M. OPRESCU

M. MIHALYI

Minimization of the Cost of Pipe Systems for Fluids Conveyance

A computing method meant for a particular case in the oil industry does not affect in the least its application to other problems of the same kind.

The implementation of an optimal pipe-line system for the conveyance of fluids, produced or to be injected, as well as for collecting waste waters, is one of the main problems concerning the reduction of capital investments under the normal development of technological processes. In this respect, we have worked out a mathematical model for computing the optimal location of a rectilinear trunk pipe-line and of the pipes connecting the sources whose fluids must be conveyed by means of digital computers. At the same time, the description of a detailed flow chart for computing the conveyance cost of pipe-line systems is given. The model was experimented with the digital computer "Economist CIFA—102" only for the case in which the connection pipes are perpendicular to the trunk pipe-line, and their unit costs are constant.

THEORETICAL CONSIDERATIONS

Given the positions $A_i(x_i, y_i)$ $i = 1, 2, \ldots, N$ of N sources of fluids which are to be collected by a rectilinear trunk pipe-line, as well as the costs per length unit c for the trunk pipe-line and $c_i (i = 1, \ldots, N)$ for the connection pipes, the position of the trunk pipe-line is to be found out in such a manner that the total cost price of the conveyance system be a minimum.

In the following it is assumed that:

— the sources $A_i (x_i, y_i)$ are located in a plane Q;

— the connection pipes are rectilinear and perpendicular to the trunk pipe-lines;

— the cost prices per length unit of the connection pipes and of the trunk pipe-line are constant.

Denoting by L the length of the trunk pipe-line and by l_i the distance between the source A_i and the trunk pipe-line, the function to be minimized will be:

$$C_s = cL + \sum_{i=1}^{N} c_i l_i \tag{1}$$

In the plane Q, an orthogonal reference system xOy can be chosen, such as all points may be situated in the first quadrant. The equation of the trunk pipe-line, written in a normal form:

$$x \sin \alpha - y \cos \alpha + n \cos \alpha = 0 \tag{2}$$

expresses its position depending on angle α built up by the trunk pipe-line direction with the axis Ox, and by the ordinate n at the origin.

For a given pair (α, n), we shall denote by O' and A_i' the projection of origin and of point A_i, respectively, upon the trunk pipe-line direction (Fig. 1). In this case the length of the trunk pipe-line is

$$L = (O'A_M' - O'A_m')$$

where A_m' and A_M' represent the nearest and the most distant projection, respectively, as against point O'.

On denoting by A_i'' the intersection of the straight line A_iA_i' with the axis Ox, the projection of the segment OA_i' on the trunk pipe-line is:

$$O'A_i' = OA_i'' \cos \alpha.$$

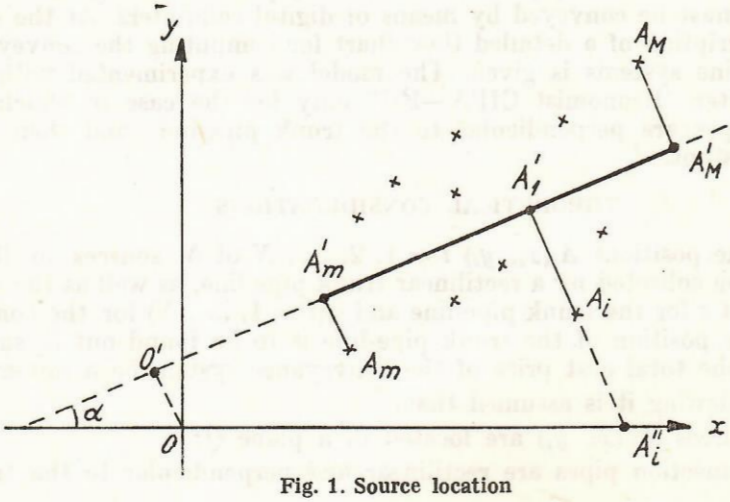


Fig. 1. Source location

Assuming that the connection pipes are perpendicular to the trunk pipe-line, the equation of the pipe passing through source $A_i'(x_i, y_i)$ will be:

$$y - y_i = -\operatorname{ctg}\alpha(x - x_i)$$

and the abscissa of point A_i'' will be:

$$OA_i'' = y_i \operatorname{tg}\alpha + x_i$$

Consequently

$$O'A_i' = y_i \sin\alpha + x_i \cos\alpha,$$

Hence, it follows that

$$O'A_M' = \max_i(x_i \cos\alpha + y_i \sin\alpha),$$

$$O'A_m' = \min_i(x_i \cos\alpha + y_i \sin\alpha).$$

On denoting $O'A_M$, $O'A_m'$ by μ and ν, respectively, the expression of the pipe-line length is given by the equation

