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RESEARCH AND DEVELOPMENT IN JAPAN – PRESENT AND FUTURE

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Technical Challenge in the Japanese Pulp and Paper Industry

For over a hundred years, the Japanese pulp and paper industry, which dates back to 1873, has had to struggle with three major problems.

For the first 40 years, it had to compete with traditional hand-sheet making. The introduction of mass-production technology from abroad allowed the machine-made paper industry to surpass hand-sheet production.

Then it had to survive against imported pulp and paper products. The Japanese pulp and paper industry maintained production by securing cheap wood resources and continuously acquiring new superior technology and process equipment from abroad, thereby improving quality and reducing production costs. In addition, protection by tariff control and reform of the industrial structure by merger helped its survival. It also benefited from the growth of the entire Japanese industry caused by the first World War. By the 1920's our industry succeeded in driving out entirely the foreign pulp and paper products from the Japanese market, and Japan became self-sufficient.

The biggest continuing problem in our industry is that of security of wood-fibre resources, and this determines the strategy behind our R and D effort.

Since imported western technology applies only to soft woods of the subarctic Zone (Picea and Abies), the industry, to secure its wood resources, had to expand into Hokkaido (the northernmost of the four major Japanese islands), South Sakhalin (Japanese

territory between 1906 and 1945), North Korea (Japanese territory between 1910 and 1945) and Manchuria (a tributary state of Japan between 1932 and 1945).

Since a shortage of subarctic soft woods became apparent during the 1930's, pulping technology, particularly for dissolving pulps, appropriate for soft- (Pinus etc.) and hardwoods of the Temperate Zone had to be developed.

Research effort was also expended to develop pulping technology for use with various non-wood resources, including herbage and seaweeds. A number of pulp and paper mills was constructed using this technology. These efforts contributed to the restoration and growth of the Japanese pulp and paper industry after the second World War. At the same time considerable R & D effort went into the adoption of new processes and equipment imported from abroad in order to make use of hard woods of the Temperate Zone.

Another characteristic feature of R & D in Japan I would like to point out is that considerable attention is given to R & D for quality improvement. As we all know, the products of pulp and paper mills do not usually go directly to the final users. Almost all products are processed by, for example, newspaper publishers, book publishers, printing companies, box board convertors, and viscose rayon makers. The quality and price demands of these Japanese intermediate processors are very severe. R & D in this area is therefore important to satisfy their demands.

The Japanese pulp and paper industry uses a variety of woods, for example, imported soft woods of the Subarctic Zone, soft woods of the Temperate Zone, hard woods of the Temperate and Tropical Zones, etc. As a result, a variety of pulping processes must be employed: one Japanese mill uses 8 different pulps in the production of newsprint[1]. To produce various papers of uniform quality at a reasonable cost in such a situation needs a good deal of R & D and statistical control at the mill site.

Like other industries, the pulp and paper industry also emphasises "Quality Control". In many factories, mill workers organise quality circles, whose activity helps to increase the

Table I. The World's Top 20 Producers & Consumers (2)

