A UNIFIED SOLUTION FOR COORDINATION BY TRIGONOMETRIC METHODS

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Abstract

This short essay discusses the application of elementary computation methods for a unified solution of coordination by trigonometry. It means that after computing bearings and distances for establishing rays, coordinates for unfixed point are obtained by using the polar method in the computation process.

Description of the basic concept is completed by the algorithm of a computation process being applicable to HT PTA 4000÷16/SHARP PC 1500A computer written in BASIC language. The software gives a real interactive communication channel between the user and the program.

The portable computer can be combined with a KA 160/CE-516P printer. The software also understands special symbols as well as the Greek and the Hungarian alphabets. Each problem is being supplied by a flowchart of the computation process.

A unique location of a new point, relative to 2 fixed stations can be achieved by observing at least two geometrical parts. Two internal angles or two sides or one angle and one side of a triangle formed by rays connecting control stations and a new point can be the geometrical parts for fixing a point.

Various methods are known for the computation of coordinates of an unfixed station. This paper discusses a unified method that applies entirely polar coordination for fixing a point. Using this method, *intersection by bearings/angles or sides* and *resection, double resection* and other methods *(Hansen, Marek)* of fixing a point can be reduced to a simple computation process of polar coordination.

Notations

l = circle reading
δ = bearing, provisonal bearing
t = distance
z_i = adjusting constant
ZK = mean adjusting constant
α = included angle
β = included angle
γ = included angle
ε = included angle

$$\left.\begin{array}{l} X = \text{(total) northing} \\ Y = \text{(total) easting} \end{array}\right\} \text{total coordinates}$$

$$\left.\begin{array}{l} \Delta X = \text{partial northing} \\ \Delta Y = \text{partial easting} \end{array}\right\} \text{partial coordinates}$$

1. Intersection

1.1. Intersection by angles

Given $A(Y_A; X_A)$; $B(Y_B; X_B)$ and the readings (l_{AP}; l_{AB}; l_{BA}; l_{BP}) to forward directions observed at A an B respectively (Fig. 1).

The internal angles are obtained as follows

$$\alpha = l_{AB} - l_{AP} \quad \text{and} \quad \beta = l_{BP} - l_{BA} \tag{1.1}$$

1.2. Intersection by provisional bearings

Given $A(Y_A; X_A)$; $B(Y_B; X_B)$ and the readings to forward directions observed at A and B. A provisional adjustment is then performed to obtain provisional bearings δ_{AP} and δ_{BP}. The direction method of triangulation is employed in the computation process (Fig. 2).

When the final bearings δ_{AP} and δ_{BP} are given then intersection by bearings is performed (Fig. 3). We also have to notice that the unfixed point P is always the second of the triangle's three points starting from A, and that lettering follows the clockwise rule (APB sequence) in the computation. The arrows pointing to the unfixed station show the bearings, while distances and bearings between AB, AP and BP are denoted by the

$$\begin{array}{ll} \delta_{AB} = \delta_3; & t_{AB} = t_3 \\ \delta_{AP} = \delta_1; & t_{AP} = t_1 \\ \delta_{BP} = \delta_2; & t_{BP} = t_2 \quad \text{symbols.} \end{array}$$

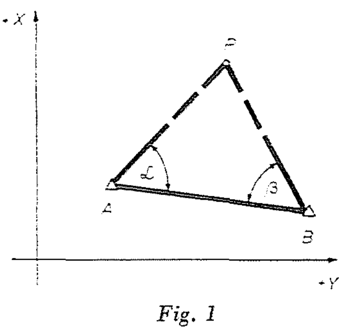


Fig. 1

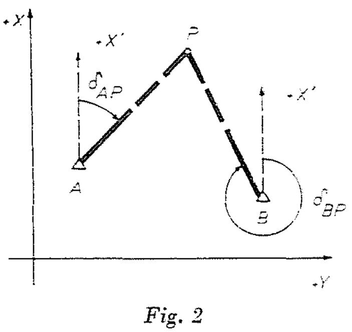


Fig. 2

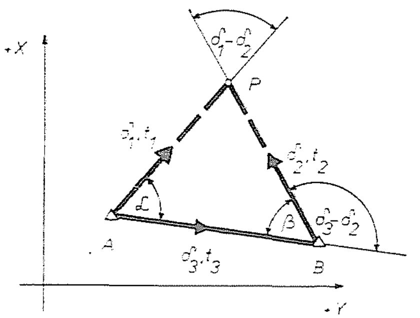


Fig. 3

Coordinates for P will be computed by the polar method based on station A involving δ_1 and t_1. Then δ_1 and δ_2 are computed using the calculated values for δ_3 and t_3 (Fig. 3).

If the angle method is applied then

$$\delta_1 = \delta_3 - \alpha \quad \text{and} \quad \delta_2 = \delta_3 + \beta \tag{1.2}$$

otherwise, δ_1 and δ_2 are known or can be computed by provisional adjustment. The distance t_1 will be obtained by using the sine formula (Fig. 3) as below

$$t_1 = t_3 \frac{\sin(\delta_3 - \delta_2)}{\sin(\delta_1 - \delta_2)} \tag{1.3}$$

The trigonometrical ratio of the compound angle for the numerator of the sine formula gives

$$\sin(\delta_3 - \delta_2) = \sin\delta_3 \cos\delta_2 - \cos\delta_3 \sin\delta_2 \tag{1.4}$$

and substituting Eq. (1.3) for the numerator into Eq. (1.2) we obtain

$$t_1 = \frac{t_3 \sin\delta_3 \cos\delta_2 - t_3 \cos\delta_3 \sin\delta_2}{\sin(\delta_1 - \delta_2)} \tag{1.5}$$

As Fig. 4 shows the following equations can be set up

$$Y_B - Y_A = t_3 \sin\delta_3 \quad \text{and} \quad X_B - X_A = t_3 \cos\delta_3 \tag{1.6}$$

Eq. (1.5) will then be rewritten into the following form

$$t_1 = \frac{(Y_B - Y_A)\cos\delta_2 - (X_B - X_A)\sin\delta_2}{\sin(\delta_1 - \delta_2)} \tag{1.7}$$

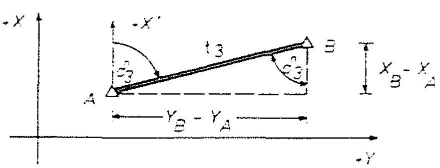


Fig. 4

And coordinates for P are computed from the formulae given below

$$\begin{aligned} Y_P &= Y_A + t_1 \sin \delta_1 \\ X_P &= X_A + t_1 \cos \delta_1 \end{aligned} \tag{1.8}$$

There is *no solution* if

$$\alpha + \beta = W$$

where $W = 180°$ or $W = 200^g$

$$\text{or } \delta_1 = \delta_2 \quad \text{or} \quad t_3 = 0 .$$

When *provisional bearings* are applied to the intersection problem then a semi-graphical provisional adjustment will be performed to the readings of the forward directions. Coordinates for the occupied stations and for the

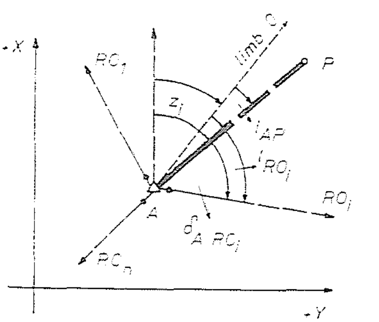


Fig. 5

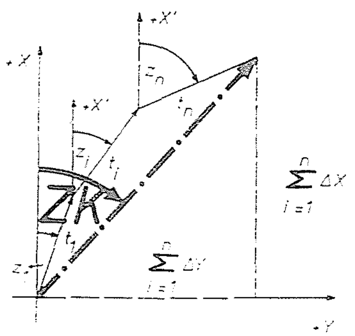


Fig. 6

reference objects are known, as well as a series of readings to the forward directions leading to the ROs and to the unfixed points (Fig. 2 and Fig. 5).

Firstly, a set of adjusting constants (z_i) is created by calculating the differences between the final bearings available and the readings belonging to the same ray. Secondly, coordinate differences (ΔY and ΔX) are computed from the adjusted constants and the corresponding distances. Then the mean adjusting constant is calculated as the closing leg of the traverse line (Fig. 6). This approximate method produces a mean adjusting constant that deviates from the value computed by the numerical method using the weighted mean by 10^{-3} second of arc, therefore, the previous one can be applied to any task that may occur in practice. The adjusting constant then will be computed as follows

$$z_i = \delta_{Ai} - l_{Ai} \tag{1.9}$$

and the distance

$$t_i = \left[(Y_i - Y_A)^2 + (X_i - X_A)^2\right]^{\frac{1}{2}} \tag{1.10}$$

and the coordinate differences

$$\Delta Y_i = t_i \sin z_i \qquad \sum_{i=1}^{n} \Delta Y_i$$

and (1.11)

$$\Delta X_i = t_i \cos z_i \qquad \sum_{i=1}^{n} \Delta X_i$$

If n is the number of the adjusting constants, then the mean value is calculated as follows

$$ZK = \text{arc tan} \frac{\sum_{i=1}^{n} \Delta Y_i}{\sum_{i=1}^{n} \Delta X_i} \tag{1.12}$$

Finally, provisional bearings for the establishing directions are obtained as the sum of the mean adjusting constant and the readings for those rays that terminates at the new point.

Then:

$$\begin{aligned} ZK_A + l_{AP} &= \delta_{AP} \\ ZK_B + l_{BP} &= \delta_{BP} \end{aligned} \tag{1.13}$$

where ZK_A and ZK_B are mean adjusting constants for sets of forward directions observed at station A and B, respectively.

If coordinates of A and B and readings for directions l_{PB}; l_{PA} observed at P and/or l_{AP} and l_{AB} observed at A; or l_{BA} and l_{BP} observed at B; (Fig. 7) are known then the internal angles are as follows

$$\begin{aligned} \beta &= W - (\alpha + \gamma) \\ \alpha &= W - (\beta + \gamma) \end{aligned} \tag{1.14}$$

where $W = 180°$ or $W = 200^g$.

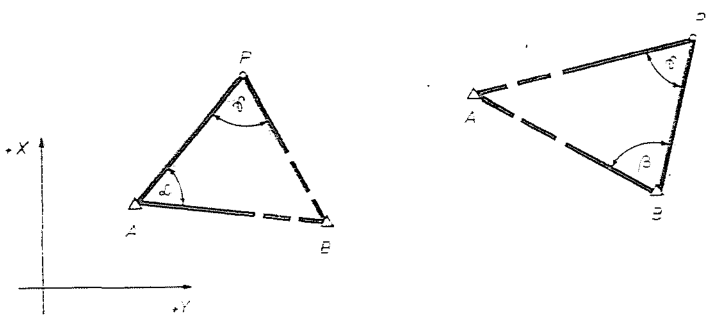


Fig. 7

Further steps in computation agree with those applied for the intersection by angles [also see Eq. (1.2); (1.7); (1.8)].

If coordinates for A and B and distances t_1 and t_2 measured at P are known then δ_3 and t_3 are also computed (Fig. 8).

