

RESEARCH IN EAST EUROPEAN COUNTRIES

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Synopsis

Organisation of research in the paper industry in socialist countries is dealt with, giving data on participation of state-owned institutes, universities and mills, on sources of financing, on co-ordination by governmental institutions, and on the percentage of fundamental research.

Co-operation within the framework of bilateral agreements or of the Council of Mutual Economic Co-operation is discussed, and some examples of such common projects are given. Some achievements in fundamental and applied research are listed. Research centres in eastern and western countries are compared.

Introduction

In 1979 seven East European countries (Bulgaria, Hungary, Czechoslovakia, German Democratic Republic, Poland, Romania and the USSR) produced 12.4 million tons of pulp, i.e. about 31 % of the total European production and about 9.5% of the world production. Their share in paper and board production amounted to about 24 % of the total European, and about 8% of the world production.

While not so important in production and comparatively low in yearly paper and board per capita consumption (ranging from 32 to 81, but on average only 39 kg), the socialist countries want to develop their pulp and paper industries not only quantitatively but also technologically, economically as well as qualitatively.

They have therefore to develop further research, both fundamental and applied.

Research Centres

In every socialist country there is at least one government controlled industrial pulp and paper research institute (in Czechoslovakia there are two, and in the USSR three, with branches in large pulp and paper mills). Moreover, in every country at least one university has a chair of pulping and paper-making or of chemical wood technology (including pulping technology). Only in the USSR are there about seven such universities, one of them being totally dedicated to the pulp and paper industry and another having a whole faculty of pulp and paper technology. Besides, in some countries there are laboratories of the Academy of Sciences working on chemistry of wood and cellulose, and on pulping technology.

With the exception of the USSR, only a few mills possess research laboratories. and there are no contract research establishments.

Planning and Funding of Research

Planning and funding of research is somewhat similar in the various socialist countries, but not identical. It will therefore be exemplified here for Polish conditions.

Problems of great importance to the national economy acquire some priority and fall into four groups: governmental, interministerial, ministerial, and concerning one branch of the economy. Every problem is co-ordinated by one research organisation which disposes for this purpose of adequate financial means provided by the Ministry of Science and Technology (for the two first, most important groups), by the Ministry of Forestry and Wood-working Industries (for the third group), or by the Central Board of the Paper Industry (for the fourth group).

Other problems may be recognised by particular mills or organisations, but they do not enjoy any priority.

Every research organisation can include in its plans some topics concerning priority problems (if it is done in agreement with the co-ordinating unit), some topics announced and financed by the mills, and also some chosen by its staff and financed by the Fund of Scientific or Technical Progress granted to it.

The selection of topics is planned for a period of five years and corrected or completed every year. It is worked out on the basis of existing and foreseen needs of the paper industry and of the national economy, as well as of world trends in science and technology of pulping, paper-making and paper converting. The problems of availability of equipment and instruments, funding and economic justification, as well as rapid implementation of the research results in industrial practice are also taken into account. A draft of the plan is prepared by the planning department and discussed by the Scientific Council; afterwards it has to be approved by the management of the research organisation (sometimes also by its superior authority).

Research Practice

The course and the results of investigations are discussed periodically at internal seminars. reports of particular stages of projects, as well as of the whole project are accepted by the commission representing the sponsor, who can ask for complementary work. If in the course of investigations the institute comes to believe that further work does not show any promise of successful conclusion the project may be terminated by bilateral agreement. Sometimes, it is agreed to allow the extension or expansion of a project. The estimate is made according to an obligatory scheme, which includes the costs of wages, materials, instruments and equipment, as well as of co-operation, while all other charges are calculated as percentages.

Most research is done by the industrial institutes (50 - 85% by value). The participation of universities in the research varies considerably in particular countries, from about 8 % in Hungary to about 45 % in Poland.

Fundamental Research

Fundamental research represents 10 - 15% of the total in the industrial institutes and 15 - 50 % at the universities. The importance of fundamental research as the indispensable basis of applied investigations is well understood. The socialist countries have great achievements in this domain, especially in the field of cellulose and lignin chemistry, in the fundamentals of various pulping, bleaching and pulp purification processes, and of paper stock refining and sizing processes. These achievements constitute a valuable contribution to world science.

