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SUPPLEMENTARY REMARKS ON INDUSTRIAL R & D MANAGEMENT

P.E. Wrist.

In the following remarks I will use the terms "research" or "fundamental research" interchangeably to denote the process of generating new insights or knowledge about the physical world at all levels of sophistication by use of the scientific method. In contrast, I will use the word "development" to cover all activities associated with the application of knowledge for beneficial purposes of a commercial nature. This is in line with Mr. Place who earlier this week suggested that, phrased in the business context, "research" is like creating an asset while "development" is putting that asset to work.

In my written paper, I have suggested that fundamental research plays an important role in the process of industrial innovation especially in facilitating innovations of a breakthrough nature. I have further pointed out several important changes that have already occurred affecting the supply side of our industry that make the present time ripe for innovation. These are changes in the:

1. relative availability of our basic raw material,
2. costly environmental regulations, and
3. the major increases in the cost of energy and uncertainties in the future stability of supply.

I have suggested also that major structural changes are also taking place in two of the major markets served by our industry, i.e., Information Handling and Packaging. In the field of Information, digital handling and storage and electronic transmission are competing increasingly with the printed form. In Packaging, systems are being modified as a result of increased concerns over toxins, and in the food industry, the increased use of specialised packaging to preserve freshness is providing new opportunities for inroads by plastics. In the past few years, a

renewed interest in biotechnology has posed a third, less clear challenge to our industry. The use of our forests as sources for industrial energy and chemical feed-stock has created a potential competing demand on this limited raw material resource.

It is certainly not clear from the voices being raised in our industry whether these changes are being viewed as opportunities for future growth by the industry or as threats to its continued existence. There should be no doubt in anyone's mind, however, that these changes will have a dramatic revolutionary impact on our industry before the end of the century. In such an environment, I would suggest, it is very important that management be asking their technical staffs the "right questions", and that our scientists and engineers provide the right fundamental research answers to support the development work that will be needed in the years ahead.

In these supplementary remarks, I would like to suggest how the R & D effort in an industrial company may be integrated into its overall Business Strategic Planning Process. I will do four things:

1. Suggest some important differences between the goals of Industrial Research and those of Academic Research:

2. Discuss how the R & D efforts should melt into, and catalyse, the corporation's overall strategic plans for growth through Technological Innovation:

3. I will then suggest a preliminary approach for determining the appropriate levels and balance within a company's R & D effort:

4. Conclude with a couple of questions that I hope will stimulate discussion by the panel and members of the audience.

On Monday, Professor Tabor reminded us that the generation of new knowledge and the training of students are the two primary functions of an academic institution. He suggested that the direction of research enquiry is largely dictated by the personal interests of the researcher (or his financial sponsor perhaps), and that it may follow transient fashions. In economic terms then, "New Knowledge" per se is the primary goal and output of research at an academic institution.

In contrast, the function of an industrial corporation is to provide goods and services to the public, and the direction which its new technology development efforts will take will be the result of decisions made by management responding to inputs from the market-place and to the way it wishes to take advantage of new business opportunities. "Knowledge generation" by an industrial R & D department therefore should be a means to an end; not an end in itself.

As Mr. Place told us on Monday, industrial innovation is the development and widespread commercial acceptance by the market-place of new products, processes or services. It is generally agreed that a society's economic growth, and the growth of individual companies within that society, rests upon a continuous flow of successful industrial innovations. Innovation, therefore, is synonymous with change.

An innovation, before it is successful, will impact all segments of a business, and therefore there is a growing trend to make the management of innovation an integral part of the overall business strategy. The R & D function has an important role to play in bringing about innovations; however, it cannot bring them off alone. Within a corporation, the R & D department should play the role of the catalyst of change. The performance of an industrial R & D department therefore must be measured in terms of its contribution to the process of innovation within the company. In carrying out this responsibility, an industrial R & D department has two major responsibilities in support of the company's growth objectives:

TABLE 1

RELATIONSHIP OF R&D TO SALE FOR REPRESENTATIVE U. S. PAPER COMPANIES ($MM)

U.S. Paper Companies	Sales	R&D Spending 1980	R&D Spending 1979	%Change 1979-80	% Of Sales
Bemis	$ 662	$ 12.0	$	45.9%	1.8%
Boise Cascade	3,019	5.0	5.2	- 4.5	0.2
Consolidated Papers	510	3.4	3.1	7.4	0.7
Crown Zellerbach	3,070	12.6	11.7	7.7	0.4
Fort Howard Paper	397	1.5	1.2	20.5	0.4
Glatfelter (P.H.)	263	1.3	1.2	5.6	0.5
Hammermill Paper	1,183	2.5		13.6	0.2
International Paper	5,043	37.0		NA	0.7
Kimberly-Clark	2,600	31.5	27.5	14.5	1.2
Masonite	511	6.0		-11.2	1.2
Mead	2,707	31.0	19.0	63.2	1.1
Rexham	169	2.1		-16.8	1.3
St. Regis Paper	2,714	10.2	9.8	4.0	0.4
Scott Paper	2,083	31.3	30.0	4.0	1.5
Union Camp	1,575	16.1		24.0	1.0
Wausau		0.2	0.2		0.1
Westvaco	1,410	14.2	10.7	32.5	1.0
Weyerhaeuser	4,536	52.2	45.0	16.0	1.2
Industry Composites:					
Chemical	89,877	2,161.1		17.4	2.4
Electronics	27,929	805.6		19.7	2.9
Information Processing:					
Computers	53,258	3,400.6		19.0	6.4
Office Equipment	13,217	562.1		20.7	4.3
Peripherals, Services	5,151	301.6		30.0	5.9
Paper	32,550	271.7		17.3	0.8

Canadian Paper Companies	R&D Spending ($MM) 1980	R&D Spending ($MM) 1979	%Change 1979-80	% Of Sales
Domtar	C$6.6	C$5.6	17.6%	0.4%
MacMillan Bloedel	9.6	7.7	24.7	0.4
Diversified Packaging Companies:				
American Can	$41.0	$39.0	5 1%	0.9%
Continental	41.0	42.8	-4.2	0.8
Owens-Illinois	26.9	22.8	18.0	0.7

1. Generating or acquiring the new technological knowledge required by the company;

2. The development of new technology and products in support of the company's business objectives.

Both objectives may be accomplished either through its own efforts or by acquisition from outside sources such as the universities or public and private institutions.

