME STEP.
      C   | EIS IS ALLOWABLE VALUE OF THE DIFFERENCE BETWEEN THE VALUES
      C   | PSI AND PHI
      C   | TO ENSURE STABILITY TS MUST BE SMALL ENOUGH. A POSSIBLE
      C   | UPPER BOUND IS BETA*(DELTA**2)/(2*PERM*HH), WHERE
      C   | DELTA IS THE SMALLEST ELEMENT SIZE NEAR THE FREE
      C   | SURFACE.
018      | READ(5,7) (FSP(I),I=1,NC)
019      | 7 FORMAT(9F8.6)
      C   | FSP(I)= FREE SURFACE BY THE START FROM A PERMANENT CONDITION
      C   | WHILE THE PROGRAM LM6 NORMALLY STARTS FROM A HORIZONTAL LEVEL
020      | KLM=0
021      | ITS=0
022      | TIME=C.0
023      | PI=3.141592654
024      | AL=AL*PI/180
025      | AR=AR*PI/180
026      | DJ=H/(NC-1)
027      | DO 5 I=1,NC
028      | BAS(I,1)=(I-1)*DW
029      | BAS(I,2)=0.0
030      | TB(I)=1
031      | 5 PB(I)=FSP(I)
032      | TB(1)=2
033      | TB(NC)=2
034      | A1=FSP(1)*COS(AL)/SIN(AL)
035      | A2=W+HH*COS(AR)/SIN(AR)
036      | DW=(A2-A1)/(NC-1)
037      | DO 6 I=1,NC
038      | TOP(I,1)=A1+(I-1)*DW
039      | TOP(I,2)=FSP(I)
040      | TT(I)=2
041      | 6 PT(I)=FSP(I)
042      | TL=2
043      | TR=2
044      | PL=FSP(1)
045      | PR=PHI
046      | NOD=NR*NC
047      | NEL=2*(NR-1)*(NC-1)
      C   | CALCULATION OF STRUCTURE OF ELEMENTS,ST.
    
```

```

0048      L=NC-1
0049      LL=NR-1
0050      DO 30 I=1,L
0051      II=(I-1)*NR+1
0052      DO 30 J=1,LL
0053      JJ=2*(I-1)*LL+2*J-1
0054      JJJ=JJ+1
0055      III=II+J
0056      ST(JJ,1)=III-1
0057      ST(JJ,2)=III+NR-1
0058      ST(JJ,3)=III+NR
0059      ST(JJJ,1)=III-1
0060      ST(JJJ,2)=III+NR
0061      ST(JJJ,3)=III
0062      30 CONTINUE
      C      END CALCULATION ST.
      C      CALCULATION OF INCLINATION OF COLUMNS.
0063      DO 31 I=1,NC
0064      A1=TOP(I,2)-BAS(I,2)
0065      A2=TOP(I,1)-BAS(I,1)
0066      SLOPE(I)=A2/A1
0067      31 CONTINUE
      C      END CALCULATION INCLINATION OF COLUMNS.
      C      CALCULATION OF TY AND PE.
0068      DO 50 I=1,NOD
0069      50 TY(I)=0
0070      DO 51 I=1,NR
0071      TY(I)=TL
0072      51 TY(NOD+1-I)=TR
0073      DO 52 I=1,NC
0074      J=(I-1)*NR
0075      TY(J+1)=TB(I)
0076      52 TY(J+NR)=TT(I)
0077      DO 53 I=1,NEL
0078      53 PE(I)=PERM
      C      END CALCULATION TY AND PE.
      C      CALCULATION OF NODAL CONTACTS,CT.
      C      CT(I,1)=I, CT(I,J), I=1,...,NOD, J=2,...,CT(I,8) ARE
      C      THE NODAL NUMBERS OF THE NODES THAT ARE IN ONE
      C      ELEMENT WITH NODE I.
0079      DO 230 I=1,NOD
0080      CT(I,1)=I
0081      CT(I,8)=1
0082      K=1
0083      J=1
0084      281 IF(J.GT.NEL) GOTO 280
0085      DO 282 II=1,3
0086      IF(ST(J,II).EQ.I) GOTO 283

```

```

0087      282 CONTINUE
0088      GOTO 284
0089      283 DO 285 I=1,3
0090      JJ=SI(J,I)
0091      DO 286 L=1,K
0092      IF(CT(I,L).EQ.JJ) GOTO 285
0093      286 CONTINUE
0094      K=K+1
0095      CT(I,K)=JJ
0096      CT(I,8)=K
0097      285 CONTINUE
0098      284 J=J+1
0099      GOTO 281
0100      280 CONTINUE
      C      END CALCULATION CT.
      C      CALCULATION OF COORDINATES OF NODES, CO.
0101      41 DO 40 I=1,NC
0102      A1=BAS(I,1)
0103      A2=BAS(I,2)
0104      B1=TOP(I,1)-A1
0105      B2=TOP(I,2)-A2
0106      II=(I-1)*NR
0107      DO 40 J=1,NR
0108      III=II+J
0109      AJ=J-1
0110      AN=NR-1
0111      AJN=AJ/AN
0112      CO(III,1)=A1+AJN*B1
0113      CO(III,2)=A2+AJN*B2
0114      40 CONTINUE
      C      END CALCULATION CO.
      C      CALCULATION OF PHI IN FIRST ESTIMATION.
0115      DO 54 I=1,NC
0116      A1=TOP(I,2)
0117      II=(I-1)*NR
0118      DO 54 J=1,NR
0119      54 PHI(II+J)=A1
0120      DO 55 J=1,NR
0121      55 PHI(J)=PL
0122      PHI(NR)=CO(NR,2)
      C      END CALCULATION PHI.
      C      CALCULATION OF INITIAL VALUES OF MATRIX AND LOAD VECTOR.
0123      DO 290 I=1,NOD
0124      LA(I)=0.0
0125      DO 290 J=1,8
0126      290 P(I,J)=0.0
      C      END CALCULATION INITIAL VALUES.
      C      CALCULATION OF MATRIX COEFFICIENTS.

```

```

0127      DO 320 I=1,NEL
0128      DO 330 J=1,3
0129      330  NO(J)=ST(I,J)
0130      DO 340 K=1,3
0131      J=NO(K)
0132      X(K)=CO(J,1)
0133      340  Y(K)=CO(J,2)
0134      B(1)=Y(2)-Y(3)
0135      B(2)=Y(3)-Y(1)
0136      B(3)=Y(1)-Y(2)
0137      C(1)=X(3)-X(2)
0138      C(2)=X(1)-X(3)
0139      C(3)=X(2)-X(1)
0140      D=X(1)*B(1)+X(2)*B(2)+X(3)*B(3)
0141      DDD=2*ABS(D)
0142      D=PE(I)/DDD
0143      DO 350 J=1,3
0144      DO 350 K=1,3
0145      350  AA(J,K)=(B(J)*B(K)+C(J)*C(K))*D
0146      DO 360 J=1,3
0147      JJ=NO(J)
0148      II=CT(JJ,8)
0149      DO 370 K=1,II
0150      DO 380 L=1,3
0151      IF(NO(L).EQ.CT(JJ,K)) GOTO 390
0152      GOTO 380
0153      390  P(JJ,K)=P(JJ,K)+AA(J,L)
0154      GOTO 370
0155      380  CONTINUE
0156      370  CONTINUE
0157      360  CONTINUE
0158      320  CONTINUE
C      END CALCULATION MATRIX COEFFICIENTS.