Sometimes the institutes are so much engaged in the practical problems of the industry that they haven't time for theoretical matters, and the universities must accept grants from the mills, or work on some centrally financed topics thereby earning money for wages, instruments and equipment.

The total costs of research in relation to the value of pulp, paper and paper converting production, amounting on average to 0.15 - 0.20 %, differ considerably in individual countries, but in all of them is considered not sufficient to hamper the development of the pulp and paper industries in these countries.

Financing of Research

The financing of research is distributed between various sources. In Poland in 1979, 33 % of all the funds for pulp paper research came from the central source, the Ministry of Science and Technology, 58 % from the Ministry concerned (Ministry of Forestry and Woodworking Industries), through the Central Board of the Paper Industry and from mills, while only 9 % came from

the institutes' and universities' own funds.

Co-operation and Collaboration

Close co-operation between industrial institutes and some universities of the countries belonging to the Council of Mutual Co-operation (C.M.C.) plays an important role in the development of research. There are always 7 - 10 issues being collectively worked on by a group of 4 - 7 institutes, one of which acts as co-ordinator for each research problem. During the work, symposia are organised to summarise the achievements and fix further lines of research. As examples of such problems, the following may be mentioned:

- methods of waste paper treatment;
- utilisation of hardwood pulps;
- surface treatment of paper and board;
- new chemical additives;
- development of production technology and improvement of particular properties of pulp and paper.

In some cases, when a large common investment is intended, as for instance the building of a reed pulp and paper combine in the Danube delta in Romania, or of a bleached sulphate pulp for Siberian larch at Ust-Ilimsk, all the participating countries are involved in some research project, the results of which are needed for the common enterprise.

The institutes and some universities of socialist countries exchange exhaustive information and documentation between one another as well as with some institutes in Western Europe, Scandinavia and North America. The Soviet Union maintains a broadly planned official collaboration in the field of technology and research with Finland, Sweden and Canada. Also, the participation of some Technical Associations in the activities of EUCEPA contributes to numerous contacts and a broad exchange of views.

Achievements in Research

Looking at the achievements in research (beyond fundamental research) in socialist countries, one must say that they are quite important. For instance, in the USSR, Akim first introduced oxygen bleaching and Nepenin worked out many modifications to the two-stage sulphite pulping process, while in the German Democratic Republic, Fiehn and Bach were the first to propose the introduction of anthraquinone to catalyse pulping. In Czechoslovakia a method of pulping beechwood with steam prehydrolysis was evolved, with the isolation of furfural, of deoxylose and of xylocel, which is used as fodder for sheep. In Romania, the sulphate pulping of reeds has been completely worked out; in Hungary, all the problems of straw pulping and utilising straw pulp for paper-making have been thoroughly investigated; in Poland, new methods of improving the properties of waste paper have been developed.

Comparison of Research Centres

It is not easy to compare research centres and organisations in eastern and western countries because on both sides there exist great differences between particular centres in their instrumentation and equipment, pilot-plant and semitechnical research facilities, in the qualifications and scientific level of the staff and in other factors governing the effectiveness of research. Such factors as the economy of the country, the technical and technological level of the industry, and the existence of stimuli for the introduction of innovations into industrial practice also complicate making comparisons.

Nevertheless, it is possible to make some approximate comparison, taking into consideration typical research centres and economic technical characteristics of the pulp and paper industry in Eastern and Western Europe (excluding Scandinavia, where pulp and paper are national industries and enjoy the highest priority).

With the exception of three very large institutes in Leningrad, Moscow and Kiev, the number of staff in institutes amounts, as in the West, to 150 - 250 people. There are also on average no perceptible differences in scientific or technical qualifications of the staff who, apart from doing research, organise and take part in domestic as well as in international symposia and conferences. They edit their own institutes' periodical publications and publish scientific and technological articles in home and foreign journals. Also, the topics of research are very similar in novelty and equally well based on fundamental investigations. The equipment and instrumentation of the Western institutes are in general more costly and sophisticated. On the other hand, the All-Union Institute at Leningrad has at its disposal, apart from a pilot plant, an experimental paper and board mill, containing among others five paper and board machines, a dry-forming machine and a bleaching plant.