In my paper I have outlined how we handle the funding and sponsorship of research projects at Mead. However, questions such as, "At what level should R & D be funded?", "By what process should R & D directions be established and managed?", "How are costs of R & D to be allocated within a company?" and "How shall the performance of R & D be judged?" are best answered on a business-by-business basis and may well be answered differently according to the size, complexity and product diversity within a company.

Table 1 includes a summary of annual R & D expenditures of some of the larger US paper companies. You will see from this list:

1. There is a wide range of R&D funding between individual companies, measured as a percent of sales, ranging from 0.1% up to 1.8%;

2. The paper industry average level, 0.8%, is low compared to the 2-3% levels for Chemicals and Electronics, and the 4-6% of the Information Processing companies. Since these industries will be the most likely competitors in the next decade for our raw materials and/or our traditional markets, we may well ask whether we are investing sufficiently in our industry's future.

I will return to this issue shortly, but before doing so let's take a look at the relationship of R & D to a business as a whole. Many of you are familiar with the concept of a Product

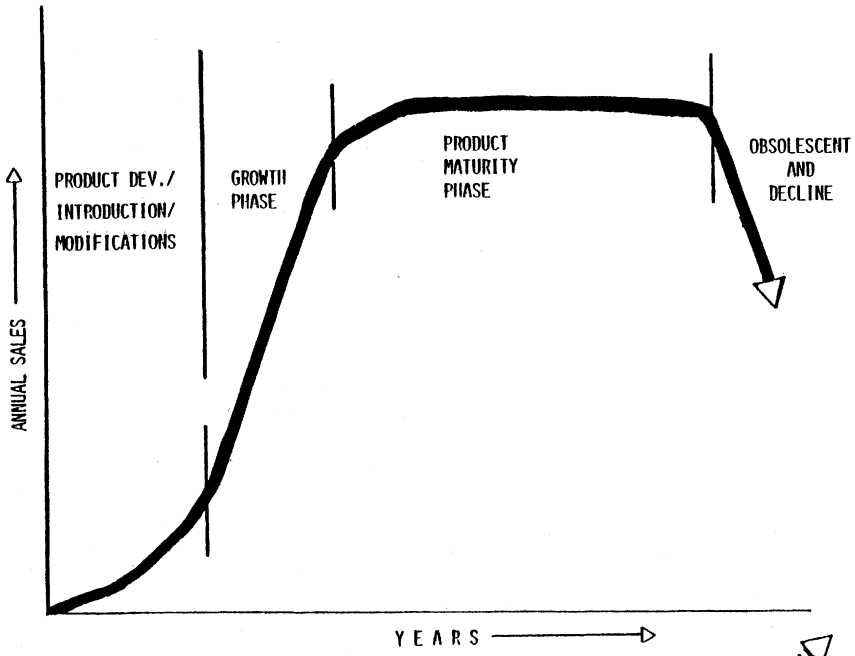

Fig 1—Product life cycle

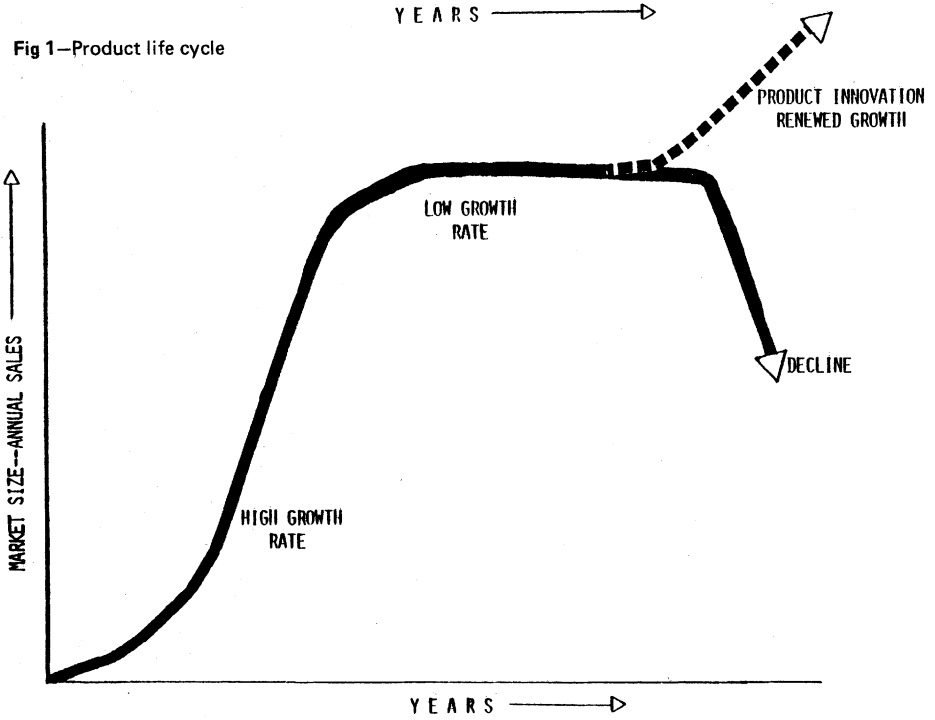

Fig 2—A market segment growth cycle.

