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POSSIBILITIES OF IMPROVING INFORMATORY SYSTEMS IN CONSTRUCTION WORK

Relying on actual examples from building practice, this paper analyses the correctness of informatory circuits, the capacity of reception, working out and transmission of information within the framework of certain services and the possibilitis of improving the informatory language.

The success scored by cybernetics in less than two decades from its birth are well known.

A great many engineers and economists who have not specialised in cybernetics are well aware of the exceptional contribution made by electronic computers to contemporary science and technique though they are less familiar with cybernetics as a science of informatory systems. In this respect cybernetics studies all kinds of organisms (machines, live beings, groups of people, etc.) from the viewpoint of the circulation of information between their component elements, the whole organism being directed towards certain given objectives.

The study of economic bodies from the informatory viewpoint, constitutes what is economic cybernetics, closely connected, as a field of preoccupation, with operational research.

Construction and assembly as well as design organizations are doubtless economic bodies and, as such, can be analysed from the informatory viewpoint.

This paper on informatory systems in construction work analyses actual examples taken from practice. The aspects under survey are the following:

a) *analysis of correctness of informatory circuits*;

b) *analysis of capacity of reception, processing and transmission of information within the framework of some given departments*;

c) *analysis of the possibilities of improving the language.*

The study of these problems has meant the use and adaptation to the specific features of construction economy, of some theoretic al notions such as: the "black box" notion, the quantity of information, entropy, perturbation, economic codification, etc.

1. ANALYSIS OF CORRECTNESS OF INFORMATORY CIRCUITS

Construction and assembly organizations at every level (enterprises, trusts, general boards, etc.) as well as design are to be considered as groups of informations called cells, connected by links through which circulate communications regarding production (informatory links) and constituting an aggregate with a number of common objectives.

One of the characteristics of the economic body considered as a cybernetics system, is the fact that the whole body can be regarded as the cell of an ultra-ordered organism, so that we are interested only in its links with the other cells. By so doing, we apply in fact the well known "black box" principle according to which the organism is considered only from the viewpoint of its external reactions. The building sites and departments of an enterprise can be considered as "black boxes", in which case only the informatory links between them and between them and the outside world will be examined, while the links on the building sites or in departments are disregarded. If a construction enterprise is considered as a "black box", we disregard everything happening inside it, and analyse only the informatory links with other units, etc.

This method of considering the problem lies at the basis of the analysis the informatory circuits of an economic circuit: first, the "black boxes" are ascertained, and then the informatory links between them are identified.

Each type of message circulating in an economic body has its own circuit; on this account, we shall analyse each type of message separately.

At present, we do not know of any strict method permitting correct designing of informatory ciruits. This is an operation relying on the specialists'experience and intuition. Generally speaking, there are two main possible faults in informatory ciruits, i. e.

a) *faults consisting in failure to contact certain cells of the organism, which the message should reach in order to be worked out*;

b) *faults consisting in useless lengthening of the circuit through inclusion of cells which it is not necessary that the message should reach.*

With the help of two examples taken from practice, we shall study the two aforementioned faults and the means of remedy. For the analysis of informatory circuits, it is most useful to draw up their graphic representation with the help of organigrams to be used in both cases.

Example I

Study of informatory circuit regarding delivery of concrete by a concrete factory supplying several building sites.

A concrete factory supplies several building sites belonging to a construction trust.

In the activity of the factory, a series of faults crop up as a result of the fact that the amount of concrete required on the building sites cannot be supplied, or the daily production capacity of the factory is incompletely used. This induces the management of the trust to order a detailed analysis of the activity of the concrete factory.

To begin with the informatory circuit of planning and of the dispatch of the concrete from the station was checked and the corresponding orga-

nigram was worked out. The relevant department of the trust, the concrete factory and the building sites constitute the "black boxes" between which the message circulates.