The only thing is that the effectiveness of research in Eastern institutes is still insufficient, the time needed for completing investigations and introducing their results into industrial practice is often too long.

Conclusions

Summing up, one could say that research in socialist and western countries does not show any serious differences, in spite of the essentially different political, social and economic conditions in which it has developed. Both sides can find some interesting and creative ideas on the other side and therefore a serious and cordial co-operation between scientists of the whole world could not only bring better and friendlier understanding, but also contribute to an improvement in the level of research work.

Transcription of Discussion

Discussion

Prof. H. W. Giertz, University of Trondheim, Norway

Having discussed the importance of fundamental research and having heard at this symposium of how many practical achievements and industrial applications have been engendered by fundamental research, I would like to know if anyone has gone over his files to see what proportion of fundamental research projects has actually given rise to useful results? In the research organisation at Trondheim we did analyse the useful returns on fundamental research and concluded that only 15% of projects that began as fundamental research had any ultimate practical use.

Mr. H.A. Posner

We have tried to check back, as you suggest, on several occasions. However, it has always turned out very difficult, for two reasons. Firstly, the records often aren't very good. It is very often the case that to unravel the course of a particular development is impossible without the assistance of the personnel involved. Secondly, we find that much of the research we do has to be considered as building blocks, not of direct relevance to an identifiable end, but nevertheless very important to it. Combinations of apparently unrelated building blocks can, sometimes and in the right hands, be the correct combination for a technical breakthrough. For these reasons we think it very difficult indeed to try to perform the sort of analysis Prof. Giertz mentions.

Dr. J. Mardon, Omni-Continental, USA

Please forgive me if I phrase this question a little tactlessly, but I want to ask about what happened at IPC when it went through its difficult period some ten years ago. At that time, as many people in the industry know, its reputation diminished, so that it made a substantial effort to reverse this change. Could you identify what aspects of IPC's work or organisation you found inadequate, and how you changed your planning in order to remedy the deficiencies?

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Mr. H.A. Posner

It is a very long story. Most people are aware that the sticky patch IPC went through in the later sixties-early seventies was partly a reflection of the mood of the times. There were however, some particular factors which contributed more than most to the problems at that time. They were quite easily identified, and all were important.

The institute at that time was trying to support its non-educational faculty on a contract research basis. This is a tough way of supporting yourself under the best circumstances. It seems to me that efficient and successful contract research organisations work very differently from most governmental research institutes. They, like everyone, have good people, and then leave them to make their own contacts and build their own organisations, subject only to the condition that they continue to turn in a profit. As soon as that condition is not met, then they are out.

At the IPC it is difficult to do that, partly because of our educational role. Thus, the use of contract research as a way for university staff to support themselves outside their academic life was one of the factors which led to the institute's difficulties.

A not-unrelated factor was our losing touch with the outside world. As is always the case, researchers would rather talk to one another than to anyone else, being quite capable of concocting enough interesting problems for one another to work on, with absolutely no reference to anyone else. So why go out to find problems? Thus I think the institute had become very much too introspective.

We also had staffing personality problems, of delayed decisions and insufficient flexibility.

Mr. G. Place, Proctor and Gamble, USA

You mentioned that the IPC targets about 50% of its resources in basic research. I believe that the paper industry is going to change its technology radically within the next two decades. What percentage of your institute's research effort is devoted to

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major technological changes, discontinuous with existing methods, as opposed to evolutionary upgrades of what we are doing now?

Mr. H.A. Posner

A relatively small percentage, at a guess about 15%, but not more than that.

Mr. G. Place

Is that because you are interacting with an industry that already exists?

Mr. H.A. Posner

Yes, and it is very understandable. The IPC is not looking at things beyond the realms of current paper-making technology, because its emphasis must be on the realistically practicable. We can and do bring up questions of discontinuous change sometimes, but they must be couched in terms of existing practicability. I don't believe it is the role of IPC to undertake that type of research except when an identifiable need for it arises. We must always be aware of what industry sees as the priorities.

