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Communication Patterns in High-Energy Physics

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Content

Introduction

No sociologist in her right mind would voluntarily depart from the relatively safe observation grounds afforded by primitive tribes, to venture a look into as select a caste as a body of physicists. Only if the fortunes of life have trapped her into providing some kind of service to this respectable community, will she find herself in the position of an observer. As is well-known to physicists, observation itself in some cases induces a modification of the environment under consideration. Disclosing the results of sociological observation may produce further changes, unconscious or determinate. The purpose of our sociologist however is not pure science, but service; she is therefore presenting here a few notes in the belief that a systematic description of the functions to be achieved and of the techniques available, may help to reduce the confusion prevailing in some areas of the communication network and may suggest some means for improving its efficiency. Among others, the functions of preprints, reports, letter-journals and conference proceedings will be analysed and an attempt will be made at establishing their relative positions[(1)]

The communication patterns reported here are those prevalent in high-energy physics and in the related fields of instrumentation and accelerator construction. They may bear some resemblance to those of other fields which would share with high-energy physics the following characteristics: rapidly developing science requiring large capital investments to carry out its experimental programs, relatively small number of laboratories involved but with world-wide geographical dispersion, traditional code of ethics widely accepted by the scientific community. Within this frame, techniques have developed to meet a variety of needs related to the communication of knowledge.

The techniques vary as the end stations vary: obviously the communication of research results takes different forms if it occurs between two scientists meeting in a conference corridor, or between a

lecturer and a group in an auditorium, or between communities of scientists which are thousands of miles apart. Communication techniques also vary according to the type of knowledge being transmitted: well -established research results for example will be channelled through alleys that would be unsuitable to lively but rough germinating ideas, and vice-versa.

Because the field is developing rapidly and because it requires large capital investments, speed is an important factor in communication. Delays occurring in the process of transmitting information may cause a waste of experimental effort: in this field as in others, a certain amount of duplication is needed; however, because of the costs involved, it has to be controlled - not blind - duplication. It should not be inferred from this argument that experimentalists only are affected by delays; theoreticians interact strongly with experimentalists and between themselves. Rapid communication enables them to keep away from played out areas and to contribute on the outposts of theoretical thought. Theoretical research seems to jump in recent years from one "fashion" to another. Some people tend to believe this is an effect of rapid communication. The roots of fashions rather lie in the unsatisfactory character of several present theories, a situation which theoreticians themselves sadly but readily admit. It is true that rapid communication may induce more physicists to work simultaneously along a new line of thought, producing therefore sharper fluctuations in fashion. But rapid communication certainly does not prevent those who are inspired by a sudden spark to work out original ideas and it does even increase the speed at which such sparks are generated.

Communication techniques first develop empirically. As time passes, some techniques are improved and stabilised to accomplish a specific function, a few even perform more than one function; others retain their informal, empirical characteristics. In the scientific community, higher status is usually acknowledged for the communication channels which convey more refined data, presented in a more elaborated form. We shall therefore conform to this status scheme and briefly review communication techniques in order of increasing elaboration.

Communication Techniques in Order of Increasing Elaboration and Synthesis

At the bottom of the ladder, we find the *oral exchange* that occurs between a limited number of scientists. For obscure reasons, a table on which food is provided seems to have some catalytic power; the catalytic effect is even greater if paper napkins or paper table-cloth are supplied. As they become scribbled with all kinds of symbols, they constitute what may be regarded as written communication of the lowest status. That their role is determinant in favouring a high level of mental activity and that this effect should not be attributed to other factors (such as wine glasses, for instance) is abundantly proved by another experimental set-up: the blackboard catalytic situation where the level of mental activity is as high as in the paper-napkin situation. Although the symbol "do not erase" is a recurring feature of the blackboard, no serious attempt has ever been made to give permanent status to the knowledge transmitted through these channels.

The next degree of elaboration is reached with letters exchanged between scientists. Sometimes they are shown around to colleagues, or a few copies are made. This apparently harmless procedure opens the door to.... the *jungle*: private communications, internal reports, technical notes, preprints, reports, lecture notes, abstracts submitted for conferences. In all this area, oral and written communication are closely interwoven. Although oral communication plays a very great role, the traces it leaves are indirect: they are hidden in the creative processes of scientific thought. Because oral communication leaves no direct traces it does not lend itself well to observation. The discussion in subsequent paragraphs will therefore be chiefly concerned with written - recorded - communication, but the complementary role of oral communication will have to be kept in mind.