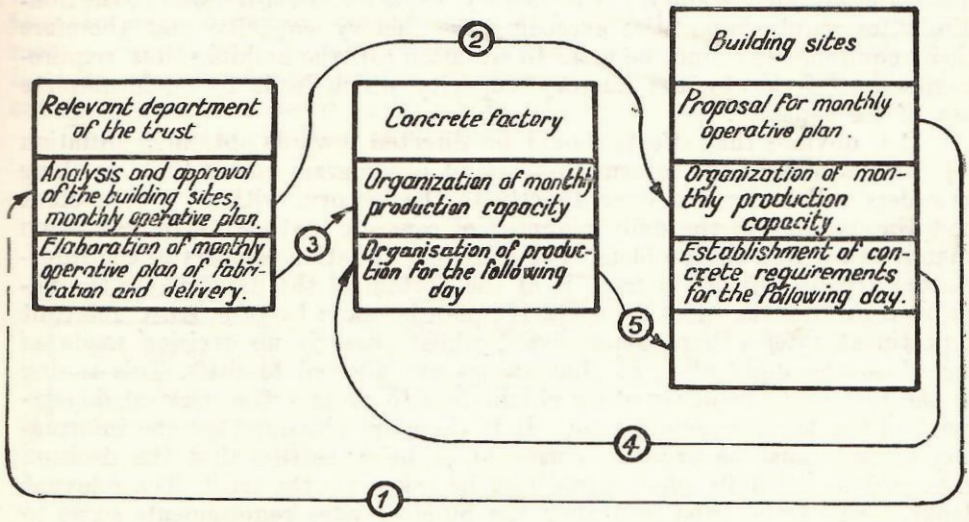

Fig. 1

As the above organigram shows, the building sites draw up the monthly operative plan, which they hand over to the trust for analyses and approval (1).

After being analysed by the specialised body of the trust, and approved, the operative plan is returned to the building sites for implementation. (2) At the same time, on basis of the building sites operative proposals, the trust draws up the monthly operative plan for fabrication and delivery, which is handed over to the concrete factory. (3). On basis of the plan, the factory organizes its production capacity for the following month. The factory's daily production and delivery are organized on basis of the requirements daily communicated by the building sites for the following day (4).

Within the limits of its scheduled capacity, the factory complies with the building sites requirements and delivers the concrete, the goods (5).

A comparative analysis of the volume of concrete requirements and of deliveries over a longer period shows that for a small number of days the requirements of the building sites (N) and the quantity of concrete produced and delivered by the factory (P) nearly equal the factory productive capacity, according to relation

$$N \approx P \approx C \tag{1}$$

For the remaining days under survey, requirements will be found to exceed production, which is very near the factory capacity, i. e.

$$N > P \approx C \tag{2}$$

or requirements are equal to production, which s inferior to the factory capacity:

$$N \approx P < C$$

An analysis of the above 3 relations which also represent the 3 situations possible in the running of the factory, shows that the only satisfactory situation is situation (1). This situation occurs when the building sites require quantities of concrete equal to the factory capacity. In situation (2), the building sites require quantities exceeding the factory capacity and therefore their requirements cannot be met. In situation (3), the building sites requirements are inferior to the factory capacity which leads to an incomplete use of its capacity.

It is obvious that efforts should be directed towards obtaining situation (1). An analysis of the informatory circuit organigram shows that as long as orders will be handed over directly to the factory, without a competent body intervening in the daily planning of concrete casting, there will be no chance of settling the problem. The following situation appears in the informatory circuit (which, in fact, is at the bottom of the deficiency): the decision regarding the monthly operative plan is taken by the trust relevant department after a thorough analysis, whilst there is no decision made in regard to the daily plan, so that things are allowed to drift. This is due to the fact that the informatory circuit fails to contact the relevant department of the trust a second time. It is therefore obivous that the informatory circuit must be urgently corrected, it being settled that the decision in regard to the daily plan should also be taken by the trust. The relevant department of the trust will alter the building sites requirements so as to obtain situation (1).