Mr. L. Rodes, São Paulo, Brazil

Some years ago you ran a strategic planning exercise in your institute. Would you say it was successful, and, if you were to repeat it, how would you change the way you conducted it?

Mr H.A. Posner

As a matter of fact we are conducting a similar exercise now. There is a wide variety of possible methodologies for such investigations. The one we at IPC selected is that which seems most appropriate to the collection of people involved, not only within but also outside the institute. Even the selection of the methodology has involved not only members of the institute, but also a number of people from industry.

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Dr. A.H. Nissan

People have been asking how much of the fundamental research effort in the various institutes has a useful outcome. One study mentioned suggests 15%, which I consider surprisingly high. To understand how this figure comes about, I think perhaps we must appreciate that the term "fundamental research" has two connotations. Thus Sir G.I. Taylor's work on the instability of rotational flow, published in the Royal Society transactions, was pure fundamental research. Studying what happens on a table roll, even when it is the same problem as Sir G.I. Taylor's, should properly be called "Paper Science fundamental research". This is therefore an application of a deeper level of fundamental research, and I presume that this is why such a relatively high proportion of what is understood in the research institute as fundamental research has a successful outcome. Now may I ask Professor Giertz to repeat his earlier question to Mr. Posner, so that others may have a chance of answering it.

Prof. H.W. Giertz

My question to Mr. Posner was, has anyone in your institute looked back through the last fifteen or twenty years' files to try to follow up lines of research, to establish whether or not they led, eventually, to useful results? This is to some degree the matter to be covered by Dr. Scheuring in his paper later today. He will show the technical leader always goes over a project after its completion to try to show what it has led to.

Mr. B.W. Burgess

We find that applications of our work can surprisingly often be traced back to fundamental research. Though we have never conducted an exhaustive examination, it is surprising how often the comment that some piece of work is clearly traceable to such and such past fundamental research is heard. Consider these examples, which all began as fundamental and basic studies: our study of pitch fouling, now being applied in the majority of Canadian mills: similarly our corrosion research, resulting in the Papritection system which greatly extends the life of bleach

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plant washers. Dr. Tabor earlier this week mentioned the work of Dr. Atack, whose study of sliding friction gave us a very useful insight into the mechanism of fibre removal in all forms of mechanical pulping. There are other examples too, where fundamental studies at our or other institutes have resulted in significant improvements to industrial processes.

Mr. G. Place

I am concerned that the paper industry must soon face serious changes, and I am trying to discover what role the various institutes are playing in identifying and forcing our attention on these changes. The structure of the funding and managerial control of these institutes suggests, in my experience, that they will be the last places to discover the discontinuities that must occur.

Mr. D. Attwood, PIRA, UK

PIRA is at present involved in pursuing such a discontinuity as those of which you speak, though it is of no help to paper-making. I am speaking of the new electronic information laboratory. This is a discontinuity that will affect us all, though it can only harm the paper industry, which will have to struggle on, trying to compete and think up different uses for paper.

Mr. B.W. Burgess

Mr. Place's question is very important. Part of the brief of our institutes must be to lead the industry, to try to determine what is going to happen in twenty year's time, so as to prepare the industry for it. We spend a lot of time on this. We have a future awareness committee engaged in technological forecasting and we make use of every device we can think of to try to anticipate future technical needs. This committee works alongside our Research Programme Committee, where the summary organisation of our research effort is done. We believe that one mechanism for initiating action on these technical step jumps is to encourage research by our staff on which they do not have to

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report. We are concerned that the level of this exploratory research in our institute has declined recently and moves are in hand to reverse this. We believe it to be of the utmost importance that a scientist can retire into a corner to try out his screwy idea before it is exposed to the harsh light of reality.

Dr. R. Martin-Löf

I agree very much with what Mr. Burgess said, with the addition that I believe the government support for our institute adds to the freedom of the scientists to explore less immediately useful directions. Thus a project doesn't have to convince industry of its viability too early.

Dr. A.J. Michell

Perhaps the best example of a discontinuity, though not a very great one, in CSIRO, was the move into composite materials. It required a completely new start by us, with initially no enthusiasm from industry. This has now changed, since we have come up with several interesting inventions and patents.