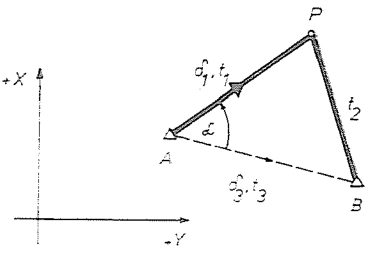


Fig. 8

Coordinates for P will then be computed using polar coordinates from A station. The cosine formula gives the solution for α as below

$$\alpha = \text{arc cos} \frac{t_1^2 + t_3^2 - t_2^2}{2 t_1 t_3} \tag{1.15}$$

Therefore, the final bearing for the forward direction to P [see Eq. (1.2)] is obtained from the following formula

$$\delta_1 = \delta_3 - \alpha$$

Note: There is *no solution* of the problem, if

$$t_1 + t_2 < t_3$$

2. Resection

Solution of resection by the Collinns' point method can be reduced to two repeatedly performed intersections.

Given $A(Y_A; X_A)$; $\mathbf{M}(Y_M; X_M)$; $B(Y_B; X_B)$ and readings to backward directions l_{PA}; l_{PM} and l_{PB} observed at P. The included angles are given as follows (Fig. 9)

$$\alpha = l_{PM} - l_{PA}$$

and (2.1)

$$\beta = l_{PB} - l_{PM}$$

The circle drawn through A, B and P will be cut by a straight line connecting P and M at P' (Fig. 10). Note that $\beta' = W - \beta$ and $\alpha' = W - \alpha$ where $W = 180°$ or $W = 200^g$.

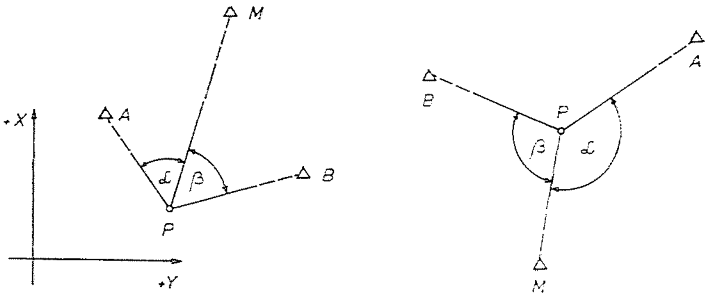


Fig. 9

Coordinates for A and B, and angles α and β are initial facts for the first intersection. After computing values of δ_3 and t_3, two bearings (δ_1 and δ_2) will be obtained from the following formulae

$$\delta_1 = \delta_3 - \beta \qquad \delta_2 = \delta_3 + \alpha\,. \tag{2.2}$$

The distance t_1 is then computed as it is shown in Eq. (1.7) where the sine rule has been applied, and Eq. (1.8) is available for computing the coordinates of P' the same as those for the first procedure.

Firstly, the bearing $\delta_{MP'} = \delta_3'$ and the distance $t_{MP'} = t_3'$ secondly, δ_1 and δ_2' bearings are computed as follows

$$\delta_1' = \delta_3' - \alpha \qquad \text{and} \qquad \delta_2' = \delta_3' + \beta \tag{2.3}$$

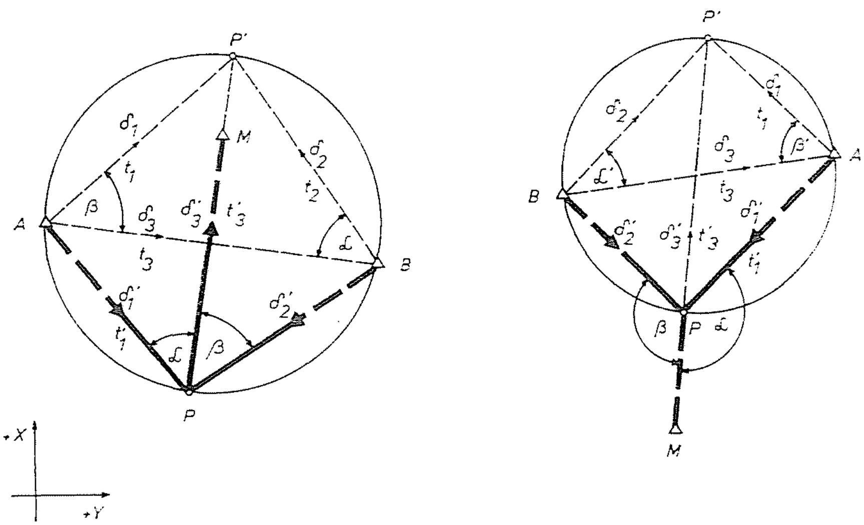


Fig. 10

Then, t_1' distance is calculated using the sine formula as shown below

$$t_1' = \frac{(Y_B - Y_A)\cos\delta_2' - (X_B - X_A)\sin\delta_2'}{\sin(\delta_1' - \delta_2')} \tag{2.4}$$

Finally, coordinates of P will be computed using polar coordinates

$$Y_P = Y_A + t_1' \sin\delta_1'$$

and (2.5)

$$X_P = X_A + t_1' \cos\delta_2'$$

The problem can be solved if

$$\alpha + \beta = W \qquad \text{and} \qquad t_{MP'} = 0 \tag{2.6}$$

$$\text{where } W = 180^\circ \text{ or } W = 200^g$$

otherwise

a) In the case of $\alpha + \beta = W$ the circle involving points A, B and P becomes a straight line and gives no solution.
The bearings δ_1 and δ_2 become parallel lines and cuts can not be achieved.
b) If $t_{MP'} = 0$ then M falls onto P' ($M = P'$ and $\delta_3' = 0$).

3. Double resection

Double resection, and its specific versions such as the Hansen and the Marek methods can be traced back to a simple resection that involves auxiliary stations in the computation.

Given $A(Y_A; X_A)$; $B(Y_B; X_B)$ and $C(Y_C; X_C)$ as well as readings l_{PA}; l_{PB}; l_{PR} to backward directions observed at P and those l_{RP}; l_{RB}; l_{RC} to forward directions observed at R (Fig. 11).

The included angles are as follows:

$$\alpha = l_{PR} - l_{PB}; \qquad \beta = l_{PB} - l_{PA}$$
$$\gamma = l_{RB} - l_{RP}; \qquad \varepsilon = l_{RC} - l_{RB} \tag{3.1}$$

First, coordinates for P' are computed. The circle, drawn through A, B and P, is cut by the straight line joining P and R at P'. Similarly, the circle drawn through B, C and R is cut by the same line at R'.

The initial data for the computation of P' by intersection are $A(Y_A; X_A)$ and $B(Y_B; X_B)$ as well as angles α and $W - (\alpha + \beta)$. After calculating bearing δ_3 and distance t_3, the δ_1 and δ_2 can be obtained as follows (Fig. 11)

$$\delta_1 = \delta_3 - [W - (\alpha + \beta)]; \qquad \delta_2 = \delta_3 + \alpha \tag{3.2}$$

Also note that $\delta_3 = \delta_{BA}$ and $t_3 = t_{BA}$!

The t_1 distance will then computed by applying Eq. (1.7) while the coordinates for P' is obtained by Eq. (1.8).

The initial data for the computation of R' by intersection are $B(Y_B; X_B)$ and $C(Y_C; X_C)$ as well as angles $W - (\gamma + \varepsilon)$ and γ. After computing bearing $\bar{\delta}_3$ and distance $\bar{t}_3$, $\bar{\delta}_1$ and $\bar{\delta}_2$ are calculated as follows

$$\bar{\delta}_1 = \bar{\delta}_3 - \gamma; \qquad \bar{\delta}_2 = \bar{\delta}_3 + [W - (\gamma + \varepsilon)] \tag{3.3}$$

Also note, that $\bar{\delta}_3 = \delta_{CB}$ and $\bar{t}_3 = t_{CB}$!

Coordinates for R' will then be obtained by using polar coordinates in Eq. (1.7) and Eq. (1.8).

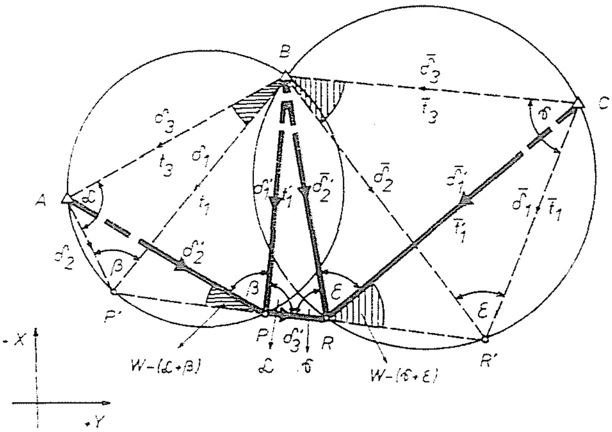


Fig. 11

If coordinates for P' and R' are available, then bearing δ_3' can be obtained and the bearing to P and R can also be computed.

Coordinates for P will be computed by intersection, where initial data are the same that have been used earlier for computing coordinates for P'. The bearings applied are

$$\delta_1' = \delta_3' - \alpha; \qquad \delta_2' = \delta_3' + [W - (\alpha + \beta)] \tag{3.4}$$

Since, bearing δ_3 and distance t_3 are given (see computation of coordinates for P'), hence the bearings $\bar{\delta}_1'$ and $\bar{\delta}_2'$ are

$$\bar{\delta}_1' = \bar{\delta}_3' - [W - (\gamma + \varepsilon)]; \qquad \bar{\delta}_2' = \bar{\delta}_3' + \gamma \tag{3.5}$$

Knowing these bearings, P and R coordinates can be computed from B and C by the polar method (see Eq. (1.7) and Eq. (1.8)).

4. The Hansen method

Given $A(Y_A, X_A)$; $B(Y_B, X_B)$ and readings l_{PA}, l_{PR}, l_{PB} for backward directions observed at P; and l_{RB}, l_{RP}, l_{RA} observed at R (Fig. 12)t Then the angles are as follows

$$\alpha = l_{PR} - l_{PA}; \qquad \beta = l_{PB} - l_{PR}$$
$$\gamma = l_{RP} - l_{RB}; \qquad \varepsilon = l_{RA} - l_{RP} \tag{4.1}$$

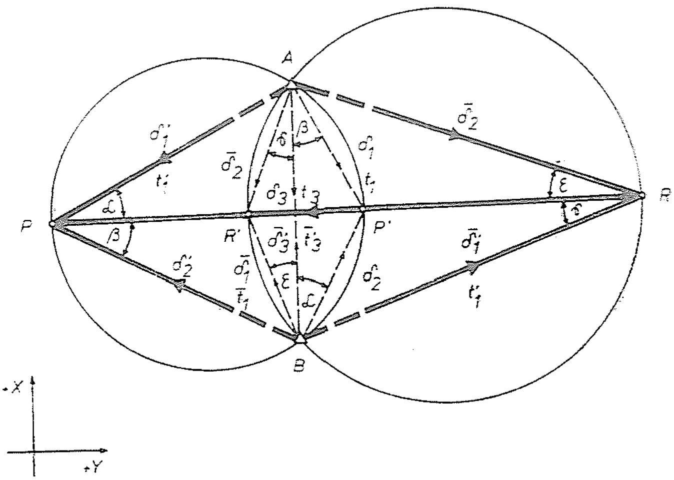


Fig. 12

The circle drawn through A, B and P points is cut by a straight line joining P and R stations at point P'. The same line also cuts a circle drawn through A, R and B at R'.

Coordinates for P' can be calculated from the given coordinates of A and B also involving α and β angles using the intersection method for computation (Fig. 12). The bearings are

$$\delta_1 = \delta_3 - \beta; \qquad \delta_2 = \delta_3 + \alpha \tag{4.2}$$

Coordinates for P' will then be computed from Eq. (1.2).