The corrected informatory circuit organigram will appear as follows:

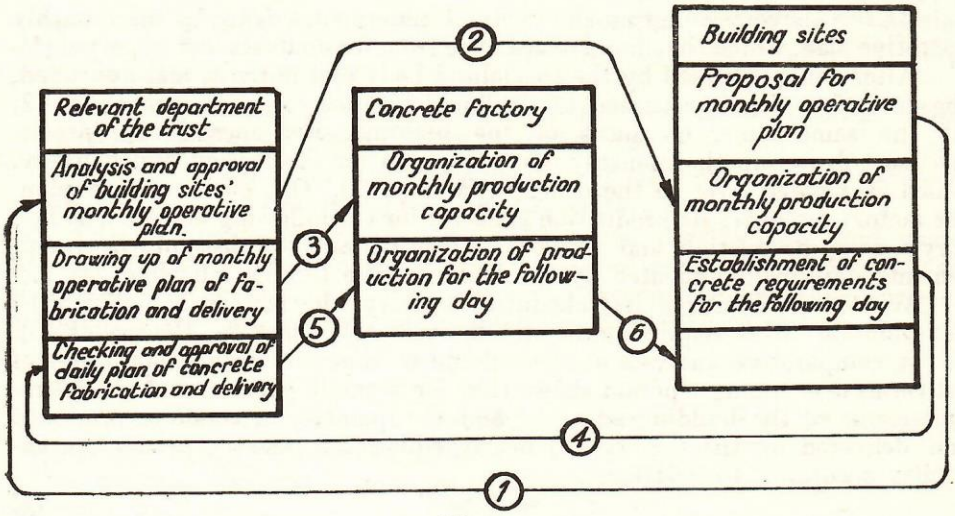

Fig. 2

Example 2

Study of the informatory circuit regarding the placing of orders for metal goods required by a construction enterprise

The enterprises within a given trust receive the metal goods they require through the intermediary of an enterprise specializing in the industrial production of such goods. In the course of the cooperation between the con-

struction enterprises and the producing metallurgical enterprise it has been found that fairly often a long time elapses between the drawing up when an order is decided on by the construction enterprise and the moment when that order is handed over to the production-workshop of the supplying factory. In order to improve the situation, it was decided to analyse the informatory circuit. For the sake of the analysis, the various departments and sections which co-operate in the drawing up and placing of orders in both enterprises are considered as "black boxes".

The organigram will be as follows:

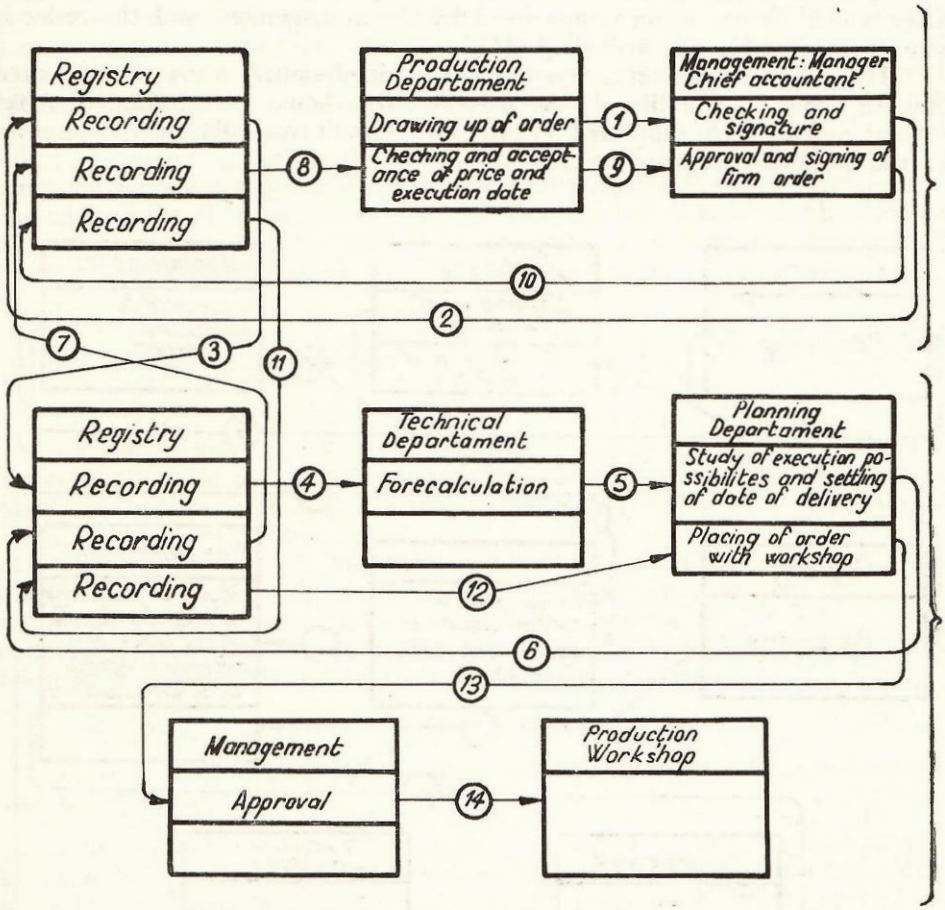

Fig. 3

As the above organigram shows, the production department of the enterprise draws up an order and sends it to the management (1) for checking and signature. The order is then entered in the books (2) and sent over to the recording office of the supplying enterprise (3). After having been entered in the enterprise books, the order goes over to the technical department (4)

where forecalculations are made on basis of the particulars stated in the order. Both the order and the forecalculation then go to the planning department (5) where the possibilities of execution are analysed and the time of execution is settled.

The order and the forecalculation with the date fixed for delivery then go to both recordig offices (6 and 7), after which the production department of the construction enterprise checks both the foreclaculation and date. Finally, the management approves and signs. Passing again through both recording offices (10 and 11), the papers again reach the planning department of the producing metallurgical enterprise where the order is sent out for execution (13), after which its execution is approved by the management and the order is sent to the production workshop (14).

The informatory circuit described above is obviously a very complicated one. In order to simplify it, the useless links should be eliminated. After several attempts, a simplified informatory circuit was obtained, as shown in the following organigram:

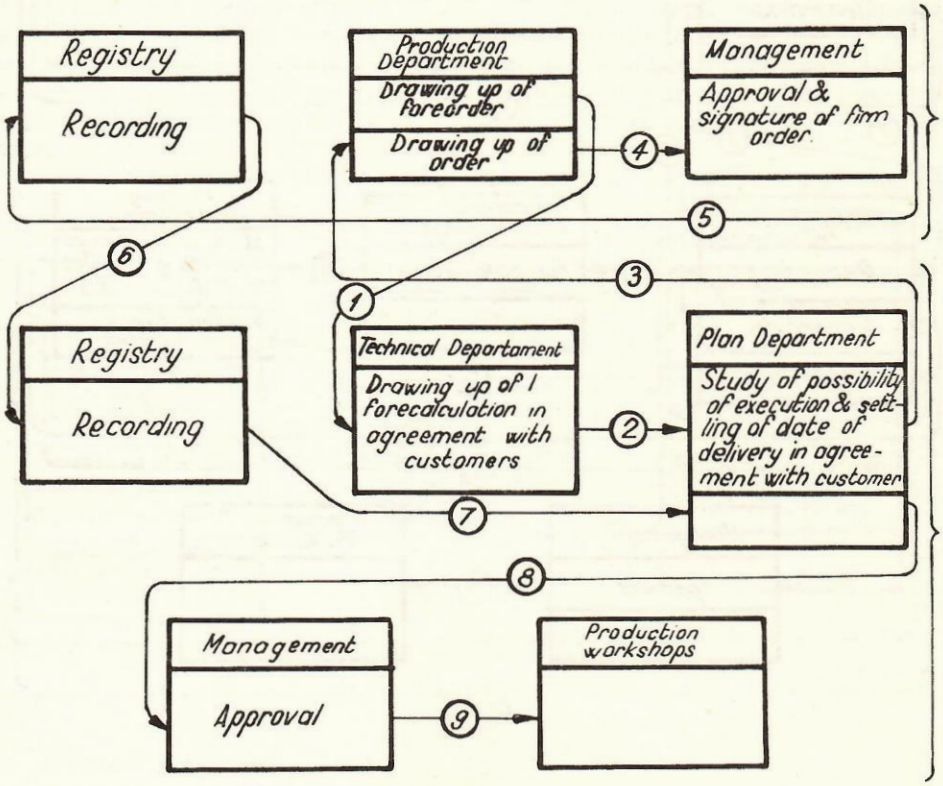

Fig. 4

The process has been simplified by elimination of the two recording offices from the circuit. In the initial variant, this precedes the signature of

the firm order, while now there is direct contact between the producing department of the construction enterprise and the technical and Planning Department of the producing metallurgical enterprise, on which occasion the figures of the forecalculation and the date of delivery are agreed upon. It is only after this that the order is worked out and from that instant goes on its way until it has reached the production workshop.