$$L = \max_i(x_i \cos\alpha + y_i \sin\alpha) - \min_i(x_i \cos\alpha + y_i \sin\alpha) = \mu - \nu \qquad (3)$$

and the expression of the distance from the source $A_i(x_i y_i)$ to the trunk pipe-line results from (2), i.e.:

$$l_i = |x_i \sin\alpha - y_i \cos\alpha + n \cos\alpha| \qquad (4)$$

The expression of the total cost of the pipe system $C_s(\alpha, n)$ can be written accordingly in the form

$$C_s(\alpha, n) = C_m(\alpha) + C_l(\alpha, n) = C\left[\max_i(x_i \cos\alpha + y_i \sin\alpha) + \min_i(x_i \cos\alpha + y_i \sin\alpha)\right] + \sum_{i=1}^{N} c_i(x_i \sin\alpha - y_i \cos\alpha + n \cos\alpha) \qquad (5)$$

where the cost of the trunk pipe-line and of the side pipe system, respectively, were denoted by $C_m(\alpha)$ and $C_l(\alpha, n)$.

This problem can be further solved parametrically. Thus, for any $\alpha \in [O, \pi]$ the total cost of the pipe system is computed by writing the n-ordinate at the origin and by choosing finally the pair (α, n) for which this cost is a minimum.

The smaller the variation Δ_α and Δ_n of the angle α and of the ordinate, at the origin, the better the approximation of the value $\min C_s(\alpha, n)$. The diminishing of Δ_α and Δ_n entails the increasing of the computing volume. To avoid this situation, without impairing the accuracy of the method, we shall remark that in (5) the value of L does not depend on n. It follows that, for a given α, $\min_n C_s(\alpha, n)$ occurs at the same time as $\min_n C_l(\alpha, n)$, where:

$$\min_n C_l(\alpha, n) = \min_n \sum_{i=1}^{N} c_i |x_i \sin\alpha - y_i \cos\alpha + n \cos\alpha| =$$

$$= \min_{n} \sum_{i=1}^{N} c_i |\cos \alpha| \, |(y_i - x_i \operatorname{tg} \alpha) - n|. \tag{6}$$

If we denote in (6): $y_i - x_i \operatorname{tg} \alpha = a_i$ and $c_i |\cos \alpha| = \gamma_i$ the minimizing of the total cost of the pipe system, for a given α, can be reduced to the following

Proposition: Given the numbers $a_1, \ldots, a_N$, arranged in the increasing succession

$$a_1 < a_2 < \ldots < a_i < a_{i+1} < \ldots < a_N$$

and the positive numbers $\gamma_1, \ldots, \gamma_N$, find out a number n, such as the sum

$$C_l(n) = \sum_{i=1}^{N} \gamma_i |a_i - n| \tag{7}$$

be a minimum.

Relation (7) can be written under the form:

$$C_l(n) = \sum_{i=1}^{j} \gamma_i (n - a_i) + \sum_{i=j+1}^{N} \gamma_i (a_i - n), \text{ where } j = 0, 1, 2, 3, \ldots, N-1 \text{ or } N$$

according as $n < a_1$; $a_k < n < a_{k+1}$; *or* $n > a_N$, i.e. (8)

$$C_l(n) = \sum_{i=1}^{N} \gamma_i (a_i - n), \quad \text{for } n < a_1;$$

$$C_l(n) = \sum_{i=1}^{k} \gamma_i (n - a_i) + \sum_{i=k+1}^{N} \gamma_i (a_i - n), \quad \text{for } a_k < n < a_{k+1} \tag{9}$$

$$C_l(n) = \sum_{i=1}^{N} \gamma_i (n - a_i), \quad \text{for } n > a_N$$

By differentiating the function $C_l(n)$ we get:

$$C_l'(n) = -\sum_{i=1}^{N} \gamma_i, \quad \text{for } n < a_1; \tag{10}$$

$$C_l'(n) = \sum_{i=1}^{k} \gamma_i - \sum_{i=k+1}^{N} \gamma_i, \quad \text{for } a_k < n < a_{k+1}; \tag{11}$$

$$C_l'(n) = \sum_{i=1}^{N} \gamma_i, \quad \text{for } n > a_n \tag{12}$$

One can see that the derivative of function $C_l(n)$ is an increasing and discontinuous function. The discontinuity points are $a_1, a_2, \ldots, a_N$, and in

the intervals (a_k, a_{k+1}) the derivative is constant. $C_l'(n)$ is increasing because it is constant for intervals of the form (a_k, a_{k+1}) and

$$C_l'(n+\varepsilon)-C_l'(n)=\begin{cases}\gamma_1-\sum_{i=2}^{N}\gamma_i+\sum_{i=1}^{N}\gamma_i=2\gamma_1>0,\\ \text{when}\quad n<a_1<n+\varepsilon<a_2\\ \sum_{i=1}^{k+1}\gamma_i-\sum_{i=k+2}^{N}\gamma_i-\sum_{i=1}^{k}\gamma_i+\sum_{i=k+1}^{N}\gamma_i=2\gamma_{k+1}>0,\\ \text{when}\quad a_k<n<a_{k+1}<n+\varepsilon;\\ \sum_{i=1}^{N}\gamma_i-\sum_{i=1}^{N-1}\gamma_i+\gamma_N=2\gamma_N>0,\ \text{when}\ n<a_N<n+\varepsilon\end{cases}\tag{13}$$