It is somewhat arbitrary to decide where the jungle stops: one experiences a complete feeling of security only after having stepped out of the whole conference field. The civilized domain of *publication* lies ahead. Elaboration here reaches a plateau; successive degrees of synthesis are better criteria for differentiating between the various types of publications: articles in scientific periodicals reporting experimental and theoretical research findings or describing apparatus, review articles in periodicals and serials critically surveying progress in a limited field over a limited period of time, essays, textbooks, treatises, etc...

A detailed analysis of how individual scientists use recorded knowledge is outside the scope of this paper. We shall just note in passing that when approaching the literature, the scientist "plugs-in" at higher or lower levels of the ladder depending on whether he wants information on a subject in which he is a relative outsider or a specialist. As a non-specialist, he may first consult a wizard who will indicate an appropriate treatise or review-article; he will then pursue his path down into the journal literature or even down to a few reports until he finds the reply to his question. He also has at his disposal bibliographies and abstract-journals; these latter tools would be more useful to the non-specialist if they clearly ranked the references according to level of synthesis. In competing with the learned colleague, bibliographical tools suffer from several handicaps: lack of qualitative evaluation of the listed references, problems of terminology and of subject definition which can be more effectively solved in oral communication.

The scientist approaching a subject with which he is familiar, enters at the journal level for permanently recorded literature. The approach is relatively easy: review articles constitute useful syntheses; along with author indexes and, to a lesser extent, with subject indexes, they help the specialist to locate the journal articles he needs. On the whole he knows the literature and finds his way through it. For jungle material, the search is more difficult. Reports are satisfactorily covered by Nuclear Science Abstracts and its indexes but scientists do not avail themselves of this tool as much as its quality would warrant. For the rest of jungle-material, mainly preprints, there are no tools and only a limited privileged class of scientists has satisfactory access to them. Informal reviews (usually lecture notes), specialised bibliographies or only author and title listings are exceptional at this level of communication; the popularity of the few existing ones indicates that they correspond to a need and even perhaps that the need is not at present sufficiently met.

Much consideration has been given in present years to the quantity of recorded knowledge which has increased in relation to the sums invested in research. Perhaps more attention could be given to elaboration and synthesis characteristics in trying to solve quantity problems. For instance, the scientist would be helped in his handling of quantity if more reviews were available at relatively short time intervals and at all levels of communication; he could then dispense with reading the detailed literature of fields in which he is not directly active but in which he wants to remain up-to-date. The respective functions and positions of the central university library vs. the sectional libraries may also be viewed in this perspective. The central library concentrates on published material, supplying a wide range of periodicals and books, meeting the students' needs and enabling scientists to approach fields other than their own specialisation. The sectional libraries (departmental or laboratory's) serve the researcher's needs; they have a limited number of books and periodicals, the most useful ones in that particular field of research. Their collection consists mainly of informal communication material, reports, preprints, covering exclusively, but in great depth, the subjects of immediate interest to the laboratory. Being closer to the scientists, the sectional library is in a better position to ensure adequate coverage, acquisition and handling of informal communication tools. It is also located where this material is qualitatively most valuable. The central library is relieved from what is for it a quantitative problem: it can act as a co-ordinator and a referral centre between the various departments.

Communication Techniques and their Respective Functions

Degrees of elaboration and of synthesis provided us, in this paper, with a convenient means for classifying a wide variety of communication techniques prevailing in the high-energy physics community. The analysis of their respective functions will explain why there are so many and why each has a justified claim to some space under the sun. Seen through the elaboration lens, some communication techniques appear more noble than others. Seen through the functional lens, all communication techniques will appear to play essential roles in the channelling of knowledge.

A - Publications

Scientific and technical journals are serving a communication function: to make research results officially and widely available to the scientific community i.e. the public. They are publications, in the etymological sense of the word. They also fulfil other functions: sifting of worthwhile material, maintenance of quality standards in contents and presentation, they afford a convenient means, at least in principle, for settling priority claims. These complementary functions, communication and safeguard of quality, impose conflicting demands: communication in a rapidly developing science requires speed while correctly writing up a paper, refereeing, in some cases modifying the original in order to meet publication requirements and finally printing take time. The editors of some scientific journals have, during the last years, devoted great efforts to cut down delays to the minimum compatible with the maintenance of quality. For a full length paper, the shortest delay elapsing between reception of the manuscript by the editor and reception of the corresponding journal issue by the subscriber[(2)] has been reduced to five months. The median delay is seven to eight months, some papers take nine or ten, only exceptionally does it take longer. It may therefore be said that the balance struck between the complementary goals of publications is on the whole a satisfactory one; it favours however quality requirements at the expense of speed. The distribution of preprints is a technique that has developed to compensate for the negative aspect of this equilibrium. It will be discussed later in detail. The importance of the delays involved in making research results available has been stressed before; it is best assessed if one keeps in mind the pace at which high-energy physics progresses and also the capital invested in setting up experiments. Seven months are sufficient time for planning, setting up and even getting well under way an expensive experiment. At all these stages, it is important to know of similar experiments which are already terminated and only awaiting publication procedures to accomplish their course. The interaction between physicists, experimentalists or theoreticians, varies with some negative power of the distance; long distance interactions would however be severely reduced if the exchange of results were to occur with a seven months retardation.