To obtain coordinates for R', γ and ε angles and coordinates of A and B are used. The required bearings then

$$\bar{\delta}_1 = \bar{\delta}_3 - \varepsilon; \qquad \bar{\delta}_2 = \bar{\delta}_3 + \gamma \tag{4.3}$$

And the coordinates for R' can be calculated by Eq. (1.2).

Then the bearings (pointing to P and R stations) will be computed considering that $\delta_3' = \delta_{P'R'}$.

A repeatedly performed intersection leads to coordinates for P.

Coordinates and angles used in the computation are the same as the values applied to the coordinates for P'. Bearings are calculated as follows

$$\delta_1' = \delta_3' - \alpha; \qquad \delta_2' = \delta_3' + \beta \tag{4.4}$$

The $\bar{\delta}_3$ bearing and $\bar{t}_3$ distance as well as the angles are the same as those used in the computation of R' when coordinates are being computed for R. Further bearings can be obtained from the following formulae

$$\bar{\delta}_1' = \bar{\delta}_3' - \gamma; \qquad \bar{\delta}_2' = \bar{\delta}_3' + \varepsilon \tag{4.5}$$

After knowing these bearings, coordinates for P are computed based on A station while coordinates for R can be calculated from B station by the polar method [see Eq. (1.7) and Eq. (1.8)].

5. The Marek method

Given $A(Y_A, X_A)$, $B(Y_B, X_B)$, $C(Y_C, X_C)$ and $D(Y_D, X_D)$ as well as readings for backward directions l_{PB}, l_{PR}, l_{PA} and l_{RD}, l_{RP}, l_{RC} (Fig. 13). Then the included angles are

$$\alpha = l_{PA} - l_{PR}; \qquad \beta = l_{PR} - l_{PB}$$
$$\gamma = l_{RC} - l_{RP}; \qquad \varepsilon = l_{RP} - l_{RD} \tag{5.1}$$

The circle drawn through A, B and P is cut by a straight line joining P and R at P' while another circle drawn through C, D and R is cut by the same line at R'. The computation process will then be started by calculating

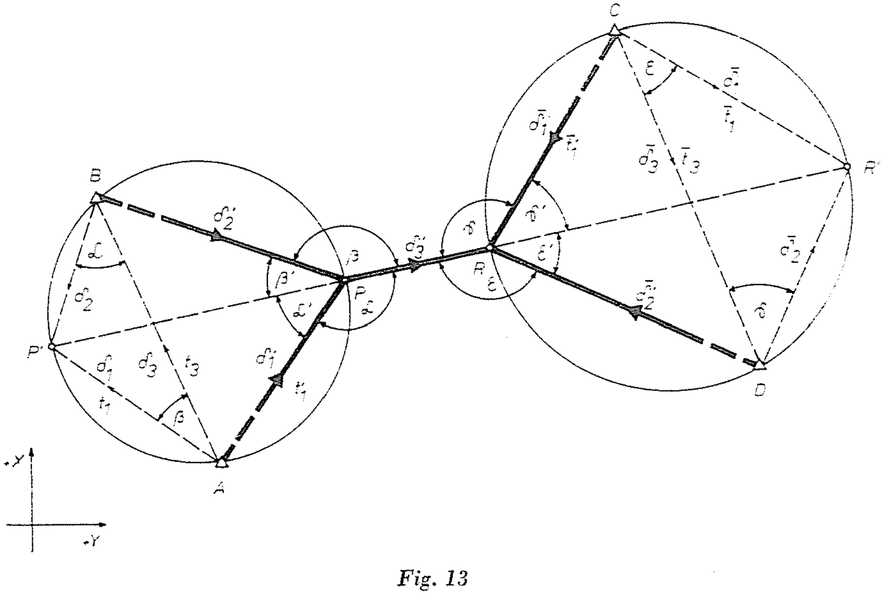


Fig. 13

coordinates for P' by using the coordinates of A and B and α and β angles (Fig. 13). It should also be noted that $\delta_3 = \delta_{AB}$ and $t_3 = t_{AB}$. Then the bearings needed for further calculations are

$$\delta_1 = \delta_3 - \beta'; \qquad \delta_2 = \delta_3 + \alpha' \tag{5.2}$$

where

$$\beta' = W - \beta \quad \text{and} \quad \alpha' = W - \alpha \tag{5.3}$$

and

$$W = 180^\circ \quad \text{or} \quad W = 200^g.$$

Equations (1.7) and (1.8) are useful for the computation of the distance t_1 and the coordinates of P'.

Similarly, coordinates for R' are computed from the coordinates of C and D using γ and ε angles as well (Fig. 13). It should be noted that $\bar{\delta}_3 = \delta_{CD}$; $\bar{t}_3 = t_{CD}$.

Then, the bearings come from the following formulae

$$\bar{\delta}_1 = \bar{\delta}_3 - \varepsilon'; \qquad \bar{\delta}_2 = \bar{\delta}_3 + \gamma' \tag{5.4}$$

where

$$\varepsilon' = W - \varepsilon \quad \text{and} \quad \gamma' = W - \gamma \tag{5.5}$$

and

$$W = 180^\circ \quad \text{or} \quad W = 200^g.$$

Equations (1.7) and (1.8) will be used in the calculation and coordinates for R'. Knowing the coordinates for P' and R', and considering that $\delta_3' = \delta_{P'R'}$, bearings belonging to the establishing directions can be obtained.

When the coordinates for P are being computed, then the same initial data are used, except the bearings that follow

$$\delta_1' = \delta_3' - \alpha' \qquad \delta_2' = \delta_3' + \beta' \tag{5.6}$$

Similarly, the computation of the coordinates for R requires the data that has been applied to the computation of $Y_{R'}$ and $X_{R'}$ coordinates. In this case, the bearings are

$$\bar{\delta}_1' = \bar{\delta}_3' - \gamma'; \qquad \bar{\delta}_2' = \bar{\delta}_3' + \varepsilon' \tag{5.7}$$

Using the equations (5.6) and (5.7) then Eq. (1.7) and (1.6), coordinates for P and R can be obtained by the application of the polar method and also involving the coordinates of B and C.

6. Program description

The unified solution of coordination is being supported by a software program which is written in BASIC language and applicable to HT PTA 4000 + 16/SHARP PC 1500 A portable computers.

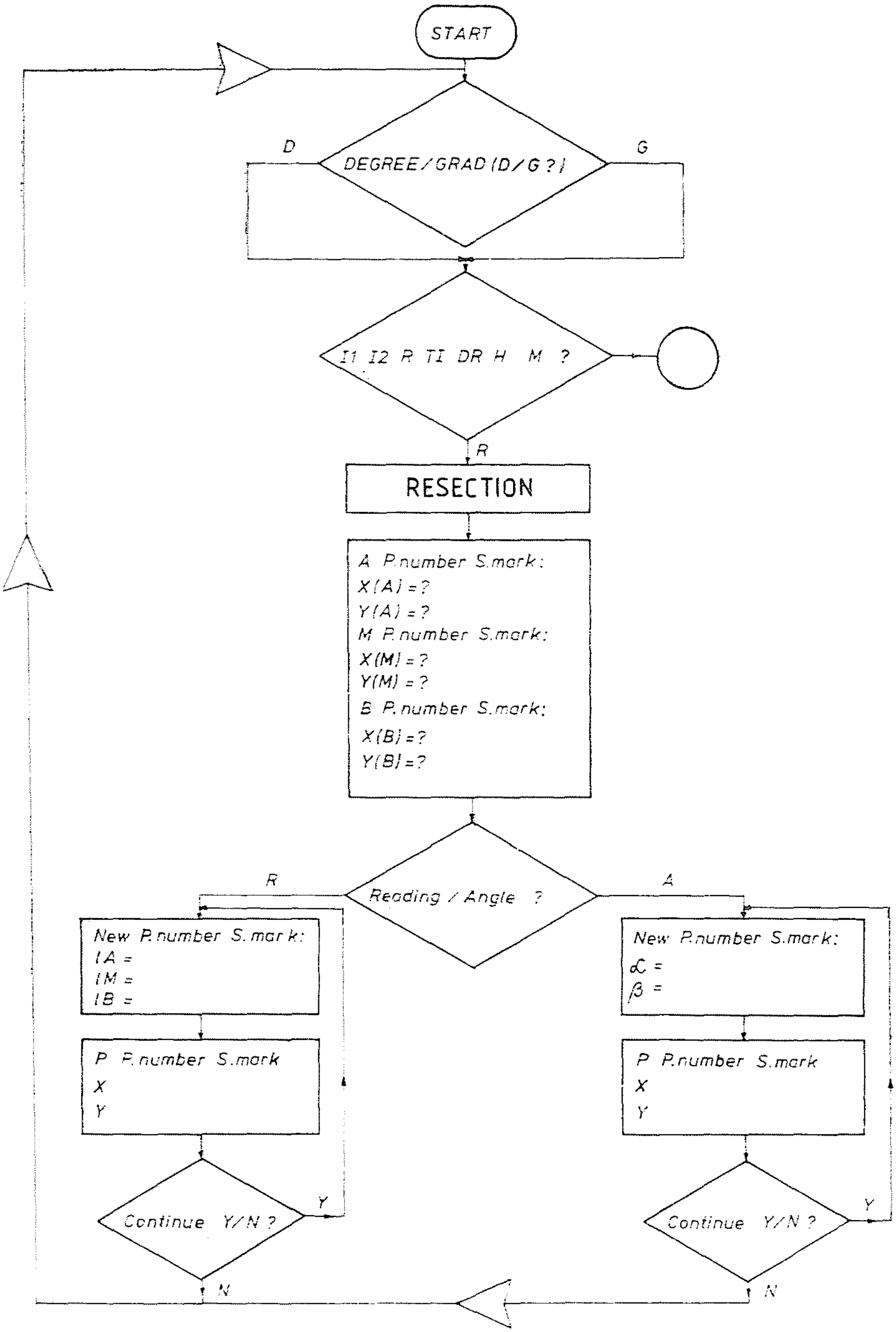

START
DEGREE/GRAD (D/G ?)
D
G
I1 I2 R TI DR H M ?
R
RESECTION
A P.number S.mark:
X(A) = ?
Y(A) = ?
M P.number S.mark:
X(M) = ?
Y(M) = ?
B P.number S.mark:
X(B) = ?
Y(B) = ?
Reading / Angle ?
R
A
New P.number S.mark:
IA =
IM =
IB =
New P.number S.mark:
α =
β =
P P.number S.mark
X
Y
P P.number S.mark
X
Y
Continue Y/N ?
Y
N
Continue Y/N ?
Y
N