$C_l'(n)$ being an increasing function, and $C_l'(a_1-\varepsilon)<0$ and $C_l'(a_1+\varepsilon)>0$, it follows that between a_1 and a_N there is n_0, $a_1\leqslant n_0\leqslant a_N$, such as $C_l'(n_0-\varepsilon)\leqslant 0$ and $C_l'(n_0+\varepsilon)\geqslant 0$. As $a_1\leqslant n_0\leqslant a_N$ it follows that there is a_j such as $a_j\leqslant n_0\leqslant a_{j+1}$.

If $a_j<n_0<a_{j+1}$, then, $C_l'(n)$ being constant in the intervals (a_j, a_{j+1}), it follows that $C_l'(n)=0$ for $n\in(a_j, a_{j+1})$, hence for the minimum one can take any $n\in[a_j, a_{j+1}]$. If $n_0=a_j$ then, for $n=aj$, $C_l'(n)<0$; accordingly, the function is decreasing, and for $n>a_j$, $C_l'(n)>0$, consequently the function is increasing. It follows that $n_0=a_j$ is just the point at which the function reaches its minimum. It is obvious that, in both cases, $n_0=a_j$ can be considered as minimum.

It clearly follows that the minimum of the function $C_1(n)$, for a given α, is reached at one of points $A_j(x_j, y_j)$ $j=1, ..., N$.

As a consequence of these remarks, we shall express the ordinate n at the origin from the expression of the pipe system total cost (5), in terms of the co-ordinates of points A_j.

Denoting by (x^j, y^j) the co-ordinates of a source A_j, situated on the trunk pipe-line, it follows from relation (2) that

$$n\cos\alpha=y^j\cos\alpha-x^j\sin\alpha\tag{14}$$

Replacing in (5) $n\cos\alpha$ by its value derived from (14), the expression of the pipe system total cost becomes a function of only α and of the co-ordinates of the sources A_j, i.e.:

$$C_s(\alpha)=c[\max_i(x_i\cos\alpha+y_i\sin\alpha)-\min_i(x_i\cos\alpha+y_i\sin\alpha)+$$

$$+\sum_{i=1}^{N}c_i\,|\,x_i\sin\alpha-y_i\cos\alpha+y^j\cos\alpha-x^j\sin\alpha\,|=C_m(\alpha)+C_l(\alpha)\tag{15}$$

In this case, the solution of the problem can be obtained by giving to α values in the interval $[0, \pi]$ and by computing the pipe system total cost for any given α, on replacing in relation (15) the co-ordinates of points $A_j(x^j, y^j)$ through which the trunk pipe-line is to pass, until the minimum cost will be found.

It is obvious that, by this method, the pipe system minimum cost will be computed with an approximation so much better as the variation pitch Δ_α of angle α in the interval $[0, \pi]$ will be smaller. To avoid a high computing volume, which may appear when Δ_α is very small, without impairing the method accuracy, one is to proceed as follows:

— Compute the pipe system cost for α, letting it vary in the interval $[0, \pi]$ by a convenient pitch (e.g. $\Delta_\alpha = 10^\circ$).

— Start the investigation again, in the interval $[\alpha_0\ \alpha_0, + \Delta_\alpha]$, where the most reduced cost of the pipe system appears, using a pitch $\Delta'_\alpha < \Delta_\alpha$(e.g., $\Delta'_\alpha = 1^\circ$).

This investigation procedure may go on util the pattern of the pipe system minimum cost differences, obtained with two succesive investigation levels, becomes smaller than, or at the most equal to, one $\varepsilon > 0$, imposed by the accuracy degree of the results required by the user or by the computer performances.

Remarking that in relation (15) the trunk pipe-line length is independent of n, for a given α, one may compute a single time the pipe-line cost, adding subsequently to it in succession the cost of the connection pipe system, given by the expression

$$C_l(\alpha) = \sum_{i=1}^{N} c_i \mid x_i \sin\alpha - y_i \cos\alpha + y^j \cos\alpha - x^j \sin\alpha \mid j = 1, 1, ..., N \quad (16)$$

It can be seen that the computing procedure is no longer conditioned by the variation pitch Δ_n, of the ordinate at the origin; this variation, for a given α, can be achieved by deplacing the pipe-line position at all points $A_j(x^j,\ y^j)$.

