SOME QUESTIONS OF EFFECTIVENESS IN APPLIED RESEARCH AND DEVELOPMENT WORK

(A QUALITATIVE ANALYSIS)

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The general conditions of the effectiveness of research work and its organization

Scientific work is a highly-complex activity, differing according to the branch of science concerned and also according to the character of the work. In the course of the development of science a large number of important *fundamental* and *applied* sciences have evolved which, even with in one particular domain, are of very different *character*, depending on whether they involve *research*, *education*, *organizing*, *industrial* or other activity.

Together with the social and technological changes, the *significance* and *forms* of scientific work have also changed.

As a result of the social great and technological changes of the century a *new relation* has evolved between *science* and *production* and science has even been called one of the important *elements* of the *up-to-date forces of production*.

In consequence of these changed relations, the work of scientific research workers and engineers has also undergone a change and has become a part of the technical preparatory work of production, an auxiliary or extended section of the latter while — in the Socialist countries — adopting increasingly the characteristic features of up-to-date Socialist large-scale production.*

In accordance with this new situation the *effectiveness* of scientific work becomes of ever greater importance and there is an increase in the number of publications concerned with the various conditions for effectiveness, since the technical development and the standard of living of the citizens of a country depends at least as much on the results achieved in the workshops of science as on the fruits of the workshops of the factories.

The enhanced significance of scientific work and the corresponding requirement for ever larger funds has also made it necessary to examine a number of *questions of economy*.

There are numerous important *personal* and *objective* conditions to *effective scientific work*.

* D. GY. SZAKASITS: On some problems of the relation between scientific research work and production (in Hungarian). Ipargazdaság, Oct. 1959. No. 7., p. 17.

Among the *personal* conditions the *main one* is that of *talent*, of *suitableness* of a bent due to a special field of interest. It has been recorded by LIEBIG that the interest he evinced for chemistry was so absorbing already in his childhood that he was finally expelled from his school for failing to learn the other subjects.

The next conditions is the *ability to engage in concentrated thought*. FARADAY carried a model of his electric magnet around with him in his pocket for nine years, always to recall it to his thoughts to enable him to *concentrate* his thoughts on this subject.

Further conditions are the originality and daring of thought, a *creative imagination*, good *powers of observation*, a sound *memory*, the facility slowly to let ideas mature, and *industriousness*. Authors writing about MARX, LENIN, EULER or BERTHELOT have frequently mentioned their excellent memories. According to EDISON, only ten percent of inventions depends on talent, while ninety percent is a question of industry and perseverance.*

Important in the course of work are *rest* and relaxation, too. It is a matter of individual inclinations, whether music, sports, or in some cases mathemathical riddles prove to be the best means of relaxation after the day's work.

The preparation of scientific *plans* to correspond with the resources available, the maintenance of order in space and time, the proper method of *assembling informations*, the science of *reading* (which has been the subject of several independent studies by prominent authors), the *classification* and arrangement of the material, the *repeated rethinking* of the subject and consultations with experts are all further important conditions of the effectiveness of scientific work.

Most outstanding scientists have been and are very parsimonious with the time at their disposal. According to THOMAS MANN time is the only value with which it is praiseworthy to be miserly. A good use of time involves a rational arrangement in space of laboratory or other equipment and also the discovery of the correct method of reading, the arrangement of the information gleaned, the seizing of ideas that prompt action etc.

Much attention is also being devoted to *research work* itself, especially in respect to its intuitive character and complex scientific and economic significance.

Intuition is, however, only one — through very important — part of research, the other very significant part being that of *organization*. The latter has by several authors been deemed frequently nearly as important as intuition, somewhat in the manner of MARSHALL's remark — in another context — that the two blades of a pair of scissors will only cut together.

* K. G. VOBLY: The organisation of scientific work (in hungarian) Budapest, 1951, Közoktatásügyi Kiadóvállalat, pp. 1—17.

The main features of research work, differing from those of other scientific and in particular of productive work, are the following:

1. As much as ninety percent of the work devoted to research may be fruitless, but the remaining ten percent may bring decisevely important technical and economic results.

2. In the course of the research work it is frequently impossible to *predict the final result* because, for instance, of the duration of the work. (The familiar example of the electronic valve shows that it was discovered some 50 years ago, but a long time — some 25 years — had been passed before the discovery became a large-scale industrial product).