The increase in the number of publications has been mentioned above. The journals have taken the necessary steps to cope with an ever increasing number of pages. Also they have applied more rigid criteria to decide what kind of detailed information is acceptable for publication; details useful to only a limited fraction of the audience have to be sacrificed, The technical report (see later paragraphs) has taken over the function of conveying these details to the specialist who needs them.

Letters to the editors have always been published in the regular journals more rapidly than full-length papers. The issuance of separate *letter-journals* represents a significant effort towards the reduction of publication delays, bringing them down to approximately five or six weeks[(2)] This achievement has met in the scientific community, the success it deserves: letter-journals have become the most popular journals in high-energy physics. A relatively new development, they suffer however from teething problems: as if the Editors had given the scientists a very welcome tool, used intensively but not precisely for the purpose for which it was intended. The Editors want the letters to be short and to be followed by full papers but two out of three letters in elementary

particle physics have not been followed by a full paper more than two years after publication. In the Editor's opinion, this shows that the letter-journals are being misused as a channel for half-baked results or even for results that later prove wrong. The scientists argue that in many cases a Letter is sufficient to adequately communicate results; also that a partial analysis of the experimental data may disclose an effect which meets the editorial requirement of bearing significantly on current research and which therefore deserves speedy publication. It is difficult for a sociologist to discriminate between these arguments. As is usual in similar cases, there is probably truth on both sides. From the sociological point of view, two aspects may be considered. First because it is a high-status communication channel, a publication, the letter-journal may lead into temptation in order to rapidly secure high-rank status (among others priority) for preliminary results, subject to modification or retraction after further study. Secondly such false tracks must constitute rather the exception than the rule, if one considers the popularity of the letter-journals as reflected by subscriptions; there is no doubt that the letter-journals perform a useful function. But the root of the problem is the definition of this function: here the divergence of opinions between the givers of the tool and the users is more fundamental. The Editors are providing a *publication*, may be a "parent pauvre" of what they refer to as the conventional journals, but still a publication with all its characteristics and implications: quality of content and of presentation, selection, ground for establishing priority claims, etc.... On the other hand, the readers use the letter-journals as a current-awareness tool, that is as a *communication* tool. The popularity of the letter-journals stems from their speed and their compactness. In the rapidly developing field of elementary particles a substantial fraction of the results meets the requirement of bearing significantly on current research. High energy physicists therefore read the Letters; .....at least the Letters; in some cases, unfortunately.....only the Letters. No wonder then that as authors they want their results to appear in the letter-journals. The pressure builds up; with it comes grumbling and sometimes also less civil forms of protest.

This and other symptoms seem to indicate that high-energy physicists crave a current awareness communication tool. Maybe such a tool should be created at a lower level of elaboration, outside the area where publication requirements and functions conflict with those of speedy communication. Such an informal tool may help to reduce the pressure placed at present on the letter-journals.

Another effective contribution made by some journals towards rapid communication is the advance publication of abstracts of accepted papers (three months delay between submission of manuscript and availability of abstract to readers). In this manner physicists at large are informed of results to be published in a near future.

Some journals and serials specialise in the publication of review articles, playing the important role of summarising the status of sub-fields. Again the usefulness of these periodicals varies with the speed at which the review articles are made available. Perhaps shorter delays could be achieved by some journals if they would concentrate on the review function and would abandon the publication of conference proceedings, a function which can be more efficiently accomplished by other methods (see later paragraphs).

One may well conclude that, as far as publications are concerned, the techniques employed are satisfactorily accomplishing the following functions: permanent recording and wide availability of selected, well-established research findings, safeguard of quality standards, definition of priorities. Journals are thus performing only part of the communication functions - the communication of refined, elaborated results - and, for some purposes, not at the pace required.