Fig. 14

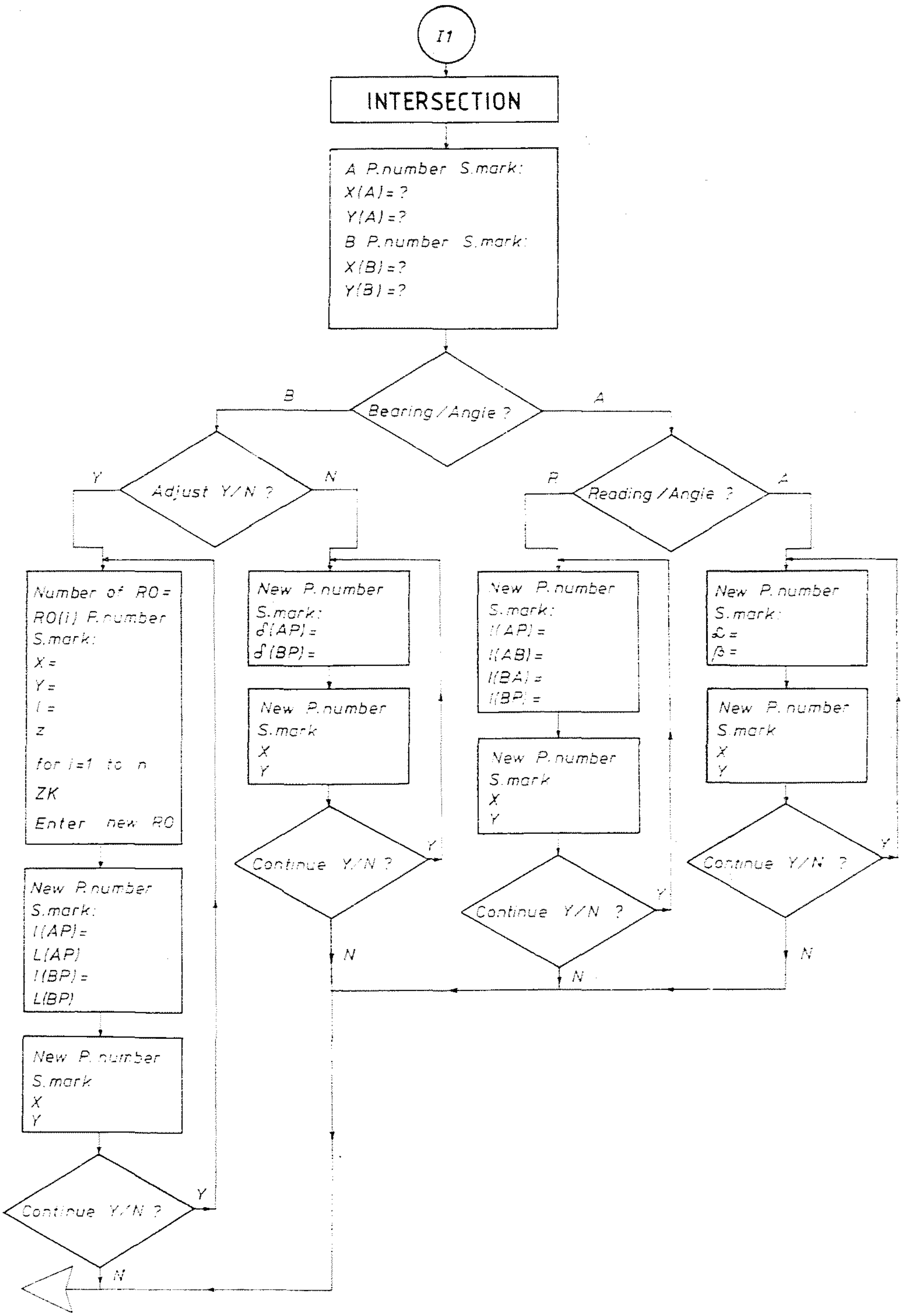

I1
INTERSECTION
A P.number S.mark:
X(A) = ?
Y(A) = ?
B P.number S.mark:
X(B) = ?
Y(B) = ?
Bearing / Angle ?
B
A
Adjust Y/N ?
Y
N
Reading / Angle ?
R
A
Number of RO =
RO(i) P.number
S.mark:
X =
Y =
l =
z
for i=1 to n
ZK
Enter new RO
New P.number
S.mark:
l(AP) =
L(AP)
l(BP) =
L(BP)
New P.number
S.mark
X
Y
Continue Y/N ?
New P.number
S.mark:
δ(AP) =
δ(BP) =
New P.number
S.mark
X
Y
Continue Y/N ?
New P.number
S.mark:
l(AP) =
l(AB) =
l(BA) =
l(BP) =
New P.number
S.mark
X
Y
Continue Y/N ?
New P.number
S.mark:
α =
β =
New P.number
S.mark
X
Y
Continue Y/N ?

Fig. 15

The user of the program is supplied with a real interactive software that makes usage of the program easy. As the flowchart of the program indicates, after entering the name of the program and starting it, the computer will ask for the input data. In the case of options, these might be the answers to the questions required by the program.

First, the option is selected according to the circle reading made on the theodolite, as shown below

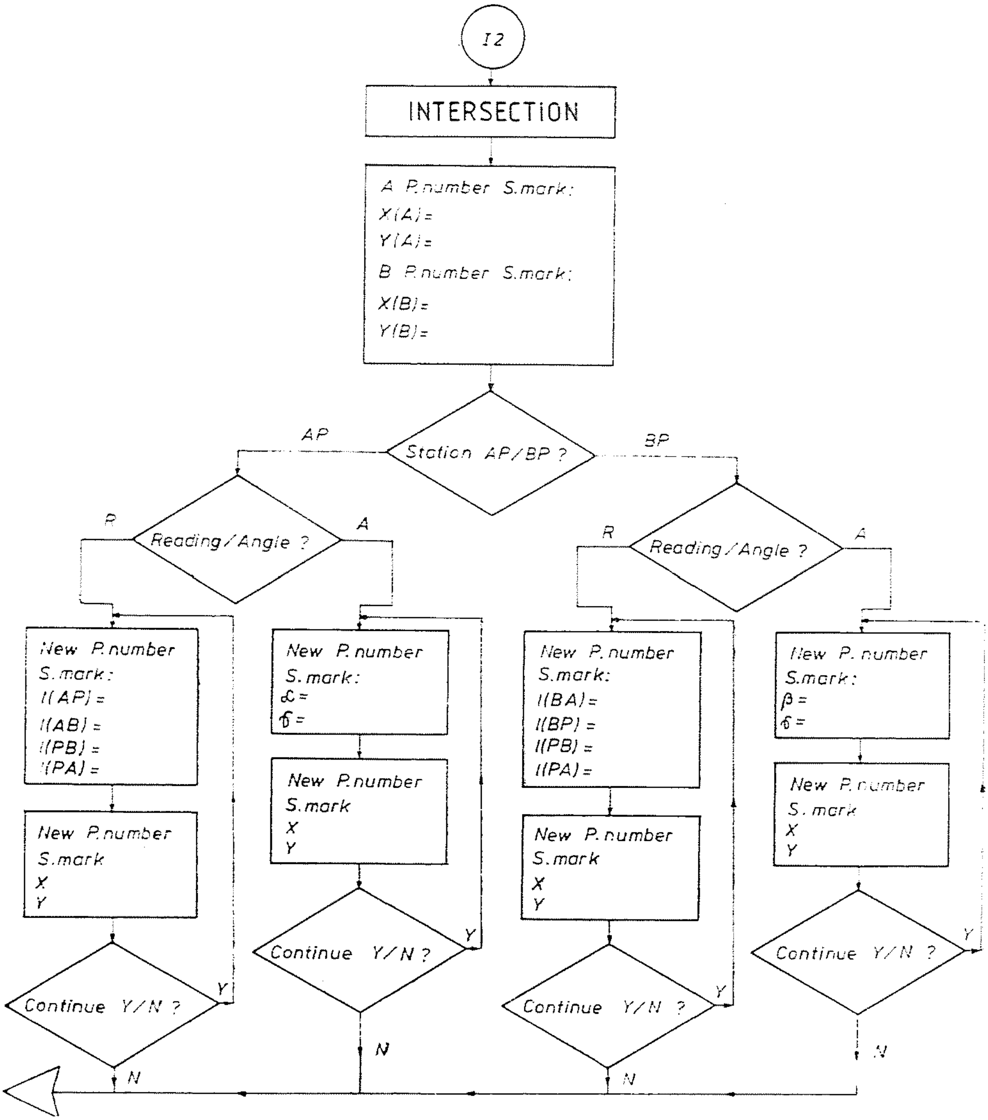


Fig. 16

DEGREE/GRAD (D/G?)

Secondly, the method of coordination is being chosen as below

I1 I2 R TI DR H M ?

Notations

I1 = intersection (angles/provisional bearing)
I2 = intersection (special version)
R = resection
TI = intersection by length
DR = double resection
H = Hansen method
M = Marek method