Life Cycle, shown in Figure 1, and the four phases of birth, growth, maturity and decline. This type of growth and decline pattern is also exhibited by broader market segments and even by industries. In these latter cases, the phase of the market's or industry's development is determined by the composite of the growth phases of the major product lines which make it up. The major difference between an industry's or an individual company's life cycle and that of a single product is that both the former have options as they enter the maturity phase to renew their growth rate by the introduction of new products to succeed the maturing ones. In this way, business growth can be maintained and the ultimate decline of the industry or company postponed. This is shown in Figure 2.

In planning a corporation's growth strategy within a given market, it is advisable to take into account:

1. the growth phase in which the market as a whole currently exists, and

2. the company's relative market share within that market.

There is a growing acceptance of the proposition that for a company to be successful in a given market, it must either be in a position of leadership or plan to reach such a position. In broadest terms, this approach leads to four broad strategic options for the company depending on how the company finds or wishes to place itself on the market growth rate/market share matrix. The four quadrants of this market matrix and the broad strategies appropriate to each are given in Figure 3. Both of these concepts of market growth cycle and corporate strategy may be combined to suggest the type and level of R & D activity that is appropriate at a given time for a company, depending on its position on the market matrix. They may be further extended to suggest those activities that must be emphasised if the company is not satisfied with its present position on the matrix and wishes to adopt a strategy to change it. This is illustrated in Figures 4(a) and (b) and Figure 5. It will be noted that there

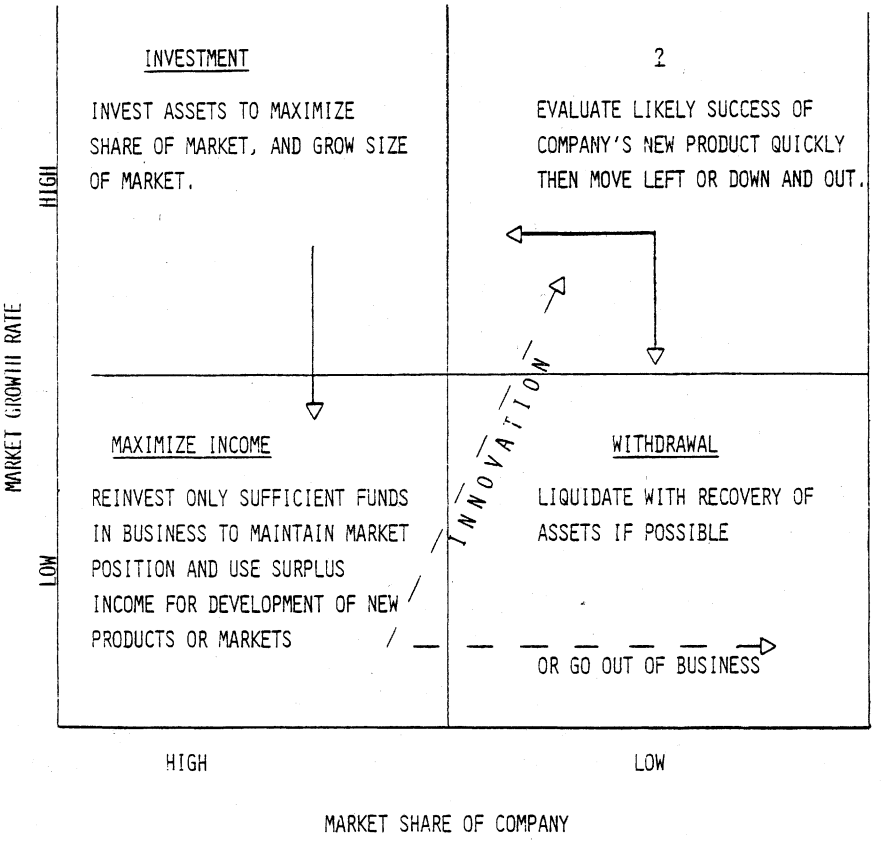

Fig 3—Business strategy matrix.

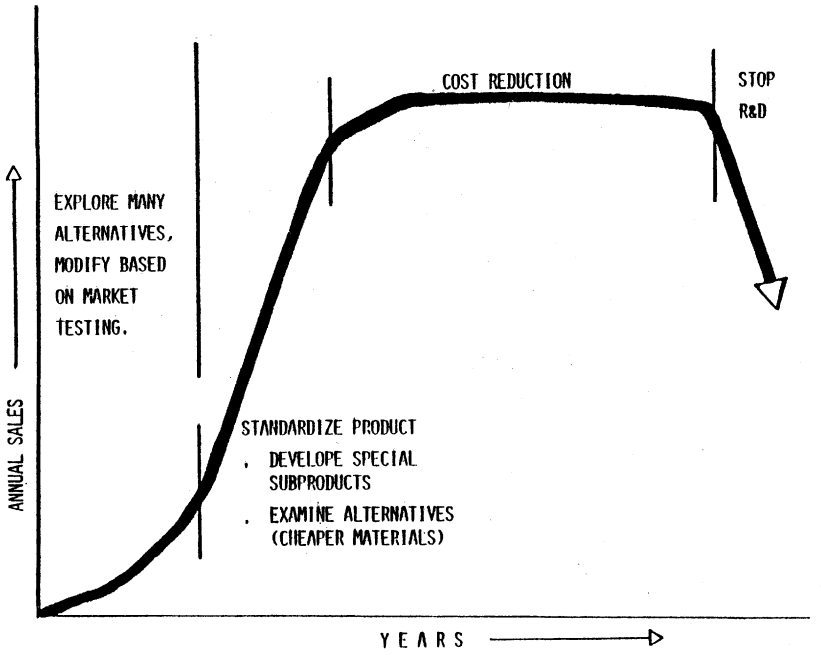

Fig 4a—R & D during product life cycle — product R & D.