3. The *gauging of the economic results* of research work may also be difficult, since returns on research may in many cases be due *not only* to the fruits of research but also to changing market conditions, or under capitalism possibly to a particular pattern of behaviour by competitors.

4. Finally, the final *establishment of the negative nature of a result is very difficult*, for the further sacrifice of intellectual and financial resources needed to turn research which today may seem fruitless into something fruitful, can not be estimated ahead. (In 1939 KIPPING declared that the industrial use of organic silicon was hopeless, and in 1943 the silicons appeared.)

The features that have been discussed and the intellectual attitudes of research workers which often differ from the usual, *confront the organizers of research work with difficult tasks.* It is not at all certain that this task can best be carried out by the best research workers but it is certain that the organizer of research must be an eminent scientist and a good organizer, able — while clearly seeing the manifold organizational problems — *successfully to solve the basic contradiction of scientific work.* This contradiction consists in that discovery, invention, ideas are mainly matters of *individual talent* and suitableness, while the elaboration of results and their technical application generally requires *tenacious collective* work, strictly conforming to the provisions of a plan, for which talent is a necessary but not a sufficient condition.

Military tactics and strategy are taught from books, and that is how generals gain their knowledge. The test of a good general is, however, not merely his talent and book-learning but the way in which he can *apply* that talent and knowledge in *a particular case*, moving large masses of people and making use of their strength and fire-power.

The *further contradiction to be resolved*, which is connected with the previous one, is similar. It is the evolution of a system of work in which the inevitable *labour and financial discipline* do not become obstacles to the *development of new thoughts* and ideas. The head of a research project must in this case be given the economic power to insure that the research workers working with him should be able to follow their own individual interests and inclinations, courageously to develop their talents, even if this involves risking

certain annually pre-contemplated sums and frequently results in costs that bring no returns. He must, however, be prepared to stop all undisciplined behaviour arising in this guise and prevent expenditure that will foreseeably never bear fruit if this is merely the chasing of a will-o'-the-wisp, a pastime which is in direct opposition to the performance of organized research work.

Since both intuition and organization are important elements of research work and since, moreover, its expenditure requirements are high, its duration limited by time factors and affected by numerous circumstances outside the scope of the research work, it is an ungrateful task to assemble the main factors that help produce a favourable climate for research. Though there are plenty of general pointers that could be enumerated, in actual fact *each individual case requires separate consideration* and adjudication according to its special features.

Research work is, however, *becoming ever more important and more costly*. Both its importance and its cost are showing an upward trend throughout the world (in some industrially-developed countries it amounts to as much — or more than — two percent of the so-called "gross national product"), so that an investigation of the general conditions of its effectiveness is also needed.

First making only a *general approach* to the effectiveness of industrial research work, the *evaluation of two questions* in particular, that are qualitatively different, but nevertheless interconnected appears to be necessary.

One is the *scientific level* of research work which depends on the *personnel making up the* research teams, the correct *choice of themes* and, in general, the securing of *the various conditions that stimulate creative work.*

The second is the *economic profit* to be derived from research work, *i. e.* the ratio of *returns to expenditure.* The economic profit derived from research work will be discussed in detail later.

For the time being let us proceed to the problems of the *scientific level* of research work.

1. Speaking of *the personnel of research* teams prof. VAN LENNEP of Utrecht has pointed out* that *in selecting a research team not only workers of high creativity* (intuition) are needed, but that the contribution of *a different type of scientific worker* is also needed to develop and work out the ideas. He mentions three types of scientific worker, according to their abilities, each of whom has his special place in a research group.

a) The type of scientific worker who can *carry out tasks* and is suited to the solution of a clearly-formulated problem by *known methods.*

b) The type of scientific worker who can *solve problems* and is suited

* D. J. VAN LENNEP: Personality and Social Factors Related to Creativity. Symposion on the Direction of Research Establishments, National Physical Laboratory, Teddington, Sept. 1956, pp. 26—28.

to the solution of a clearly-formulated problem by *methods that are not yet known.*

c) Finally those who have *the ability to produce something new, to create* and who are able to invent *important new ideas.*

(This three-fold classification may perhaps best be approximated in the terminology used in Hungary by the concepts of subordinate research workers, independent research workers and innovators or inventors.)