In CSIRO, being a government body, the advisory committees are purely advisory. All the decision making power lies in the hands of the senior executive, who can see a project started if he feels sufficiently strongly about it.

Mr. E.J. Justus, Beloit Corporation, USA

Discontinuities, doing things differently, always need one or two dedicated people, backed by a courageous organisation, to come to fulfilment. The onus of responsibility for adopting a new idea lies with the paper industry itself. The problem of the transfer of good ideas from laboratory to mill makes demands as great on individual courage as on technology.

Prof. N. Hartler, RIT, Sweden

I think that the industrial committees play a very useful role in directing the institutes' research programmes, but that it is unreasonable to expect them to take much part in

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identifying the long range changes, the discontinuities. The responsibility for this must be with the individual institute staff, who must be sufficiently strong to resist following completely what the industry committee says. They must be forceful enough to be able to see their own ideas through, and good enough that these ideas will be of value. But the responsibility for step changes must be with individuals in the institutes.

Mr. S.O. Dillen, Stora Kopparberg, Sweden

I think there are two aspects of the discontinuity subject, and the answers so far given don't match the question put. The answers tend to have been concerned with the difficulties of adaptation, of the individual effort needed to force changes through, which is indeed one aspect of the matter. But I think that the questions have been asking to what extent research in institutes can hope to recognise the discontinuities: quite another matter. It is by no means self-evident that it is in the institutes' interests to make discontinuous discoveries, because of the drastic effects they would have on the industry.

Dr. A.H. Nissan

That is why they are called discontinuities: some companies discontinue. I have not found a single instance in history of an important or novel idea being born in the mind of the majority. The ideas from which discontinuities stem invariably occur to a minority of one, and they are almost never welcome. We shouldn't be concerned about that, as one of their strengths is their ability to withstand criticism. They will not be valuable if they can't. Anyone with suggestions of how to foster such ideas should please speak up.

Prof. D. Wahren, IPC, USA

On what criteria do the members of the panel believe that a research director should work when trying to judge whether or not to support a new idea, such as might give rise to a discontinuity?

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Mr. B.W. Burgess

With difficulty. There are no rules, and such decisions can only be made with support, advice, and, ultimately, courage. Our institute recently moved into bio-technology. We don't know what will result, though we hope it will be useful. We do expect, however, to have to support that work for a good number of years with no returns. The initiative to move into this field came entirely from within the institute, and has had nothing to do with the industry.

Mr. J. Adams, BPBIF, UK

Nothing has been said here about the role of universities in fundamental research. I suggest that they have a much greater likelihood of provoking the development of discontinuities than do the research institutes, because of their greater potential for cross-fertilisation from different disciplines.

And now I would like to ask Professor Göttching whether he, in view of recent EEC bureaucratic intervention in the matter of the amounts of waste paper to be included in pulp, believes that the European research institutes should work more closely with the industry federations, the better to resist bureaucratic pressures?

Prof. L. Göttching

You are asking for better co-operation between the research institutes and the industry federations in the various countries of the EEC. This you think would be the way to improve communication between the research institutes and the EEC bureaucracy. But I think that they work very closely together already, at least in West Germany. And then there is the question of who should try to improve this communication, the federations or the institutes. I think it would be a matter for the federations, as they have the necessary power.

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Dr. A.H. Nissan

I draw a different conclusion from the recent EEC experience mentioned. I believe there are problems faced by all industries, particularly paper, which are not purely political or commercial, but have also a technological content, such as this one regarding the inclusion of a greater proportion of waste paper in new pulp than hitherto. These problems must be studied within the industry, even at the risk of a disquieting result. It will be impossible to stop that study; so surely it is better that it shouldn't be conducted by outside amateurs, who may well fail to take important technical aspects into consideration. I am certain that it is better in the long term for the industry's research institutes to investigate responsibly and fully the fringe problems such as conservation, pollution and safety.