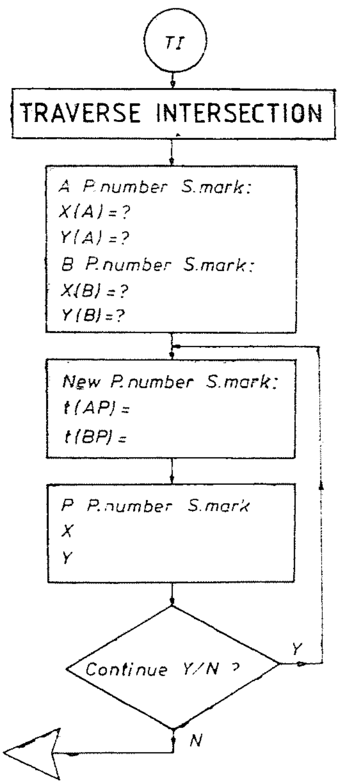


Fig. 17

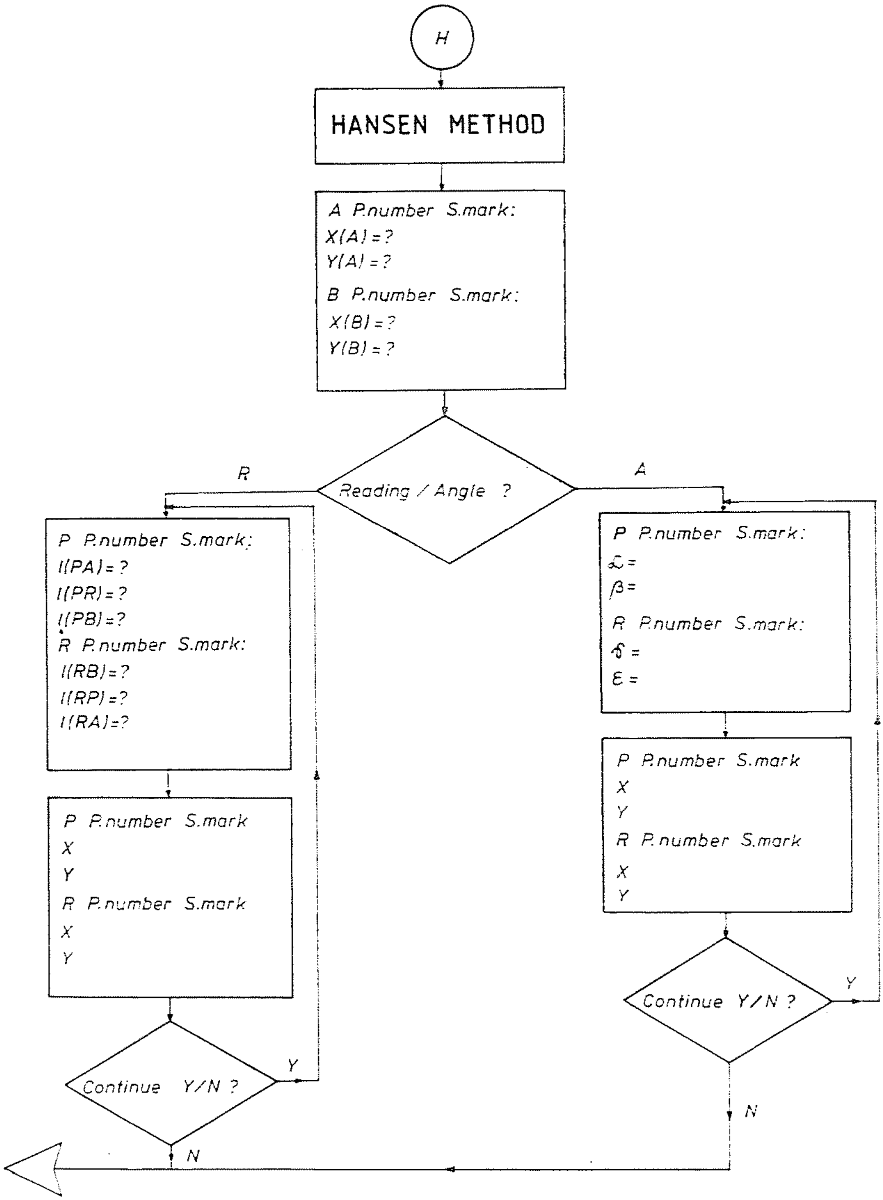
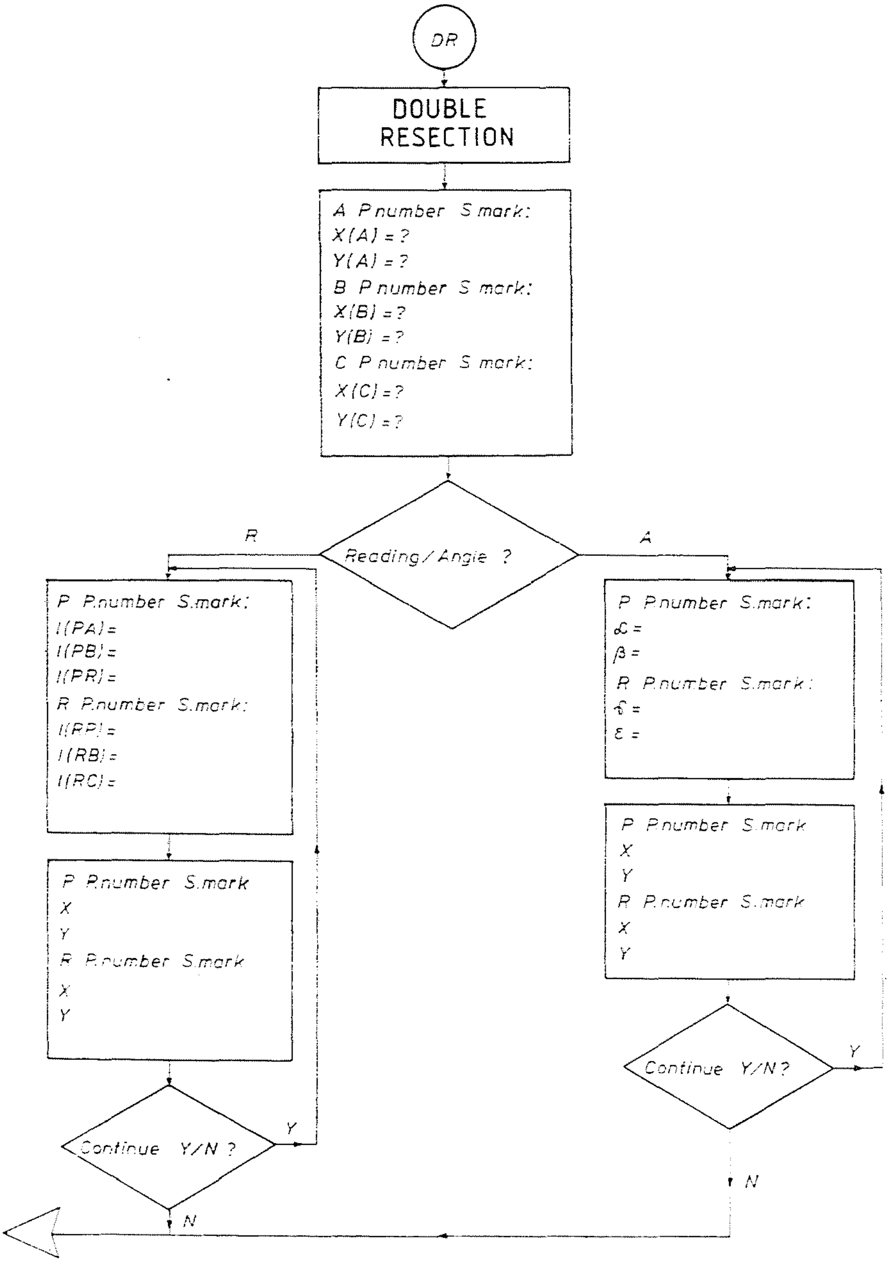

H
HANSEN METHOD
A P.number S.mark:
X(A) = ?
Y(A) = ?
B P.number S.mark:
X(B) = ?
Y(B) = ?
Reading / Angle ?
R
A
P P.number S.mark:
l(PA) = ?
l(PR) = ?
l(PB) = ?
R P.number S.mark:
l(RB) = ?
l(RP) = ?
l(RA) = ?
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N
P P.number S.mark:
α =
β =
R P.number S.mark:
γ =
ε =
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N

Fig. 18a



DR
DOUBLE RESECTION
A P.number S.mark:
X(A) = ?
Y(A) = ?
B P.number S.mark:
X(B) = ?
Y(B) = ?
C P.number S.mark:
X(C) = ?
Y(C) = ?
Reading/Angle ?
R
A
P P.number S.mark:
l(PA) =
l(PB) =
l(PR) =
R P.number S.mark:
l(RP) =
l(RB) =
l(RC) =
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N
P P.number S.mark:
α =
β =
R P.number S.mark:
δ =
ε =
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N

Fig. 18b

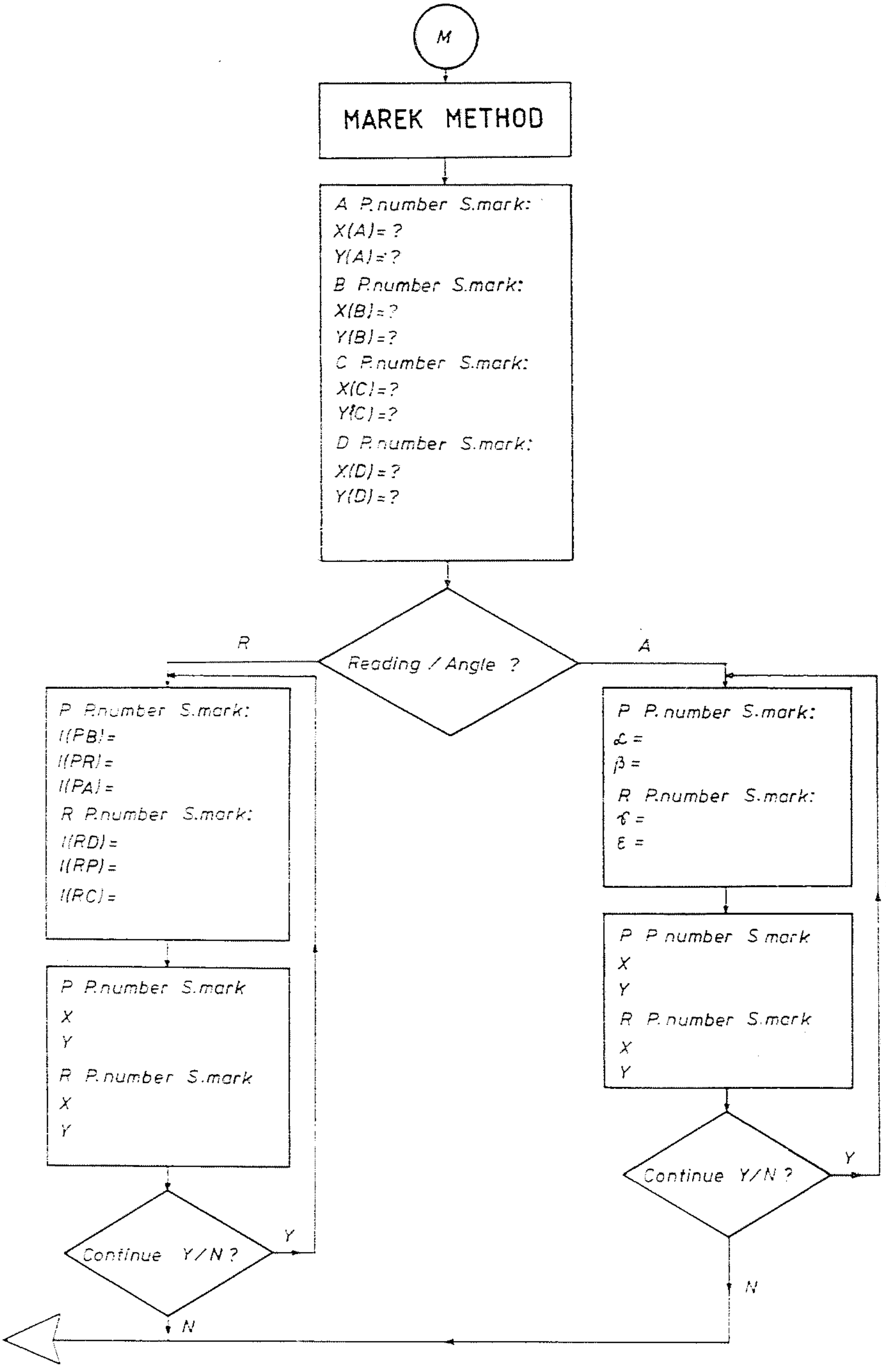

M
MAREK METHOD
A P.number S.mark:
X(A)= ?
Y(A)= ?
B P.number S.mark:
X(B)= ?
Y(B)= ?
C P.number S.mark:
X(C)= ?
Y(C)= ?
D P.number S.mark:
X(D)= ?
Y(D)= ?
Reading / Angle ?
R
A
P P.number S.mark:
l(PB)=
l(PR)=
l(PA)=
R P.number S.mark:
l(RD)=
l(RP)=
l(RC)=
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N
P P.number S.mark:
α =
β =
R P.number S.mark:
γ =
ε =
P P.number S.mark
X
Y
R P.number S.mark
X
Y
Continue Y/N ?
Y
N