2. *In connection with the choice of a suitable subject for research* prof. BERNAL* also points out that although the importance of the individual talent of research workers has not decreased with the development of research work, it is in itself usually not sufficient for the performance of research work that can also be called economically effective. The history of inventions shows — he says — that success is not only a result of personal suitableness but of the correct posing of the problem of "*what to do research on*", the proper choice of theme and the organization of the work to be done.

The achievement of success thus requires the assessment of a host of *factors independent of* the research work itself, such as the requirements that arise, the given marketing possibilities, the evaluation of various cost and price factors, etc. The literature in this respect generally emphasises the importance of "*horizontal team-work*", and the growing need for it which here generally means the purposeful co-operation of the experts of various fields in the interests of the success of research work.

3. Much has been written by many authors on *providing various conditions as incentives to creation.* One of the reasons is that this is obviously a subject about which it is easier to write, than to carry it out well in a particular situation.

The problem embraces the solution of a series of complex tasks. Seizing only upon some of the most important of these, the following may be mentioned:

a) The *provision of suitable equipment, apparatus, materials, instruments, etc.*

b) Promotion of the intellectuel flexibility and versatility of research workers and the correct appreciation of the characteristics due to their age.

c) The provision of appropriate financial and moral incentives to scientific work.

d) Release from the burden of administrative work.

e) The establishment of good scientific and industrial relations and many other similar requirements that could be enumerated indefinitely.

It is, however, decisive in attempting to fulfil these requirements to *realize* that the "product" of the productive work of a research establishment is thought, an idea. It is therefore essential that as many and as good "products" as possible, should result.

* J. D. BERNOL: Fundamental and Applied Aspects of Research Problems, *ibid.*

It is, moreover, extremely important to *understand* that in order to attain the desired aim it is necessary to have the carefully organized, hard, exhausting, collective work of the users, the appliers and the operatives to supplement the work of the individual creators of ideas. Their work is also deserving of serious help and appreciation.

Finally, *it must be known* which are the most suitable *means* to employ, to attain a given *end*.

There may be a case where the *best use if the inclinations and abilities of the workers* available is the decisive feature. Scientific workers who have just graduated, for instance, may for lack of the necessary practical industrial knowledge or interest, be inclined rather towards research on the fundamental sciences and only gradually acquire a taste and sufficient experience for the solution of industrial problems.

In other cases *the use of the creativeness of research workers, as a characteristic of their age* may be an important task. For instance the younger age-groups who already possess much knowledge and some experience may be expected to produce more grandiose ideas, but the experience and advice of older colleagues may also frequently be of great help to them.

In yet another case the *through appreciation of the economic* (*e. g.* market) or *technical* (technological) *requirements of the firm* awaiting the fruits of the research may be one of the most important tasks for the research workers. It may also happen that success depends mainly on the *good co-operation* established between individual research workers, research teams or between research workers and technologists, and on the amount of help each can give the other. Truly great talent cannot be organized — say some. Others emphasise — most correctly — that the organization of research work only affects very *few* truly great talents (perhaps 5 per cent of the community) while the *majority* co-operating with the few great talents need exact organization and strict administrative order, to enable them to do good work.

Some heads of research must above all see that the research workers enjoy full freedom from care and must do all increase their sense of financial and moral security, while for others, at a given stage of the work, it may be most important to keep the research workers' "cost and time conscience" awake.

In conclusion it may be stated that it appears from the tasks which have here only been presented in general outlines, that *no principles of universal validity can be formulated* to ensure the success of the work of the heads of research projects.

When examining the general conditions of the economic effectiveness of research work it is sound practice — in order to obtain a broader perspective and be able to draw conclusions — to undertake also *an international comparison* of the weight, the significance, the mode of organization, the appropriate

place and the extent of the intellectual effort and financial expenditure devoted to research.

The organization and aims of the work are, due to the difference in the social and economic order, different in the socialist and in the capitalist countries. It is therefore *by no means easy to* find a suitable *basis for comparison.* Certain concepts differ in content in the socialist and the capitalist social orders, but some figures may nevertheless be compared.