Paper & Board Production (1,000 tons)			Pulp Production (1,000 tons)			Per Capita Consumption (kilograms)		
	1979	1978		1979	1978		1979	1978
1. USA	58,882	57,524	1. USA	45,103	45,581	1. USA	289	274
2. Japan	17,525	16,488	2. Canada	19,516	18,914	2. Canada	215	221
3. Canada	13,490	13,270	3. Japan	9,993	9,391	3. Sweden	213	203
4. USSR	8,800	9,200	4. Sweden	9,083	8,557	4. Fed. Rep. Germany	205	143
5. Fed. Rep. Germany	7,444	6,870	5. USSR	9,000	9,400	5. Denmark	174	167
6. Sweden	6,280	5,702	6. Finland	7,037	6,078	6. Finland	165	129
7. Finland	5,738	5,127	7. China, People's Rep.	4,000	4,000	7. Switzerland	161	151
8. France	5,261	4,964	8. Brazil	2,443	2,004	8. Japan	151	142
9. Italy	5,101	4,615	9. Fed. Rep. Germany	1,966	1,843	9. Netherlands	148	148
10. China, People's Rep.	5,000	5,000	10. France	1,928	1,920	10. New Zealand	147	123
11. United Kingdom	4,198	4,152	11. Norway	1,529	1,384	11. Belgium	145	134
12. Brazil	3,002	2,534	12. Austria	1,223	1,103	12. Norway	136	136
13. Spain	2,251	2,175	13. Spain	1,215	1,225	13. United Kingdom	134	130
14. Mexico	1,731	1,597	14. New Zealand	1,201	1,009	14. Australia	133	125
15. Netherlands	1,704	1,671	15. Italy	1,188	1,203	15. France	117	111
16. Korea, Republic of	1,630	1,436	16. South Africa	988	879	16. Austria	103	95
17. Austria	1,565	1,435	17. India	860	840	17. Italy	93	81
18. Norway	1,400	1,240	18. Czechoslovakia	858	859	18. Iceland	83	83
19. Taiwan	1,336	1,159	19. Poland	774	821	19. Dem. Rep. Germany	81	79
20. Australia	1,310	1,232	20. Portugal	728	616	20. Taiwan	80	80

morale of mill workers and to bring about improvements in their daily practice. The Honshu Paper Co. is the only pulp and paper manufacturer to have received the prestigious Deming Award.

R & D is carried out not only at the research laboratory, but also in co-operation between mills and the headquarters R & D or technical service division.

Research and Development in Japan

1. A Glimpse into the Japanese Pulp and Paper Industry

First of all, the size and position of the Japanese pulp and paper industry are to be illustrated by various statistics. Although our industry ranks in the top group amongst world pulp and paper producers, it ranks in the lower group compared with other Japanese industry (See Tables I and II).

Productivity is increasing steadily, although profits are still very low (see Figures 1 and 2). The activity of the Japanese pulp and paper industry is illustrated in Figure 3.

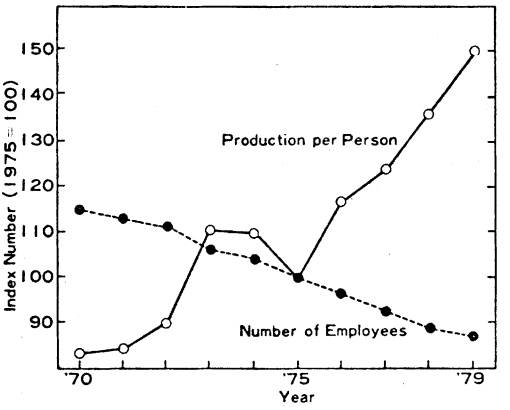

Fig 1—Changes in number of employees and production per person in Japanese pulp and paper industry (4).

Table II. Japan's Big Industries and Their Employees in 1977 (3)

Industry	Production Shipment			Number of Employees		
	Rank	billion yen	%	Rank	1,000 persons	%
Transportation Machinery, Equipment	1	19,079	12.2	4	923	8.5
Food	2	18,597	11.9	2	1,148	10.6
Electrical Machinery, Equipment	3	15,076	9.6	1	1,236	11.4
Iron & Steel	4	13,270	8.5	10	468	4.3
Machinery, Including Arms	5	12,726	8.1	3	1,052	9.7
Chemical Products	6	12,535	8.0	11	430	4.0
Petroleum & Coal Products	7	8,960	5.7	19	45	0.4
Fabricated Metal Products	8	7,893	5.0	6	812	7.5
Textile Mill Products	9	7,181	4.6	5	892	8.2
Ceramics, Stone & Related Products	10	5,787	3.7	7	530	4.9
Non-ferrous Metals & Products	11	5,274	3.4	16	200	1.8
Pulp, Paper & Paper Products	12	5,051	3.2	13	304	2.8
Publishing & Printing	13	4,964	3.2	9	479	4.4
Wood & Wooden Products	14	4,207	2.7	12	423	3.9
Cloth & Other Textile Products	15	2,573	1.6	8	529	4.9
Precision Machinery, Equipment	16	2,392	1.5	15	252	2.3
Furniture & Fixture	17	2,289	1.5	14	299	2.8
Rubber Products	18	1,745	1.1	17	157	1.4
Leather & Fur	19	823	0.5	18	90	0.8
Other Manufacturing		6,494	4.1		607	5.6
Total		156,918	100.0		10,875	100.0