DATA RECORDING IN THE COMPUTER STORE

The programming of this computation method of the pipe system total cost is easy to carry out, even with small digital computers.

The input data and the constants of the problem consist of:

— The co-ordinates $(x_i y_i)$, $i = 1, ..., N$, of all sources summing up $2N$; the first to be recorded are the vertices of the convex polyhedron, which includes all sources. This sequence is non-essential, since it is done only with the aim of reducing the computation volume intended to find out, the pipe-line length by means of relation (3). The sequence is based on the remark that, on computing the pipe-line length, only the projection of the convex circumscribed vertices on the trunk pipe-line direction could be points of A'_m or A'_M type.

— The unit costs of the connection pipes and the unit cost of the trunk pipe-line, for which $N + 1$ computer store cells must be reserved.

— The number (η) of the convex polyhedron vertices, recorded in octal digits in one computer store cell.

— The total number (N) of sources recorded in octal digits in one com*puter store cell.*

— The pitch Δ_α, in centesimal degrees, the constants 0 and 200, for which three cells of the computer store are reserved.

— The constants $\pm \max_i (x_i + y_i)$ necessary to initialize the computing process of the length L, given by relation (3), two cells being necessary for it.

The program achieved for the digital computer "Economist CIFA-102" takes up 168 store cells, of which 112 are occupied by instructions, 19 are reserved to the working addresses and 37 to the constants used with the program. In addition, a sub-routine is used for $\sin \alpha^c$ and another for $\cos \alpha^c$, α being expressed in centesimal degrees.

By means of this program it is possible to compute the minimum cost of a pipe system involving over 1,000 sources, which sufficiently covers all real problems which may arise in practice.

DESCRIPTION OF THE COMPUTATION FLOW CHART

Unit 1. Introduces, for the beginning, 0 in α. (Fig. 2 *a* and Fig. 2 *b*).

Unit 2. Prints α.

Units 3—6. Connect the sub-routines $sin\, \alpha^c$, $cos\, \alpha^c$ and assign the computed values to cells S and C, respectively.

Units 7—8. Initialize the loop for the computation of the value $\max_i (x_i \cos \alpha + y_i \sin \alpha)$, by introducing 1 in i and $- \max_i (x_i + y_i)$ in μ_1.

Unit 9. Assigns to A the value of the expression $y_i \sin \alpha^c + x_i \cos \alpha^c$.

Unit 10. Is the content of the address negative?

Units 11—12. Assign to A_1 the value of A shifted to R.H., if A is positive, and the value of $|A|$ shifted to R.H. and with changed sign, if A_1 is negative.

The number of bits by which the shifting should be done is appreciated by the programmer in terms of the error introduced by the sub-routines used, $\sin \alpha$ and $\cos \alpha$.

These shiftings are hence effected with the aim to suppress the errors which apper, after computing, in the R.H. side of the register, this ensuring the correct operation of unit 13.

Units 13—15. Are testing the sign of the expression $\mu_1 - A_1$. If $\mu_1 - A_1 < 0$, A_1 is assigned to μ_1 and A to μ. If $\mu_1 - A_1 \geqslant 0$, the execution is transferred to unit 16.

Units 16—17. Test if the expression $A = y_i\, S + x_i\, C$ was computed for all co-ordinates $(x_i y_i)$ of sources representing the convex polyhedron vertices. If not, i.e. if $i < \eta$, the value $i + 1$ will be assigned to i and the expression A will be computed again for the co-ordinates of the next vertex. If $i = \eta$, the execution is transferred to unit 18.

Units 18—19. Initialize the loop for the computation of the value $\max_i (x_i \cos \alpha + y_i \sin \alpha)$, by introducing 1 in i and $\max_i (x_i + y_i)$ in ν_1.

Unit 20. Assigns to A the value of the expression $y_i \sin \alpha + x_i \cos \alpha$.

Unit 21. Is the content of address A negative?

Units 22—23. Assign, respectively, to A_1 the content of address A shifted to R.H., if A is positive, and the modulus of the content of address A