C      GAUSS-SEIDEL ITERATION.
0159      IT=0
0160      RELAX=1.7
0161      K=2
0162      510  DO 520 I=1,NDD
0163      IF(TY(I).GT.1) GOTO 520
0164      CC=LA(I)
0165      II=CT(I,8)
0166      DO 530 J=2,II
0167      530  CC=CC-P(I,J)*PHI(CT(I,J))
0168      CC=CC/P(I,1)
0169      CC=PHI(I)-CC
0170      PHI(I)=PHI(I)-RELAX*CC
0171      520  CONTINUE
0172      II=II+1

```



```

0173 IF (IT.EQ.20 ) RELAX=1.0
0174 L=5*K
0175 M=L+1
0176 IF (IT.EQ.M) GOTO 540
0177 IF (IT.EQ.L) GOTO 550
0178 GOTO 510
0179 550 DO 551 I=1,NOD
0180 PSI(I)=PHI(I)
0181 551 CONTINUE
0182 GOTO 510
0183 540 DIG=0.0
0184 DO 552 I=1,NOD
0185 DI=ABS(PHI(I)-PSI(I))
0186 IF (DI.GT.DIG)DIG=DI
0187 552 CONTINUE
0188 IF (DIG.LT.EIS) GOTO 553
0189 IF (IT.GT.MAXIT) GOTO 553
0190 K=K+1
0191 GOTO 510
0192 553 IF (KLM.EQ.0) DIG1=DIG
C END GAUSS-SEIDEL ITERATION.
C CALCULATION OF NODAL FLOWS.
0193 DO 401 I=1,NC
0194 K=I*NR
0195 Q(I)=0.0
0196 L=CT(K,8)
0197 DO 401 J=1,L
0198 Q(I)=Q(I)-P(K,J)*PHI(CT(K,J))