B - The "Jungle" or the "Open-Air" Market

That as harmless a subject as communication techniques in physics might generate explosive controversies dawns rather as a surprise on the unwarned observer. This seems to be the case for the area of communication techniques lying between private letters and journal articles; it was referred to as the "jungle" in previous paragraphs. Authoritative voices outlaw reports while other authoritative voices stimulate their production and while official agencies organise their distribution. The dissemination of partially-baked ideas is condemned by the very institutions who publish them as abstracts before physical societies' meetings. Preprints are blamed for all the evils of human nature and prosper from one year to the other. This area trades in ideas as lively as open markets, in southern sunny countries, trade in the basic necessities of household consumption. The flexibility of its trading methods is essential to its productivity: the enforcement of rigid trading rules would cause the area to disappear. Such a danger however is hypothetical, the rules would more likely fail.

Some people distrust open markets because they offer less resistance to dishonest practices. Although this claim is not totally unfounded, it should be remembered that the physics community has a long tradition of respect for a fairly rigid ethical code; also that within such a relatively small community, no one's behaviour goes long unnoticed. The problem is not so much dishonest practices as the difficulties well-intentioned scientists may experience in discovering what are the accepted practices. A discovery made more difficult in the face of the contradictory authoritative opinions mentioned above. Some shopping guidance is needed in order to use the market effectively. The first obvious need is for a definition of terms: a number of apparent difficulties will be eliminated in this way. The second need is for a definition of functions, i.e. a description of the uses generally made of given communication techniques. While attempting to establish these definitions, we shall refrain from giving an extensive survey of all shades of meaning used in the trade or from describing their historical background: we will choose particular definitions because they are the most common or the most fruitful.

Scientific and technical reports are documents which contain *useful* technical or scientific data not suitable for publication in periodicals. They are usually reproduced in a few hundred copies by near-print methods (offset, mimeography, hectography) and are identified by a code (initials followed by number) given by the issuing agency. They are indexed in Nuclear Science Abstracts, and are - or should be - available to anyone interested. In some laboratories reports bear the date of the day on which they are ready for near-printing, that is when the last corrections have been made[(3)]; at this time, the code number is assigned.

What constitutes "useful technical or scientific data not suitable for publications in periodicals"?. Detailed descriptions of experimental apparatus only of interest to a limited audience, computer programs used in connection with a specific experiment qualify for this definition. Such reports are complementary to publications in periodicals and are themselves a form of publication. From this analysis, it appears that they should be freely quoted in formal publications, the reference giving full bibliographical description (authors, title, date, number of pages, issuing agency, and code number).

Other useful material qualifying for reports are translations and lecture notes. The latter deserve special notice: they are roughly edited notes connected with seminars held for a specific audience (e.g. lectures given by theoretical physicists to experimentalists); they constitute an informal up-to-date review of a subject. That they perform a useful function and correspond to a deeply rooted need can best be illustrated by a few figures; between 2,000 and 3,500 copies of such lecture notes are requested from CERN, while for other reports the range is between 1,000 and 1,500 copies. It may be argued that the size of the demand would warrant formal publication. A step has recently

been taken by publishers in this direction. The success of the enterprise will depend on the ability to lighten the editing burden placed on the author and to meet speed and cost requirements.

Although terminology and external appearance may lead to confusion, *"internal reports"* should be clearly distinguished from the scientific and technical reports just discussed. They also carry a code-number and are also reproduced by near-print methods, but only in a few tens of copies. They are usually although not exclusively generated by groups constructing accelerators and equipment[(4)]. Internal reports are working tools for the specialist: the data they contain may prove wrong in a nearby future and they may without formality be superseded by another internal report; they can dispense with the formal acknowledgement of other scientist's contribution, they may be written in jargon. They are only available to the specialist because he alone can assess their limitations and interpret their content. Because of all these characteristics, they are not indexed in abstracts journals and they should preferably not be referred to in the literature, certainly not as "internal reports" or by code number. If the need arises to give, in a formal publication, credit for a contribution expressed in an internal report, it is suggested that the quotation take the form: author, private communication, date[(5)].

Surrounded by all these precautions, the internal report safely travels thousands of miles without leaving the circle of initiated specialists. Trouble starts, however, when as a consequence of sufficient research, the working tool finally contains a wealth of well-established, useful data. At this stage, the "internal report" may differ from the technical report only in editorial aspects. Authors are usually encouraged to edit such documents into more formal reports which can be made widely available or to publish them in journals. Development scientists are however under such pressure in high-energy physics laboratories that they rarely manage to perform this editing task.