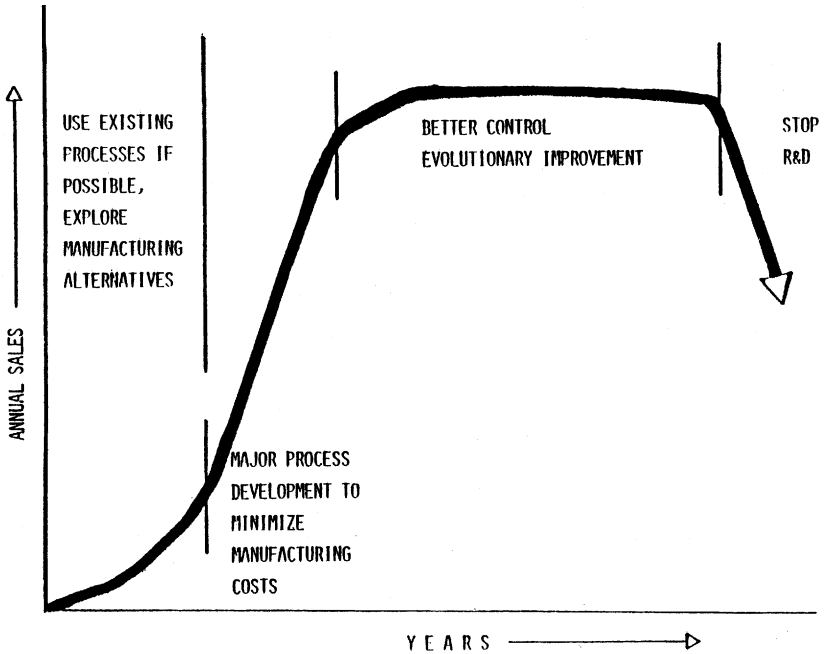

Fig 4b—R & D during product life cycle — process R & D.

are completely different strategies for product and process research, and the relative emphasis between the two is different at different stages of a business life cycle. The emphasis in the early phases of the business cycle is on products, and then passes to the process as maturity is reached.

In applying these concepts to a multi-division or multi-company, it is usual to find that different divisions are positioned in different quadrants of the market matrix. In this case, the type of R & D needs for the individual divisions will vary accordingly. My company has examples of business divisions in all four quadrants. The normal progression over time in a business is to progress slowly counter-clockwise to the lower right hand quadrant and then out of existence. If the business is to renew itself after it reaches the mature phase, it must find ways to innovate new products and services and start the cycle over again. This progression is shown by the arrows in Figure 5.

A company faces its greatest strategic challenges when one of the following instances occurs:

1. The company wishes to change dramatically its relative position in the business matrix;

2. Outside forces change the basic economics of the market-place or those of potential competitors outside the industry who wish to enter it;

3. New technological changes (often arising outside the industry) alter the characteristics of the market-place and the relative advantages of competitors within it.

This close relationship between R & D activities and those of the business as a whole suggests that the level and nature of a company's R & D efforts should be closely coupled to its strategic plans for change.

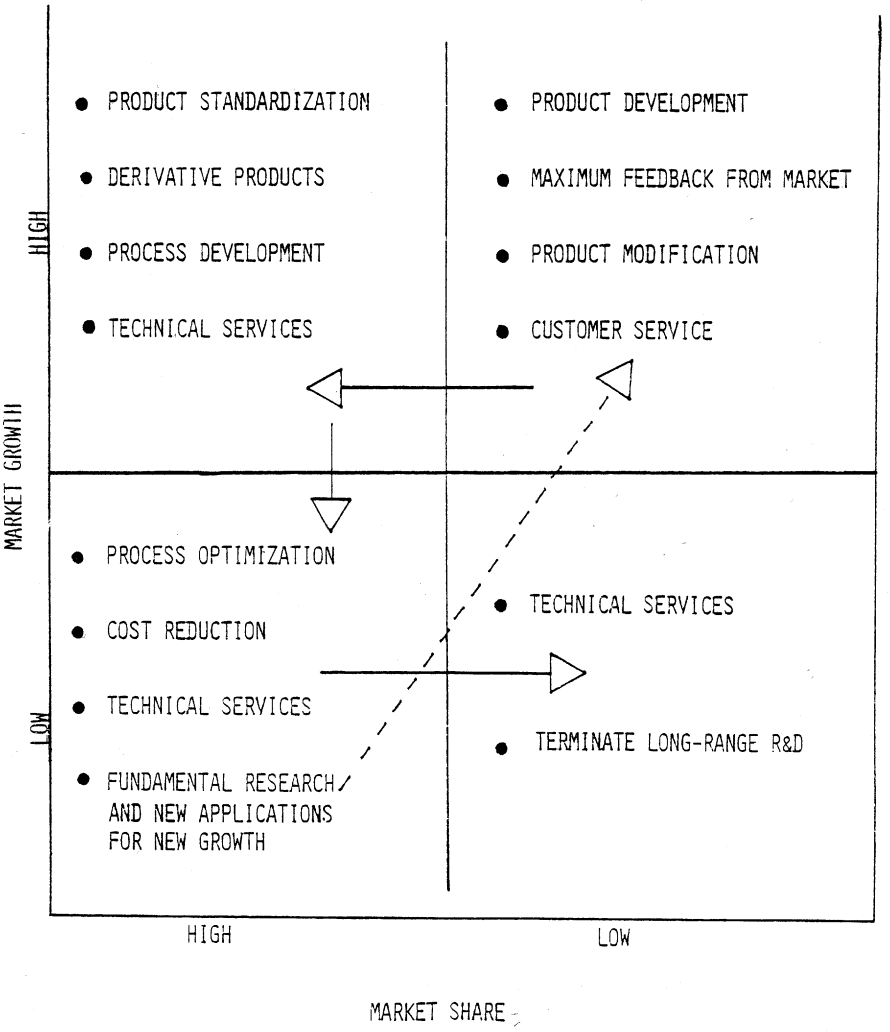

Fig 5—R & D strategy related to the market growth/market share matrix.

