A. MĂCRIŞ

Methodology of Establishing the Optimal Achievement Duration of the Energetic Investments

If you can trust yourself, when all men doubt you,
But make allowance for their doubting, too.

„*If*" by Rudyard Kipling

The achievement of an investment represents a complex process, which includes a great variety of activities, and has a certain display in time, with a view to introducing new production capacities in the country's economic circuit. The achievement cycle of an investment consists in the following main parts: conception (location study, technical-economic study) and designing (lay-out, investment execution design), technological equipment contracting, delivery of this equipment, execution of the building and erecting works, and the commissioning of the production capacities which make out the investment's object.

The achievement duration of this cycle is of great importance when computing the relevant investment economic efficiency. The reduction of the investment achievement cycle, within certain basic technical-economic limits, forms one of the main concerns of the investment designers, performers and beneficiaries. An investment achievement duration, as short as possible, is generally desirable, since, thanks to it, new production capacities enter earlier the economic circuit, and there arise possibilities of increasing the respective socialist accumulation.

Duration reduction must take into account following conditions: the reduced durations must be technically workable, as there is a certain limit, a "human barrier", which cannot be overpassed, despite all used additional means of production and labour forces; the spreading out in time of the invest-

ment achieving must be correlated with the financing limits, established for each time period (yearly, as a rule), for each kind of activity: studies and designing, equipment contracting and building-erecting works, a.s.o.

The achievement of an investment is done on the basis of a program, of a time scheme of the different stages, known as the general diagram of the spreading-out in time of the execution, which is an important instrument in managing and controlling the investment achieving. This diagram, carried out according to the classical method (Gantt diagram), has the advantage of being simple, ready to be plotted, while its intuitive aspect suggests the investment evolution in time. Gantt diagram is not satisfactory for more complex works, where more factors occur, with more complex incidents in time, with ample technological and organizational connections.

The important achievement stages of an investment are worked out in the execution diagrams, according to the classical method, generally in series: conception and designing, equipment contracting and delivery, execution and commissioning. The reduction of the investment-achieving total duration of the investment cycle, is obtained by reducing each stage, often to the quality's detriment. Actually, these stages also have coincidences in time, since a certain stage can start before the ending of the previous stage. In this lies the possibility of reducing the investment cycle, without compressing the component stages. Yet in order to use these reserves, it is necessary to know the component activities of each stage, the reciprocal links between these activities, their reciprocal conditioning. To this end, the representation of the operations of a stage by graphs (network-graphs) is used.

A certain execution duration is obtained by plotting the graph in a first version. The parameter, submitted to optimization in the first stage, is the execution duration. A few versions are computed, by acting upon the operation durations on the critical path, with a view to reducing them.

The general problem, which arises when optimizing energetic investment achieving programs, is to take into account, not only the execution-duration criterion, but other criteria as well: works cost-price reduction, minimal equipment immobilization, ensurance of the continuity and uniformity of using resources, achieving of a minimal recovery time of investments, spreading-out in time of investment fonds, by taking into account the updating of expenses.

In what follows, these stages are detailed, and the computation methods, used algorithms and calculation examples are displayed.

PLOTTING THE GRAPH FOR THE SET OF ACTIVITIES LEADING TO THE INVESTMENT ACHIEVING

The plotting of the graph, for a reduced-volume work and for a well outlined process, is a relatively simple problem. It is recommended, for high-complexity works, to plot graphs by merging the network-subgraphs, plotted for distinct fields of the modelled process. The subgraph merging is done by drawing them one near another, and by linking them through connection knots. If the graph obtained in this way is not considered as being too intri-

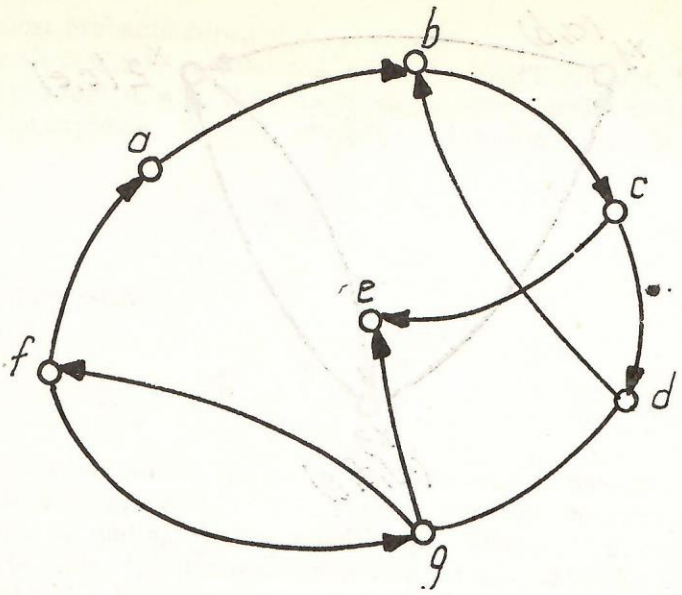

Fig. 1

cate and too detailed, it will be arranged by levels (generations), and its vertexes will be numbered.

Let graph $G = (X, \Gamma)$ and a partitioning X_i, $i = 1, 2, ..., r$ be, such as

$$\bigcup_{i=1}^{r} X_i = X$$

$$X_i \cap X_j = \varnothing \text{ for any } i, j = 1, 2, ..., r.$$

The condensed graph is $G' = (X_0, \Gamma_0)$ where $X_0 = \{X_1, X_2, ..., X_r\}$, and Γ_0 is defined as follows: X_i, $X_j \in \Gamma_0$ only and only if there is a vertex $x \in X_i$, and a vertex $y \in X_j$ such as x, $y \in \Gamma$.