Fig. 19

```
10:"C"REM
   COORDINATION
15:REM Programmer
    ERIK PAPP
   01-17-1989
20:CLEAR :CLS
   INPUT "DEGREE/
   GRAD      (D/G
   ?) ";D$
25:IF (D$="D")+(D
   $="G")
    <>1THEN 20
30:IF D$="D"THEN
   DEGREE :W=180:
   O=360:O$="DEGR
   EE":GOTO 40
35:IF D$="G"THEN
   GRAD :W=200:O=
   400:O$=" GRAD"
40:CLS :INPUT " I
   1 I2 R TI DR H
     M  ? ";U$
45:IF (U$="I1")+(
   U$="I2")+(U$="
   R")+(U$="TI")+
   (U$="DR")+(U$=
   "H"  )+(U$="M"
   )<>1THEN 40
50:IF U$="I1"THEN
   180
55:IF U$="I2"THEN
   220
60:IF U$="R"THEN
   90
65:IF U$="TI"THEN
   990
70:IF U$="DR"THEN
   1060
75:IF U$="H"  THEN
   1210
80:IF U$="M"  THEN
   1370
90:CSIZE 3:LPRINT
   "  RESECTION":
   LPRINT "  ----
   ------";GOSUB 1
   520:DIM A(3,2)
   ,A$(3),P$(3)
100:A$(1)="A",A$(2
    )="M":A$(3)="B
    ";N=3;GOSUB 15
    25
110:GOSUB 1590:IF
    (I$="R")+(I$="
    A")<>1GOSUB 15
    90
115:IF I$="R"THEN
    130
120:IF I$="A"THEN
    125
125:U4=1:U=1:COSUB
    1580:GOTO 1600
130:GOSUB 1590:U4=
    0;CLS :INPUT "
    |A=";LA,"|M=";
    LK,"|B=";LB;S$
    ="L=":S=LA;
    COSUB 1740;S=L
    K;GOSUB 1740
135:S=LB;GOSUB 174
    0:IF W=180AND
    O=360THEN LET
    LA=DEG LA:LK=
    DEG LK:LB=DEG
    LB
140:A=LK-LA:B=LB-L
    K;U=1:GOSUB 16
    15
145:IF (A+B)=WTHEN
    1780
150:I=3; J=1:U=1:
    COSUB 1650:D3=
    D;D1=D3-B;D2=D
    3+A;GOSUB 1700
    :Y=DY;X=DX
155:DY=YP-A(2,1):D
    X=XP-A(2,2):
    GOSUB 1660:D3=
    D:D1=D3-A:D2=D
    3+B;U=0:DY=Y;D
    X=X:GOSUB 1700
158:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
160:IF (K$="Y")+(K
    $="N")<>1THEN
    158
165:IF K$="Y"AND U
    4=1THEN 125
170:IF K$="Y"AND U
    4=0THEN 130
175:IF K$="N"THEN
    20
180:CSIZE 3;LPRINT
    "INTERSECTION"
    :LPRINT "-----
    -------":COSUB
    1520:DIM A(2,2
    ),A$(2),P$(2)
190:A$(1)="A":A$(2
    )="B":N=2:
    GOSUB 1525
200:CLS :INPUT "Be
    aring / Angle
    ? ";B$
205:IF (B$="B")+(B
    $="A")<>1THEN
    200
210:IF B$="B"THEN
    310
215:IF B$="A"THEN
    220
220:GOSUB 1590:IF
    (I$="R")+(I$="
    A")<>1GOSUB 15
    90
225:IF I$="R"THEN
    240
230:IF I$="A"THEN
    290
240:GOSUB 1580:
    INPUT "|(AP)="
    :AP,"|(AB)=";A
    B,"|(BA)=";BA,
    "|(BP)=";BP:S$
    ="L="
250:S=AP:GOSUB 174
    0:S=AB:GOSUB 1
    740:LPRINT :S=
    BA:GOSUB 1740:
    S=BP:GOSUB 174
    0
```

Fig. 20

```
255:IF W=18ØAND Q=
    36ØTHEN LET AP
    =DEG AP:AB=DEG
    AP:BA=DEG BA:B
    P=DEG BP
26Ø:A=AB-AP:B=BP-B
    A:U=1:GOSUB 16
    15:I=2:J=1:U=Ø
265:IF (A+B)=WTHEN
    178Ø
27Ø:GOSUB 165Ø:D3=
    D:D1=D3-A:D2=D
    3+B:GOSUB 17ØØ
    :IF U1=1THEN
    RETURN
273:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
275:IF (K$="Y")+(K
    $="N")<>1THEN
    273
28Ø:IF K$="Y"THEN
    24Ø
285:IF K$="N"THEN
    2Ø
29Ø:GOSUB 158Ø:
    GOSUB 16ØØ:U=Ø
    :U1=1:I=2:J=1:
    GOSUB 265
293:INPUT "Continu
    e Y/N ? ";K$
295:IF (K$="Y")+(K
    $="N")<>1THEN
    293
3ØØ:IF K$="Y"THEN
    29Ø
3Ø5:IF K$="N"THEN
    2Ø
31Ø:CLS :INPUT "Ad
    just Y/N ? ";T
    $
315:IF (T$="Y")+(T
    $="N")<>1THEN
    31Ø
32Ø:IF T$="Y"THEN
    37Ø
325:IF T$="N"THEN
    33Ø
33Ø:GOSUB 158Ø:
    INPUT "δ(AP)="
    ;D1,"δ(BP)=";D
    2:S$="δ=":S=D1
    :GOSUB 174Ø:S=
    D2:GOSUB 174Ø
335:IF W=18ØAND Q=
    36ØTHEN LET D1
    =DEG D1:D2=DEG
    D2
34Ø:IF ABS (D1)=
    ABS (D2)THEN 1
    78Ø
35Ø:I=2:J=1:GOSUB
    165Ø:GOSUB 17Ø
    Ø
353:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
355:IF (K$="Y")+(K
    $="N")<>1THEN
    353
36Ø:IF K$="Y"THEN
    33Ø
365:IF K$="N"THEN
    2Ø
37Ø:CLS :INPUT "Nu
    mber of RO= ";
    M:DIM B(M,2),C
    (M),T$(M):SY=Ø
    :SX=Ø
38Ø:FOR U=1TO M:
    CLS :WAIT Ø:
    PRINT "RO(";
    STR$ U;")P.num
    ber S.mark: ";
    :INPUT T$:T$(U
    )=T$
39Ø:CLS :WAIT Ø:
    PRINT "X(";T$;
    ")= ";:INPUT B
    (U,2)
4ØØ:CLS :WAIT Ø:
    PRINT "Y(";T$;
    ")= ";:INPUT B
    (U,1)
41Ø:CLS :WAIT Ø:
    PRINT "1(";T$;
    ")= ";:INPUT L
42Ø:LPRINT "  Adju
    sting point":
    TAB 3:LPRINT T
    $(U)
43Ø:LPRINT "X=";B(
    U,2):LPRINT "Y
    =";B(U,1):S$="
    L=":S=L:GOSUB
    174Ø
44Ø:DY=B(U,1)-A(1,
    1):DX=B(U,2)-A
    (1,2):GOSUB 16
    55
445:IF W=18ØAND Q=
    36ØTHEN LET L=
    DEG L
45Ø:C(U)=D-L:S$="z
    =":IF C(U)<Ø
    THEN LET C(U)=
    C(U)+Q
455:K1=5E-5:K2=1E+
    4:IF W=18ØAND
    Q=36ØTHEN LET
    S=DMS (C(U)+K1
    ):GOTO 47Ø
46Ø:IF W=2ØØAND Q=
    4ØØTHEN LET S=
    C(U)+K1
47Ø:S=(INT (S*K2))
    /K2:GOSUB 174Ø
    :LPRINT :SY=SY
    +T*SIN C(U):SX
    =SX+T*COS C(U)
    :NEXT U
48Ø:DY=SY:DX=SX:
    GOSUB 166Ø:S=D
    :ZA=D
485:IF W=18ØAND Q=
    36ØTHEN LET S=
    DMS (S+K1):
    GOTO 5ØØ
49Ø:IF W=2ØØAND Q=
    4ØØTHEN LET S=
    D+K1
```

Fig. 21

```
500:S=(INT (S*K2))/K2:S$="ZK=":U2=1:GOSUB 1740:CSIZE 3
512:LPRINT S$;F$;U$;LEFT$ (D$,2);U$;MID$ (D$,3,2)
520:CSIZE 2:LPRINT :LF -1:GOSUB 1570
525:IF U5=1THEN 680
530:CLS :INPUT "Number of RP= ";M:DIM D(M,2),E(M),E$(M):SY=0:SX=0
540:FOR U=1TO M:CLS :WAIT 0:PRINT "PO(";STR$ U;")P.number S.mark:";:INPUT E$:E$(U)=E$
552:CLS :WAIT 0:PRINT "X(";E$;")= ";:INPUT D(U,2)
560:CLS :WAIT 0:PRINT "Y(";E$;")= ";:INPUT D(U,1)
570:CLS :WAIT 0:PRINT "l(";E$;")= ";:INPUT L
580:LPRINT "  Adjusting point":TAB 3:LPRINT E$(U)
590:LPRINT "X=";D(U,2):LPRINT "Y=";D(U,1):S$="l=":S=L:U2=0:GOSUB 1740
600:DY=D(U,1)-A(2,1):DX=D(U,2)-A(2,2):GOSUB 1655
610:IF W=180AND Q=360THEN LET L=DEG L
620:E(U)=D-L:S$="z=":IF E(U)<0THEN LET E(U)=E(U)+Q
625:K1=5E-5:K2=1E4:IF W=180AND Q=360THEN LET S=DMS (E(U)+K1):GOTO 640
630:IF W=200AND Q=400THEN LET S=E(U)+K1
640:S=(INT (S*K2))/K2:GOSUB 1740:LPRINT :SY=SY+T*SIN E(U):SX=SX+T*COS E(U):NEXT U
650:DY=SY:DX=SX:GOSUB 1660:S=D:ZB=D:U3=0:U5=1:GOTO 485
660:GOSUB 1580:INPUT "l(AP)=";LA,"l(BP)=";LB:S=LA:S$="l=":U2=0:GOSUB 1740
670:IF W=180AND Q=360THEN LET LA=DEG LA
680:D1=LA+ZA:IF D1>QTHEN LET D1=D1-Q
690:S=D1:IF W=180AND Q=360THEN LET S=DMS (S+K1):GOTO 700
695:IF W=200AND Q=400THEN LET S=S+K1
700:S=(INT (S*K2))/K2:S$="L=":GOSUB 1740:LPRINT
710:S=LB:S$="l=":GOSUB 1740:IF W=180AND Q=360THEN LET LB=DEG LB
720:D2=LB+ZB:IF D2>QTHEN LET D2=D2-Q
730:S=D2:IF W=180AND Q=360THEN LET S=DMS (S+K1):GOSUB 740
735:IF W=200AND Q=400THEN LET S=S+K1
740:S=(INT (S*K2))/K2:S$="L=":GOSUB 1740:LPRINT
750:I=2:J=1:GOSUB 1650:GOSUB 1700
753:CLS :INPUT "Continue Y/N ? ":K$
755:IF (K$="Y")+(K$="N")<>1THEN 753
760:IF K$="Y"THEN 660
765:IF K$="N"THEN 20
770:CSIZE 3:LPRINT "INTERSECTION":LPRINT "------------":GOSUB 1520:DIM A(2,2),A$(2),F$(2)
780:A$(1)="A":A$(2)="B":N=2:GOSUB 1525
790:CLS :INPUT "Station AP/BP ? ";L$
```