This proposition has suggested that a good way of looking at R & D in a company is in terms of a matrix in which the level of R & D activity is set out on one axis of the matrix and the rate of technological change a company desires to bring about in its share and the growth rate of the markets it serves is on the other. Such a matrix is proposed in Figure 6.

Although I have attempted to use quantitative measures on the axes of Figure 6, these are not intended to be more than illustrative at this time. An R & D programme correctly matched to the company's evaluation of its market's growth rate potential will fall on the matrix diagonal. Levels of R & D activity lying off the diagonal are either too high or too low for the company's chosen strategy.

Imbalance between an R & D programme and the corporate goals will eventually lead to frustration in the R & D staff and dissatisfaction with R & D performance on the part of management. Choosing the desired rate of change, and therefore the appropriate level of R & D funding, is a management strategy decision in which R & D should help by pointing out opportunities for business growth which can arise from technological changes. Once the level of funding has been established, however, the R & D department has the primary responsibility to develop the best approaches to reach the agreed goals. In Figure 6, I have suggested the appropriate mix of R & D activities within each segment of the matrix diagonal. It will be noted that the make up of these R & D programmes changes dramatically from one segment to another. Once again, if the content of the R & D programme is not appropriate to the company's strategic goals it will lead to frustration and disappointment.

Although these concepts are largely quantitative in nature at this time, I hope you will find them useful in trying to relate the management of your own R & D efforts to the strategic needs of your company.

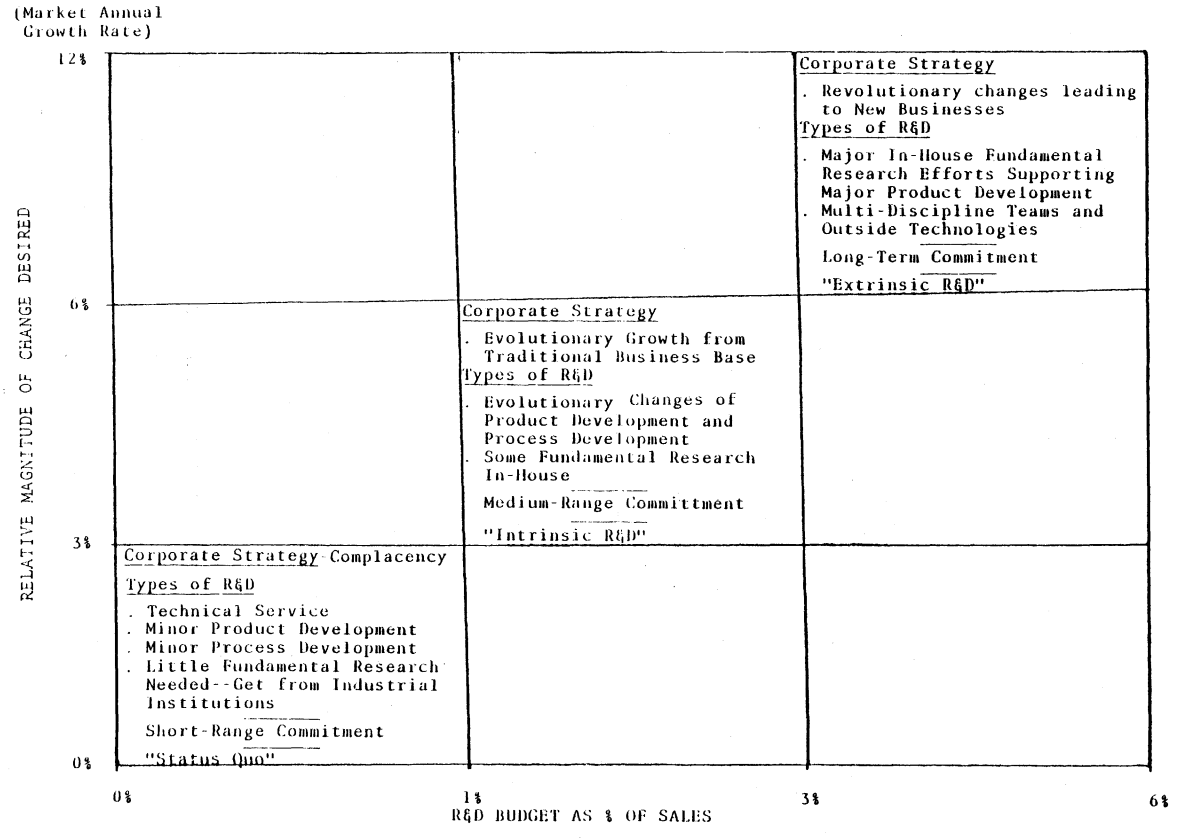

Fig 6—Matrix showing type and amount of R & D needed for different business strategies.

In closing, I would like to propose two questions for discussion:

1. What is an appropriate level of R & D activity for the forest product industry in general, and individual companies in particular, in the next decade?

2. Part I-- What is the appropriate level and nature of the new knowledge, the fundamental research, that will be required to meet our industry's strategic opportunities in the future?

   Part II -- What are the respective roles of the universities and our own industry's institution and corporate R & D groups in ensuring the availability of this knowledge when it is needed in the future?

If you believe the paper industry is entering a period of static or declining growth, you may conclude that our industry or your company is already doing too much fundamental R & D; R & D that won't be helpful in reaching our future goals.