0199 401 CONTINUE
0200 DO 415 I=1,NC
0201 IF (KLM.EQ.0) Q1(I)=Q(I)
0202 415 CONTINUE
C END CALCULATION NODAL FLOWS.
C CALCULATION OF APPARENT EVAPORATION.
0203 DV=(TOP(2,1)-TOP(1,1))/2
0204 H(1)=Q(1)/DW
0205 L=NC-1
0206 DO 402 I=2,L
0207 DW=(TOP(I+1,1)-TOP(I-1,1))/2
0208 402 H(I)=Q(I)/DW
0209 DW=(TOP(NC,1)-TOP(L,1))/2
0210 H(NC)=Q(NC)/DW
0211 DO 403 J=1,10
0212 A1=(TOP(2,1)-TOP(1,1))/6
0213 H(1)=(Q(1)/A1-H(2))/2
0214 DO 404 I=2,L
0215 A1=(TOP(I+1,1)-TOP(I,1))/6
0216 A2=(TOP(I,1)-TOP(I-1,1))/6

```

```

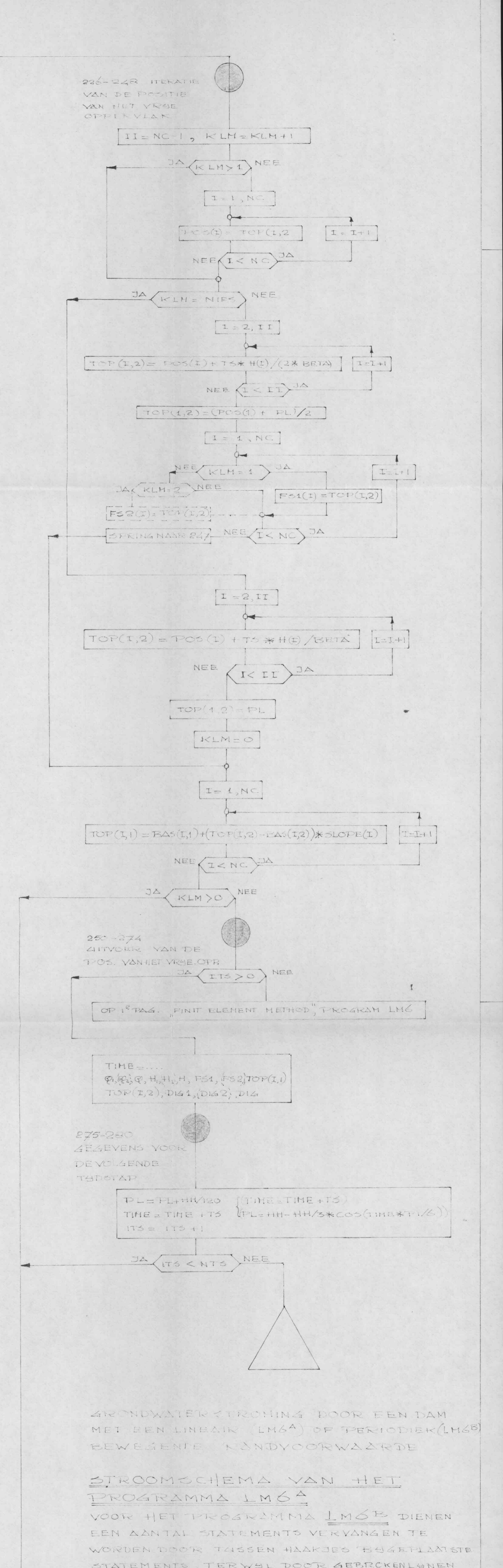
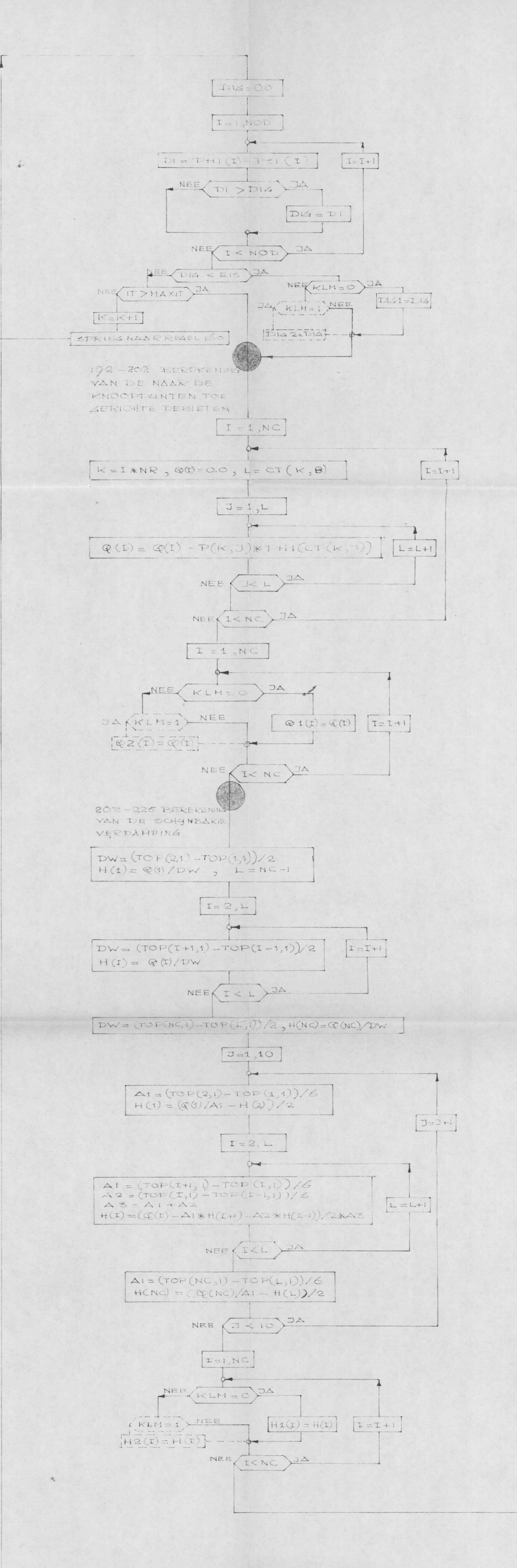
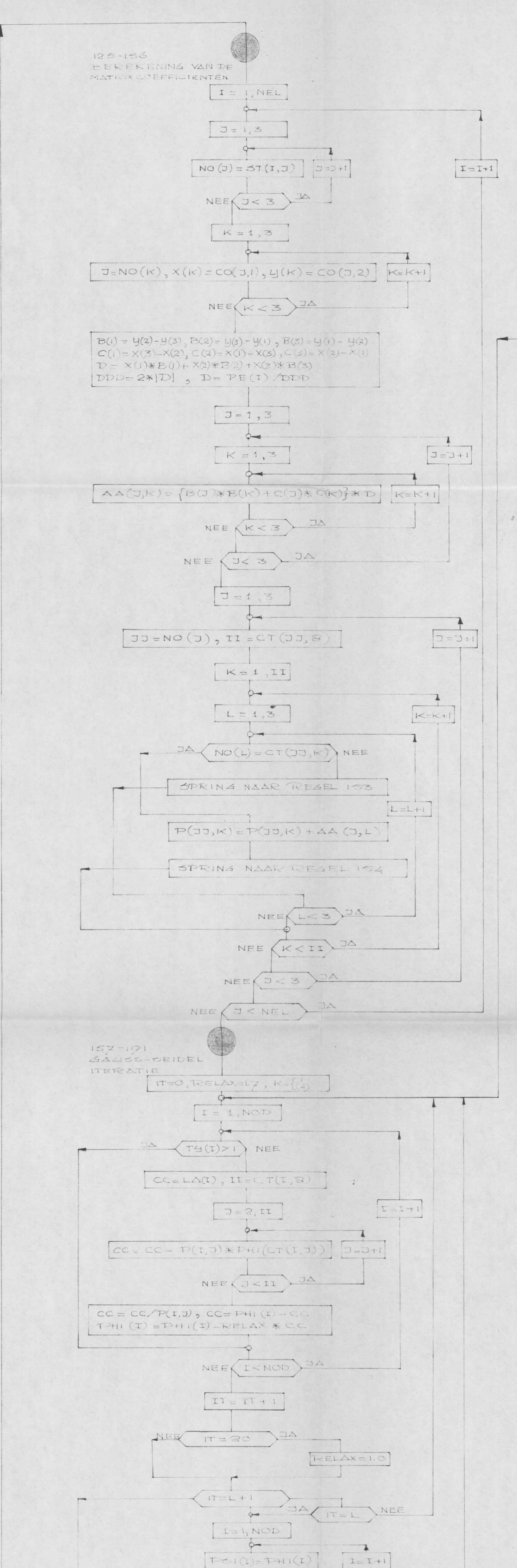
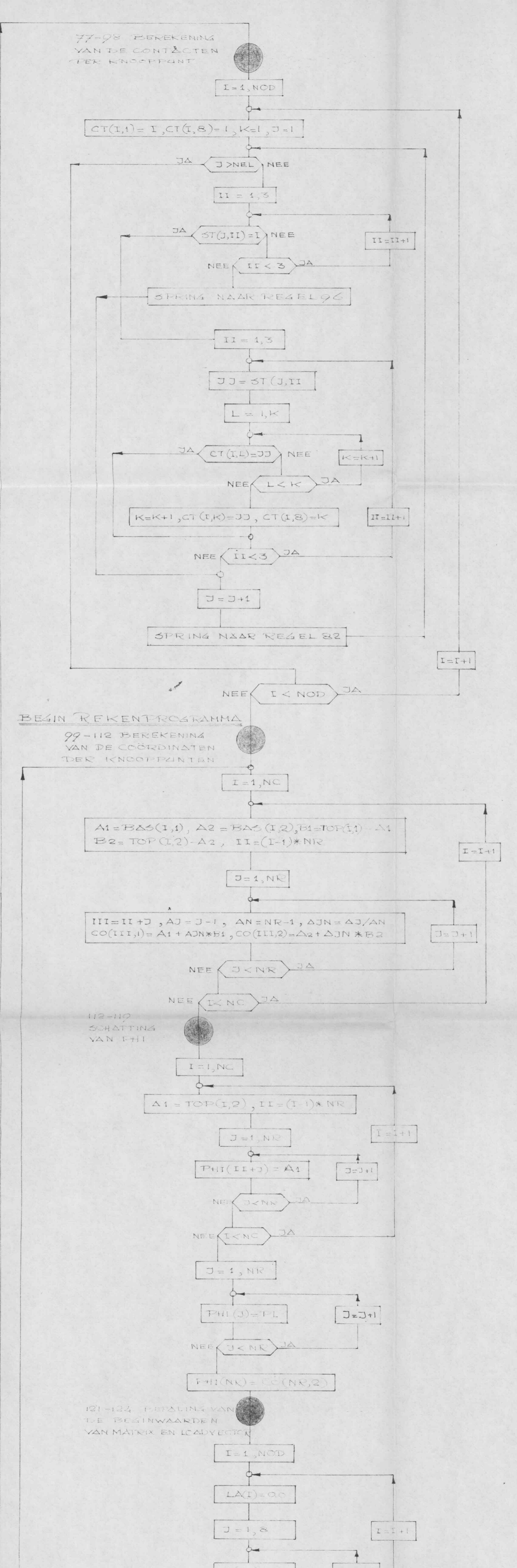
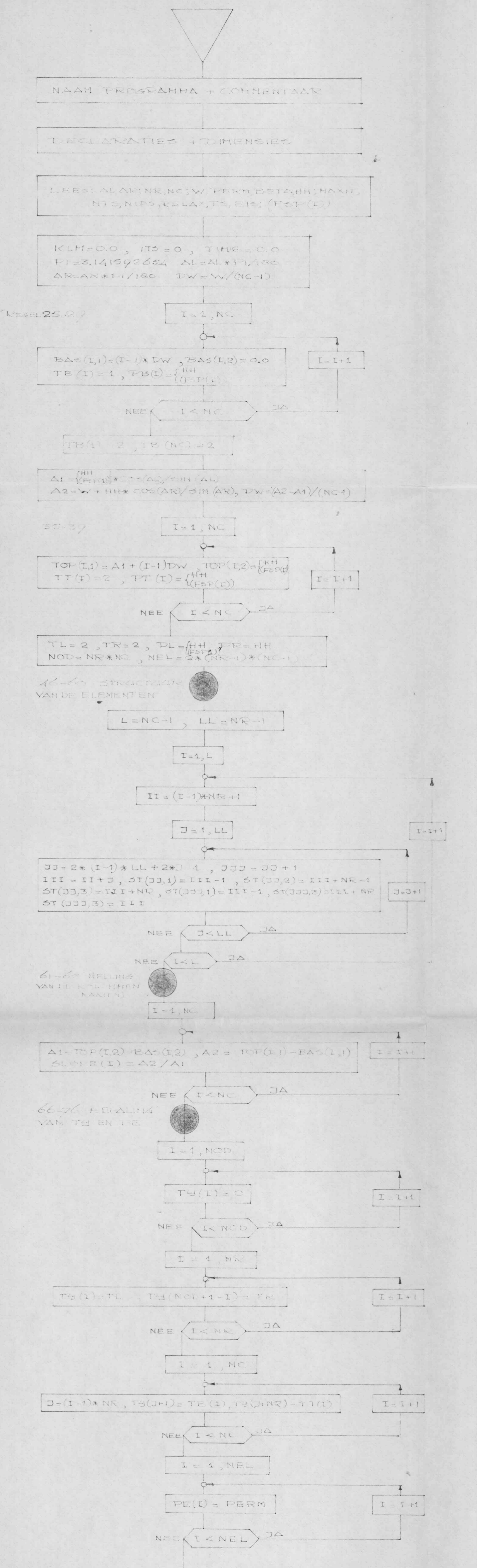
0217      A3=A1+A2
0218      404 H(I)=(Q(I)-A1*H(I+1)-A2*H(I-1))/(2*A3)
0219      A1=(TOP(NC,1)-TOP(L,1))/6
0220      H(NC)=(Q(NC)/A1-H(L))/2
0221      403 CONTINUE
0222      DO 416 I=1,NC
0223      IF(KLM.EQ.0) H1(I)=H(I)
0224      416 CONTINUE
C      END CALCULATION H.