Graph $G = (X, \Gamma)$ is presented in Fig. 1. Let set X be partitioned as follows:

$$X_1 = \{a, b\}$$

$$X_2 = \{c, e\}$$

$$X_3 = \{d, f, g\}$$

$$X_1 \cup X_2 \cup X_3 = X = \{a, b, c, d, e, f, g\}$$

$$X_1 \cap X_2 \cap X_3 = \varnothing$$

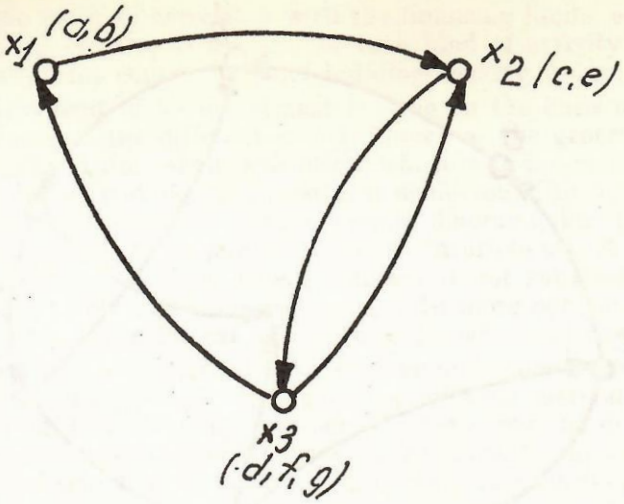

Fig. 2

The condensed graph $G' = (X_0\, \Gamma_0)$ is shown in Fig. 2 and has set $X_0 = \{x_1, x_2, x_3\}$ and map $\Gamma_0 = \{x_1 - x_2, x_2 - x_3, x_3 - x_2, x_3 - x_1\}$ since element x_1 contains $b \in x_1$, and x_2 contains $c \in x_2$, and b, $c \in \Gamma$, a.s.o.

ESTABLISHING ACTIVITIES DURATIONS AND CALCULATION OF THE CRITICAL PATH

From the viewpoint of durations' establishing way, two versions of critical path methods are distinguished: deterministic version, in which durations have a unique value, supposed to be sure, established through norms, experiences, statistical data, a.s.o., and probabilistic version, in which durations are estimated in a probabilistic manner. These are the methods known under the denomination PERT, with its versions.

Both the deterministic version of establishing durations, for most of the activities, and the PERT method, are used in establishing the general graph of achievement of an energetic investment, since a series of activities, e.g. the experts opinion on a designing stage, the equipment contracting, a.s.o., have durations.

Using PERT method, competent experts estimate three durations for each activity, i.e.:

— optimistic duration, established within the most favourable working conditions, denoted by a_{ij};

— pessimistic duration, established within the most unfavourable working conditions, denoted by b_{ij};

— the most probable duration, m_{ij}.

In order to facilitate calculations, with the PERT method, the distribution law β is adopted, with the help of which, after a serios of simplifying hypotheses, the expression for computing mean duration d_{ij} can be set down

$$d_{ij} = \frac{a_{ij} + m_{ij} + b_{ij}}{6}$$

as well as the dispersion

$$\sigma_{ij}^2 = \left(\frac{b_{ij} - a_{ij}}{6}\right)^2.$$

The moments calculation is done in the same way as with the deterministic model, by taking, instead of deterministic duration, the expected duration (d_{ij}). Values d_{ij} and σ_{ij} are computed in the Table with the help of the initial values (a_{ij}, m_{ij}, b_{ij}). Final moment dispersion is obtained by adding dispersions assignable to the activities on the critical path. Since we know the expected value of the final moment (total duration T_n and final-term dispersion σ_n^2) we can determine the achievement probability of any planned term T, by computing the reduced variable x:

$$x = \frac{T - D_{ij}}{\sigma_n}$$

which is distributed according to the normal law of distribution. The probabilities corresponding to the different x values may be read in the normal distribution Tables.

We give, in what follows, a direct computing example on the diagram, for the simple-configuration graph in Fig. 3.

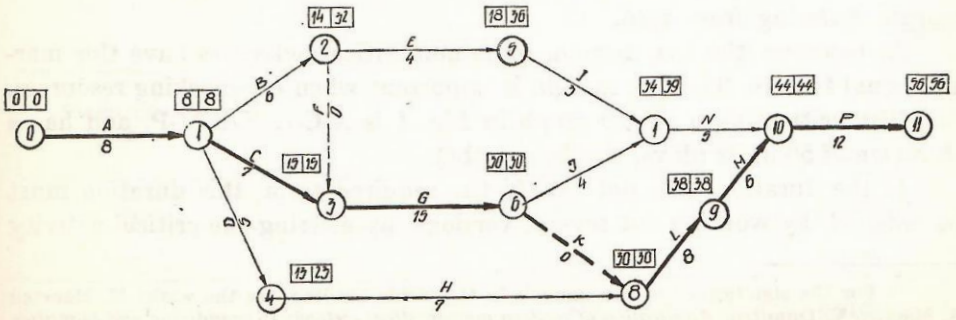

Fig. 3

The calculation results are written down in Table 1

Table 1*

Activity's code	d_{ij}	t_i^0	$t_i^M = t_i - d_{ij}$	$t_j^m = t_i^0 + d_{ij}$	t_j^1	t_j^0	Total margin $t_j^1 - t_j^m$	Free margin $t_j^0 - t_j^m$	Critical operations
A	8	0	0	8	8	8	0	0	yes
B	6	8	26	14	32	14	18	0	—
C	7	8	8	15	15	15	0	0	yes
D	5	8	18	12	23	13	10	0	—
E	4	14	32	18	36	18	18	0	—
G	15	15	15	30	30	30	0	0	yes
H	7	13	23	20	30	30	10	10	—
I	3	18	36	21	39	34	18	13	—
J	4	30	35	34	39	34	5	0	—
L	8	30	30	38	38	38	0	0	yes
M	6	38	38	44	44	44	0	0	yes
N	5	34	39	39	44	44	5	5	—
P	12	44	44	56	56	56	0	0	yes

It is established, from Table, that all non-critical activities have total margin differing from zero.

As concerns the free margin, some non-critical activities have this margin equal to zero. The free margin is important when ear-marking resources.

The critical path of the graph in Fig. 1 is A-C-G-K-L-M-P, and has a duration of 56 units (days, weeks, months).