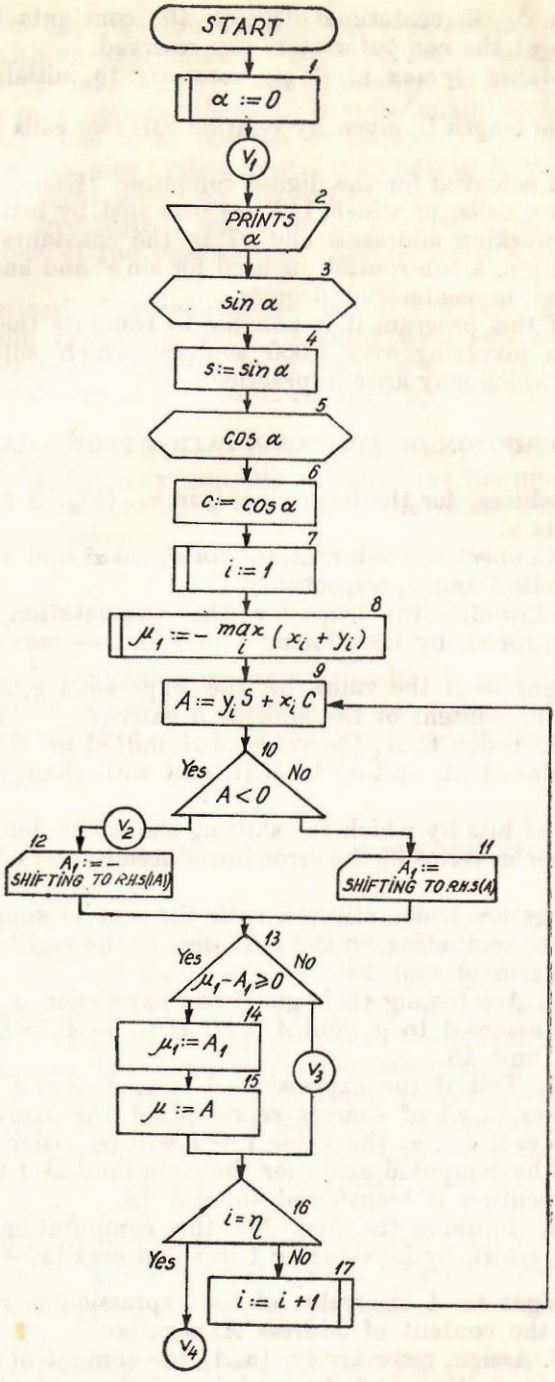


Fig. 2. *a* Computation of the trunk pipe-line cost ($C_m(\alpha)$)

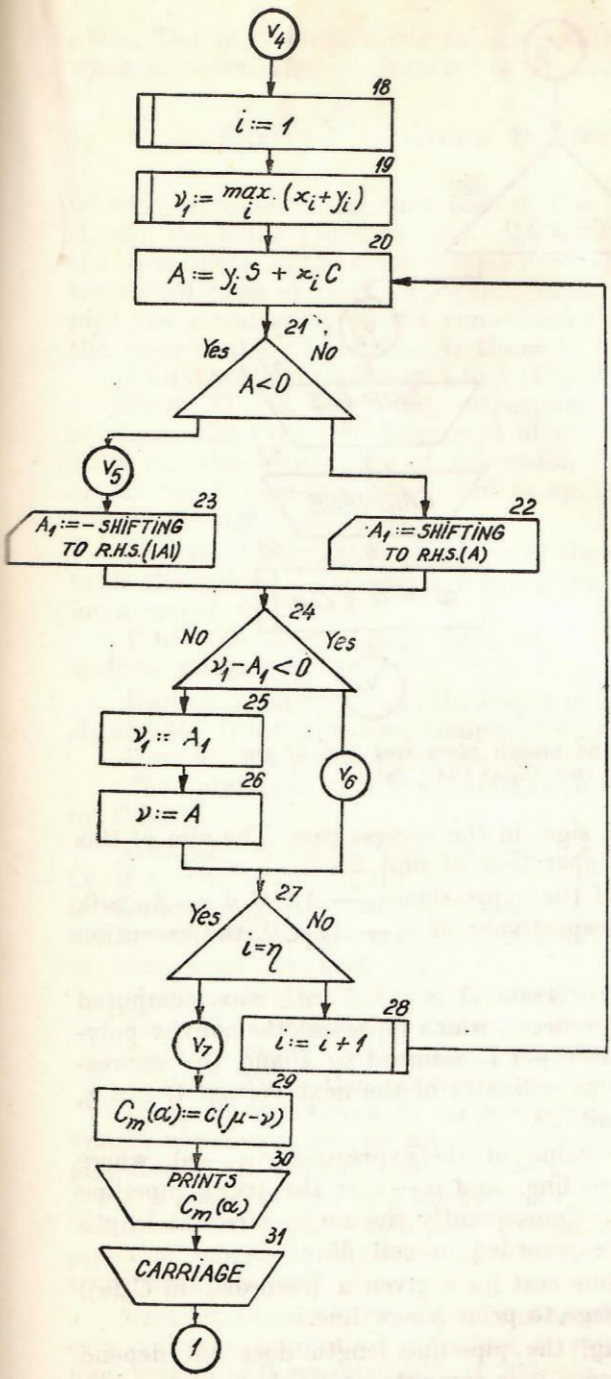

v_4
18
$i := 1$
19
$\nu_1 := \max_i (x_i + y_i)$
20
$A := y_i S + x_i C$
21
Yes
No
$A < 0$
v_5
23
$A_1 :=$ – SHIFTING TO R.H.S.(|A|)
22
$A_1 :=$ SHIFTING TO R.H.S.(A)
24
NO
Yes
$\nu_1 - A_1 < 0$
25
$\nu_1 := A_1$
26
$\nu := A$
v_6
27
Yes
No
$i = \eta$
v_7
28
$i := i + 1$
29
$C_m(\alpha) := c(\mu - \nu)$
30
PRINTS $C_m(\alpha)$
31
CARRIAGE
1