We have mentioned above that in the midst of the very confused jungle picture, it would sometimes be necessary to choose. Our description of the relationship between journal articles, reports and internal reports stresses among the prevailing practices those that appear to us as the most fruitful. Our criterion is usefulness: we share the widespread opinion that if a document contains useful data it should be easily and widely available. Among existing relationships we choose to describe as "ideal" those which conform to this goal. The real picture is not quite as simple. However, in analysing it we shall see that what causes the difference between ideal and real is in itself a relatively simple factor which, if faced realistically, may be overcome. On the market, internal reports as described above are mixed with others which only have the external appearance of internal reports. The latter differ only in form and availability- not in content - from scientific reports or even from journal articles. To understand this situation, a difference has first to be stressed. The most effective way for an experimental physicist and for a theoretician to translate into an objective form his achievements, is to express them in recognised publications. Some circles are even so sensitive to this factor that they tend to create "publish or die" psychoses. The teams concerned with technical development are in a quite different situation. They are under pressure to produce instruments; these instruments themselves constitute the tangible element of the scientists' achievements. In high energy physics, the pressure to produce results is as great for experimentalists and theoreticians as for development scientists. The first find the necessary time to polish papers because publication is part of the process by which their results are given an objective form. The latter do not find the time because their results first materialize in the instrument. Development scientists do not need to publish or at least publication is only a secondary objective for them. They of course need to communicate among themselves but this function can be achieved very informally. During the course of development, polishing becomes an unaffordable luxury. In some areas of the development field, the unpolished report has become under the pressure of circumstances, the almost exclusive means of *communication*. Considerations of form - not of content- govern the issuance of documents as internal reports rather than as technical reports or

journal articles. The journal article in these subject fields then essentially accomplishes the function of reviewing a sub-field for the benefit of the non-specialist or of the newcomer. This situation could be accepted as such if it didn't carry with it two drawbacks. First the difficulty, except for the specialist, to distinguish between documents that are only working tools and documents that convey final results. Secondly the distribution of those documents being rather unsystematic, they cannot be properly indexed and abstracted. They are therefore not available to all those who might use them, but only to a limited privileged circle.

The root of the problem is a matter of form vs. time. Because of the conflicting requirements of development and publication, any exhortation or arbitrary ruling designed to require that development scientists publish more or publish in a better form is likely to remain fruitless. The solutions therefore have to be found either in a lowering of publication standards which would carry its own drawbacks, or preferably in providing the scientist with editorial assistance. Some way of achieving this has to be devised if the goal of making research results widely available is to be maintained. In this area new solutions will have to be tried; we shall come back to this point in the last section of this survey.

The production of *progress reports* is known to scientists as a recurring duty, slightly unwelcome because they have to be written in response to externally imposed deadlines rather than according to project maturation. This negative psychological trait along with other factors may explain why scientists use them relatively little. Progress reports yield information on research in progress and are one of the few written sources conveying negative results.

Preprints are near-printed copies of manuscripts submitted for publication in journals. They are temporary documents whose function is to bridge the time-gap created by publication delays. There is a tendency to confuse them with reports, partly as a result of their similar appearance. The main source of confusion however lies in the practice maintained by some laboratories of assigning to preprints, code numbers of the reports series. Considering the function and nature of preprints, another widespread practice appears more adequate: the preprint is issued without any code number and the indication "submitted for publication" appears on the title page. Preprints are given a more limited distribution than reports: they are circulated to scientists actively engaged in the same field who will benefit from a saving in delays or from a stimulus towards new approaches. Because they are temporary and not widely available, preprints are not abstracted in Nuclear Science Abstracts. If the need arises to quote a preprint, the reference takes the form: author, title, submitted for publication. As soon as the article, sometimes an improved version of the original manuscript, has appeared, the preprint can and should be destroyed: quotation then, refers to the publication only. Although the task is not always easy, great care should be devoted to find and give publication references rather than references to preprints, and this not only for rational reasons: ill feelings are generated when a contribution is referred to as "private communication" or "preprint" while it has already appeared in a journal.

Preprints, as a communication technique, have been blamed for several evils. Because of their haphazard distribution, they tend to create a privileged class: the set of scientists whose names appear on mailing lists. Following the successful experience of a large laboratory, an increasing number of research institutes are now setting up a preprint service that extends to the whole staff of a laboratory the mailing-list privilege. Preprint services are usually operated in connection with a specialised library or a research group. Preprints dealing with subjects of immediate interest to the staff are acquired systematically: scientists known to be working in the field are personally requested to place the address of the laboratory's preprint service on their mailing-list. As they arrive, documents are rapidly processed and brought to the attention of the staff by a list and a display. They are destroyed after the article has appeared. In one of these services, preprints coming

from all parts of the world are available to any member of the staff, on the average three days after they have been received, that is ten days after they have been mailed. The median time saved by this procedure, that is the median time elapsing between reception of the preprint and reception of the journal issue containing the corresponding article, is seven months. This kind of privately operated preprint service is still too difficult or too expensive to set up for the majority of physicists working in smaller laboratories or in university departments. A co-operative preprint service could provide all scientists working in high-energy physics with equal opportunities of access to this channel of communication. The initiative of co-ordinating efforts or of pooling resources has however not yet been taken.