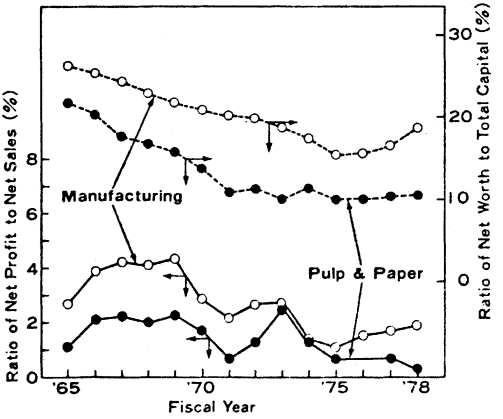

Fig 2—Comparison of changes in profit ratio and net worth between pulp and paper industry, and all manufacturing industry in Japan (5).

Wood resources are obtained mostly as wood chips from foreign and domestic wood suppliers. Imported wood chips amount to more than 40% according to the statistics. However if one includes lumber mill waste from imported woods, real imported raw materials amount to more than 50%.

2. Pulp and Paper Research Organisations

2.1. Academic Research

In Japan the majority of scientific research is carried out in universities and government research institutions. A university has a number of faculties, such as science, engineering, agriculture, etc., each faculty being different in its philosophy on research administration. As its name implies, the Faculty of Science focusses on pure scientific research, while the Faculties of Engineering and Agriculture are orientated towards technological development, and technical science and art.

Up to 20 - 30 years ago, many faculty members in Engineering used to show an interest in cellulose chemistry, and undertook fundamental research on pulp and paper-making, especially on dissolving pulp. However their interest now has shifted to synthetic polymer chemistry, and cellulose and polysaccharides are not favoured research subjects any more.

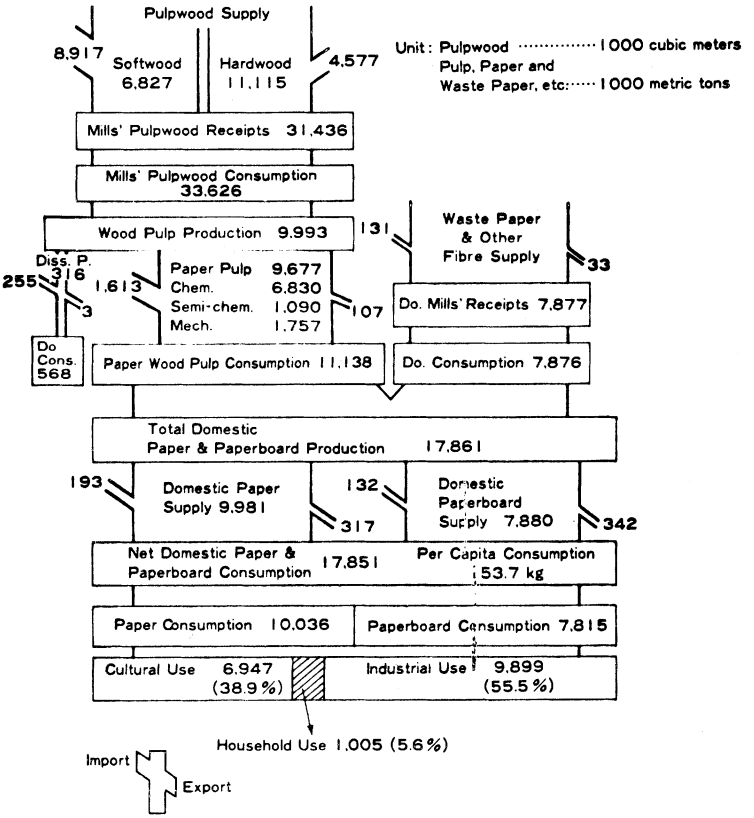

Fig 3—Outline of Japanese pulp and paper industry's activity in 1979 (6).