In the literature of the capitalist countries for instance the following are used as bases for comparison:

1. The ratio of the total expenditure in a particular country on research, to the "*Gross National Product*" (GNP)* or to the overall *value of net industrial production.*

2. It is also usual to present research expenditure *by industries* as a percentage *of the annual turnover.* (These figures are, however obviously not very revealing *in respect to the sums involved,* for 0.8 percent of the annual turnover of say, a large steel trust may be very much larger than 2 per cent of the annual turnover of a food-processing firm. This figure is thus only suited to comparisons of the research expenditures of *firms of identical size within identical industries.* In this sense, however, it may provide very interesting information.)

2. The number of scientific workers in a particular country.

Of these the comparison of the figures mentioned in 1., the so-called GNP figures, presents obvious difficulties due to the necessary transfer calculations.

The comparison of 2. and 3. is, however, fairly simple.

Under a socialist economic system the research establishments are maintained by the Academies of Sciences, the industrial ministries, universities and larger industrial firms. The necessary finances are provided partly through the State budget, partly the technical development funds of the firms.

Under the capitalist economic system there are *State* research establishments (mainly for research projects in the public interest) and research institutes set up by *foundations*, mainly on a so-called "nonprofit" basis. These devote their incomes to perfecting their equipment and apparatus and engage in many research projects which are not commissioned by anyone (*e. g.* the Mellon Institute in the USA, or the Battelle Memorial or Standford Institutes).

There are, moreover *private* research establishments (generally so-called *profit-making* institutes, which undertake research assignments in return for a financial charge to their clients), the research institutes of *firms* and *universities* and finally the so-called *research associations* (co-operatives of smaller firms to solve their research problems together.)

* The meaning of the "Gross National Product" (GNP) in our terms is: the National Income, plus Amortization Costs.

The considerable requirements of expenditure on research have led to attempts in the various countries to compare their expenditures and in this context the question has often been asked: *how much should industry in general spend on research?* According to the opinion of the Federation of British Industries, it would be desirable if the larger industrial firms devoted 1—2 per cent of their annual turnover to research purposes. A further finding has been that it is the old, so-called classical branches of industry that spend least on research, and that there too, it is in connection with the oldest products that least research is done. In the metals industry for instance much more has been spent on research on metals that only first used in this century, than on others that can still be called more or less recent.

The proportionate development of research work

Of basic importance among the organizational measures that increase or decrease the effectiveness of scientific work is the *maintenance of proportionate development*, the rational and reasonable co-ordination of research activity on the fundamental and the applied sciences.

There is a fairly-strong connection between *fundamental research* and the territory, population density and natural resources (plentiful or inadequate raw materials) of a country and also the development of its national income. The rich countries with highly-developed industries and large populations are usually in the vanguard of the development of the fundamental sciences for they can more easily undertake the considerable financial and intellectual expenditure necessary for research than the smaller countries. Since some branches of fundamental research (*e. g.* some fields of nuclear physics, etc.) require enormous finances and large numbers of excellent research workers, the establishment of suitable proportions between fundamental and industrial research work is a problem which is also of considerable economic importance. Generally, this involves *two types of proportion :*

1. The establishment of healthy proportions *generally, between all fundamental and applied industrial research* expenditures, both of intellect and of finances.

2. *The satisfaction of the fundamental research requirements of the applied industrial research and development in the various industries.* For industrial research that is not backed by fundamental research corresponding to its requirements, sooner or later becomes the equivalent of a "sell-out" of the stock of information of that research.

The application of the *categories of research requirements* enables the character, order of importance and even the approximate expenditure requirements of the research work concerned to be surveyed, at least in general terms. The method for determining the volume of expenditure on fundamental

research by using these categories requires that finances be available in the first place to aiding fundamental work that supports the ear-marked industrial research projects and not to subjects chosen at random and unconnected with the above.

An investigation of the dynamic changes in research requirements can, on the other hand, give some previous information on the *order of magnitude of the expenditure* on the backing up by fundamental work of the applied (industrial) research that is done.*

The main aims in rational proportioning are the following:

First : in some branches of science, especially in those that require large research teams, expensive laboratories, equipment and apparatus *competition* with the larger, richer, more-developed industrial powers is somewhat *hopeless*. In these branches of science it appears to be far more suitable to adopt the *results* achieved by these larger countries.

Secondly : the sole basic requirement in fixing proportions can only be the short and long-range needs of the people's economy and not the over-satisfaction of an individual bent or sphere of interest which is in no important way connected with our plans and aims. Not only research work must be adapted to individual interest, but individual interest must also be directed to aims that correspond with those of our people's economy.