If the duration does not satisfy the required term, this duration must be reduced, by working out several versions, by altering the critical activity

*) For the significance of the symbols in the Table heading, see the work: M. Mănescu A. Măcriş., V. Dumitru. *Application of modern mathematical methods in organizing and planning, building and erecting works.* Ed. Academiei, 1969.

durations, by changing the process technology, improving the network-graph topology, a.s.o.

At the beginning, such measures are taken, which lead to the reduction of the total execution duration, without implying additional resources.

When, on the critical path, there are also activities whose durations have been set down by means of the PERT method, we also proceed to the calculation of the achieving probability of the total execution duration.

We consider, in the example in Fig. 3, that the activities 1—3, 8—9 and 10—11 are random and have pessimistic, mean and optimistic duration, as in Table 2, where the total duration is also computed. One can see in this Table that the activities, whose duration has been established in a deterministic way, are zero. The probability of achieving total duration is computed in Table 3.

Table 2

Activities on critical path	a_{ij}	m_{ij}	b_{ij}	Duration		$\sigma_n^2 = \left(\frac{(b_{ij} - a_{ij}}{6}\right)^2$	σ_n
				d_{ij}	cumulative		
0—1	8	8	8	8	8	0	
1—3	6	6.5	10	7	15	0.44	
3—6	15	15	15	15	30	0	
6—8	0	0	0	0	30	0	
8—9	3	8	15	8	38	4	
9—10	6	6	6	6	44	0	
10—11	10	11	18	12	56	1.77	
$d_{ij} = 56$						6.21	2.5

Table 3

Programmed T	$T - c$	$x = \frac{T - d_{ij}}{\sigma_n}$	Achieving probability
50	−6	−2.4	0.0082
56	0	0	0.5000
90	4	1.37	0.9100

EXECUTION-DURATION OPTIMIZATION BY TAKING INTO ACCOUNT THE WORK COST

There is, generally, a connection between the execution duration and the work cost, such that the problem arises of determining the duration which corresponds to the minimal price.

Let T be the execution duration of an investment or work, in which each of the n activities are carried out with optimal durations D_k, and minimal cost C_k. The investment achieving is obtained, in these conditions, with a minimal total cost $\sum_{1}^{n} C_k$. We mean, by optimal or normal duration, the execution duration having the most reduced expenses.

The increasing of this duration leads to higher costs, due to the indirect expenses and to the inadequate exploitation of the production capacity. The decreasing of this duration also leads to higher costs, due to higher direct expenses, and to the necessary additional resources.

The problem which arises, is that of computing minimal additional costs, involved by the reduction of the execution duration T.

We suppose the following data are known for every activity: optimal duration D_k; minimal duration d_k; execution cost C_k depending on the execution duration $C_k = f(d)$. Let us suppose that this function is expressed by discrete values, attached to a series of execution durations, computed, e.g., every month (D_k — 1 month, D_k — 2 months, D_k — 3 months, ..., d_k). The calculation is carried out by several iterations, and after each iteration a duration reduction of a month is obtained, namely with a minimal cost.

At the first iteration, an activity on the critical path is selected, which can be modified by a month, with a minimal additional cost.

In this way, all activity moments, situated down-side the activity whose duration was changed, can get ahead by a month.

If we reduce the execution duration of an activity by a month, in the studied network-graph, the vertexes of the graph can be separated into two subsets: that of the vertexes whose minimal moments get ahead; that of the vertexes whose minimal moments are most influenced.

These two subsets can be separated by a cut Γ_1, which will cross the activity which got ahead, and all activities possessing a free margin.

If the free margins, associated to the cut, are superior to a month duration, the reduction by a month of the selected-activity duration will not change the critical path in the graph.

Otherwise new critical activities appear.

We obtain, with each iteration, an increase of the program cost, but a minimal one.

The general method of computing the minimal additional cost is as follows:

— consider the graph plotted, from the critical path (or pathes), obtained as a result of an (n-order) iteration;

— associate to each arc of this graph the cost ΔC_k, corresponding to the reduction by a month of the relevant activity duration;

— compute, with the help of the Ford-Fulkerson algorithm, the maximal flux, associated to the critical-path graph, whose arcs limit-capacities are ΔC_k;