Whereas in the Faculty of Agriculture, research on pulp and paper, focussing on lignin chemistry, is conducted by scholars of forest product chemistry, research on the physical aspects of pulp and paper-making has recently been begun. Scholars in the fields of chemical and mechanical engineering are not integrated into the research organisations of the pulp and paper industry. Forestry belongs to the agriculture faculty, while botany belongs to the science faculty.

The number of universities in Japan which have forestry and forest products departments are 25 and 7 respectively. But there are 28 universities which offer courses related to forest products. These departments run several laboratories on specific subjects, each of which forms a research group with faculty members (one professor, one assistant professor and two assistants), and several graduate students. The numbers of graduates from the forestry departments in 1979 were 981, 70 and 26 with Bachelors, Masters and Doctors degrees respectively, and 183, 80 and 30 students were graduated from the forest products departments with Bachelors, Masters and Doctors degrees respectively(7). Of these very few graduates took positions in the pulp and paper industry.

The Wood Research Institute at Kyoto University is the only university-based institution in this area.

Government research institutions which carry out R & D related to the pulp and paper industry are as follows:

Ministry of Agriculture:	Forestry and Forest Products Research Institute.
Ministry of International Trade and Industry:	Agency of Industrial Science and Technology.
Ministry of Finance:	Printing Bureau, Research Institute. (does research on bank notes).

Chemical Research Institute,

Industrial Products Research Institute,

Research Institute for Polymers and Textiles,

Government Industrial Research Institute, Nagoya,

Government Industrial Institute, Shikoku.

Table III. Comparison on R & D in Japanese Pulp and Paper Industry, 1978. (8)

Class		Number of companies	Companies accompanying R & D	
			Number of companies	Percentage
Total number		3,570	315	8.8
Capital	3-10 million yen	2,101	100	4.8
	10-100	1,229	124	10.1
	100-1,000	204	60	29.4
	1,000-10,000	33	28	84.8
	10,000 or more	3	3	100.0
Size of persons employed	1-299 persons	3,494	261	7.5
	300-999	57	36	63.2
	1,000-2,999	12	11	91.7
	3,000-9,999	7	7	100.0
	10,000 persons or more	0	-	-
Sales	Less than 100 million yen	1,505	100	6.7
	100-1,000	1,496	27	1.8
	1,000-10,000	515	142	27.5
	10,000 or more	55	47	85.5
Regular researchers	0 persons	3,391	136*	4.0
	1-29	169	169	100.0
	30-99	8	8	100.0
	100 or more	2	2	100.0
Operating profits	Less than one million yen	2,365	14	0.7
	1-100	982	188	19.1
	100-1,000	196	89	45.6
	1,000 or more	27	25	92.5

Note: Figure with* includes only external researchers or intramural non-regular researchers.

2.2. Experimental and Technical Advice Agency of Local Government

Local government in Japan operates various experimental laboratories and technical advice agencies to suit the needs of local industry. These organisations have a role in offering research and development facilities for the small- to medium-size enterprises which cannot afford their own. Special experimental stations for the small- to medium-size pulp and paper producers, and Japanese hand-sheet makers are located in the prefectures of Hokkaido, Saitama, Shizuoka, Ehime, Kochi, Toyama and Gifu. Also forest experimental stations are located in almost all prefectures.