On the other hand, you may accept the analysis in my printed paper that the major changes which have already taken place affecting our industry in the fields of energy, environment and raw material supply, and the heightened competition from electronic communication and plastic packaging systems present opportunities for renewed growth. If so, you should then decide we are doing too little fundmental research, and perhaps question whether what we are doing is being directed towards the right objectives. Your answers to these questions may well depend on the company with which you are associated, and upon the country in which you live.

Discussion

Discussion following prepared discussion contribution from Dr. J. Mardon.

Mr. D. Attwood, PIRA, UK

Dr. Asaoka, in your preprint you discuss Japanese government subsidies to your institute. Can you tell us please a little more about this, in particular, what ratio of funding you expect from industry and from government?

Dr. H. Asaoka, JPRI, Japan

The Japanese government gives no subsidy to any industry. If the government wants work done in a particular field, it discusses this with the appropriate companies, who put up the necessary money. Thus, in general, the government doesn't subsidise any industry.

Mr. A. Ibrahim, AccuRay Corporation, USA.

Mr. Justus, references to the concept of the extended nip press can be found as long ago as 1967-68, where Wahlström and others showed that the applied pressure and its duration could be varied to achieve optimum pressing of a specific grade. This work was supported in publications of Beloit's own research. I see Beloit's development of the extended nip press as the first stage in the practical application of these results. Does your Corporation have any plans to go to a second stage, in which the applied pressure and the drainage flow are under operator control, and variable to suit the product?

Mr. E. Justus, Beloit Corporation, USA.

The extended nip press is a project on which Beloit have been working for over ten years. On a three dimensional plot, showing sheet moisture as a function of both nip residence time and nip pressure, the area of practical interest can be enlarged with the extended nip press to include nip residence times of up to 30 ms, at pressures up to about 600 psi, leading to increases in sheet dryness of some 25% over conventional presses.

Physically, the heart of the extended nip press is a curved shoe fitting beneath the press roll. It is about ten inches long in the machine direction, and loaded hydraulically to about 600 psi, equivalent to about 6000 pli in a conventional nip. There is a belt adjacent to the shoe, and the two felts and the paper sheet run between the belt and the Venta-nip press roll.

Lubrication is by oil applied between the belt and the shoe, whose mechanics are the same as those of a crown-controlled roll. The first commercial unit was assembled and run in the shop, and has been running on a paper machine some nine months. A full report will be given on it at the Tappi meeting shortly.

It is imagined that an extended nip press could be used in a liner-board machine as second after a double felted first press. This combination should give drynesses into the dryer section of above 45% dry. The advantages of the extended nip press seem to include a reduction of about 25% in the amount of water to be evaporated, and an approximately 15% increase in sheet density.

Mr. S.F. Brailsford, Reed International Consultants Ltd., UK

Mr. Justus, you implied that it was best for machinery development to be left to the manufacturers. However, surely the interests of the paper and board machinery suppliers are diametrically opposed to those of the paper manufacturers? We, the paper producers, prefer to use the least quantities of chemicals and the cheapest machines possible, which must surely be against the interests of the chemical suppliers and machinery builders. Thus I put it to the panel that the paper manufacturers find it hard to believe that it is in their own best interests to leave all R & D to the suppliers.

Mr. E. Justus

I don't want to travel with an airline that designs its own aircraft and I don't believe that in the long run it would be economical for airlines to do so. Machine building is a specialised trade, and the builders are to be commended for eliminating expensive and difficult to maintain, but very profitable, items from machinery (e.g. suction rolls).

Machine speeds have doubled on almost every grade of paper over the past twenty five years, and the cost of machinery per unit of production has increased less in the paper industry than in almost any other.

Dr. A. Mawson, Wiggins Teape, UK

Many people in paper-making argue as Mr. Brailsford, but I believe that competition forces suppliers to continue improving the performance and productivity of machinery. While I believe that discontinuous innovation is most likely to arise outside the industry, I am sure that incremental technical improvements will always come from within.

Mr. B.W. Burgess, PAPRICAN, Canada

The position isn't at all clearly defined. No organisation has a monopoly of expertise, so I don't agree with Mr. Justus that all machinery development should be left to the manufacturer.

Dr. D.A.I. Goring, PAPRICAN, Canada

Mr. Justus, is your Corporation working on air-forming for high speed machines?

Mr. E. Justus

No, and there is a reason. It seems to us that what gives paper its particular characteristics, is the hydrogen bond. Dry-forming is for speciality products, while my Corporation is in the business of supplying machinery for making commodity grades. We intend leaving dry-forming to the speciality machine builders.

Dr. A.H. Nissan, Chairman

This issue doesn't need to be polarised, and while I would hate to suppress inventiveness amongst users, I think that I am in favour of most of this development being done by machinery builders. The cost of research by suppliers can, except for royalties, be distributed over a large number of units if it is successful, whereas this is not the case of research by users.

Mr. B.W. Attwood, Consultant, UK

Mr. Justus must realise from his own experience that machinery innovation can be a two way process. His corporation has made use of ideas developed by paper-makers and developed them to levels unattainable by their originators.

On the subject of air-forming, it is important to bear in mind that it is a speciality process, not for general application. I am concerned that, unless it is being done in secret, none of the major machinery manufacturers is investigating either this or any other of several new ideas, which may be the precursors of technology discontinuities. It looks very much to me as though the main research effort at this time is into evolutionary modification.

Dr. N.K. Bridge, PIRA, UK

A report on innovation and the factors influencing it has been prepared by the Science Policy Research Unit at the University of Sussex. One of the conclusions presented there was that innovation is often initiated by users, then further developed by the suppliers. This seems very natural, and I am sure that Mr. Justus recognises the approach.