Dr. R. Martin-Löf

The Swedish experience in the environmental debate was that by taking the lead and the initiative, industry could so improve its relations with the government that its point of view is much more fairly heard. I think the outcome has been greatly more satisfactory to us than it would if the initial study had been left to the National Environmental Board. I think industry must vigorously study its own problems because that is the only way of ensuring that proposed solutions fall within practical technology, and that end products meet the customers' requirements without being hazardous.

Dr. J.E. Luce, International Paper, USA

Returning for a moment to the question of discontinuities, I am sure no-one here believes they are spontaneous. Discontinuities result from the combination of two processes. Firstly, there must be the recognition of a need, that is to say, an overall need, which might be defined by asking "What business are we in?". Thus in the paper industry we are in the business of substrates, communication, wrapping or cleaning up mess. Secondly, one has to ask oneself what alternative ways are available for satisfying those needs, other than those in current

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use. Generally, scientists aren't very good at asking these overall questions, but one thing fundamental researchers are good at is recognising opportunities for satisfying these needs. I suggest that even the largest companies are not able to support truly fundamental research, but they are aware of the needs. Thus the combination necessary for a discontinuity to result can occur if the links between the large company, with its knowledge of the needs, and the fundamental research institute can be strengthened. This I see as the weakest link and one that must be reinforced even if it involves considerable retraining of the people involved.

Mr. G. Place

Dr. Goring said that the greatest ideas can only arise from mountains of solid background work, and I agree with him. But my experience suggests that they usually occur only at interfaces between disciplines, not within the core of a single discipline. Thus, for them to arise there must be interaction between several sciences besides the one of need. Having created a climate in which there is this required interaction, then the exploratory team investigating it should, I think, be fairly small: one or two of the right people is probably the correct size: with any more it is likely the team would come apart. Thus I think it is worth keeping the number of people involved in the early stages small, at least until they begin to produce some results: then it becomes sensible to increase the effort. One of the roles I believe could be usefully fulfilled by the research institutes is the bringing together of the various disciplines from the universities, with whom they often have closer ties than industry does. The resulting interactions I believe, as I have said, would provide the groundwork for Dr. Goring's flags of achievement.

Mr. P. Waern-Bugge, Stora Kopparberg, Sweden

According to the figures given in the preprints, Europe manufactures some forty million tonnes of paper annually. The larger part of this goes forward to converting in one way or

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another, and yet almost all the research funds are spent in the paper industry, and very little on converting. In fact there is an appalling lack of basic research on the downstream side of our industry, which I think reflects a lack of innovative thinking on the part of the end users. If any of the panel would care to elaborate on that I would be the most interested.

Dr. R. Martin-Löf

To a large extent I think rectifying this deficiency should be the responsibility of the paper industry. Converters are the paper industry's customers and as such should be encouraged to develop their uses for paper. Any rapprochement must also include the converting machinery manufacturers, and will take courage and determination. There is every reason for the paper industry to take the initiative in this, and to try to get as much as possible out of the contact. There should be two-way communication, so that, for example, paper can be matched to ink rather than, as is usually the case, the reverse.

Mr. D. Attwood

The paper industry has sometimes been very bad at recognising discontinuities when they occur in the downstream industries. For example, when web offset printing for newsprint was introduced, the paper industry failed to take notice, and all the research had to be done afterwards, at great expense. There are now new developments taking place in packaging, which the paper is not good enough to handle. We seem again to have been caught unawares by these developments, and I suggest that we should spend more time talking to downstream equipment manufacturers in future, to try to be aware of what changes are in the offing.

Mr. E.J. Justus

I want to say a few words in support of Mr. Posner. The strength of the Institute of Paper Chemistry, and the other institutes, lies primarily in their education role. The outstanding young people from these institutes who enter the

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industry give it its great strength. Our company does not look to these institutes to do our research work for us. We are interested in the Ph.D. and other research work that is done, but the primary function of these institutes is as centres of educational excellence.

Mr. P. Wrist, Mead Corporation, USA

Mr. Posner described some of the changes that were made in the re-organisation of the IPC. In particular he mentioned that changes were made to the mixture of personalities, which, it was felt, had become too homogeneous. Probably one of the essential ingredients in furthering a discontinuity is a mixture of personalities and disciplines.