2.3. Research and Development by Private Enterprises

Internal R and D Expenditure (companies)	Big 5	Big 10	Big 20	
Number of companies	5	10	20	
Proportion of large companies to total	0.1%	0.3%	0.6%	
Sales	28.8%	47.1%	58.4%	4,394,000 M Yen
Operating profits	33.0%	47.8%	63.4%	216,202 M Yen
Persons involved in R and D	36.4%	50.1%	61.1%	2,786 people
Regular researchers	32.5%	48.2%	80.2%	1,448 people
Internal R and D expenditure (disbursement)	40.3%	56.5%	68.0%	13,292 M Yen

Table IV
R and D of big companies in Japanese pulp and paper industry, 1978(8)

Table V. Comparison on R & D between Pulp & Paper Industry and Manufacturing Industry in Japan, 1978. (8)

	Pulp and paper industry	Manufacturing industry
Total number of companies	3,570	97,665
Number of companies accompanying R & D	315	13,955
Number of companies conducting intramural R & D	315	13,269
Number of regular researchers per 1,000 persons employed (persons)	15	32
Number of persons engaged in R & D per 1,000 persons (persons)	27	63
Percentage of intramural expenditure on R & D (cost) to sales	0.49	1.83
Intramural expenditure on R & D per company (Annual cost : 10,000 yen)	4,220	14,466
Intramural expenditure on R & D per regular researcher (Annual cost : 10,000 yen)	918	1,362

Table VI. Composition of Intramural Expenditure on R & D by Type of R & D, 1978. (8)

	Basic Research	Applied Research	Development Research
Pulp and Paper Industry	3.2%	18.9%	77.9%
Manufacturing Industry	4.6%	18.0%	77.4%

The majority of major pulp and paper company have their own research and development facilities. Their statuses are summarised in Tables III to V.

Compared with other industries, the pulp and paper industry has a rather low posture in R & D. This seems to be true also all over the world. Some comparisons between the U.S., Canada and Japan are shown in Figs. 4 to 7.

Spending on R & D in the private sector goes mostly on development, about 2/3 (see Table VI).

During 1973 to 1974, large amounts of research expenditure went into the area of environmental protection (see Table VII).

It seems that the reasons for the large fluctuations in the number of people engaged in research is due to frequent exchange between researchers and mill engineers. As stated at the beginning, R & D in Japan is carried out not only in the research laboratory (statistics shown here are obtained only for research laboratories), but also at the mill site.

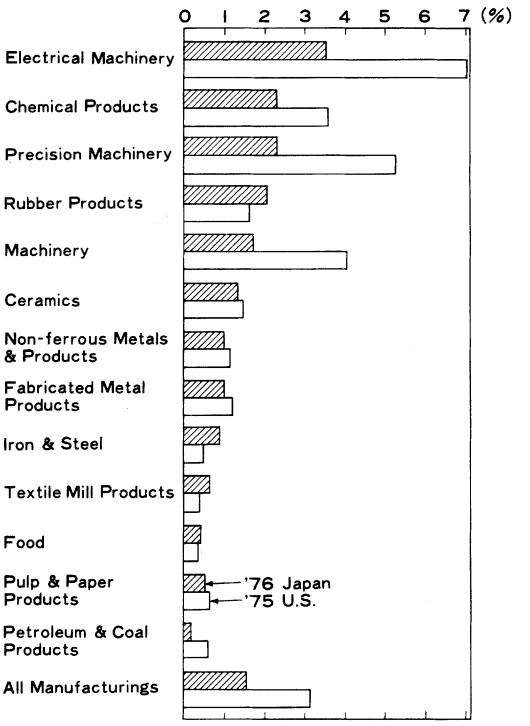

Fig 4—Comparison of expenditure on R & D (cost) as percentage of sales by major industries in Japan and U.S. (9).