Mr. F. El-Hosseiny, Weyerhaeuser, USA

I think that the development of machinery should be left to anyone who wants to do it, though I agree that the manufacturers are likely to make a better and cheaper job of it. But paper-makers have to be careful not be inveigled into buying extremely expensive equipment that they neither understand nor need.

Dr. J. Colley, APPM Ltd., Australia

Development and innovation doesn't stop as soon as equipment is delivered to the paper mill machinery house. Most installations have an element of speciality about them, and no manufacturer can expect his machines to suit every application straight away. The last stage of development, in the paper mill, is usually conducted by the paper-maker, though with the manufacturer usually present too.

Dr. J. Mardon, Omni-Continental, USA

Dr. Justus has a valid point, from one particular viewpoint. The key to managing R & D lies not in knowing what to do, but in knowing what not to do. By tying up a lot of limited resources of expertise and equipment in machinery research you are not equipped for, your research operation will be very ineffective and you would have done better leaving it to the manufacturers. I am sure that is what Mr. Justus was referring to, as both he and I have seen many examples of it. If a paper-maker has an innovative idea, then his most effective way to exploiting it, is to develop it himself as far as he reasonably can, before taking it to the machine builder for further improvement. But to try to produce large scale pilot plant is a mistake.

Dr. A.H. Nissan

Without wishing to take sides, I will just mention that Tsai Lun, M. Robert, and the Fourdrinier brothers were all users. The twin-wire was a user development, and I think George Tomlinson was a user. But machinery builders have produced revolutionary changes also. Dr. Mardon's point about when to take a developing idea to a machine builder is important, because, whatever else, the builder does have experience of how to design and make pieces of machinery that work, and the outcome of the idea will be much influenced by whether or not it works. There isn't however a god-given law about this.

Mr. G. Place, Proctor and Gamble, USA

I believe there is a god-given law on this subject, which is that the R & D management and the general management of a company must have a very clear view of what business they are in. What I hear from Mr. Justus is a very clear view of his business, and therefore a very clear view of the research his company will undertake. If a revolutionary change does come about then Beloit either will have to have made arrangements with their research group to switch to the new technology, or go out of business. Thus the primary strategic question for a company is to resolve what business they are in, and for both R & D and general

management to see it the same way. This view of the business can be as narrow and specialised as you like, provided there isn't some discontinuous change of technology. As soon as one occurs, the view will have to be widened if the company is to remain in business.

Mr. E. Justus

A lesson I saw illustrated very well the other day during a visit to the Imperial War Museum is that the simplest way of doing a thing is the best. The example I saw was of World War II aero engines, amongst which the successful ones stood out by virtue of their simplicity and cleanliness of design. I thought this example one of the best of the artistry and rightness of design that I have ever seen.

Dr. A Mawson

The similarity between two of the engines you looked at, the Rolls and the Daimler Benz, probably illustrates a point we are overlooking, namely that we learn much from our competitors.

Dr. A.H. Nissan

Before bringing the discussion back to paper-making, I must just say that the most successful aero-engine design has been the turbine, developed by an RAF engineer, a user.

Mr. B.W. Attwood

What happens to an innovator from a paper mill who has a idea, but who can't interest anyone, either machinery builders or other paper-makers, in it? He must have something material to show them, because innovation is concerned with doing things differently.

Mr. P.E. Wrist, Mead Corporation, USA

I see a difference between invention and innovation. The innovation mentioned by the previous speaker was not in widespread, successful, commercial use and therefore was not, as I understand it, an innovation. It was only at the stage of

invention. To qualify as an innovation, as I see it, an invention has to be in commercial use.

Mr. J. Gough, Wiggins Teape, UK

Mr. Wrist, in the last diagram you showed in your presentation, demonstrating the relationship between the research resources required and the rate of growth sought, what was the scale of the x axis, the research resources? If it was percentage annual sales, then it implies that for a major breakthrough, it is necessary to spend around 6% of annual sales revenue on R & D. This is an unheard-of figure in our industry.

Mr. P.E. Wrist

Those figures were drawn from the examples firstly of a number of companies undertaking minor product development, who seemed to be spending, on average, rather less than 1% of annual sales: secondly, those who, while doing good development work, were remaining within their industries, spending 1-3%: thirdly, some examples of companies breaking into new markets. I would be the first to agree that present annual sales is a poor way of quantifying expenditure. For a conglomerate, with enormous sales, the amount required to penetrate a new market is a rather small percentage. My main point in that diagram was, to make a major breakthrough a company must spend on R & D at far higher rate than it need just to maintain market position.

Dr. A.H. Nissan

If, in a business with annual sales of $1 m, a product improvement is introduced that increases sales to $2 m, then it doesn't follow that R & D spending should double. So, this annual sales percentage issue is very misleading. I have seen only one article, many years ago, where an attempt was made to calculate, accurately, recommended levels for R & D expenditure. The calculations were involved, and required taking account of product life and profitability, amongst other things.

Mr. D.G. Croxon, Kimberly-Clark

Mr. Wrist, would you think it advisable to involve research workers in discussions of profitability, or do you believe they should be left totally in isolation, not even allowed telephones?

Mr. P.E. Wrist

I don't think taking their telephones away will much improve profits. There is an advantage in having at least the research managers know something about business and the factors that influence profit. However, that isn't their primary concern, which must be the identification of new technical opportunities to be brought to the main management's attention. They must point out the advantages, while recognising that the company is a team effort in which there are others more skilled in making financial judgements. This way lies the course to a true corporate decision on the viability of new projects. Profitability is very difficult to relate to R & D, and by loading such matters onto R & D personnel, the risk is of giving them too much to worry over, such that their performance is impaired. Still, they should be aware that making a profit is one of their company's objectives.