Fig. 22

```
795:IF (L$="AP")+(
    L$="BP")<>1
    THEN 790
800:IF L$="AP"THEN
    810
805:IF L$="BP"THEN
    900
810:GOSUB 1590:IF
    (I$="R")+(I$="
    A")<>1GOSUB 15
    90
815:IF I$="R"THEN
    830
820:IF I$="A"THEN
    872
830:GOSUB 1580:
    INPUT "l(AP)="
    ;AP,"l(AB)=";A
    B,"l(PB)=";PB,
    "l(PA)=";PA:S$
    ="l="
840:S=AP:GOSUB 174
    0:S=AB:GOSUB 1
    740:LPRINT :S=
    PB:GOSUB 1740:
    S=PA:GOSUB 174
    0
845:IF W=180AND Q=
    360THEN LET AP
    =DEG AP:AB=DEG
    AB:PB=DEG PB:P
    A=DEG PA
852:A=AB-AP:G=PA-P
    B:B=W-(A+G):
    GOSUB 1615:I=2
    :J=1:GOSUB 165
    0:GOSUB 1830
853:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
855:IF (K$="Y")+(K
    $="N")<>1THEN
    853
860:IF K$="Y"THEN
    830
865:IF K$="N"THEN
    20
872:GOSUB 1580:
    INPUT "α=";A,"
    γ=";G:S$="α=";
    S=A:GOSUB 1740
    :S$="γ=":S=G:
    GOSUB 1740
875:IF W=180AND Q=
    360THEN LET A=
    DEG A:G=DEG G
876:B=W-(A+G):
    GOSUB 1615:I=2
    :J=1:GOSUB 165
    0:GOSUB 1830
878:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
880:IF (K$="Y")+(K
    $="N")<>1THEN
    878
885:IF K$="Y"THEN

880:IF (K$="Y")+(K
    $="N")<>1THEN
    878
885:IF K$="Y"THEN
    870
890:IF K$="N"THEN
    20
900:GOSUB 1590:IF
    (I$="R")+(I$="
    A")<>1GOSUB 15
    90
905:IF I$="R"THEN
    920
910:IF I$="A"THEN
    960
920:GOSUB 1580:
    INPUT "l(BA)="
    ;BA,"l(BP)=";B
    P,"l(PB)=";PB,
    "l(PA)=";PA:S$
    ="l="
930:S=BA:GOSUB 174
    0:S=BP:GOSUB 1
    740:LPRINT :S=
    PB:GOSUB 1740:
    S=PA:GOSUB 174
    0
935:IF W=180AND Q=
    360THEN LET BA
    =DEG BA:BP=DEG
    BP:PB=DEG PB:P
    A=DEG PA
940:B=BP-BA:G=PA-P
    B:A=W-(B+G):
    GOSUB 1615:I=2
    :J=1:GOSUB 165
    0:GOSUB 1830
943:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
945:IF (K$="Y")+(K
    $="N")<>1THEN
    943
950:IF K$="Y"THEN
    920
955:IF K$="N"THEN
    20
960:GOSUB 1580:
    INPUT "β=";B,"
    γ=";G:S$="β=";
    S=B:GOSUB 1740
    :S$="γ=":S=G:
    GOSUB 1740
965:IF W=180AND Q=
    360THEN LET B=
    DEG B:G=DEG G
966:A=W-(B+G):
    GOSUB 1615:I=2
    :J=1:GOSUB 165
    0:GOSUB 1830
968:CLS :INPUT "Co
    ntinue Y/N ? "
    ;K$
970:IF (K$="Y")+(K
    $="N")<>1THEN
    968
975:IF K$="Y"THEN
    960
980:IF K$="N"THEN
    20
990:CSIZE 3:LPRINT
    "  TRAVERSE":
    LPRINT "INTERS
    ECTION":LPRINT
    "-------------"
    :CSIZE 2
```

Fig. 23

```
995:DIM A(2,2),A$(
  2),P$(2)
1000:A$(1)="A":A$
     (2)="B":N=2:
     GOSUB 1525
1010:GOSUB 1580:
     INPUT "t(AP)
     =";T1,"t(BP)
     =";T2
1020:USING "###,#
     ##,###,###.#
     ##":LPRINT "
     t=";T1;
     LPRINT "t=";
     T2:I=2:J=1:
     GOSUB 1650:D
     3=D:T3=T
1025:IF (T1+T2)<T
     3THEN 1780
1030:A=ACS ((T1^2
     +T3^2-T2^2)/
     (2*T1*T3)):D
     1=D3-A:U=0:
     GOSUB 1710
1035:CLS :INPUT "
     Continue Y/N
     ? ";K$
1040:IF (K$="Y")+
     (K$="N")<>1
     THEN 1035
1045:IF K$="Y"
     THEN 1010
1050:IF K$="N"
     THEN 20
1060:LPRINT " ";
     CSIZE 3:
     LPRINT "   D
     OUBLE":
     LPRINT "  RE
     SECTION":
     LPRINT "  --
     --------":
     GOSUB 1520
1070:DIM A(3,2),A
     $(3),P$(3):A
     $(1)="A":A$(
     2)="B":A$(3)
     ="C":N=3:
     GOSUB 1525
1080:GOSUB 1590:
     IF (I$="R")+
     (I$="A")<>1
     GOSUB 1590
1085:IF I$="R"
     THEN 1100
1090:IF I$="A"
     THEN 1095
1095:U4=1:GOSUB 1
     790:GOTO 114
     5
1100:U4=0:CLS :
     INPUT "P P.n
     umber S.mark
     :";P$,"l(PA)
     =";PA,"l(PB)
     =";PB,"l(PR)
     =";PR
1110:CLS :INPUT "
     R P.number S
     .mark:";R$,"
     l(RP)=";RP,"
     l(RB)=";RB,"
     l(RC)=";RC
1120:TAB 3:LPRINT
     P$;S$="l=";S
     =PA:GOSUB 17
     40:S=PB:
     GOSUB 1740:S
     =PR:GOSUB 17
     40
1130:TAB 3:LPRINT
     R$:S=RP:
     GOSUB 1740:S
     =RB:GOSUB 17
     40:S=RC:
     GOSUB 1740
1135:IF W=180AND
     Q=360THEN
     LET PA=DEG P
     A:PB=DEG PB:
     PR=DEG PR:RP
     =DEG RP:RB=
     DEG RB:RC=
     DEG RC
1140:A=PR-PB:B=PB
     -PA:G=RB-RP:
     E=RC-RB:U=0:
     GOSUB 1615
1145:IF (A+B)=WOR
     (G+E)=WTHEN
     1780
1150:I=1:J=2:
     GOSUB 1650:D
     3=D:D1=D3-(W
     -(A+B)):D2=D
     3+A:U=1:
     GOSUB 1700:P
     Y=YP:PX=XP
1155:Y1=DY:X1=DX
1160:I=2:J=3:
     GOSUB 1650:D
     3=D:D1=D3-G:
     D2=D3+(W-(G+
     E)):GOSUB 17
     00:RY=YP:RX=
     XP
1165:Y2=DY:X2=DX
1170:DY=RY-PY:DX=
     RX-PX:GOSUB
     1655:D3=D:D1
     =D3-A:D2=D3+
     (W-(A+B)):J=
     2:U$=P$:U=0:
     U3=1
1175:DY=Y1:DX=X1:
     GOSUB 1700
1180:D1=D3-(W-(G+
     E)):D2=D3+G:
     J=3:U$=R$:U3
     =0
1185:DY=Y2:DX=X2:
     GOSUB 1700
1188:CLS :INPUT "
     Continue Y/N
     ?.";K$
1190:IF (K$="Y")+
     (K$="N")<>1
     THEN 1188
1195:IF K$="Y"AND
     U4=1THEN 103
     5
1200:IF K$="Y"AND
     U4=0THEN 110
     0
1205:IF K$="N"
     THEN 20
```

Fig. 24

```
1210:LPRINT " ";:
     CSIZE 3:
     LPRINT "   H
     ANSEN":


     LPRINT "    -
     ------";
     GOSUB 1520
1220:DIM A(2,2),A
     $(2),P$(2):A
     $(1)="A";A$(
     2)="B":N=2:
     GOSUB 1525
1230:GOSUB 1590:
     IF (I$="R")+
     (I$="A")<>1
     GOSUB 1590
1235:IF I$="R"
     THEN 1250
1240:IF I$="A"
     THEN 1245
1245:U4=1:GOSUB 1
     790:GOTO 130
     0
1250:U4=0:CLS :
     INPUT "P P.n
     umber S.mark
     :";P$,"|(PA)
     =";PA,"|(PR)
     =";PR,"|(PB)
     =";PB
1260:CLS :INPUT "
     R P.number S
     .mark:";R$,"
     |(RB)=";RB,"
     |(RP)=";RP,"
     |(RA)=";RA
1270:TAB 3:LPRINT
     P$:S$="\=":S
     =PA:GOSUB 17
     40:S=PR:
     GOSUB 1740:S
     =PB:GOSUB 17
     40
1280:TAB 3:LPRINT
     R$:S=RB:
     GOSUB 1740:S
     =RP:GOSUB 17
     40:S=RA:
     GOSUB 1740
1285:IF W=180AND
     Q=360THEN
     LET PA=DEG P
     A:PR=DEG PR:
     PB=DEG PB:RB
     =DEG RB:RP=
     DEG RP:RA=
     DEG RA
1290:A=PR-PA:B=PB
     -PR:G=RP-RB:
     E=RA-RP
1300:IF (A+B)=WOR
     (G+E)=WTHEN
     1780
1310:I=2:J=1:
     GOSUB 1650:D
     3=D:D1=D3-B:
     D2=D3+A:J=1:
     GOSUB 1700:P
     Y=YP:PX=XP
1315:Y1=DY:X1=DX
1320:I=1:J=2:
     GOSUB 1650:D
     3=D:D1=D3-E:
     D2=D3+G:
     GOSUB 1700:R
     Y=YP:RX=XP
1325:Y2=DY:X2=DX
1330:DY=RY-PY:DX=
     RX-PX:GOSUB
     1655:D3=D:D1
     =D3-A:D2=D3+
     B:J=1:U$=P$:
     J=0:U3=1
1335:DY=Y1:DX=X1:
     GOSUB 1700
1340:D3=D:D1=D3-G
     :D2=D3+E:J=2
     :U$=R$:U3=0
1345:DY=Y2:DX=X2:
     GOSUB 1700
1348:CLS :INPUT "
     . Continue Y/N
      ? ";K$
1350:IF (K$="Y")+
     (K$="N")<>1
     THEN 1348
1355:IF K$="Y"AND
     U4=1THEN 124
     5
1360:IF K$="Y"AND
     U4=0THEN 125
     0
1365:IF K$="N"
     THEN 20
1370:CSIZE 3:
     LPRINT "
     MAREK":


     LPRINT "
     ------";
     GOSUB 1520
1380:DIM A(4,2),A
     $(4),P$(4):A
     $(1)="A";A$(
     2)="B";A$(3)
     ="C";A$(4)="
     D";N=4:GOSUB
     1525
1390:GOSUB 1590:
     IF (I$="R")+
     (I$="A")<>1
     GOSUB 1590
1395:IF I$="R"
     THEN 1410
1400:IF I$="A"
     THEN 1405
1405:U4=1:GOSUB 1
     790:GOTO 145
     5
1410:U4=0:CLS :
     INPUT "P P.n
     umber S.mark
     :";P$,"|(PB)
     =";PB,"|(PR)
     =";PR,"|(PA)
     =";PA
```