Next, preprints are blamed for being misused as tools for the establishment of unfair priorities. This question of priorities itself is a hornet's nest which luckily falls outside the scope of this survey. That the object of our observations, a communication channel, may be subjected to such dishonouring accusations, leads us however to approach the hornet's nest; we shall consider it from a careful distance. In a highly competitive field where academic recognition of a scientist's achievements is essentially the only status-conferring process, matters of priorities, of authorship, etc. acquire great social significance. In their quest for contributions to be made to scientific progress - and original contributions which implies to be first in the race to discovery - physicists have to reckon with several factors, extraneous to their personal scientific capabilities: adequate financial support, ease of access to research facilities, opportunities to express themselves in the community among others through the publication channels. In this frame, preprints too may play a modest role which we want to discuss. It should however be borne in mind that they are not unique in this social interplay: human nature and academic mores being what they are, even if the preprint road to priorities was blocked, all other outlets would still be available for status-seeking energies. A question must be raised first: do preprints confer priorities ? The reply is "yes" and also "no". "Yes" in the sense that, according to the community's ethics, credit is to be given to a scientist for an original contribution, be it only an idea or a suggestion, independently of the form oral or written, in which it is expressed. "No" in a formal sense, i.e. claims are in principle settled according to the date at which a manuscript is received by a journal. Some observers have been afraid that the market may become flooded with half-baked ideas or results hastily distributed in order to secure unethical priorities. The facts however seem to contradict this pessimistic view: abuses are not more frequent nor more successful in this field of communication than in other areas of scientific activity. The great majority of scientists pay little attention to dishonest practices; contemptuous ignorance or condescending irony are powerful means of coercion in the community. If purposeful attempts at establishing false priorities are rare, errors by lack of information are more frequent: they appear as omissions to give another scientist credit for a contribution expressed in a preprint and awaiting the completion of publication processes. Such cases are the more harmful because they needlessly generate suspicions. They would occur more rarely if knowledge about the preprint market would be equally available to all.

Last but not least, we shall consider one of the most lively areas of the open-air market. A thickly-packed crowd surrounds a stage. Some elbowing seems to be related to the filtering process by which people are admitted one by one to pace the stage, scribble on a blackboard and talk. Before they leave, they occasionally exchange a few sentences with someone in the audience. Apart from these minor contributions, the audience is generally quiet, respectful of some of its members' sleep. But as it disperses after the show is over, the audience warms up: subgroups form, conversations, arguments are carried out everywhere. When quiet has almost been restored, another stage is set up... *Conferences* obviously are an essential part of the communication process: they provide a great density of close interactions between scientists and benefit of the flexibility of oral communication. To attend a conference, its sessions as well as its corridor conversations or its meals, is one of the most effective ways of keeping oneself informed of current developments in the field. The

popularity of conferences reflects their usefulness. To support this statement let us just repeat a rumour recently overheard: the planning-committee of a forthcoming conference was faced with the painful necessity of eliminating applicants in excess of auditorium capacity. By some clerical mistake, the circular-letters expressing the committee's regrets to non-accepted applicants were printed on the back of posts announcements and were mailed before the error was spotted. The announcements were for temporary posts during the conference: receptionists, slide operators, public address system operators, door guardians, coffee-room attendants, waiters, ash-tray cleaners, corridor-sweepers, first-aid assistants. It is reported that for the first time in history, a conference will be administratively overstaffed.

Abstracts of papers submitted to conferences serve as a basis for the selection of oral presentations and are necessary to rapporteurs. They constitute a rough guide of what will be discussed and are useful to participants for scheduling attendance to various sessions. However because abstracts have to be prepared two and half months in advance, the data they contain sometimes is of a wishful nature. It would therefore appear sounder practice to distribute them only to participants at the time the conference opens, rather than to give them wide distribution in a form that may be mistaken with publication.