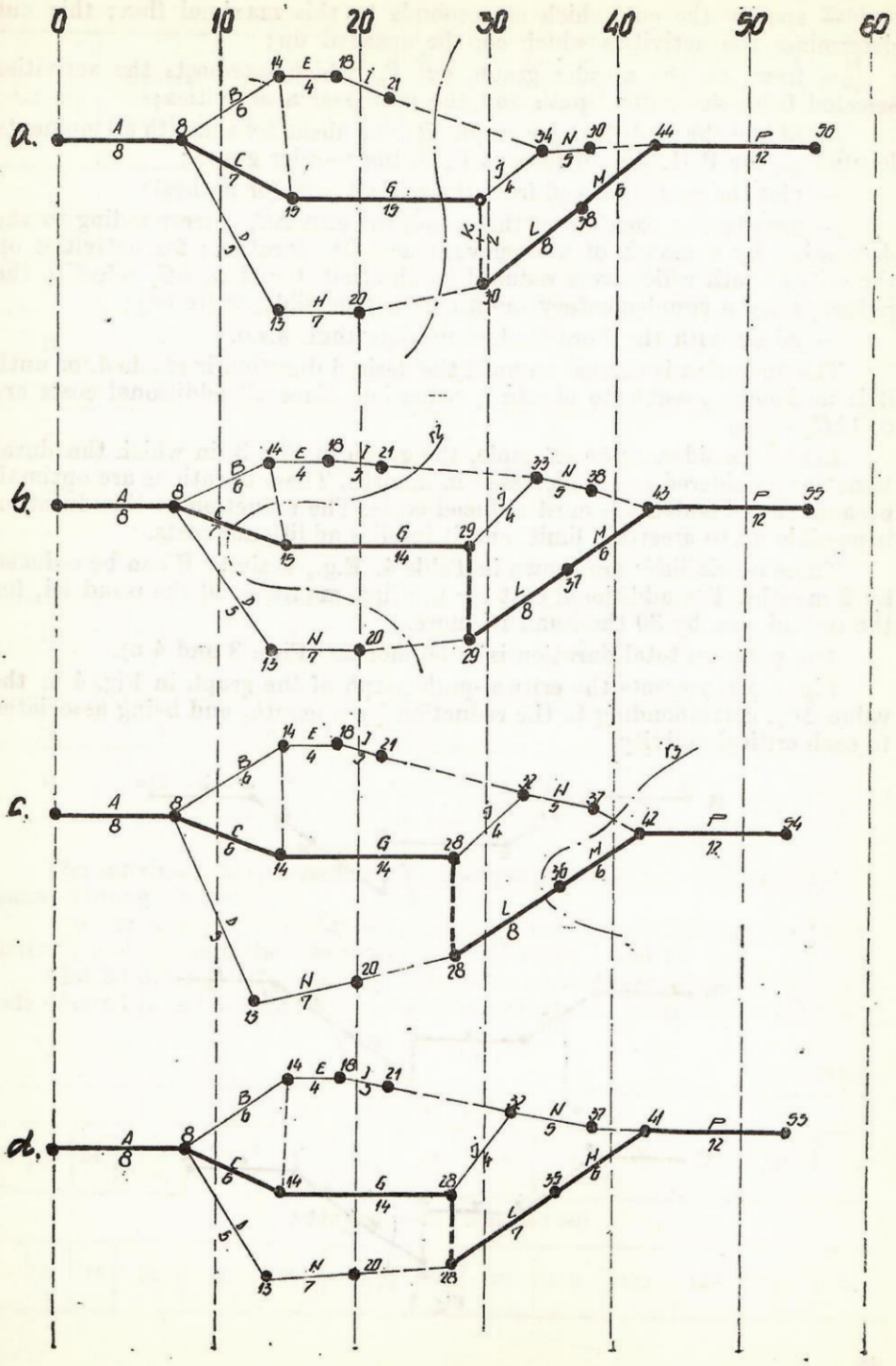

Fig. 4

— specify the cut which corresponds to this maximal flux; this cut determines the activities which can be speeded up;

— treat, on the n-order graph, cut Γ_n which intersects the activities selected from the critical path and the free-margin activities;

— re-plot the $(n + 1)$ order graph, moving ahead by a month all moments located on the R.H. side of the cut Γ_n in the n-order graph;

— plot the graph derived from the critical path (or pathes);

— associate to each arc of this graph the cost ΔC, corresponding to the decreasing by a month of the relevant activity duration; for activities on the critical path which were reduced by the first iteration, ΔC_k refers to the reduction by a supplementary month (if not possible, write ∞);

— go on with the Ford-Fulkerson algorithm, a.s.o.

The operation is carried on until the desired duration is reached, or until it is no longer possible to obtain a reduction, since all additional costs are ∞ ($\Delta C_k = \infty$).

Let us consider, as an example, the graph in Fig. 3, in which the durations are considered to be expressed in months. These durations are optimal, because they involve the most reduced costs. The reduction of this duration is possible up to a certain limit, and it implies additional costs.

These possibilities are shown in Table 4. E.g., activity B can be reduced by 2 months. The additional cost for the first month is 20 thousand lei, for the second one, by 30 thousand lei more.

The program total duration is of 56 months (Figs. 3 and 4 a).

Fig. 5 a represents the critical-path graph of the graph in Fig. 4 a, the value ΔC_k, corresponding to the reduction by a month, and being associated to each critical activity.

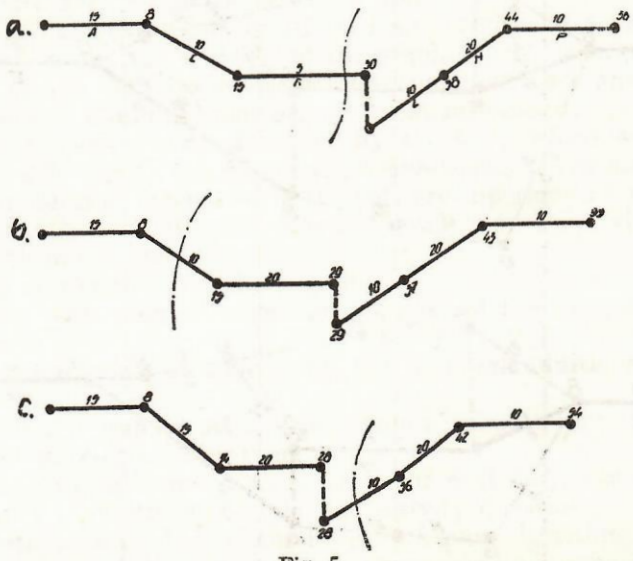

Fig. 5

Table 4

Activity	Optimal duration (months)	Minimal duration (months)	Cost of reduction by 1 month (thousand lei)	Cost of reduction by 2 months (thousand lei)	Cost of reduction by 3 months (thousand lei)	Cost of reduction by 4 months (thousand lei)
A	8	6	15	26	–	–
B	6	4	20	30	–	–
C	7	5	10	15	–	–
D	5	4	30	–	–	–
E	4	3	5	–	–	–
G	15	12	5	20	20	–
H	7	5	15	25	–	–
I	3	3	–	–	–	–
J	4	3	30	–	–	–
L	8	7	10	–	–	–
M	6	4	20	40	–	–
N	5	4	30	–	–	–
P	12	8	10	15	20	25

The maximal flux, associated to this graph, is 5, and the minimal cut passes through activity G.

Plot, on the graph in Fig. 4 a, cut Γ_1, which passes through the critical activity and through the free margins of activities I and H.

Plot 2d-order graph (Fig. 4 b), which has all vertexes located on the R.H. side of cut Γ_1, and is ahead by a month as against the initial graph (Fig. 4 a).

Table 5

Operation duration													
56	55	54	53	52	51	50	49	48	47	46	45	44	43
Additional costs (thousand lei)													
–	5	15	25	35	50	65	70	90	110	130	155	195	∞

The total duration decreased by 1 month, the cost increased with 5 thousand lei (minimal possible increase).