The two foregoing examples show that the improvement of informatory circuits does not require a special technique, but that it is within the reach of anyone well acquainted with the economic organism. In connection with the empiric aspect of the method for the correction of informatory circuits shown above, we must say that it is not in compliance with the methods and practice of operational research for the mathematical modelling of economic phenomena. At present, our researchers are preoccupied with the problem of finding a strict algorism enabling correct organization of informatory circuits in economic organisms. In this respect, some people suggest the possibility of employing the graph theory, but there are difficulties in connection with the semantic aspects of information, such as the problem of measuring the correctness of a link between two cells, etc. Unfortunately, this method of analysis is very seldom used in practice although it would substantially improve the organization of technical administrative work.

2. ANALYSIS OF THE CAPACITY OF RECEPTION, WORKING OUT AND ISSUE OF INFORMATION WITHIN SOME GIVEN DEPARTMENTS

As shown above, a very large number of various messages circulates between the cells of the construction and design organizations: notes and other documents, technical designs, verbal and telephone communications, instructions, reports, etc.

All types of messages have a number of features in common which, once known, make it possible to determine the influence over the capacity of reception, working out and launching of information within the different departments, for the benefit of employees and devices. The study of these features is made with the help of the Information Theory.

Example 3

Dimensioning of the telephone dispatch department in a large construction and assembly unit.

The dispatch department of a large construction and assembly unit is provided with a telephone-dispatch department. The latter works as follows: a telephone dispatcher receives all the communications from the building sites, which he enters in a register; these communications are read and analysed by a member of the management who distributes them to the different departments. The communications to be transmitted to the building sites are entered in their turn in another register and, after being approved by the mangement, are transmitted by the same telephone dispatcher. In order to have the whole flow of telephone information between head office and building sites checked by the management, it has been decided that all communications should be transmitted according to the above system, direct

verbal contacts between the different departments and building sites being allowed only in very special cases.

In this centralized system of transmission of information, the telephone dispatcher is overloaded with messages and is unable to cope with the work. In numerous cases the building sites are unables to communicate various urgent messages on account of the telephone being engaged. On the other hand, the notes dispatched from the head office sometimes fail to be transmitted in time. As a consequence, the need arises of analysing the centralized telephone dispatch service in order to find a scientific solution.

A first measure is designed to eliminate useless comunications, to avoid repetitions and to word the messages as concisely as possible. To this end, printed forms have been issued for the communications of the building sites and of the head office alike. The form has a number of headings which must be filled in (for the building yards statement regarding the receipt of materials, the number of workmen, the equipment, the means of transport, etc,; for the head office communications with regard to the arrival of a trainload of materials, the sending of requested workmen, equipment, etc.). There is also a column for special situations. To avoid the agglomeration of messages at certain hours, it was decided that each building site should be assigned a time for ringing up the telephone dispatcher. It was also decided that the first part of each telephone call should deal with the head office messages and the second part with those of the building sites. After these measures were decided upon, they were tested in order to ascertain how the centralized telephone dispatch department was working under these new conditions. Experimentation over a period long enough to be conclusive led to the conclusion that such measures could not ensure a satisfactory solution of the problem of the transmission of communications, as it was obvious that a single telephone dispatcher and a single telephone line could not ensure satisfactory working of the system. *Under these conditions, there arose the problem of strict dimensioning of the telephone dispatch service, to which purpose the Information Theory was applied.* The following formula was used:

$$\varphi = \frac{v.\ max\ I(\alpha\,\beta)}{H}$$

This formula helps to determine the number v of elementary signals which can be received and be written down by the telephone dispatcher per time-unit. The necessary elements are:

— φ = average-number of elementary symbols which can be received on the telephone and taken down by one employee per unit of time on the assumption that there are no disturbances on the line and that the specialised language in which the messages are worded is new to the employee: this value can be obtained from specialists in telephone communications.