C      ITERATION OF POSITION OF FREE SURFACE.
0225      II=NC-1
0226      KLM=KLM+1
0227      IF(KLM.GT.1) GOTO 406
0228      DO 405 I=1,NC
0229      405 POS(I)=TOP(I,2)
0230      406 IF(KLM.EQ.NIFS) GOTO 403
0231      DO 407 I=2,II
0232      407 TOP(I,2)=POS(I)+TS*H(I)/(2*BETA)
0233      TOP(I,2)=(POS(I)+PL)/2
0234      DO 414 I=1,NC
0235      IF(KLM.EQ.1) FS1(I)=TOP(I,2)
0236      414 CONTINUE
0237      GOTO 410
0238      408 CONTINUE
0239      DO 409 I=2,II
0240      409 TOP(I,2)=POS(I)+TS*H(I)/BETA
0241      TOP(I,2)=PL
0242      KLM=0
0243      410 CONTINUE
0244      DO 411 I=1,NC
0245      411 TOP(I,1)=BAS(I,1)+(TOP(I,2)-BAS(I,2))*SLOPE(I)
C      END ITERATION POSITION FREE SURFACE.
0246      IF(KLM.GT.0) GOTO 41
C      OUTPUT FREE SURFACE.
0247      IF(ITS.GT.0) GOTO 610
0248      WRITE(6,601)
0249      601 FORMAT(1H1,' FINITE ELEMENT METHOD')
0250      WRITE(6,602)
0251      602 FORMAT(1H , ' PROGRAM LM6')
0252      610 WRITE(6,603) TIME
0253      603 FORMAT(1H1,' TIME =',F12.6)
0254      WRITE(6,604)
0255      604 FORMAT(1H , ' NODAL FLOWS AND APPARENT EVAPORATION Q1 Q H1 H
0256      DO 605 I=1,NC
0257      WRITE (6,606) Q1(I),J(I),H1(I),H(I)
0258      606 FORMAT(1H ,4F12.6)
0259      605 CONTINUE
0260      WRITE(6,611)

```

```

0261      611 FORMAT(1H1,'FIRST AND DEFINITE POSITION OF FREE SURFACE')
0262      DO 613 I=1,NC
0263      WRITE(6,612) FS1(I),TOP(1,1),TOP(1,2)
0264      612 FORMAT(1H ,3F12.6)
0265      613 CONTINUE
0266      WRITE (6,607) IT
0267      607 FORMAT(1H0,'AFTER',I5 , ' ITERATIONS THE DIFFERENCE IN THE
0268      WRITE (6,608)                                     VALUES:
0269      608 FORMAT(1H , 'OF PHI IS APPROXIMATELY')
0270      WRITE (6,609) DIG1 ,DIG
0271      609 FORMAT(1H , 2F12.8)
C      END OUTPUT.
C      TIME STEP.
C      IN THIS PROGRAM THE WATER LEVEL AT THE LEFT SIDE SLOPE
C      OF THE DAM, WHICH IS DENOTED BY PL, INCREASES BY A COSINUS
C      IN EACH TIME STEP. FOR OTHER TYPES OF FLUCTUATIONS THIS
C      PART OF THE PROGRAM MUST BE ADJUSTED.