Fig. 5 b represents the critical-path graph of the 2nd-order graph in Fig. 4b.

The maximal flux associated to this graph is 10, and the minimal cut passes through activity C. The algorithm is applied as per the first iteration.

The operation goes on, until the desired duration is reached, on until there exists no other possibility.

Table 5 displays the computation results. After iteration 12, the total duration is of 44 months and the additional costs are 195 thousand lei. The computation cannot be carried on, since all additional costs of the critical-path operations are ∞.

If we consider that the work value for the normal duration — D_{ij} — is $P = 1{,}300$ thousand lei, plot as in Fig. 6, direct costs, in terms of execution duration $e_d(t)$.

VARIATION OF INDIRECT COSTS IN TERMS OF EXECUTION DURATION

The reduction of the execution duration leads to the decrease of the variable indirect expenses.

The percentage of the variable expenses from the total amount of indirect expenses is about 60% in the case of building and erecting works.

In this branch also the indirect expense volume out of the expense total volume (P) is of about 20%.

The saving resulting for the indirect expenses, depending on the execution, have this value:

$$e_i = 0.2 \cdot P - 0.2 \cdot P\left(0.4 + 0.6\,\frac{T_n}{D_{ij}}\right), \quad \text{where}$$

D_{ij} — optimal execution duration of delivery (from the works cost viewpoint)

T_n — various execution durations.

The savings achieved by the decrease of the indirect expenses, for the example in Table 5, are computed in Table 6.

Results are plotted in Fig. 6, curve $e_i(t)$.

Table 6

Plan = 1,300 thousand lei

Crt. number	T_n months	e_i (thousand lei)	Crt. number	T_n months	e_i (thousand lei)
1	56	0	7	50	17
2	55	3.9	8	49	19.5
3	54	6.5	9	48	22
4	53	8.0	10	47	26
5	52	11.7	11	46	28.5
6	51	14.5	12	45	32.5
			13	44	34.5

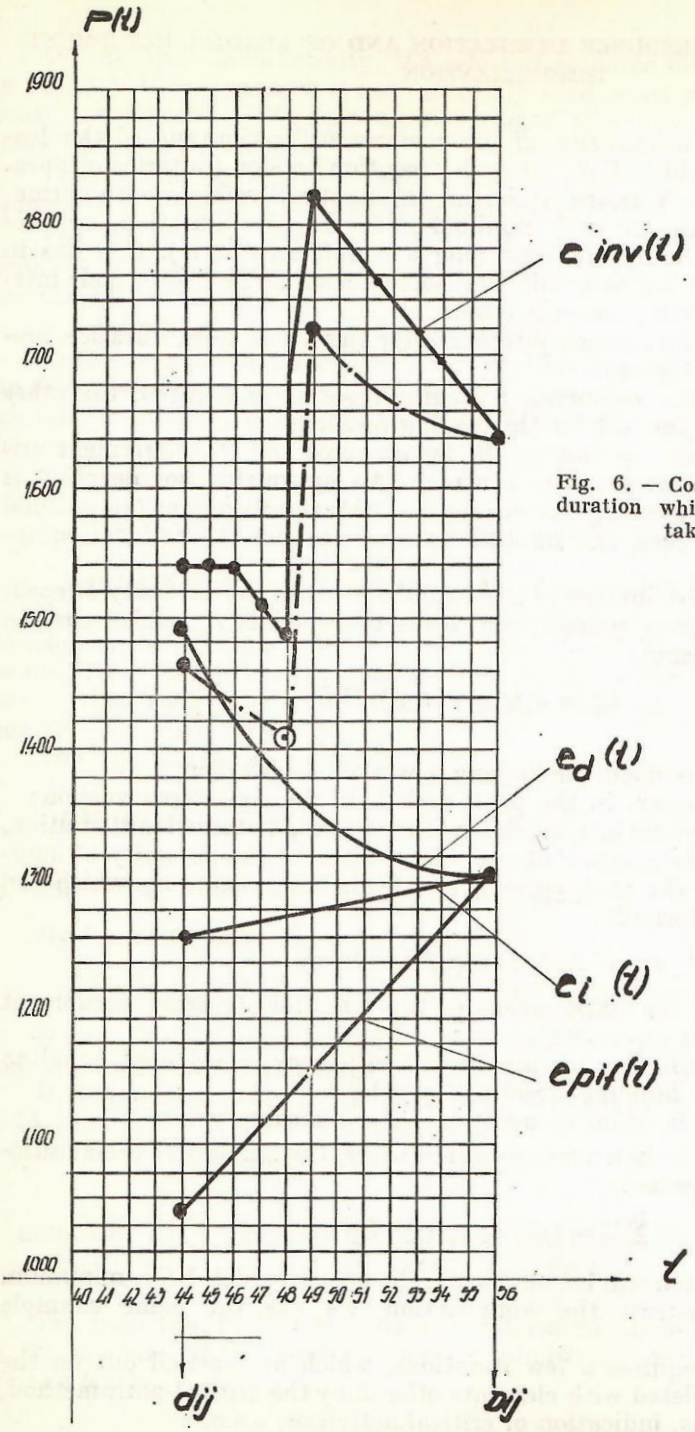

Fig. 6. — Cost variation dependig on duration while several parameters are taken into account

OPTIMIZATION OF RESOURCE UTILIZATION AND OF LEADING-EQUIPMENT IMMOBILIZATION

Proceed to the optimization of the resource utilization and of the leading-equipment immobilization, for each execution version (in terms of duration), or only for a few versions, which are intersecting (versions with normative execution duration, or with minimal-cost execution duration, or execution durations necessary for observing a compulsory term). One has in view rational distribution of available resource, such as to ensure their integral, uniform and continuous utilization.

The plotting of the necessary resource for the whole work duration presents itself like a histogram.

If there are several resources, a leading resource is selected, the other ones following the regime set for the leading resource.