Third : no rational proportioning can fail to consider that a country cannot neglect the *development of its fundamental scientific culture* or the provision of "credits" to the work of one or other of its great scientists who is engaged in fundamental scientific work. This, on the other hand, means that — despite the aims above-listed — certain previously-determined sums must annually be devoted to this purpose.

The concentration of research

The concentration of research work is an organizational task of equal importance to that of proportionate development. This applies both to concentration *on a national scale* and *within a research establisment.*

The *themes* ear-marked *for research* in a particular *country* must be proportionate to the soberly-estimated possibilities of the country's intellectual and financial effort. To undertake more is to risk the performance of less, while a more modest set of aims will increase the probability of successful completion.

The concentration of *research themes within a research establishment* is also of great importance. It is by no means a sound idea to set out a large number of themes that are beyond the capabilities of the establishment or of its

* J. KLÁR: The Use of the Categories and Dynamic Elements of Research Requirements. Periodica Polytechnica Engineering 4, 179.

workers. Instead, suitable *research teams must be organized* and *attention concentrated on fewer, but important themes*. Experienced and qualified research heads must be placed at the heads of the teams, to ensure a sound collective effort. Obviously, the number of scientific workers of excellent quality available in each branch of science is limited and cannot be increased at will at a particular moment. Thus, instead of dealing with many themes, attention must be directed to the completion of fewer, but important tasks.

The basic *test* of the success of a *research result* is generally the *industrial investment* in which it is put into practice. Not infrequently the number of investments (industrial applications) following upon research results is in inverse proportion to the number of research themes at a particular establishment, since the intellectual or financial resources of the establishment are insufficient for the solution of the research problems.

The problem of the *location of research establishments* is connected with that of the concentration of research. The various types of research work have their *optimal places*, as indicated by international practice.

Thus it is a fact acknowledged the world over that the most suitable place to concentrate fundamental research is at the *universities*, or university institutions. The *fate of the replacement of scientists* both for the independent research institutes and the works laboratories is year by year decided for the greater part at the universities. These institutions therefore occupy key positions in the development of the country's research work. The *utilization* of the scientific work of the universities is also favourable because all the buildings, equipment and personnel can be used both for instruction and for research. The universities, moreover, provide unique opportunities — through the co-operation of their various faculties — for the relatively simple and cheap harmonization of the various fundamental and applied research projects and thus for the *establishment of ideal scientific co-operation* (if the universities are the place for ideal scientific co-operation in the interests of research it may also be said that the *works laboratories* of the large *industrial firms can provide ideal co-operation for the attainment of favourable economic results*, for theory and practice the scientific aim and the interests of the firm may both be satisfied *in one place, with common valuation*).

The setting up of an independent industrial research institute becomes necessary when it is a matter of concentrating problems that concern several firms or *several sectors* that have no separate works laboratories, and of carrying out research work for them.

The establishment of such large independent research institutes requires not only considerable expenditure but also involves the solution of difficult problems of organization. These include, for instance, apart from the sound planning and suitable equipment of the institute, the organization of *good co-operation* with the firms concerned or, what is tantamount, the exclusion

of the possibility of *l'art pour l'art* research, divorced from the needs of life and of practice, being carried out in the independent institute.

Institutes of this type must, in their particular field, become so to speak the *central brain-trusts of their principals.* They must solve the tasks with which they are entrusted and must at the same time — in as far as the momentary situation demands — also raise new ideas and make suggestions to potential users.

Thus when a country makes decisions on *the places* where research is to be done and on *the type of institute to be set up* it also frequently decides on the important problem of the appropriate concentration of research.

The co-operation of research workers

It is perhaps the *experimentalists* among the scientists who most frequently find that the *timely* recognition of facts that sometimes seem simple and the *rapid* solution of apparently easy tasks are in fact by no means simple, easy problems.

One of these seemingly obvious and easy tasks is the *attainment of suitable scientific co-operation* in the course of research work. Experience nevertheless shows that its fulfilment in practice is frequently insufficient or altogether missing.

Research work may require many types of organized scientific co-operation, each of which has its own signification in the corresponding period of the work.

Recently the international literature has also devoted much attention to this problem. This attention is justified, for the effectiveness of most research results depends in no small measure on the co-ordination and value of the various opinions relating to the project.