Fig 2 b

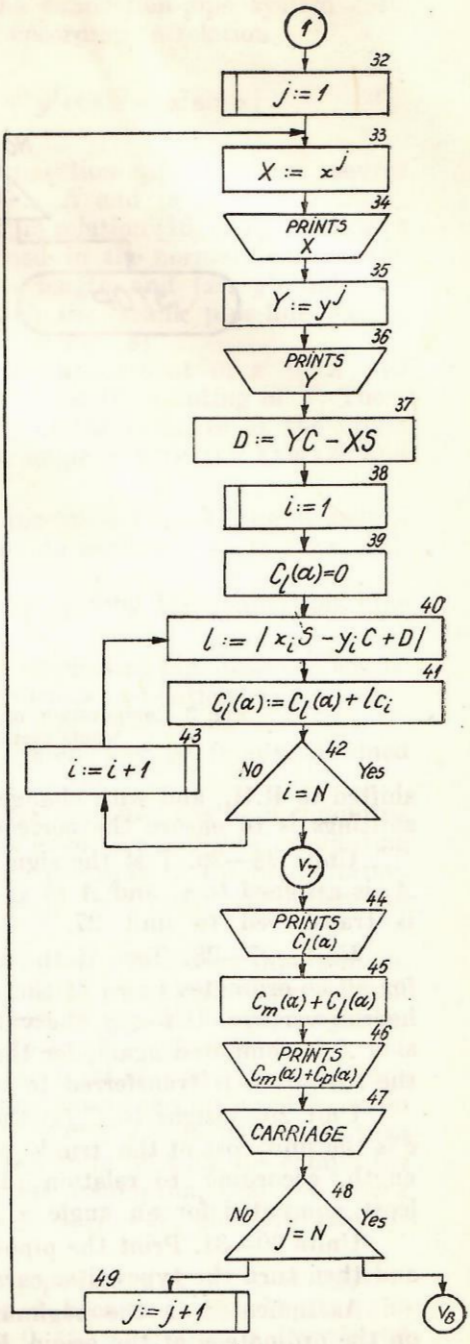

1
32
$j := 1$
33
$X := x^j$
34
PRINTS X
35
$Y := y^j$
36
PRINTS Y
37
$D := YC - XS$
38
$i := 1$
39
$C_l(\alpha) = 0$
40
$l := |x_i S - y_i C + D|$
41
$C_l(\alpha) := C_l(\alpha) + lc_i$
43
$i := i + 1$
42
NO
Yes
$i = N$
v_7
44
PRINTS $C_l(\alpha)$
45
$C_m(\alpha) + C_l(\alpha)$
46
PRINTS $C_m(\alpha) + C_l(\alpha)$
47
CARRIAGE
48
NO
Yes
$j = N$
49
$j := j + 1$
v_8

Fig. 2 c

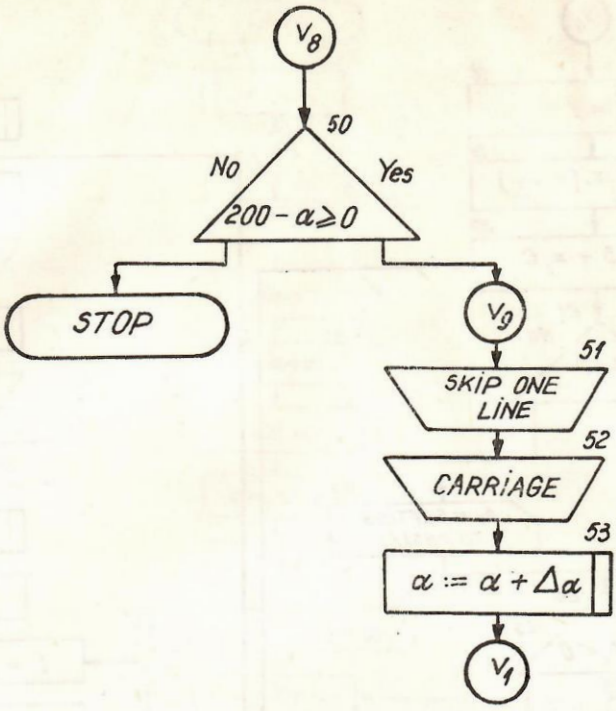


Fig. 3. Computation of the branch pipes cost and of the whole system cost ($C_l(\alpha)$ and $C_s(\alpha)$)

shifted to R.H., and with changed sign, in the reverse case. The aim of this shiftings is to ensure the correct operation of unit 24.