It is possible, when optimizing the labour-force and the equipment utilization, that the trends may be contrary. An optimizing computation is done in this case, by selecting one version out of several versions (an optimal one, for the labour forces, and another optimal one, for the rational equipment utilization).

A non-uniform distribution of labour force leads to the necessity of ensuring housing in the peak periods, and leads to expenses E_c, which can be expressed by the formula:

$$E_c = a(n_{max} - n_{opt}), \text{ [lei]}$$

where:

a — necessary investment for lodging a worker, lei/worker;
n_{max} — number of workers in the peak period, in the considered version;
n_{opt} — number of workers in a version with uniform, flattened distribution.

A non-uniform distribution of equipment leads to the necessity of additional equipments in the peak periods, and leads to expenses E_u, which can be expressed by the formula:

$$E_u = \Delta M_b(1 + p_t)^t \text{ lei, where}$$

ΔM_b — increase of the fixed means of the site, for covering equipment requirement peak (lei);
p — normed coefficient for investment efficiency, considered equal to 0.17 in the building-erecting branch;
t — utilization duration of additional fixed means, years.

For several distribution versions of resources, the amount of the additional expenses is computed:

$$\Sigma E = (\pm)\, E_c + (\pm)\, E_u \text{[lei]},$$

The optimal version will be, obviously, the one for which ΣE is minimum.

In order to illustrate the computation, we use the same example (Fig. 3 and 6).

The algorithm requires a few iterations, which are carried out on the Gantt diagram, completed with elements offered by the critical-path method, total and free margins, indication of critical activities, a.s.o.

Denote, over each activity, the relevant resource intensity, and totalize by vertical. If the resource is not uniformly used, start shifting some operations, in the limits of the free margins and, if otherwise not possible, in the limits of the total margin.

The optimizing criterion, with each iteration, consists in the sum of squares of the resource consumption (Kilbrew-Burgess criterion).

The computation is systematized in Tables, as in Fig. 7. In this figure, resources (labour forces) are optimized for the execution version with a total duration of 56 months.

We shall proceed in the same way, for all the other versions 55, 54, ..., 46).

In the version studied in Fig. 7, after 5 iterations the optimal levelling of the resource comsumption is reached, since the indicated optimizing criterion exhibits its minimal value (1,249). With this version, in the last iteration, the resource peak decreases by a conventional unit (100 workers).

This fact entails an economy of

$$E_c = a(n_{max} - n_{opt}) = 1{,}400 \ (900 - 800) = 140{,}000 \text{ lei.}$$

a — 1,400 lei/worker represents the unit expenses for lodging one worker.

We consider, in order to illustrate the calculation, that a more rational distribution of equipment is attained, by levelling the labour force. Let us assume, for instance, that operations A, B, D, E, require a crane. With iteration O, this crane is necessary for 18 months, with the last iteration, for 34 months.

The additional expenses are:

$$E_u = \Delta M_b(1 + p) = 100{,}000 \ (1 + 0.17) \ \frac{34 - 18}{12} = 100{,}000 \times 1.24 = 124{,}000$$

lei, where $\Delta M_b = 100{,}000$ lei is the crane value.

By totalizing costs E_c and E_u we get:

$$\Sigma E = (\pm) \ E_c X (\pm) \ E_u = -140{,}000 + 124{,}000 = -16{,}000 \text{ lei}$$

Hence, the resource levelling in the studied version (execution duration: 56 weeks) leads to savings of 16,000 lei.

It is proceeded in the same way for all versions ($d_{ij} = 55$ months, ..., $d_{ij} = 44$ months).

In fig. 6, curve $e_{res}(t)$ was not plotted.

ECONOMIC EFFICIENCY OF INVESTMENT RATE AND OF REDUCING THE COMMISSIONING TERM

The reduction of the commissioning term of an energetic object leads to an increase of the electrical energy production and to the relevant savings (e_{pif}).

$$e_{pif} = E(D_{ij} - T) \cdot c_0,$$

where:

E — yearly production, kWh/year;
D_{ij}, T_n — have the significances from the previous chapters;
c_0 — achieved savings per 1 kWh (lei/kWh).

We consider $E = 5{,}000{,}000$ kWh/year; $c_0 = 0.05$ lei/kWh, for the example dealt with in the previous chapters.

The achieved savings in various versions are computed in Table 7.

Results are plotted in Fig. 6, curve $e_{pif}(t)$.

With regard to the cost differences, resulted from different spacing-outs in time of the investment funds, we consider, in a first approximation, that their distribution by periods is equal.

In the hypothesis of a uniform yearly distribution of the investment, I_r is computed according to the formula:

$$I_r = I_{an} \sum_{1}^{n} (1 + p)^{n-1},$$

where:

I_{an} — yearly investment for the considered hypothesis;
n — number of years necessary to achieve the investment.

Table 7

$E = 5{,}000$ MWh/year; $c_0 = 0{,}05$ lei/kWh

Order nr. of activities	$D_{ij} - T_n$ year	e_{pif} (thousand lei)
1	0	0
2	1/12	21
3	2/12	42
4	3/12	62.5
5	4/12	84
6	5/12	105
7	6/12	125
8	7/12	147
9	8/12	168
10	9/12	187.5
11	10/12	210
12	11/12	232
13	12/12	250