Analyses of the subject deal with several problems such as the correct means of establishing *information liaisons within a laboratory*, moreover *liaison between the research institutes* concerned and finally liaison between the research establishments and the industrial firms concerned.*

The main features of co-operation in the course of a particular piece of scientific research work are therefore as follows:

a) the *search* for contacts,

b) the *establishment* of contacts,

c) the securing of *lasting contacts.*

* A. H. RUBENSTEIN: Liaison Relations in Research and Development. IRE Transactions on Engineering Management, **2**, EW-4 1957.

D. C. PELZ: Some social factors related to performance in a research organisation. Admin. Science Quarterly, Dec. 1956.

C. SHEPHARD—I. R. WECHSELL: The relations between three interpersonal variables and communication effectiveness; a pilot study. Sociometry, **XVIII**, May, 1955, pp. 10—100.

The *first group of tasks* requires the investigation of the conditions which can ensure that a given item of information *should reach those whom it concerns, in time.*

Those whom their common research activities make dependent on one another must be *in time* to establish the proper contacts with each other. Many pieces of research have been failures because those who could successfully have supplemented each other's work either did not seek or did not find the suitable form of liaison with one another.

The *second group of tasks* is concerned with the *concept of the liaison* once it has been *established.* Contacts of this type are effective if there is a high degree of probability that the *information is suitable* and that the success of its use is determined not by the uncertainty of the content or communication of the information but by extraneous circumstances.

Special attention should be devoted to overcoming the difficulties that arise from the differing *intellectual levels* of the workers engaged in co-operation or the *difference in their approach.* The difference in intellectual level or in approach is here not to be interpreted as involving a *higher* or a *lower level* but a fundamentally *different* type of intellectual work. The conditions for the establishment of liaison may be absolutely different in the case of people working on an *identical* intellectual level, with identical approaches (*e. g.* research workers between each other) and others on different levels of intellectual activity (*e. g.* between research workers, technologists or even business and administrative personnel).

Good co-operation may here be impeded by differences of opinion arising from the *differing approaches* and divergent considerations. In this respect it may suffice to refer to an outstanding example: the differences of opinion which can so frequently be observed in the course of the collaboration of scientific and administrative workers.

Finally, *the third group of tasks* is concerned with *the possibilities for maintaining permanent liaisons.*

Permanent liaison is needed, for instance to avert potential obstacles to the undisturbed establishment of *the indispensable permanent co-operation* that may be needed for the attainment of some particular research aim.

The *number, duration and method of the contacts* depends on the nature of the work, the field of applied technology involved, the organizational structure of the establishments involved in the liaison, etc.

Depending on these conditions, *several useful types of permanent liaison are possible.*

One of these possibilities, for instance is that the one organization should entrust *one or more of its representatives* with the maintenance of the necessary liaison with the other organization.

Another possibility is for the two organizations to establish more or less permanent *liaison groups.*

Finally, a solution may be adopted for the maintance of good collective work in which *the two co-operating organizations* set up a special *third organization* for this purpose.

Which of the above possibilities is the suitable method of organization in a given instance, always depends on the *aim* to be attained by co-operation.

The next task is to see to it that any *obstacles that do arise, are eliminated in time.* This makes it necessary to make a *preliminary estimate* of the possible obstacles that may arise in practice.

In order to derive a generally valid model, suited to the obviation of obstacles that have been registered, the next step should be to find some sort of common denominator to the various obstacles to liaison. The finding of such a common denominator, however, is hardly possible without the postulation of analytical abstractions of doubtful value. The trouble with such abstractions is that it is rarely possible to turn them into instruments that are of use in practical life.

RUBENSTEIN* for instance recommends that the concept of the "*distance*" of the organizations intended mutually to co-operate, should be formulated as the uniform theoretical measure of the obstacles that arise.

In his analysis of this concept he distinguishes two basically different types of "distance":

a) hierarchic or horizontal "distance",

b) functional or vertical "distance".

The first is the hierarchic difference of level between the different organizations, due to their decision-making or, for instance, supervisory rights. (*E. g.* the research laboratory and the management on the relations between the management and a sub-contractor working for it.) *The second concept refers to the "distances" between people* engaged in activities or fulfilling tasks *within one institution.*

The concepts both of horizontal and of vertical distance may, in accordance with the aims of the particular investigation, always be appropriately sub-divided. Thus, for instance, the concept of *vertical distance* may be further divided to cover the distances arising from differing aims, from the *different* knowledge and learning required for the fulfilment of various tasks (the education, wages, scientific degree differences), and many other factors.