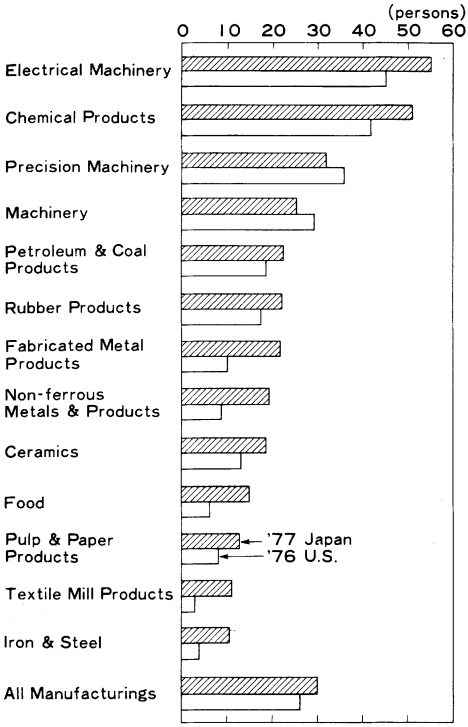

Fig 5—Comparison in number of regular researchers per 1,000 employees of major industries in Japan and U.S. (9).

An example of the essential organisational structure related to R & D in one Japanese company is illustrated in Figure 8. Not shown in Fig. 8, the special product division has its own technical staff and development group.

Divisions or sections at a mill have several technical staff with university degrees who sometimes conduct research, survey, testing and development in addition to their regular supervisory work. This is the way that a young engineer is trained to a management position. However, no effort is made to create a research specialist.

	Basic Research	Applied Research	Development Research
Pulp and paper industry	3.2%	18.9%	77.9%
Manufacturing industry	4.6%	18.0%	77.4%

Table VI
Composition of intramural R and D expenditure, 1978(8)

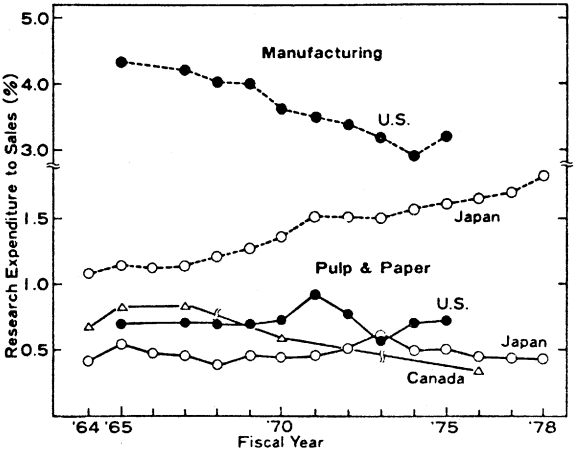

Fig 6—Changes in R & D expenditure as percentage of sales (8, 9, 10).

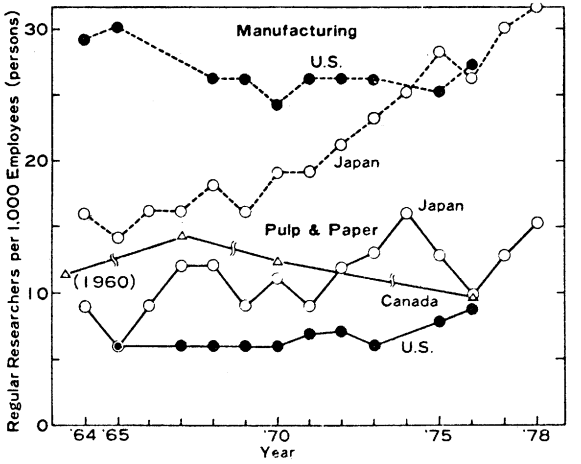

Fig 7—Changes in number of regular researchers per 1,000 employees (8, 9, 10).