— max I ($\alpha\,\beta$) represents the numeric characterisation of the disturbances in this transmission and also the coefficient of the decrease in the theoretical speed v owing to the deficiencies in audition and transcription of messages; this characterization can also be obtained from specialists in telephone communications.

— H = entropy of the language in which the transmission is made. In respect to this figure, a first approximation can be given by the value 4.1 representing the entropy of the Rumanian language; actually

this value is considerably smaller than the degree of novelty of a specialised language, it is much smaller than that of everyday language; besides, the value 4.1 takes into account but in a smaller measure, the interdependence of symbols in a message. It rests with the future to make strict statistical calculations to determine the real entropy of the specialised language in constructions.

After establishing the value v for the dimensioning of the telephone dispatch, i.e. the number of telephone dispatchers and telephone apparatus to be assigned to the different departments, the average number of elementary signals being transmitted per hour from the building sites to the head office and from the head office to the building sites should be ascertained. This can be done by statistical investigation (with observance to the laws of mathematical statistics).

The results of investigation will show that some building sites speak more and some less, for which reason the time schedule of their telephone calls must fix different intervals for each building site. If $V'_1 . V'_2, \ldots V'_n$, represent the average daily elementary signals transmitted by the n building sites, V''_1, $V''_2, \ldots V''_n$ the average daily number of signals transmitted by the head office to the n building sites, then $V_i = V'_i + V''_i$ $(i = 1, 2, \ldots n)$ will be the average number of signals transmited in both directions between building site i and the head office. If V is calculated per hour, the number N of telephone dispatchers and telephone apparatus will be given by the expression:

$$N = \frac{\sum_{i=1}^{n} V_i}{8\,V}$$

Value N will always be rounded off in excess.

The method suggested here can also be used in other cases in order to determine the necessary number of employees and devices whenever there is a question of issuing and receiving written or verbal messages. This means that we shall be able to dimension the cells of an economic organism, with regard to the capacity of issue and receipt of messages, endowing them with enough employees and devices to ensure the transmission of messages at the speed required by the production process.

Besides issuing and receiving information, the cells of an economic organism also have to fulfil the functions of working out, memorizing and taking decisions. In relation to all these functions the problem of speed arises (for working out, memorizing, subjected to the process of deciding) per unit of time. In principle, it is quite possible to establish statistically the capacities of working out, memorizing and deciding, of some given economic organisms, such capacities being expressed in a number of elementary signals per unit of time for each category of messages. This will alow the dimensioning of each cell in an economic organism regarding the capacity of all its information functions.

3. ANALYSIS OF POSSIBILITIES OF IMPROVING THE LANGUAGE

The problem of economy in messages, i.e. their most concise form of expression, is most important, for successful solution entails a great economy of time. A message concisely expressed implies its "translation" from one language into another.

The basic theorem in codification states that in the case of a message being codified from language L_1, with k_1 elementary symbols, into language L_2, with k_2 elementary symbols, if the length of a message expressed in L_1 is n_1 symbols, its length expressed in L_2 could not be smaller than:

$$n_2 = n_1 \frac{10 \text{ kg}_1}{10 \text{ kf}_2} \text{ symbols}$$

We can draw as near to $n_2 = 13.28$ as we wish, if we use the "lump method" of codification, i.e. if we assign directly a group of symbols to the message expressed by L_1, as a whole, instead of heaving each symbol of the initial message assigned to a group of symbols in the codified message. In case of long messages, this method entails an important economy.

Example 4

Economy in the codification of messages at a station for mechanized calculations in construction work.

In a large construction and assembly unit there is to be found a mechanized station of calculation endowed with machines using punched cards with 45 columns. This station carries out an important volume of operations for technical and accounting evidence, doing the work of a large number of men.

One of the problems arising in regard to the rational use of machines is the economic codification of messages, which brings about an increase in output. Each card is a primary document in which a part of the columns is assigned for the record of identification data and another part for the record of numbers used in arithmetical operations. The problem of economic codification consists in the inclusion of the maximum number of identification data in a minimum of available columns. Identification data actually means the recording of information for working out purposes and they are constantly more valuable when more detailed.