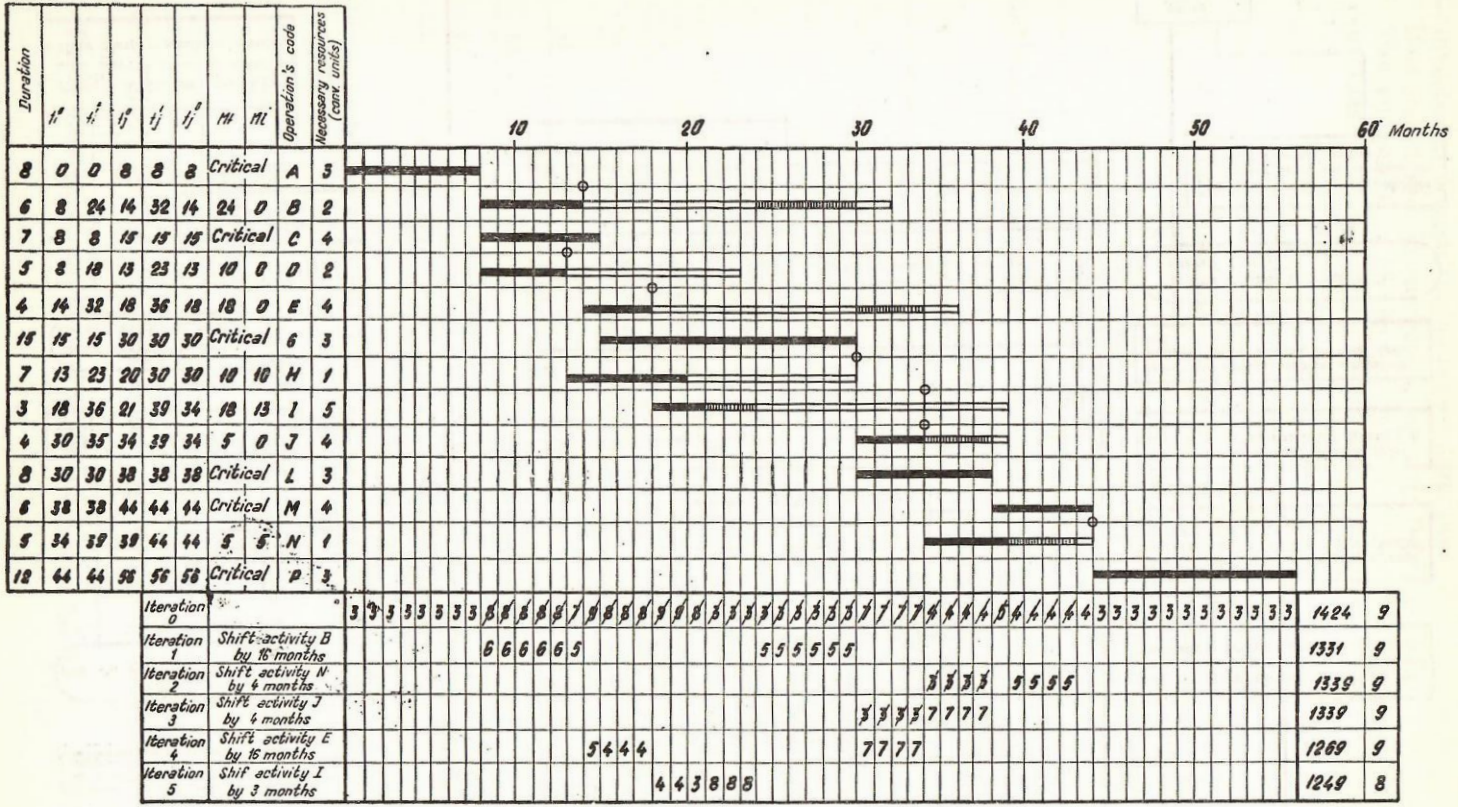
Duration
Operation's code
Necessary resources (conv. units)
Critical
10
20
30
40
50
60
Months
Iteration 0
Iteration 1
Shift activity B by 16 months
Iteration 2
Shift activity N by 4 months
Iteration 3
Shift activity J by 4 months
Iteration 4
Shift activity E by 16 months
Iteration 5
Shif activity I by 3 months
1424
1331
1339
1339
1269
1249