0272      TIME=TIME+TS
0273      PL=HH-HH/3*COS(TIME*PI/6)
0274      ITS=ITS+1
0275      IF(ITS.LT.NTS) GOTO 41
0276      STOP
0277      END

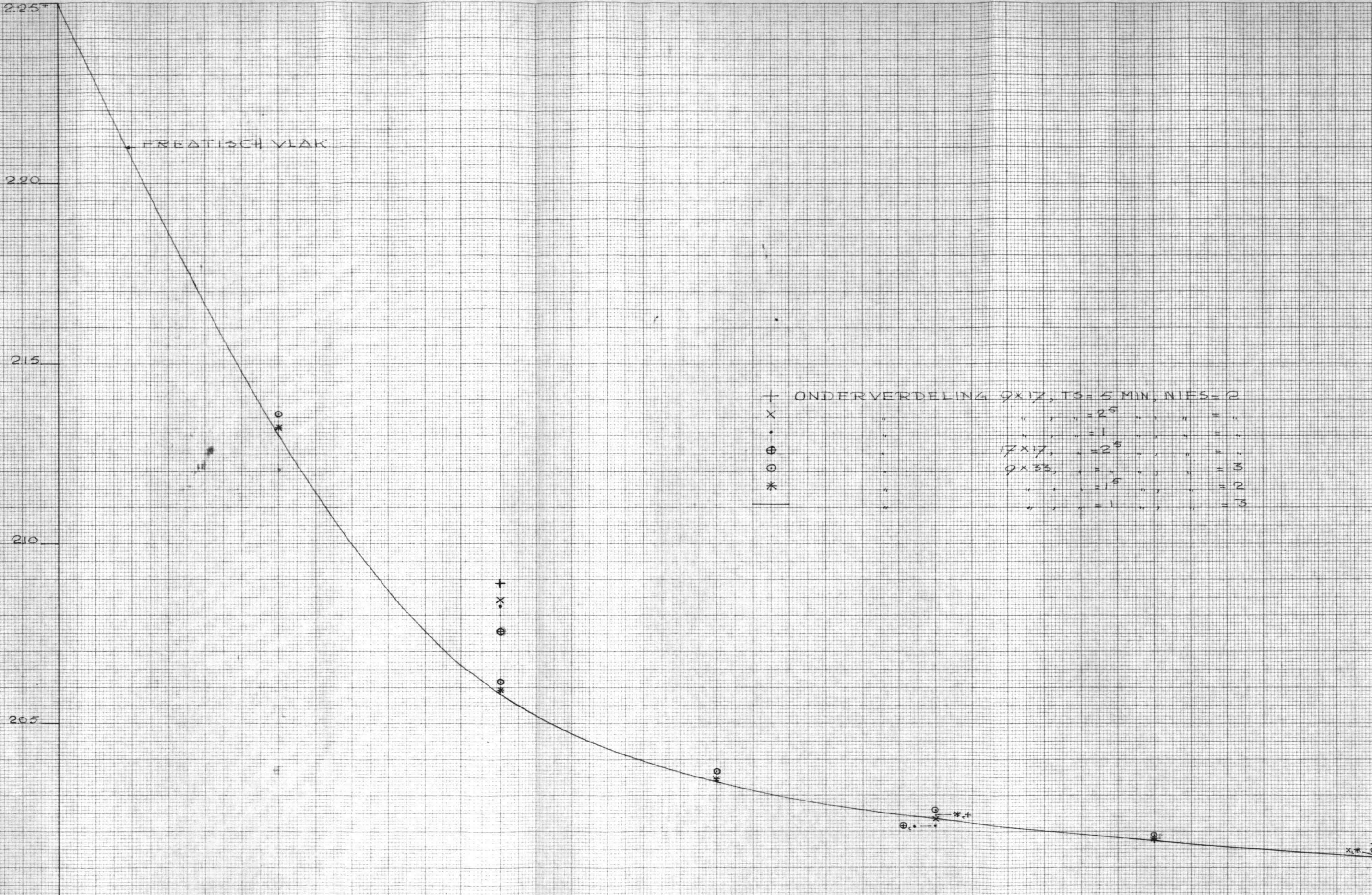
```



F. b. v.

Lab. bibl.

Kes Vörsing



$dw = \frac{1100}{32} = 0.34375$

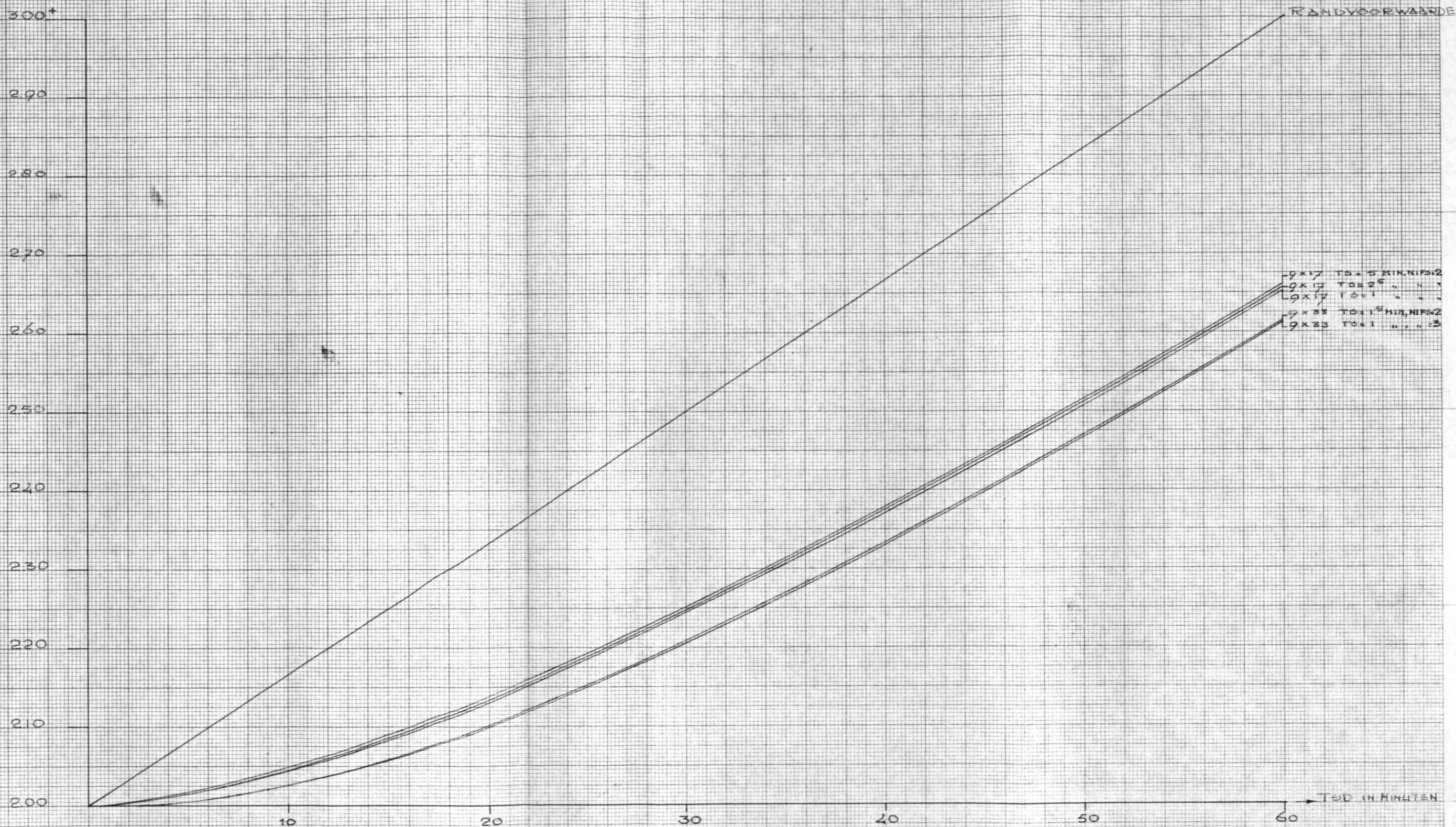
RAAI VIII

RAAI VII

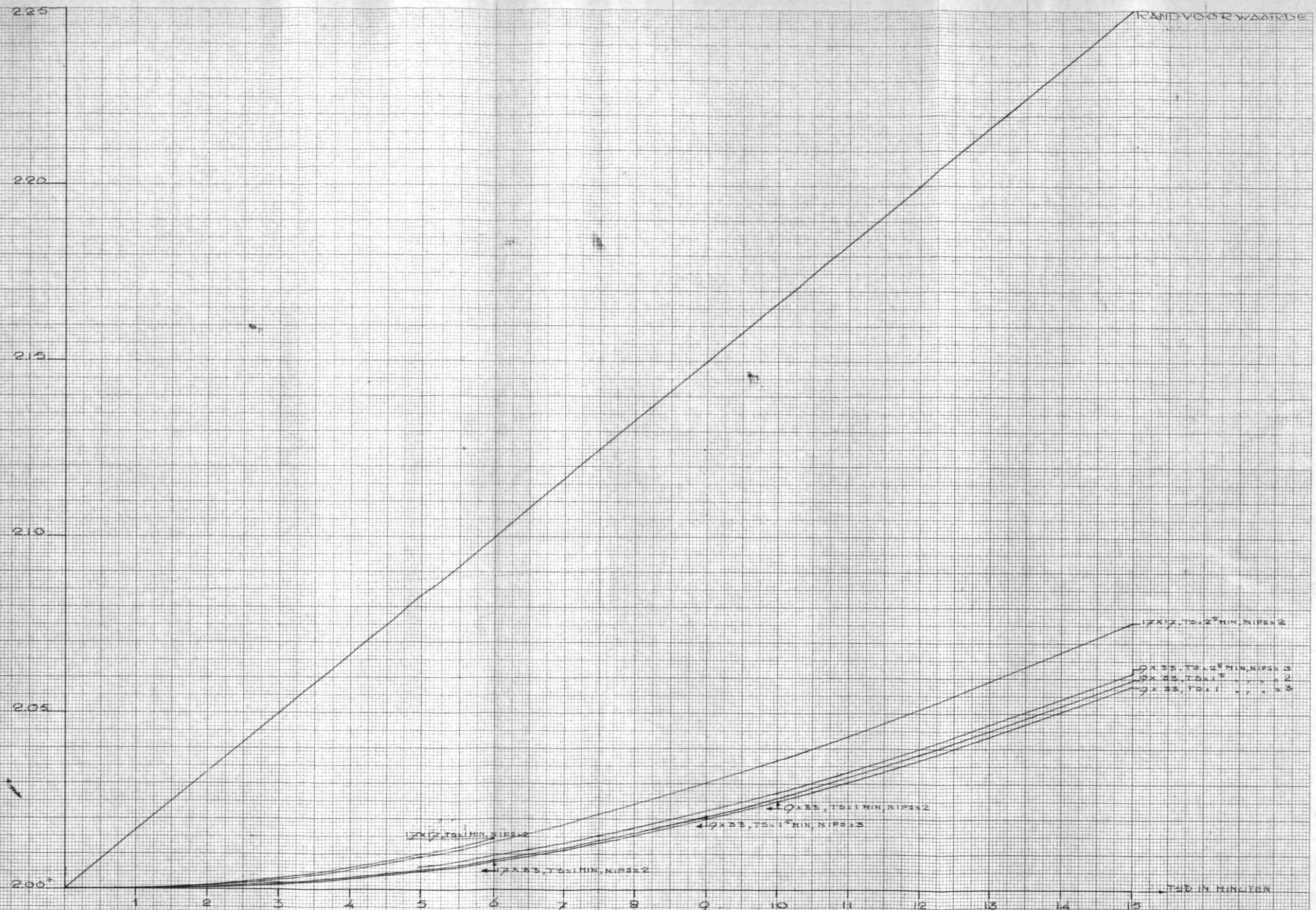