Fig. 25

```
1420:CLS :INPUT "
     R P.number S
     .mark:";R$,"
     !(RD)=";RD,"
     !(RP)=";RP,"
     !(RC)=";RC
1430:TAB 3:LPRINT
     P$:S$="L=":S
     =PB:GOSUB 17
     40:S=PR:
     GOSUB 1740:S
     =PA:GOSUB 17
     40
1440:TAB 3:LPRINT
     R$:S=RD:
     GOSUB 1740:S
     =RP:GOSUB 17
     40:S=RC:
     GOSUB 1740
1445:IF W=180AND
     Q=360THEN
     LET PB=DEG P
     B:PR=DEG PR:
     PA=DEG PA:RD
     =DEG RD:RP=
     DEG RP:RC=
     DEG RC
1450:A=PA-PR:B=PR
     -PB:G=RC-RP:
     E=RP-RD
1455:IF (A+B)=WOR
     (G+E)=WTHEN
     1790
1460:I=2:J=1:
     GOSUB 1650:D
     3=D:D1=D3-(W
     -B):D2=D3+(W
     -A):U=1:
     GOSUB 1700:P
     Y=YP:PX=XP
1465:Y1=DY:X1=DX
1470:I=4:J=3:
     GOSUB 1650:D
     3=D:D1=D3-(W
     -E):D2=D3+(W
     -G):GOSUB 17
     00:RY=YP:RX=
     XP
1475:Y2=DY:X2=DX
1480:DY=RY-PY:DX=
     RX-PX:GOSUB
     1655:D3=D:D1
     =D3-(W-A):D2
     =D3+(W-B):J=
     1:U$=P$:U=0:
     U3=1
1485:DY=Y1:DX=X1:
     GOSUB 1700
1490:D1=D3-(W-G):
     D2=D3+(W-E):
     J=3:U$=R$:U3
     =0
1495:DY=Y2:DX=X2:
     GOSUB 1700
1498:CLS :INPUT "
     Continue Y/N
      ? ";K$
1500:IF (K$="Y")+
     (K$="N")<>1
     THEN 1498
1505:IF K$="Y"AND
     U4=1THEN 142
     5
1510:IF K$="Y"AND
     U4=0THEN 141
     0
1515:IF K$="N"
     THEN 20
1520:LF -1:CSIZE
     1:TAB 14:
     LPRINT G$:K=
     5E-4:CSIZE 2
     :LPRINT :
     RETURN
1525:REM DATA INP
     UT
1530:FOR H=1TO N:
     CLS :WAIT 0:
     PRINT A$(H):
     " P.number S
     .mark:";:
     WAIT :INPUT
     P$:P$(H)=P$
1540:CLS :WAIT 0:
     PRINT "X(";P
     $;")= ";:
     INPUT A(H,2)
1550:CLS :WAIT 0:
     PRINT "Y(";P
     $;")= ";:
     INPUT A(H,1)
     :NEXT H
1555:REM PRINT CO
     ORDINATE LIS
     T
1560:FOR H=1TO N:
     TAB 3:LPRINT
     P$(H):USING
     "###,###.###
     ,###.###":
     LPRINT "X=";
     A(H,2):
     LPRINT "Y=";
     A(H,1):
     LPRINT
1565:NEXT H
1570:LPRINT "-----
     --------------
     --":RETURN
1580:CLS :INPUT "
     New P.number
      S.mark:";U$
     :RETURN
1590:CLS :INPUT "
     Reading / An
     gle ? ";I$:
     RETURN
1600:INPUT "α=";A
     ,"β=";B:S=A:
     S$="α=":
     GOSUB 1740:S
     =B:S$="β=":
     GOSUB 1740
1605:IF W=180AND
     Q=360THEN
     LET A=DEG A:
     B=DEG B
1610:IF U=1GOTO 1
     45
```

Fig. 26

```
1615:IF A<0THEN
     LET A=A+Q
1620:IF B<0THEN
     LET B=B+Q
1625:IF G<0THEN
     LET G=G+Q
1630:IF E<0THEN
     LET E=E+Q
1640:RETURN
1650:DY=A(I,1)-A(
     J,1):DX=A(I,
     2)-A(J,2)
1655:IF DY=0AND D
     X=0THEN 1780
1660:IF DX=0THEN
     LET DX=1E-10
1670:D=ATN (DY/DX
     ):IF DY>0AND
     DX>0THEN 169
     0
1675:IF DY>=0AND
     DX<0OR DY<0
     AND DX<0THEN
     LET D=D+W:
     GOTO 1690
1680:IF DY<0AND D
     X>0THEN LET
     D=D+Q
1690:T=SQR (DY*DY
     +DX*DX):IF T
     =0THEN 1780
1695:RETURN
1700:T1=(DY*COS D
     2-DX*SIN D2)
     /SIN (D1-D2)
1710:YP=A(J,1)+T1
     *SIN D1:XP=A
     (J,2)+T1*COS
     D1:IF U=1
     THEN RETURN
1720:K=5E-4:Y=YP+
     SGN YP*K:X=X
     P+SGN XP*K:
     IF U2=1THEN
     RETURN
1725:TAB 3:LPRINT
     U$:USING "##
     #,###,###,##
     #.###";
     LPRINT "X=";
     X:LPRINT "Y=
     ";Y:IF U3=1
     THEN RETURN
1730:IF U3=0GOSUB
     1570:RETURN
1740:U$="-":O$="0
     ":F=INT S:Z=
     (S-F)*1E4:F$
     =STR$ F:Z$=
     STR$ Z
1745:IF LEN F$<3
     LET F$=O$+F$
     :GOTO 1745
1750:IF LEN Z$<4
     THEN LET Z$=
     O$+Z$:GOTO 1
     750
1760:IF U2=1THEN
     RETURN
1770:LPRINT S$;"
                ";F$;U
     $;LEFT$ (Z$,
     2);U$;MID$ (
     Z$,3,2):
     RETURN
1780:LPRINT :
     LPRINT "    N
     O SOLUTION !
     ":GOSUB 1570
     :GOTO 1840
1790:INPUT "P P.n
     umber S.mark
     :";P$,"α=";A
     ,"β=";B
1800:INPUT "R P.n
     umber S.mark
     :";R$,"γ=";G
     ,"ε=";E
1810:TAB 3:LPRINT
     P$:S$="α=":S
     =A:GOSUB 174
     0:S$="β=":S=
     B:GOSUB 1740
1820:TAB 3:LPRINT
     R$:S$="γ=":S
     =G:GOSUB 174
     0:S$="ε=":S=
     E:GOSUB 1740
1825:IF W=180AND
     Q=360THEN
     LET A=DEG A:
     B=DEG B:G=
     DEG G:E=DEG
     E
1828:RETURN
1830:D3=D:D1=D3-A
     :D2=D3+B:U=0
     :GOSUB 1700:
     RETURN
1840:CLS :WAIT 64
     0:PRINT " *
     * * * * END
     * * * * * "
     END
```

Fig. 27

```
INTERSECTION
-------DEGREE-------
 238 stone
X=     150,159.380
Y=     788,535.810

 240 stone
X=     149,434.750
Y=     789,363.870
--------------------
 Adjusting point
 5008 stone
X=     148,581.840
Y=     787,695.280
L=       055-30-00
z=       180-00-23

 Adjusting point
 1255 tower
X=     154,468.840
Y=     790,348.950
L=       202-47-57
z=       180-01-22
ZK=180-01-11
--------------------
 Adjusting point
 1255 tower
X=     154,468.840
Y=     790,348.950
L=       191-04-26
z=       179-59-58
ZK=179-59-58
--------------------
L=       266-28-30
L=       086-29-41

L=       118-58-03
L=       298-58-01

 101 stone
X=     150,132.854
Y=     788,102.753
--------------------
```

```
INTERSECTION
-------GRAD-------
 238 stone
X=     150,159.380
Y=     788,535.810

 240 stone
X=     149,434.750
Y=     789,363.870
--------------------
δ=       096-10-54
δ=       332-10-58
 101 stone
X=     150,132.854
Y=     788,102.756
--------------------
INTERSECTION
-------DEGREE-------
 1403 stone
X=     150,278.000
Y=     790,999.930

 1424 stone
X=     152,329.510
Y=     790,603.520
--------------------
L=       292-25-46
L=       343-03-48

L=       169-03-49
L=       204-16-14
 1404 stone
X=     150,731.465
Y=     789,992.963
--------------------
```

```
INTERSECTION
-------GRAD-------
 1424 stone
X=     152,329.510
Y=     790,603.520

 1403 stone
X=     150,278.000
Y=     790,999.930
--------------------
α=       048-48-76
β=       036-22-22
 1405 stone
X=     151,657.711
Y=     791,547.968
--------------------
TRAVERSE
INTERSECTION
--------------------
 136 stone
X=      38,240.150
Y=      23,887.700

 148 stone
X=      38,190.320
Y=      23,959.230
--------------------
t=         415.240
t=         647.280
 134 stone
X=      38,604.910
Y=      23,683.066
--------------------
t=       1,308.510
t=         969.600
 135 stone
X=      38,191.817
Y=      22,989.631
--------------------
```

Fig. 28

```
  DOUBLE
RESECTION

------ GRAD ------

  1224 stone
X=    152,329.510
Y=    790,603.520

  1225 stone
X=    152,860.280
Y=    791,526.140

  2062 stone
X=    153,410.980
Y=    792,723.880

--------------------
  1405 stone
l=      000-00-00
l=      259-48-36
l=      128-19-44
  105 stone
l=      000-00-00
l=      289-67-07
l=      155-81-45
  1405 stone
X=    151,657.710
Y=    791,547.971
  105 stone
X=    152,019.320
Y=    792,194.990
--------------------
```

```
   HANSEN

---- DEGREE ----

  1404 stone
X=    150,731.460
Y=    789,882.960

  1404 stone
X=    151,657.710
Y=    791,547.970

--------------------
  1423 stone
α=      256-58-03
β=      032-36-00
  1424 stone
γ=      043-38-20
ε=      035-12-25
  1403 stone
X=    150,277.994
Y=    790,999.930
  1424 stone
X=    152,329.510
Y=    790,603.518
--------------------

  RESECTION

---- DEGREE ----

  4052 stone
X=    171,551.140
Y=    808,024.290

  4015 stone
X=    169,244.100
Y=    809,114.510

  4224 stone
X=    168,812.930
Y=    806,922.400

--------------------
l=      000-00-00
l=      114-26-39
l=      212-33-55
  102 stone
X=    163,984.175
Y=    827,858.073
--------------------
```

```
   MAREK

---- GRAD ----

  1403 stone
X=    150,278.200
Y=    790,999.930

  1224 stone
X=    152,329.510
Y=    790,603.520

  2062 stone
X=    153,410.980
Y=    792,723.880

  2339 stone
X=    151,268.110
Y=    792,794.230

--------------------
  1405 stone
l=      000-00-00
l=      128-19-44
l=      284-70-39
  105 stone
l=      000-00-00
l=      110-41-29
l=      266-22-53
  1405 stone
X=    151,657.710
Y=    791,547.970
  105 stone
X=    152,019.321
Y=    792,194.990
--------------------
```

Fig. 29

Then, the number/name of the fixed points are entered which will be followed by the relevant coordinates. Initial data are also printed at the same time.

When entering the degree, it should be clearly stated if readings to directions or calculated angles involved in the process. Distance and coordinates are considered in mm, while angles are taken in degrees, minutes and seconds or in grades and its decimals when they appear on the display. Small dots will separate them from each other.

In the flowchart, input data will be followed by quotation mark whilst data blocks will be followed by an equation mark and a question mark alike. Finally, results are listed and printed, then the computation can continue.

The possibility of the solution of the problem will also be investigated and if there is no solution, running of the program halts

NO SOLUTION!

is printed, and

*** END ****

remark can be seen on the display.

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