The "diagnosis" of factors such as this, or of similar ones, and the value of the "therapy" to be applied as a result are, of course, two different sets of problems.

* A. H. RUBENSTEIN: op. cit. (The problems of liaison discussed above are also developed in detail by the author in the same paper)

The *significance of the diagnosis* lies in that it directs attention to an important factor in decreasing the effectiveness of research work, which is in itself a significant contribution to eliminating the trouble.

The problem of *therapy* involves far graver and more complex relations. Above all the question arises of whether the *result* that may be expected of the cure is *proportionate* to the *sacrifice of the financial and intellectual effort* expanded, for if it were applied it might require the solution of complex organizational and personnel problems.

Ultimately, even if the diminution or elimination of one particular "distance" should prove to be uneconomical there are generally others, whose abolition is economical and possible. The "interpretation services" of the various liaison groups mentioned in the literature, *which help formulate a common language and thus a common way of thought between the organizations destined to co-operate, the many directing, consultative, co-ordinating and planning committees are all also suitable for a sound approach to this aim.

In general terms it may be stated that the neglect of live problems, the underestimation of their effect in increasing or decreasing the effectiveness of research is a mistake that is similar to that of over-estimating the practical use of this type of analytical abstraction.

In order to achieve this aim a *new approach*, a new attitude is generally needed.

In the course of up-to-date research the place of "*I*" is generally taken by that of "we" and increasingly *groups of research workers* appear, instead of individual research scientists, working *alone*.

With the rapid development of science and technology, research problems become ever more complex and composite and require many types of knowledge, diverse skills, increasing compilation of information and widespread documentary work. Individual research workers left to themselves can hardly cope with these manifold tasks, not to mention the fact that the necessary investigations and experiments themselves need many types of equipment, instruments and apparatus that are not always available in one particular place.

Under the capitalist system there are frequently numerous obstacles to such co-operation, which spring from the essence of that system and cannot usually be overcome, for the competition between the various firms, business secrets and many similar factors limit reasonable co-operation in certain respects.

* I. Ross and F. Haary: Identification of the liaison persons of an organisation. Management Science, Liaison, 1, Apr.—July 1955, 251—258.

H. Guetzkow and H. A. Simon: The Impact of Certain Communication Nets upon Organisation and Performance in Task-Oriented Groups. Management Science, Apr.—July 1955, 233.

Under the socialist system, however, these limits have disppeared and we no longer have the type of competition or business secrets between State firms that would prevent their necessary and fruitful collaboration.

Co-operation must therefore — where necessary — be applied both to the regular *exchange of experiences between research workers* and to the organized and regular common effort of *the various research establishments* and the *firms interested* in the research projects, to achieve the aim that is set as soon and as best as possible.

This result can only be achieved by eliminating unjustified personal vanity or unjustified financial interestedness that would disturb the spirit of co-operation and by organizing sound collective work.

The significance of documentation in helping research work

Documentation is an important aid to research. Research institutions which recognise this in time, receive considerable help from their good documentary services. Unsatisfactory documentation within a particular institute may generally be attributed to two different basic reasons: either the individual research workers are not sufficiently aware of the extent to which sound documentation can help their research work, or the fault lies in the service itself, in its unsatisfactory or incorrect functioning. Bad documentation can strengthen some research workers in their belief that this work can not be expected to be of considerable help in their work.

The wherewithal of successful documentary work are the specialized libraries and periodicals of the research institutes, their collections of standards and patents, moreover the travel and research reports and expert opinions in the archives and,finally, the collection of company literature.

The *stock of periodicals* generally includes the following more important publications:

a) reference journals
b) theoretical periodicals,
c) applied (industrial) periodicals
d) industrial and trade papers
e) company journals and prospectuses.

The *collection of standards* includes the home and foreign standards relative to the various fields of research (*e. g.* on the materials used, the auxiliary materials, apparatus, etc.)

Finally, the *collection of patents* includes both the patents that have sprung from the themes worked out by the institute over a number of years and also those that are connected with, or necessary for, the work of the institute.