HET RESULTAAT VAN VERSCHILLENDE ONDERVERDELINGEN VERGELEKEN MET 9x33, $t_s = 1$ MIN, NIFS = 3 OP TJDSTIP $t = 15$ MIN

BIJ LINEAIR STIJGENDE RANDVOORWAARDE

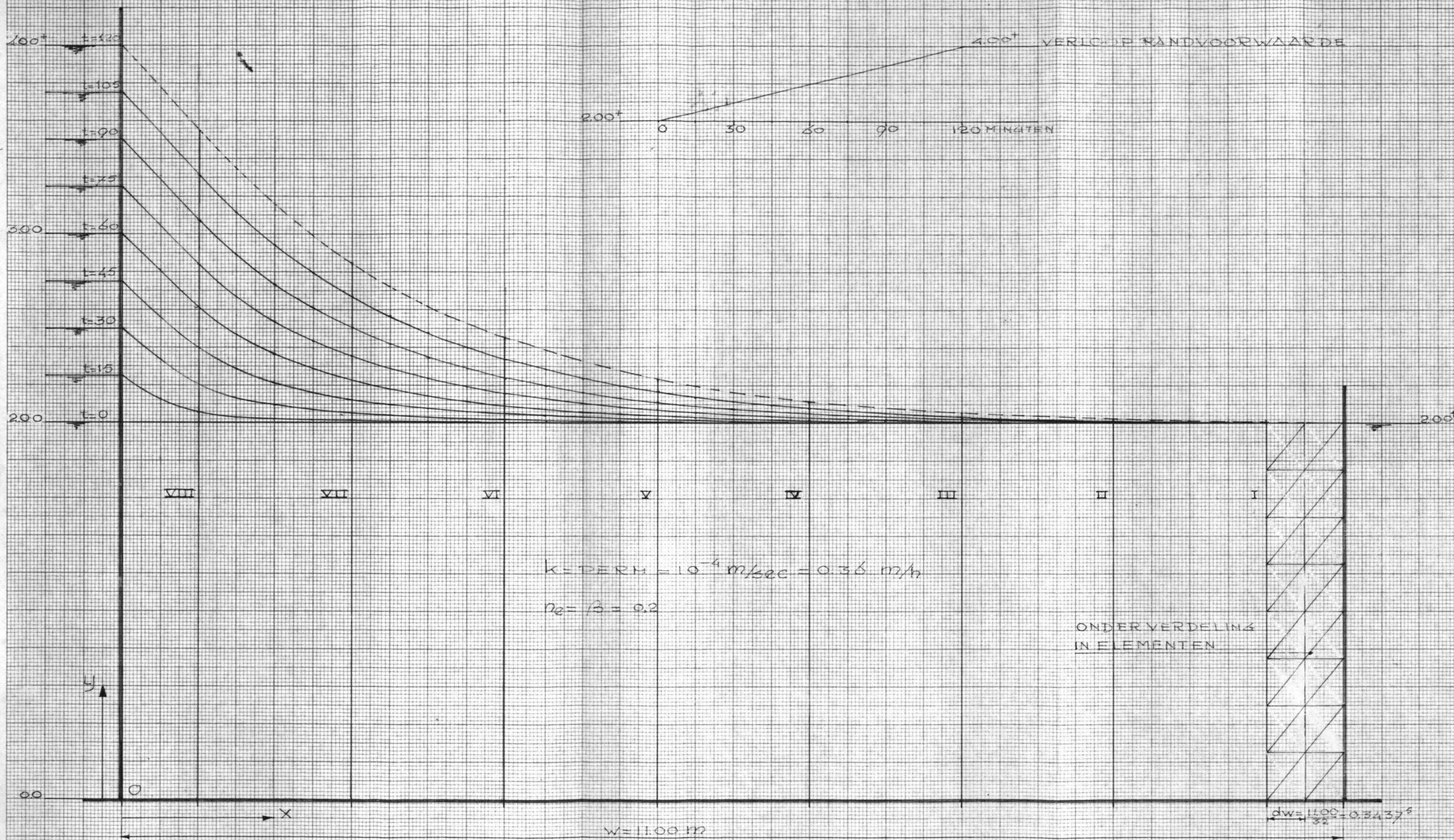
BILAGE VIII.1B



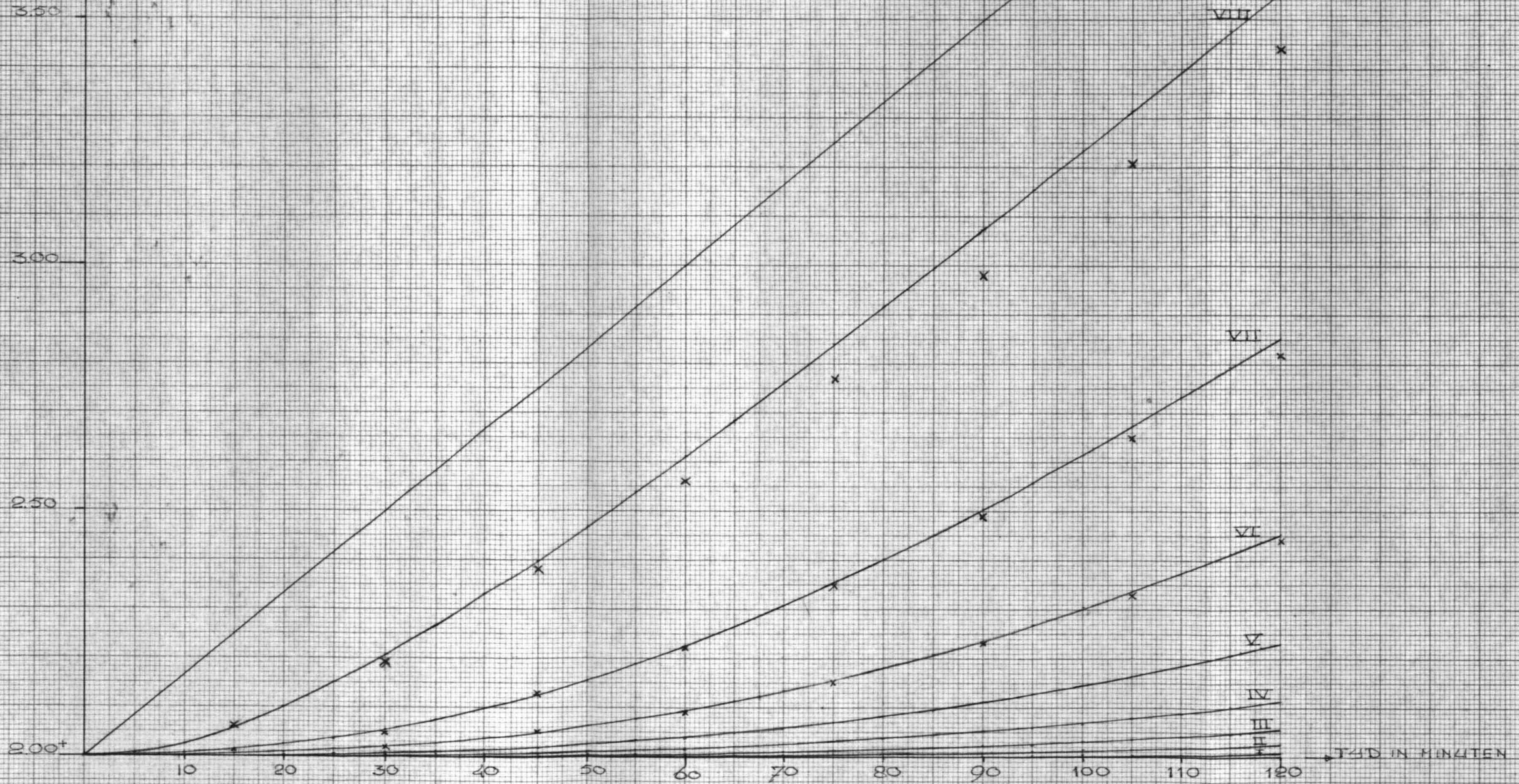
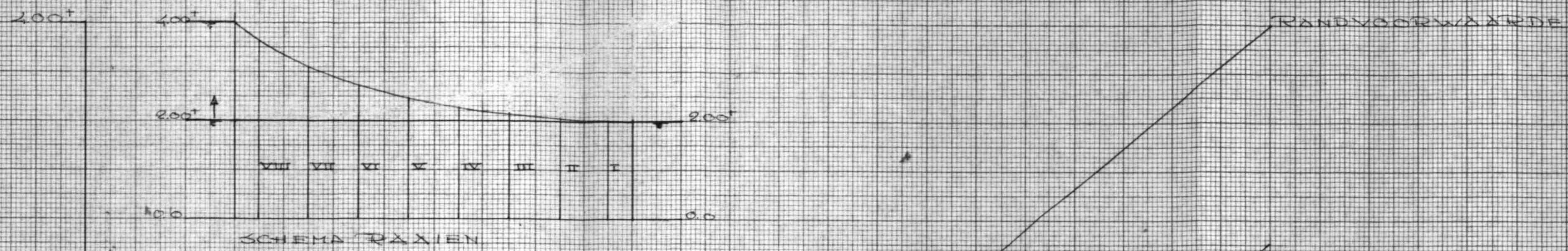
VERLOOP VAN DE HOOGTE VAN HET FREATISCH VLAK IN RAAI VIII BIJ LINEAIR STIJGENDE RANDVOORWAARDE
BIJ VARIATIE VAN ONDERVERDELING, TJDSTAPGROOTTE EN NIFS