Fig. 7

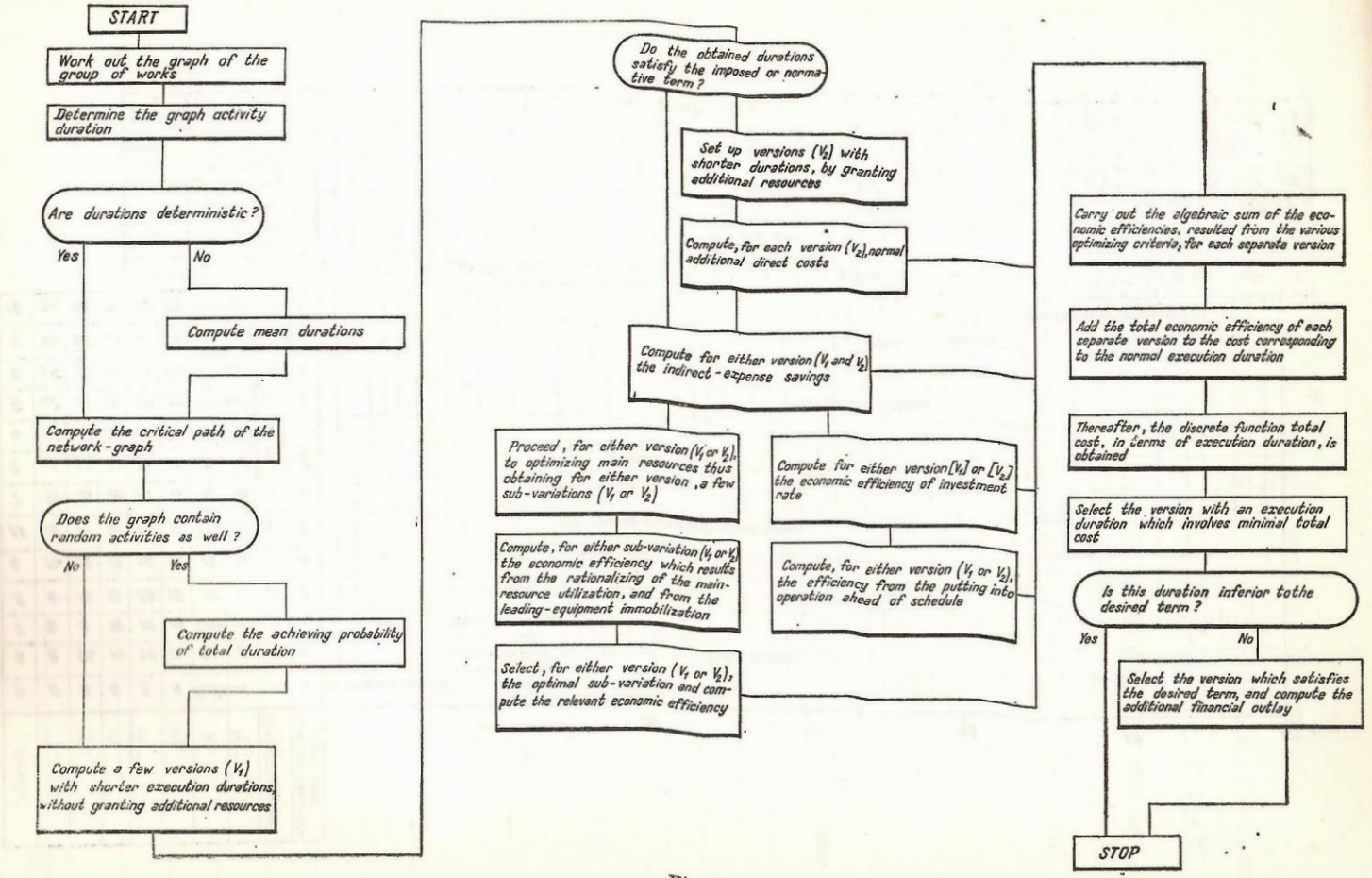
START
Work out the graph of the group of works
Determine the graph activity duration
Are durations deterministic?
Yes
No
Compute mean durations
Compute the critical path of the network-graph
Does the graph contain random activities as well?
No
Yes
Compute the achieving probability of total duration
Compute a few versions (V1) with shorter execution durations, without granting additional resources
Do the obtained durations satisfy the imposed or normative term?
Set up versions (V2) with shorter durations, by granting additional resources
Compute, for each version (V2), normal additional direct costs
Compute for either version (V1 and V2) the indirect-expense savings
Proceed, for either version (V1 or V2), to optimizing main resources thus obtaining for either version, a few sub-variations (V1 or V2)
Compute, for either sub-variation (V1 or V2) the economic efficiency which results from the rationalizing of the main-resource utilization, and from the leading-equipment immobilization
Select, for either version (V1 or V2), the optimal sub-variation and compute the relevant economic efficiency
Compute for either version [V1] or [V2] the economic efficiency of investment rate
Compute, for either version (V1 or V2), the efficiency from the putting into operation ahead of schedule
Carry out the algebraic sum of the economic efficiencies, resulted from the various optimizing criteria, for each separate version
Add the total economic efficiency of each separate version to the cost corresponding to the normal execution duration
Thereafter, the discrete function total cost, in terms of execution duration, is obtained
Select the version with an execution duration which involves minimal total cost
Is this duration inferior to the desired term?
Yes
No
Select the version which satisfies the desired term, and compute the additional financial outlay
STOP

Fig. 8

p — investment economic-efficiency coefficient:
it is considered, in energetics, equal to 0.1.

The computation of the reported investments, in various hypotheses, is centralized in Table 8.

Table 8

Crt. nr. of activities	Yearly investment I_{an} (thousand lei)	n (years)	I reported (thousand lei)	Difference (+) e_{inv} (t) (thousand lei)
1	$\frac{1\,300 \times 12}{56} = 277$	4.65	1,640	340
2	284	4.58	1,660	360
3	290	4.5	1,680	380
4	295	4.4	1,700	400
5	300	4.32	1,730	430
6	305	4.25	1,760	460
7	310	4.15	1,780	480
8	317	4.10	1,820	520
9	325	4.0	1,505	205
10	332	3.9	1,530	260
11	346	3.82	1,650	260
12	346	3.75	1,550	270
13	355	3.65	1,560	260

Note: Calculation example for I reported:

$$I_{rep} = 277 \sum_{1}^{4.65} (1 + 0.1)^{n-1} = 277(1.1^{365} + 1.1^{2.65} + 1.1^{1.65} +$$

$$+ 1.1^{0.65} + 1 = 1,640$$

In the Table's last column, differences resulted from investment reporting are computed.

These differences are plotted in Fig. 6, curve $e_{inv}(t)$.

Curve $e_{tot}(t)$ (dotted line) is obtained by summing up all curves in Fig. 6. This curve represents the graph of the work total cost, in terms of execution duration.

The logical diagram of the optimizing process is exhibited in Fig. 8.

LA METHODOLOGIE D'ETABLIR LA DUREE OPTIME DE REALISATION DES INVESTISSEMENTS ENERGETIQUES

L'auteur expose une méthodologie d'établir la durée optime pour réaliser les investissements, ayant pour point de départ la méthode du chemin critique et prenant en considération les paramètres suivants: la durée des travaux, les coût des travaux, la continuité et l'uniformité des ressources, l'immobilisation minime des outillages importants, la mise en oeuvre avant terme, l'immobilisation des fonds.

On trace une courbe qui représente la variation du coût total par rapport à la durée, tenant compte de tous les paramètres énoncés. On peut choisir la durée optime au point de vue de l'économie nationale.

Cette durée n'est pas toujours optime pour les organismes d'exécution. C'est un problème de décision.

МЕТОДИКА УСТАНОВЛЕНИЯ ОПТИМАЛЬНОЙ ДЛИТЕЛЬНОСТИ ВЫПОЛНЕНИЯ ЭНЕРГЕТИЧЕСКИХ КАПИТАЛЬНЫХ ВЛОЖЕНИЙ

Автор излагает методику установления оптимальной длительности выполнения капитальных вложений, основывающуюся на методе критического пути, с учетом следующих параметров: длительность работ, их стоимость, последовательность и однородность ресурсов, наименьшее замораживание важного оборудования, досрочный ввод в действие, замораживание фондов.

Приводится кривая, представляющая собой вариацию общей стоимости в зависимости от длительности с учетом всех перечисленных параметров. Можно выбирать оптимальную длительность в народнохозяйственном отношении.

Эта длительность не всегда является оптимальной для организаций-исполнителей. Это вопрос принятия решения.