The Advisory Committee felt that further re-organisation was still needed, so they tried to advise the institute management of the direction in long-term research where they felt there was need for knowledge. I believe it is in supplying essential understanding that an institute's main purpose lies, rather than the development of this understanding to useful applications.

After considerable discussion, five areas in need of long term investigation were identified. The emphasis on the long term was felt to be important because of the institute's one step removal from the market place; it was felt that the institute should not chase after every short term development of the market, which it couldn't possibly hope to follow because of this position of remove. The five areas have continued important over the past eight or nine years.

The first was the supply of raw materials, the concern being to maintain adequate supplies to ensure the healthy future of the industry. Within this overall title investigations ranged from genetics to pulping yield improvements. The continuing recommendation from this branch of the work has been that the productivity of our eventually finite land resource must be continuously improved.

The second area investigated was energy consumption. It was recognised that the paper industry is highly energy intensive, second only to aluminium smelting. Thus here too, there must be

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continual pressure to improve the energy efficiency of the process.

The third area was that the popular view of the environment had seen a discontinuous change, so that many actions acceptable before 1970 were no longer so after 1970. This has created the opportunity for a considerable re-evaluation of the economic factors in decision making in our industry. The initial reaction from the industry was to patch up, and reduce the impact of the waste produced. This approach has been replaced over the years by one in which the total amounts of waste are reduced, which of course has benefitted the first two fields of study.

The fourth area concerned the capital intensiveness of the industry. It is becoming increasingly more costly to introduce a new unit of production in paper-making, and, even without revolutionary change, it is important continuously to improve the process of productivity. This of course involves further investment, and so the process was thoroughly examined to try to reduce some of the capital intensity.

The last area chosen for investigation concerned the fact that very little account of intended end use is ever taken in the design or testing of our products. Q.C. tests tend to be limited to what is easy, without any real evidence that these have much relevance to properties important in the market place. So effort has been spent trying to discover what properties are of importance to end users, to try to optimise the product without excessively increasing raw material demand.

Dr. A.H. Nissan

I appreciate your having made this contribution at this juncture, where I am sure it is appropriate, and thank you for having made it at such short notice.

Dr. A. Mawson, Wiggins Teape, UK

I wish to return to the question of revolutionary change, discontinuities, that we began discussing. It has been proposed that the universities might be the ideal germinating ground for the seeds of such changes, and also that collective

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government funding actually acts against the stimulation of revolutionary change. It is indeed true that large government finance (e.g. the EEC) tends to go into the collective interests of the industry, where collaboration presents no threat, and that this tends to promote the status quo. But in the U.K. money for R & D is being put increasingly into specific companies within an industry, which by helping to avoid the problems of confidentiality, opens the possibility of more revolutionary changes. This approach can, of course, give rise to products like Concorde, for which the primary need was never properly identified, and whose spin-off products weren't sufficiently immediately useful to be widely adopted.

The question of whereabouts to find the most fertile ground for revolutionary change has concerned several speakers here, and surely the need for cross-fertilisation must be apparent. But if this cross-fertilisation is to occur within a committee, it must be a committee of one only, and of course modern specialisation renders such committees very unlikely to have the necessary range of experience. The main problem, therefore, I see as being one of tapping existing sources of knowledge, mainly in universities, which is a slow, laborious job. I myself am trying to undertake it and I seek suggestions as to how I can improve my technique

Dr. J. Colley, APPM Ltd., Australia

Yesterday Professor Judt called upon the Research Institutes of the developed countries to do more work for the benefit of the developing countries. Could you briefly outline the extent to which the CSIRO Division of Chemical Technology answers this call.

Dr. Michell

The CSIRO Division of Chemical Technology has been engaged for some years in the assessment of the pulping qualities of woods from Papua New Guinea and Malaysia and in advising these countries in their negotiations of chip export contracts with pulpwood buyers from the developed countries. The work has also included assessments of the potential of possible re-

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afforestation species. The work is being done in collaboration with the forest departments of the countries concerned and has included training programmes for their personnel.

The work was funded initially by the Australian government through the Australian Development Assistance Bureau but more recently funding has been provided by the governments of the participating countries.