Units 24—26. Test the sign of the expression $\nu_1 - A_1$. If $\nu_1 - A_1 \geqslant 0$, A_1 is assigned to ν_1 and A to ν, respectively. If $\nu_1 - A_1 < 0$, the execution is transferred to unit 27.

Units 27—28. Test if the expression $A = y_i S + x_i C$ was computed for all co-ordinates $(x_i y_i)$ of the η sources, which represent the convex polyhedron vertices. If $i < \eta$, the value $i + 1$ is assigned to i and the expression A is computed again, for the co-ordinates of the next vertex. If $i = \eta$, the execution is transferred to unit 29.

Unit 29. Assigns to $C_m(\alpha)$ the value of the expression $c(\mu - \nu)$, where c is the unit cost of the trunk pipe-line, and $\mu - \nu$ is the trunk pipe-line length, according to relation (3). Consequently the main pipe-line length cost, computed for an angle α, is recorded in cell M.

Units 30—31. Print the pipe-line cost for a given α (recorded in $C_m(\alpha)$) and then turn the typewriter carriage to print a new line.

As indicated in the beginning, the pipe-line length does not depend on the ordinate n at the origin, hence it is computed a single time for a gi-

ven α. The next units serve to compute the connection-pipe system cost, when n varies. The computation is effected according to relation

$$C_l(\alpha) = \sum_{i=1}^{N} c_i \mid x_i \sin\alpha - y_i \cos\alpha + y^j \cos\alpha - x^j \sin\alpha \mid$$

where c_i represents the unit cost of the connection pipe between source A_i and the trunk pipe-line, and $(x_i y_i)$ $i = 1, ..., N$ and (x^j, y^j) $j = 1, ..., N$, the co-ordinates of the sources. More precisely, in relation (16) (x_i, y_i) indicates the co-ordinates of source A_i, which, introduced in the normal form of the pipe-line equation, give the connection-pipe length and (x^j, y^j) indicates the co-ordinates of sources A_j through which the trunk pipe-line passes.

Unit 32. Assigns initially 1 to j. (Fig. 2c and Fig. 3)

Units 33—36. Carry out, respectively, the assignment of x^j to X, the printing of X, then the assignment of y^j to Y and the printing of Y. These units initialize computing of expression (14) of the ordinate at the origin of the trunk pipe-line, which builds up the angle α with the axis Ox and passes through source A_j.

Unit 37. Assigns to D the value of the expression $YC—XS$, i.e. it assigns to D the value of expression $n \cos \alpha$ computed according to relation (14), for a given source A_j.

Units 38—39. Initialize the loop for computing the connection pipe system, assigning 1 to i and 0 to $C_l(\alpha)$.

Unit 40. Assigns to cell l the length of the connecting pipe between source A_i and the trunk pipe-line, computed as according to relation (4).

Unit 41. Assigns to $C_l(\alpha)$ the value $C_l(\alpha) + lc_i$.

The total cost of the connection pipe system will be finally obtained in $C_l(\alpha)$.

Unit 42—43. Check if the cost of all connection pipes has been computed i.e. if $i = N$. If $i < N$, the value $i + 1$ is assigned to i and the computing is resumed, beginning with block 40, i.e. one proceeds to the computation of the connection pipe cost of next source A_{i+1}. If $i = N$, the operation is transferred to unit 44.

Unit 44. Prints $C_l(\alpha)$, i.e. the total cost of the connection pipe system.

Unit 45. Computes $C_s(\alpha, n)$, i. e., the total cost of pipe-line system.

Unit 46. Prints $C_m(\alpha) + C_l(\alpha)$, the total cost of the whole pipe system.

Unit 47. Turns the typewriter carriage, to print a new line.

Units 48—49. Check if, for a given α, the total cost of the whole pipe system was computed, for all situations arising from the shifting of the main pipe-line in all points $A_j(x^j, y^j)$ $j = 1, ..., N$, i.e. if $j = N$. If $j < N$, then $j + 1$ is assigned to j and the loop is resumed, from unit 33, for computing the total cost of the whole pipe system, in the assumption that the trunk pipe-line passes through the next point A_{j+1}. If $j = N$, the operation is transferred to unit 50.

Unit 50. Checks if the dip of the trunk pipe-line $\alpha \leqslant 200^c$. If $200^c - \alpha < 0$, the computing procedure is stopped, because the total cost of the pipe system will repeat itself. If $200 - \alpha \geqslant 0$, the operation is transferred to unit 51 (index c points out that centesimal degrees are used).

Units 51—52. Let a line free and turn the typewriter carriage, with a view to keep apart the results obtained for a given α, from the results to be computed for $\alpha + \Delta_\alpha$.