In investigations of the effectiveness of the information services in a research institute it is usual to proceed from an *analysis of the stock of periodicals.* A suitable point of departure, for instance, is the *analysis of the refer-*

ence journals. The reference journals of a particular subject or a sector of industry make it easy to establish a list of the more important theoretical and applied scientific periodicals concerned with the subject.

It is desirable to extend the analysis both to the *supervision of the documentation* of the necessary *periodicals* and the *distribution by languages* of the periodicals. It may, for instance, be established how many references are to be found in a particular reference journal and from how many periodicals they were collected. The next step is to find out how many of the home and foreign periodicals used for reference — with due regard to their importance — are present in the library of the research institute. If the investigation shows that a large part of the periodicals quoted, or at least the more important ones, are present in the library of the research institute, then it may be said that at least the point of departure for good documentary work has been established.*

Supervision by the method outlined discloses whether *the choice* of periodicals subscribed by the library of the institute is correct, *from the professional point of view.*

The next step is *to investigate the appropriate distribution by languages* of the periodicals, with a view to the ratio of the main languages that may be found from the publication, to the passive knowledge of languages by the research workers and to the ratio of the periodicals subscribed by the library.**

* The regular, direct perusal of the more important periodicals of both the theoretical and the applied sciences is absolutely indispensable. These must therefore be processed at "first hand" in the institute and the research workers themselves must become acquainted with them. Experience gained so far shows that the more effective way of doing this work is if the institute does not rely on the adoption of the material of some extraneous documentary service. The reference parts of these journals must also be watched, for it is by no means indifferent to know what these journals consider worth reporting within a particular subject or profession.

** In one of the research institutes — taking the UNESCO figures for 1956 as a basis — the distribution was as follows:

	Ratio of world languages on the basis of books published in 1956 %	Passive knowledge of languages by research workers %	Number of periodicals subscribed by the library
English	21,9	42,4	53
Russian	16,0	37,3	30
German	15,5	60,9	50
French	9,8	18,6	18
Italian	6,7	10,0	3

(Compiled by Mrs A. VIGH-SOMOGYI)

The table shows that the ratio of the distribution by languages of the periodicals was, with a view to the knowledge of languages of the scientists and the periodicals subscribed by the library, *favourable.*

In their investigations of the conditions for the effectiveness of documentary services some authors point out* that documentary work done in national centres or sub-centres for the greater part results in necessarily impersonal and stereotype solutions. The solution of individual, direct documentation problems is either not at all, or very rarely, possible in such a wide framework and is in most cases uneconomical. Instead, the right solution is, if the periodicals are perused, marked out for card-indexing and the card-index edited *by a documentation expert working within the institute.*** In this case a thorough knowledge of the whole of the material makes it possible for the documentary expert even to solve complex tasks and to ensure the change of constant further education in the problems handled by the institute. His task in this case includes ear-marking the reference journals, preparing various reports, editing information bulletins, etc: in the course of this work he can benefit from the advantages of studying a well-equipped institute library (an easier survey of the material, a more intensive and direct readers' service, etc.), moreover of using the large-scale methods and wider field of the documentation centres.

The methods of dealing with specialist books are fairly generally developed and need therefore not be treated in greater detail here.

Last, but not least, an indispensable condition for good documentation is the appropriate organization of *the co-operation of the various documentary services.* In the course of this co-operation the person in charge of this work in a research institute may supply important and valuable data to the national documentary network and may also receive similarly important facts, both home and foreign, from these institutions.

For the greater part the development of science and the research aimed at promoting that development cannot be done in isolation. The work of later scientists is linked to that of their predecessors, perfects it, and refines it. But the work of the contemporaries is also linked, and research workers may frequently receive a valuable documentary stimulus not only from the branch of science they cultivate, but from other or boundary sciences.

Good documentary work may therefore best be compared to a complex signalling system that draws attention of research workers to all the more important circumstances that may help their work, connects the past with the present and arranges, in order of their importance, all the results which the research workers concerned will need in the future course of their work.

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*Mrs. A. VIGH-SOMOGYI: Manuscript on the effectiveness of a documentary service.

** According to the view of the same author, up to about 150 research workers and taking the perusal of 250 periodicals as a basis (not counting the reference journals), moreover, up to a maximum of 500—600 subjects to be watched, the perusal of the necessary material and the editing of the card-indexes can be adequately done by one person.