VERLOOP VAN DE HOOGTE VAN HET FREATISCH VLAK IN RAAI VIII B4 LINEAIR STAGENDE RANDVOORWAARDE
 B4 VARIATIE VAN ONDERVERDELING 4, TJDSTAPAROOTTE EN NIPS GEDARENDE HET EERSTE KWARTIER

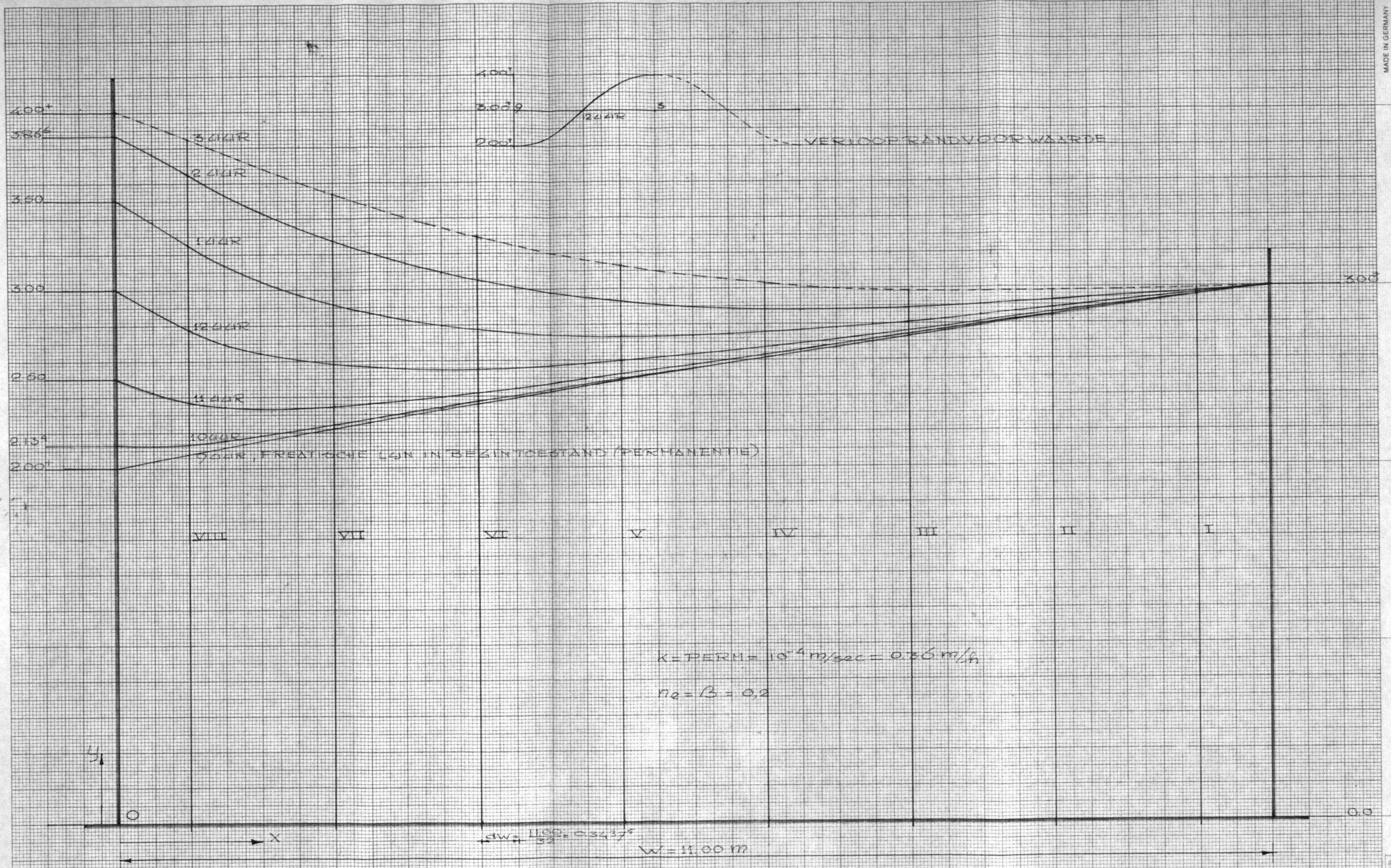


VERLOOP FREATISCH VLAK IN ZANDBLOK BIJ LINEAIR STIJGENDE RANDVOORWAARDE



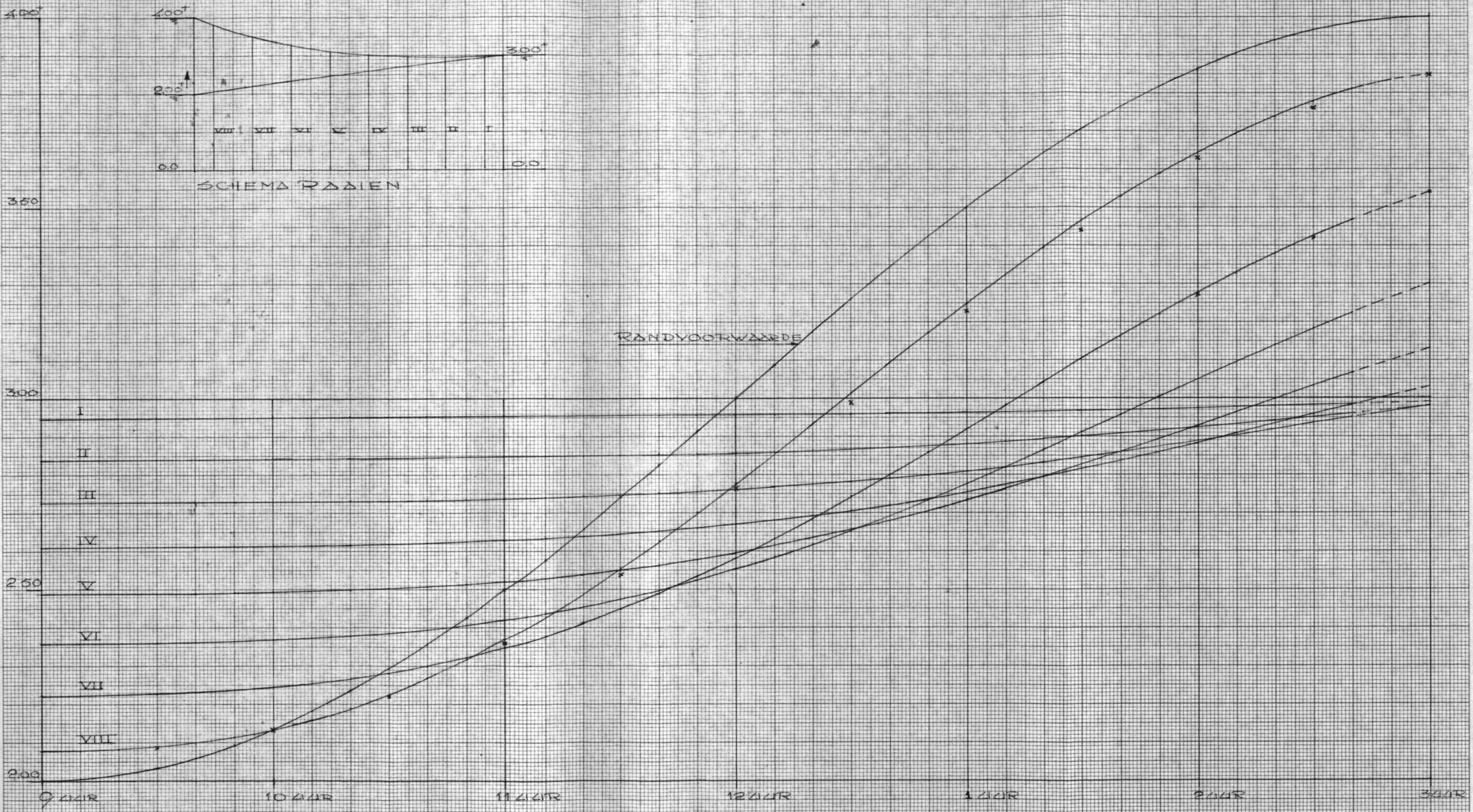
VERLOOP VAN DE HOOGTE VAN HET VRIJE OPPERVLAK IN DE TJD BIJ LINEAIR STIJGENDE RANDVOORWAARDE

BEPAALT MBV ONDERVERDELING 9x33, T₀ = 1 MIN, NIEFS = 3
x WAARDEN VERKREGEN BIJ TOEPASSING VAN DITTE METH. VOLGENS LIT. 7



VERLOOP FREATISCH VLAKE IN ZANDBLOK BIJ PERIODIEK VERLOPENDE RANDVOORWAARDE

MADE IN GERMANY
 SELECT A 3 297 x 420 mm



VERLOOP VAN DE HOOGTE VAN HET VRIJE OPPERVLAK IN DE TJD BIJ PERIODIEK VERLOPENDE RANDVOORWAARDE

WAARDEN VERKREGEN MET ONDERVERDELING 2x33, 16-2⁵MM, NIE5-9
 DIERE METHODE VOLGENS LIT. 7