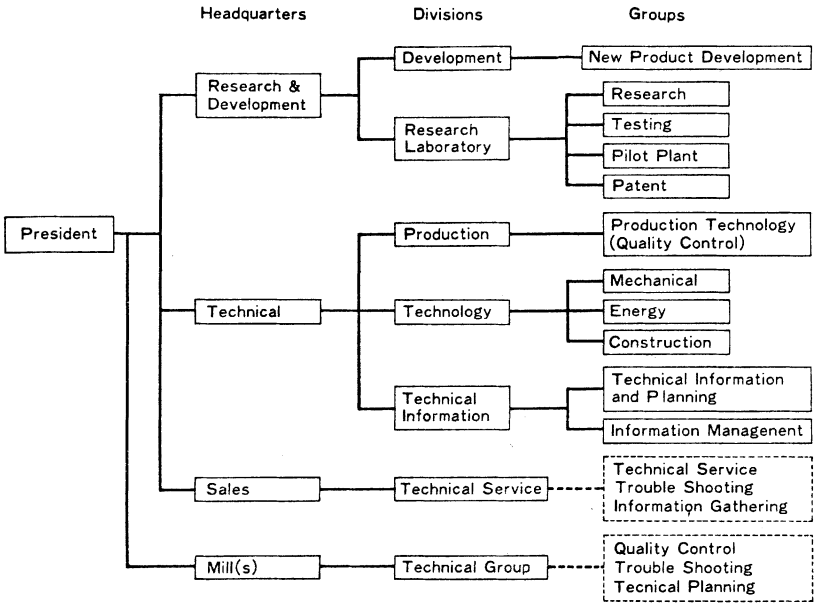

Fig 8—Research and technical organization of a pulp and paper company.

Table VII. Percentages of Companies Accompanying R & D and Expenditure on R & D for Environmental Protection (9)

Year		1971	1972	1973	1974	1975	1976
Percentages of companies accompanying R & D for environmental protection	Pulp and Paper	21.3	24.0	35.9	24.1	15.1	16.3
	Manufacturing	8.4	12.1	16.0	14.7	10.3	9.5
Percentages of expenditure on R & D (cost) for environmental protection	Pulp and Paper	2.4	8.9*	53.9*	13.0*	9.2*	7.4
	Manufacturing	3.1	4.4	6.0	5.3	5.7	4.8

Note: Figures with* include the expenditure on R & D for "Pollution-Free" pulping developed by Japan Pulp and Paper Research Institute Inc., which was given subsidy for R & D of key technology by MITI.

Table VIII. Major Subsidies for R & D in Science and Technology

(Unit : million yen)

System (Ministry)	Aid	Budget		
		1978	1979	1980
(Science and Technology Agency)				
Subsidy for Experiment and Exploitation of Invention	1/2	25	25	15
(Ministry of Education)				
Subsidy for Study of Science		26,500	30,043	32,500
Subsidy for Private Group relating to Science Research		467	490	507
(Ministry of International Trade and Industry)				
Subsidy for R & D relating to Key Technology	3/4, 2/3, 1/2	3,242	3,180	3,226
Subsidy for Improvement in Technology	3/4, 1/2	952	940	1,004
Subsidy for R & D in Technology	1/2, 1/4	470	432	471
(Ministry of Transport)				
Subsidy for R & D in Application of Science and Technology		176	184	187

2.4. Industry-University Co-operation and Joint Research Institutes

About 120 years ago Japan began systematically to acquire western culture. Western science and technology were also introduced into Japan at the same time. Various systems which had been perfected in the west arrived in Japan via different routes without mutual consultation.

University, industry and government institutes operate independently, and there is a tendency to stand aloof from other activity. This is encouraged by the vertical administrative structure of Japanese society. The complex structure of science and technology administration is shown in Fig. 9. Mutual contacts amongst each agency are practically non-existent.

Recently, it has become a consensus that promotion of science and technology is a necessity of survival for Japan, which lacks natural resources and energy.