Conference proceedings contain the complete record of communications and discussions and therefore are of great usefulness, particularly to those who did not have the privilege of attending the conference. The proceedings of smaller conferences have been successfully produced in report form and distributed within two or three months. Reproduced by photo-offset, the rapporteur papers of a recent major conference were available after one month[(2)]. However the full proceedings of major conferences have required a minimum of six months to be available on the scientists' desks and more generally the delay is one year. Six months appear to be the minimum compatible with a certain amount of editing and with printing. It is the time required to produce and distribute a *publication*. If scientists were prepared to satisfy themselves with an unedited document of rough appearance, produced by photo-offset, they could, two months[(2)] after the conference is over, have on their desks the extensive and complete record of papers and discussions assorted with an author index. In addition to being available rapidly, such a record would have the advantage of not being mistakable for a conventional publication. Indeed since a few years the proceedings of some conferences have been edited as books or journal issues. Their refined aspect creates confusion, leading erroneously to the belief that all papers appearing in conference proceedings are equivalent to journal articles. This in turn leads to such questions as: should conference proceedings exclude papers that have already been accepted for publication in a journal ? Should journals refuse papers that have appeared in conference proceedings ? In fact conference proceedings do not meet the requirements for publication status: there is no selection[(6)] and, more important, the reported results are not necessarily the outcome of fully completed pieces of research. Conference papers are snapshots of research projects, taken at a given moment of the year. Conference proceedings are an album of snapshots. The photographers of course try to make the best of their model, working hard during the preceding weeks, assembling sufficient raw materials, polishing up various facets. Although make-up is ruled out, not all facets are necessarily polished at the time the flash-light is turned on. The function of conferences and consequently of conference proceedings clearly is very different from the function of publications, discussed in earlier paragraphs, which is to permanently record well-established results. Any semblance of interference between conference proceedings and journals is therefore a false problem. It is quite normal that a paper first appear in the proceedings of a conference and be followed later by a journal article reporting a more refined version of the results. Two arguments, delays and confusion, plead in favour of abandoning the trend towards edited proceedings and in favour of replacing them by an informal, more rapidly produced and widely available record. Publication of well polished results would then entirely return to the best equipped channel for this purpose, the scientific periodical.

As a conclusion of the "jungle" or "open-air" market, we observe that it is even more difficult to trade in germinating ideas than in well-established results. The diversity of techniques employed on the open-air market reflects the diversity of creative processes. In view of this diversity it may be argued that the high-energy physics community is doing an overall good communication job and that all is needed is a contemplative "laissez-faire" attitude. On the other hand, it may also be argued that the efficiency of the communication network is a vital element for scientific progress and that no opportunity of improving communication should be neglected. When such a dynamic attitude has been taken in the past, it has brought forward excellent results as for instance, the effective job accomplished by the AEC Division of Technical Information in indexing and abstracting nuclear science reports and in integrating them with conventional literature. Initiatives could be taken to ensure: that the need for a *current awareness* information tool be met, that circulating preprints be known by *all* those to whom they may be useful, that conference records be *immediately* available to those who did not have the privilege of attending the conference itself, that editorial assistance be available to *facilitate* the production of reports and of more formal publications extracting *useful* information from working documents.

Scientists' Participation in the Operation of the Communication Network

Scientists and information specialists have already been co-operating for a long time in institutions and agencies concerned with the handling of information. The National Science Foundation is supporting programs designed to provide some training in science for information officers and some training in information handling and retrieval for scientists. The President's Scientific Advisory committee has underlined the point that research includes not only the generation of information but also its channelling; it has stressed the need for scientists to assume responsibility for both of these aspects. At the higher levels of responsibility, communication techniques are considered a part of research techniques and the need for scientists to participate in the operation of the communication network is clearly recognized.

The situation does not appear to be as clearly understood, on the average, by physicists working in laboratories or university departments. Even when they desire more adequate access to information, any investment in staff, space or expenditure to improve the situation appears to them as a curtailment on research; not to speak of an investment of some of their own time and effort. Among the many reasons for this attitude, the high demands placed on available means by more tangible and more immediate aspects of research certainly play a role. But more important, perhaps is the failure of those in charge of providing information services to secure the scientist's confidence by understanding his needs and meeting them. To break this vicious circle, the training programs mentioned above will in the long run be of help. More immediate results will be produced by an increased participation of scientists in information activities.

If proper inducements are devised, it might prove relatively easy to secure scientists' co-operation on broad-scale information programs. It also is not too difficult to encourage highly-qualified physicists to produce reviews at the publication level. Scientists' co-operation will however be much more difficult to secure for bottom of the ladder information: the scientist actively engaged in research is under too great pressure to be able to contribute to the improvement of communication tools or to transmit in adequate form the knowledge he is continuously generating. The antinomy between the two tasks is such that no exhortation can succeed in modifying the situation. Here there is a definite need for innovation.

A possible line of innovation which might be explored, in high-energy physics institutions, is suggested by the three following considerations.