Unit 53. Assigns the value $\alpha + \Delta_\alpha$ to α and takes over the computing process from unit 2.

The output format is given in Table I, which represents two iterations of an experimental example, carried out with the digital computer "Economist CIFA-102".

Table I

0.000000	303.9999		
4.000000	4.000000	161.9999	465.9999
7.999999	10.000000	225.9998	529.9998
11.000000	0.000000	289.9999	593.9999
21.000000	12.999999	333.9999	637.9999
22.999999	4.000000	161.9999	465.9999
12.999999	9.000000	201.9999	505.9998
1.000000	303.2572		
4.000000	4.000000	167.5142	467.7714
7.999999	10.000000	238.2351	538.4923
11.000000	0.000000	269.5345	569.7917
21.000000	12.999999	271.6942	571.9515
22.999999	4.000000	303.1812	503.4384
12.999999	9.000000	195.7585	496.0157

In the two-number rows, the first one shows the angle value in centesimal degrees, while the other indicates the trunk pipe-line cost for the dip α.

In the four-number rows, the first two indicate the co-ordinates of point $A_j(x^j, y^j)$ through which the trunk pipe-line with dip α passes, and the last two represent the connection pipe system cost and the total cost of the whole conveyance system, respectively.

Hence the minimum of the pipe system cost lies among the numbers of the fourth column. The minimum, once chosen, the co-ordinates of the point through which the trunk pipe-line is bound to pass, as well as the connection pipe system cost are on the respective line: the two-figure line of the respective iteration will furnish indications concerning the dip and the cost of the trunk pipe-line.

This data output format has the advantage that, when, due to site conditions (ravines, marshes, buildings a.s.o.), the optimal position of the trunk pipe-line cannot be chosen, another sub-optimal position may he chosen, in order to avoid the plots of land counter-indicated for the trunk pipeline location.

CONCLUSIONS

The suggested model offers advantages both concerning the programming facility and the performances, even when using small and slow computers. It can be remarked that we have always in view, besides the solving accuracy, the reducing of the computation volume too:

— According to the demonstrated proposition, during the computation process the ordinate at the origin, for a given direction of the trunk pipe-line, is carried out only by successively replacing the co-ordinates of sources in relation (15) of the total cost, the finding out of the optimum being simultaneously ensured.

— Computing the trunk pipe-line length for a given direction is done a single time according to relation (3) and only for the co-ordinates of the vertices of the convex polyhendron circumscribing all sources.

— Reduction of pitch Δ_α is achieved only to the extent that the interval within which the system total cost minimum lies, is found out.

We consider that the presented model offers a clear advantage upon the one described by C.H.Keith in [1], in which the variation of parameters α and n by pitches Δ_α and Δn considerably increases the computation volume, simultaneously reduces the method accuracy, and may miss even the optimum position of the trunk pipe-line.

REFERENCES

1. KEITH, COATS H.: *Optimum Location of Trunklines in Oil and Gas Fields.* Journal of Petroleum Technology, September 1963.
2. * * * *Noi soluţii de optimizare a transportului fluidelor pe conducte în industria petroliferă.* Tema I.C.F.E. Cîmpina XI.5. 1966.
3. * * * *Conductă pentru evacuarea ţiţeiului de la parcul 13 la depozitul 160 Videle.* Proiect tehnic No. 1 500—3 342 P.A.E. I.P.F.E. Ploieşti.

LA MINIMISATION DU COUT DES SYSTEMES DES CONDUITES DE TRANSPORT DES FLUIDES

Le modèle mathématique élaboré pour le calcul de l'emplacement optime de la conduite magistrale rectiligne et des conduites de jonction avec les sources, dont les fluides doivent être transportés, permet l'utilisation des ordinateurs électroniques. Les auteurs donnent la description du schéma logique détaillé pour le calcul du coût du système des conduites. Le modèle a éte expérimenté sur l'ordinateur électronique ECONOMIST CIFA 102 dans le seul cas où les conduites de jonction sont perpendiculaires sur la magistrale et leurs coûts unitaires sont constants.

МИНИМИЗАЦИЯ СТОИМОСТИ СИСТЕМ ТРУБОПРОВОДОВ ДЛЯ ТРАНСПОРТИРОВКИ ЖИДКОСТЕЙ

Математическая модель, разработанная для расчета оптимального расположения магистрального трубопровода и трубопроводов для связи с источниками, жидкости и газы которых должны транспортироваться, позволяет использовать электронные счетные машины.

Авторы статьи дают подробное описание логической схемы для расчета стоимости системы трубопроводов для транспортировки. Модель была опробована на электронном вычислителе ECONOMIST CIFA 102 только для случая, когда трубопроводы связи перпендикулярны к магистрали, а их единичные стоимости постоянны.