Dr. J.L. Brander, Wiggins Teape, UK

Expenditure on R & D is sometimes believed to be a function of what industry you are in. In other branches of machinery building 6% of annual sales is considered adequate to keep market position, without expecting any breakthroughs. I would like to ask Mr.Justus if the same is true in paper machine building?

Mr. E. Justus

6% is a lot and we would like to have a budget like that, but we don't.

Dr. M. Hussain, Abitibi-Price, Canada

From one of the charts in Dr. Asaoka's paper, I see that Japan consistently spends less as a sales percentage on R & D than we do in USA, in every industry except iron and steel.

Since we all recognise that the Japanese economy is doing better than that of the US, is there something significant in that? Also, I would like to ask Mr.Justus if he would care to comment on the suggestion I have heard, that Beloit deliberately held the extended nip press back in order to protect their foundry business?

Mr. E. Justus

The reason for the extended nip press' long development period, was arriving at a suitable mechanical arrangement that would survive in a paper mill. The belt was the most difficult part of the assembly. Our first design made use of hydrostatic rather than hydrodynamic bearings. The development has been hard work, and if you were to see our annual expenditure figures you would see that we weren't trying to hold back on it. We are in competition with the world in machinery production and if we have a development that will make more paper at lower cost, we won't hold back on it.

Dr. A.H. Nissan

The development time of the extended nip press was not unusually long.

Mr. A.G. Marriott, BPBIF, UK

There has been very little discussion about the financial justification for R & D, though it has been suggested, especially by Mr. Wrist, that it is essential for a company's survival. Would anyone of the panel like to comment on the quite widely held belief that it doesn't pay to be market leaders in an innovation, and that the second group in, the copiers, stand to do much better? The Japanese at one stage of their post-war development seemed to illustrate the truth of this.

Dr. A. Okagawa, JPRI, Japan

Japanese industry spends roughly 0.3 to 0.4% of sales on R and D, which is comparable with what is found in other countries, not less as has been suggested.

Dr. W. Adams, AccuRay, USA

We have discussed to some extent how inventions come about, before being developed into innovations. I think they usually come into being wherever a problem is well identified, and where there is stress. The greatest inventiveness is shown in time of war, or when companies are in trouble. So if people of inventive minds are subjected to stress, then inventions result. To develop further, to the innovation stage, using Mr. Wrist's definition, involves people with marketing skills. So, bearing in mind what I've said, I would like to ask anyone on the panel if they have ever tried taking their problems to their suppliers in a stressful way?

Dr. A.H. Nissan

Can anyone on the panel define "a stressful way"?

Mr. P.E. Wrist

The big thing that helps change an invention into an innovation is an identifiable market need. The chance of rapid adoption of an invention when there is a need for it are great. This shows in statistics too, such that some 80% of innovations can be shown to be in response to previously identified market needs, whereas only 20% arise without a market need. That doesn't mean that the latter group is unimportant, because when such inventions finally gain acceptance they often provoke change, revolutionary rather than evolutionary.

Lasers are a good example. For years after their development they were virtually unexploited, yet now we see that they will probably be at the heart of the next revolution in communications technology. We need both kinds of inventions, but in an industry where it is important to make a profit every year, it is probably better to look for inventions that meet market needs, rather than the other sort.

Mr. E. Justus

If a customer with an invention wants to provoke a response from us, then his best chance is to spell stressful "M-O-N-E-Y".

Dr. A.H. Nissan

On that, which defines the essence of all our involvement in the industry, I think we should call a halt.

Today we have had fourteen panelists give their views on various aspects of R & D, and I think that the fact that I have had to cut short the discussions must testify to the high standard of their various presentations. Thank you for putting such efforts into the preparations.

Concluding Remarks

Mr. M.I. MacLaurin

Firstly, I want very much to thank Dr. Nissan for so ably chairing today's proceedings. It required much preparation and hard work, but the results have well justified the effort. So, on behalf of us all, Alfred, thank you.

Thank you, also, the Engineering Dept. Staff who have been working behind the scenes, handling the audio equipment and projectors, as well as the very efficient people, Sandra and all the UMIST students, who have been doing all the microphone work, and the two girls, Katherine and Dawn, who have been manning the front desk.

I will be brief in closing this symposium because many people have a lot of travelling to do this evening, and I want to sustain our reputation for being on time. But I shall speak for a few minutes about the next, the eighth, to be held in 1985.

Firstly, a large number of delegates has in fact responded to my request for opinions yesterday, and it is quite clear that we shall be at Oxford unless some compelling difficulty arises. We shall start investigating right away, to see how things can best be arranged to overcome some of the problems we have had here. But is does seem that a majority would prefer being at Oxford.

Secondly, this particular meeting in its first morning and its last day, has departed somewhat from the tradition of these symposia, and I think that format has been timely for 1981, especially as regards todays discussions. However, I think it is not something we shall repeat too soon, and the 1985 meeting will

be essentially scientific throughout, with a return to the format of previous symposia in the series.

Thirdly, you may recall that, in my opening remarks on Monday, I suggested we didn't need a theme for 1985. Well, even before the first working session Dr. Rance had put his disagreement on record, and it has become clear during the week that most people here disagree with me on that. So I am now persuaded of my folly and publicly repent.

What really convinced me was the emergence during the week, based upon a lot of help from everyone, of an idea for a theme, endorsed by the committee. We shall have to sort out the wording of it, but, as we all know, the paper-making processes and the properties of paper products depend very much on the properties of the pulps we use and the processes by which we prepare them. In 1985 we intend to bring those relationships together as the theme for the symposium. If anyone has ideas about this, even if you think it is utterly wrong, I would like you to write to one or other of the committee.

Now, all that remains to be said is thank you to everyone for taking part in the week's events. Travel home safely, and let's all meet again in 1985.