- 1. Scientists want better communications: they would like to keep themselves more adequately informed of current developments and they understand the need for writing up their research results in a form accessible to the non-specialist.
- 2. There is a widespread concern about an insufficient supply of physicists in coming years. There also is a rising concern with the loss of women scientists because of the difficulties they encounter in maintaining their professional qualifications during the child-bearing years of their lives. During this comparatively short period of time, women once adequately trained and active in science, completely lose contacts with the rapid developments of the field and may be unable to resume research after their children are off their hands. Too many college girls qualifying for scientific training but aware of the difficulties experienced by their predecessors choose to major in other fields. Among Western nations, the United States has taken the lead in the concern with the loss of trained womanpower and in pioneering towards solutions to the problem: academic institutions are providing retraining courses compatible with homemaking responsibilities, grants are becoming available for resuming research on a part-time basis, the National Manpower Council has recommended that employers experiment with part-time employment for women wanting to carry on or to resume professional activity.
- 3. The larger experimental teams now working around the accelerators usually include one or two scientists who are seen more often in the library, who borrow more preprints and reports than others. Whether these scientists are more literature-minded by birth or by need does not really matter. What is important is that the teams have naturally developed a pattern by which a few individuals perform a communication function for the benefit of the whole group.

In view of the manpower concerns and of the unsatisfied communication needs, it seems that the high-energy physics community could try to apply this pattern more systematically. Part-time positions requiring formal training in physics and adequate knowledge of information techniques could be created within the scientific teams. The tasks to be accomplished in these positions would for instance include: scanning regularly the published and unpublished literature in fields of interest to the team and bringing to attention relevant contributions; writing up reports on current research and contributing to the editing of formal papers; editing lecture notes; participating in some aspects of public relations; providing scientific assistance to the library, e.g. for the performance of bibliographic searches, the selection of material to be acquired and its indexing by subject. An essential aspect of the proposal is that these staff-members are to be part of a scientific team. To be informed on the teams interest, to participate in its discussions, to attend lectures and seminars would be as much their duty as to perform their other tasks. These positions would constitute ideal grounds for keeping in touch with the field. They could be made available on a part-time basis to women who can temporarily devote only a fraction of their time to professional activity. These women may later resume full-time research or any combination of research and information. High-school teachers may also be interested in these part-time posts. Teaching would certainly benefit from close contacts with research, therefore adding long-term results to the immediate advantages of such a collaboration.

Conclusion

Anthropologists are familiar with the observation that the communication of knowledge takes rudimentary forms among primitive societies, a situation which is as much the result as the cause of technical stagnation. We are therefore not surprised to find that as refined a subject as high-energy physics and its related fields, has developed a variety of techniques to fulfil the functions of communication. In first approximation, these techniques meet the goals they have been assigned. But not all the goals have yet been fully recognised and met. Scientific societies, national bodies, educational institutions are aware of the need for effective communications and are supporting vigorous research programs that will undoubtedly produce further improvements in information handling and retrieval techniques. These improvements will more probably bear on publications, i.e. on communication channels in the upper half of the elaboration ladder, rather than on specialised current-awareness material of hot interest to high-energy physicists, but to them only. Because, for this material, the end stations of the communication network are within the boundaries of high-energy physics, the initiative of promoting improvements will have to come from the scientific community itself. Who will take the initiative to promote the steps that require cooperation? The big laboratories, because they are better equipped to do it ? They however are the privileged few in the field of communications and are therefore less sensitive to needs. The scientists scattered all over the world in smaller laboratories and university departments? Wherever the initiative would come from, it would be rewarding for all. It would contribute to ensure that all knowledge relevant to high-energy physics be accessible through an integrated communication network allowing a continuous flow of information from the informal internal report to the more elaborate publications.

(1) The author wishes to express her gratitude to all members of the scientific community who, in writing or in the course of conversations, have enabled her to acquire some insight on this subject.

(2) Real delays are considered, i.e., the time required for documents to be available to the scientist. These delays include production time as well as distribution time; the latter in some cases is not negligible

(3) Authors tend to introduce long production delays for reports: several months may elapse between the first draft for a report and the final changes brought to the typed stencil. In comparison, typing and reproduction delays are negligible.

(4) When dealing with technical subjects, they are also called "technical notes" or "engineering notes". When dealing with physics subjects, they are sometimes called "private communications". We choose to call them "internal reports" because this terminology is widely used for both subjects and because it stresses the characteristic that the document is for *internal* circulation among a limited group of specialists.

(5) To help identify internal reports the following devices are used. The front page carries the explicit statement: "This is a private communication; it should not be quoted or copied without the author's permission". The identification code omits the initials of the issuing agency and is accompanied by the words "internal report".

(6) Almost all submitted papers appear in the proceedings although only part of them, on the basis of abstracts, are accepted for oral presentation

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