At the station, the data regarding transport by car, are worked out among other data. Using the "classical" method of codification, the assignment of columns for identification data is effected as follows *).

— 2 columns for identification of the work performed with computers;
— 3 columns for the number of the document;
— 2 columns for the identification of the "moto" section and column to which the vehicle used in transport belongs;
— 4 columns for the driver's mark;
— 5 columns for the truck license number;
— 2 columns for the tonnage of the vehicule used for transport;
— 3 columns for the calendar date;
— 1 column for the category of road;
— 2 columns for the order number in the particular transport effected on the respective day;
— 2 columns for the code identifying the enterprise for the benefit of which transport is effected.
— 2 columns for the building site code;

*) the assignment of n number of columns for the codification of identification data means that the figure representing the respective code is expressed n figures.

— 2 columns for the object code;
— 1 column for the employee who confirms the transport.
Total: 31 columns assigned to identification data.

The remaining 14 columns (from 45) are assigned to the numbers to be worked out.

If all the data included in the 31 columns could be expressed more economically, the number of columns thus saved could be used either for the recording of other identification data or for the recording of other numbers representing quantities.

From the viewpoint of the Information Theory *), the problem is the study of the possibility of translating an expressed message with the help of an alphabet of 10 symbols (the figures 0,1...9) so as to reduce its length to as few symbols as possible. Thus formulated, and using the "lump" theory of codification shown above, the problem seems to be easily and quickly solved. In actual practice, the problem is more complicated as "lump" codification of a message expressed in 31 symbols as above, would make it impossible for the punched cards machines to sort out the cards directly according to each identification datum, without effecting a general sorting out. For instance, in the "classical" method of codification, the cards may be marked down directly according to columns 3,4 and 5, i.e. according to the order number of the document or according to columns 12, 13, 14, 15 and 16, i.e. according to the circulation number of the truck, etc. This is not possible in "lump" codification. However, careful analysis of the significance of the columns makes "lump" codification possible for part of the columns. Thus, the columns representing the enterprise code (columns 25 and 26) the building site code (columns 27 and 28), the object code (columns 29 and 30) and the code of the employee confirming the transport (column 31), can be codified in a "lump".

The "Lump" codification system of the 7 figures recorded in columns 24—31 of the classical codification, is the following: if A is the maximum number of enterprises, B the maximum number of building sites in each enterprise, C the maximum number of objects in each building site and D the maximum number of employees for each object, then the number representing "lump" codification will be:

$$N = a\,(B+1)\,(C+1)\,(D+1) + b\,(C+1)\,(D+1) + c\,(D+1)$$

in which a.b.c. and d represent the number of the enterprise, of the building site, of the object and of the employee who codifies.

If for instance, in the above example, we consider that $A = 15$, $B = 14$, $C = 24$, $D = 4$, $a = 12$, $b = 8$, $c = 18$ and $d = 2$, the code will be:

$$\begin{aligned} 12 \times (14+1)(24+1)(4+1) &= 22{,}500 \\ 8 \times (24+1)(4+1) &= 1{,}000 \\ 18 \times (4 \times 1) &= 90 \\ & \quad 2 \\ & \overline{23{,}592} \end{aligned}$$

*) More precisely, the problem belongs to the Code Theory, once part of the Information Theory and now independent.

which means that 5 columns of the perforated card will be used instead of the 7 which would have been necessary on the classical codification, which was 12 08 18 a, this means 2 columns saved.

It has been proved that this codification system is univocal, i.e. that it cannot lead to confusion.

Decodification, i.e. the reading of the code, implies some calculations which are, however, quite simple.

In order to decodify, we begin by dividing the number N by the product $(B + 1)\ (C + 1)\ (D + 1)$. The result obtained represents the value of a. The remainder of the divison is divided by $(C + 1)\ (D + 1)$, the result being the value of b. Finally, the remainder is divided by D + 1 in order to obtain the value of c. The remainder is the value of d.

When the demands of technical accounting evidence require a maximum of economy in the use of the columns of the punched cards, the use of a codification such as that shown above, implying some supplementary but simple calculations, can sometimes appear justified, as it economizes some columns.

Conclusions

The purpose of the examples given in this paper has been to outline some possibilities of application of economic cybernetics in construction. They are but a foreshadowing of the perspectives opened to construction economy by the introduction of cybernetics methods.

The possibilities of improving the system of economic messages, with the help of the Information Theory summarily sketched in examples 3 and 4, are of great importance. To improve the circulation system of messages relating to production is to contribute in a large measure to the success of production.

It goes without saying that the application, even as an experiment, of the principles of the Information Theory in the organization of the transmission of economic information, calls for a series of studies and preparatory measures. Thus, a first step would be the issue of specialised "dictionaries" containing the terminology used in construction work. Statistical studies could help to establish the frequency of various terms and the entropy of the language for the sake of economic and rational codification.

A modern system of centralized management of economic organizations with the use of electronic computers is unconceivable without such rational and economic codification.

Examples 1 and 2 have outlined the possible negative effects of a defective organization of informatory circuits in construction work. The role played by informatory circuits in such an organism is decisive. Such circuits are key factors in the management, and the working of the organism depends on their correct disposition and application. Cybernetics has brought out this fact and we may state that successful management of economic organisms depends in a large measure on correct understanding of the role of information circuits.

The mastering by engineers and economists of modern methods of operational research and economic cybernetics, and their practical application in construction work would unquestionably help to enhance the quality of organizational work and management in production.

POSSIBILITÉS D'AMÉLIORATION DES SYSTÈMES INFORMATIONELS DANS LA CONSTRUCTION

Dans cet ouvrage, on analyse, sur des exemples réels, pris dans la pratique des constructions, les aspects suivants :

a) Correctitude des circuits informationnels.

b) Capacité de réception, remaniement et transmission des informations dans le cadre de certains services.

c) Possibilités d'amélioration du language informationnel.

De l'examen de la correctitude des circuits informationnels, il résulte que l'organisation de constructions-montage est considérée comme un ensemble de cellules, unies par des liens informationnels. On constate qu'il existe deux défections principales, possibles dans les circuits informationnels, notamment :

— défection consistant à éviter certaines cellules où le message devrait arriver pour être remanié ;

— défection consistant dans la longueur inutile du circuit par suite de l'inclusion dans le dit circuit de certaines cellules où il n'est pas nécessaire que le message arrive.

L'ouvrage propose des solutions pouvant remédier à ces défections.

Concernant la capacité de réception, remaniement et transmission des informations, on suggère la possibilité de dimensionner le service téléphonique du dispatcher auprès d'une grande unité de constructions-montage, en se basant sur la connaissance de la langue dans laquelle se font les transmissions et sur la caractéristique numérique des perturbations du canal.

En ce qui concerne les possibilités d'amélioration du language, on propose l'élaboration d'un code économique auprès d'une station de calculs mécanisés pour constructions, en se fondant sur la connaissance des lois de base de la codification.

ВОЗМОЖНОСТИ УЛУЧШЕНИЯ СИСТЕМ ИНФОРМАЦИИ В СТРОИТЕЛЬСТВЕ

В статье рассматриваются на основе взятых из практики строительства реальных примеров следующие аспекты:

а) правильность цепей информации;

б) способность приема, переработки и передачи информации в пределах служб ;

в) возможности улучшения языка информации.

При рассмотрении правильности информации строительно-монтажная организация считается совокупностью ячеек, связанных отношениями информации. Учитывается, что существуют две основные неполадки цепей информации, а именно :

— неполадки, заключающиеся в обходе ячеек, в которые необходимо поступление сообщения для переработки;

— неполадки, заключающиеся в излишней длине цепи в результате включения в нее ячеек, в которые нет необходимости поступления сообщения.

В статье предлагаются решения для устранения этих неполадок.

В отношении способности приема, переработки и передачи информации указывается возможность обеспечения телефонного диспетчерского обслуживания в крупной строительно-монтажной организации на основе знания энтропии языка, на котором ведется передача, и численной характеристики помех в канале.

В связи с возможностями улучшения языка предлагается разработать экономический код на станции механизированных расчетов для строительства на основе знания основных законов кодификации.