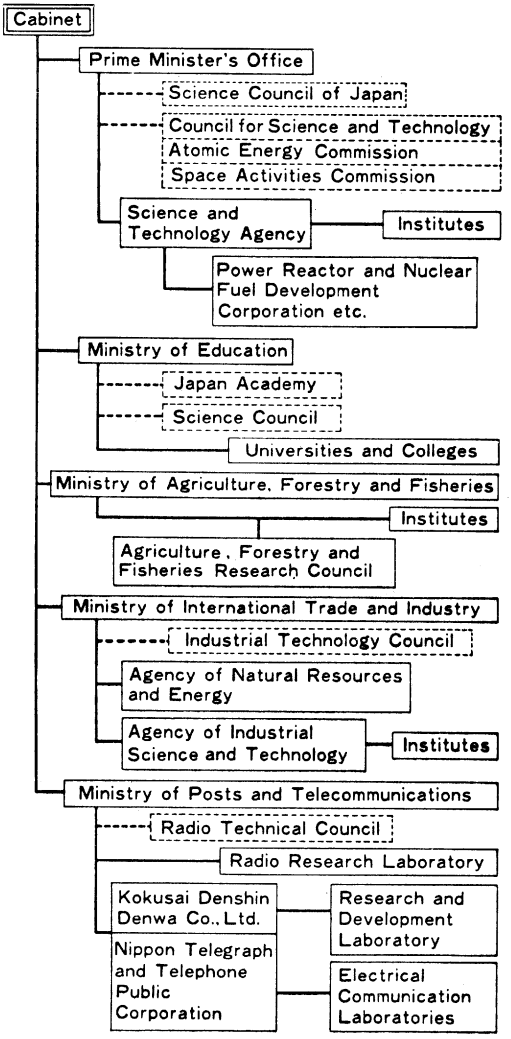

Fig 9—Administrative organization of science and technology in Japanese government.

Many authors write to this effect.

It is also pointed out that, in order to develop the originality and creativity of the Japanese people, the following measures must be taken: (1) reviewing the educational system, (2) promotion of interdisciplinary research, and (3) industry-university co-operation.

The first step toward industry-university co-operation is mutual understanding. For this purpose there are several scientific societies and technical associations. the Japanese pulp and paper industry has close relationships with "The Japan Wood Research Society" and "The Society of Fibre Science and Technology, Japan", in their chemical work. These societies have pulp and paper research committees. "The Society of Polymer Science, Japan" also has a relationship with the industry. Discussion on lignin chemistry has been organised for the past 25 years by "The Chemical Society of Japan" which is the largest and most authoritative society in Japan.

On the other hand, people working in the pulp and paper industry have formed "The Japanese Technical Association of the Pulp and Paper Industry", whose board consists not only of people from industry but also of university scholars. The wood science research committee of J. TAPPI is active in exchanging information between industrial workers and university scholars.

"The forecasting Association of Pulp and Paper Technology of Japan" which is formed by a group of scholars from government, universities and industry, each member with purely individual interest, is also active in its role, and published technical forecasts in 1976 and 1979.

At this point I would like to mention a profile of Tsukuba Scientific Community which is located about 60 km north of Tokyo, with an area of approximately 2700 ha. The community includes The University of Tsukuba, The University of Library and Information Science and 49 ministerial research institutions. Construction of the community took more than 10 years, and nearly all facilities are completed now and had started operation by 1980.

In addition, a subcommunity of twenty four private research institutes, including ours, will be located in the western section of Tsukubu community. Tsukubu Expo '85 (The International Exposition of Science and Technology) will be held in this area in 1985.

The original concept behind the Tsukubu community was to transfer a number of administrations that did not, in view of their functions, have necessarily to be located in Tokyo, thus decentralising the population of the capital city. During the investigation into this the necessity of reforming the Japanese scientific research system in the long term was advocated. As it stood it was a reflection of Japanese technology which, while having achieved a lot, was still at too low a level for the purposes of technical development.

It was decided that the way for Japan to fulfil her obligations as a member of the international community was by promoting fundamental and comprehensive research, by conducting research into environmental protection and the security of natural resources, and by developing human achievement through international co-operation.

This was the main argument at the time.

One of the concrete outcomes was the relocation of several government research institutes which had been distributed among various administrative departments, thus creating an environment in which fundamental, academic, comprehensive and innovative research could be carried out.

At the same time, the question was raised as to whether the present system of higher education is suitable in view of the recent transition towards an information-rich, high-knowledge society. To meet this the University of Tsukuba was established in this scientific community. The University of Library and Information Science was also established to train engineers of information science. The University is the only one of the kind in Japan.

In contrast to these far-sighted actions of the Japanese government and society, the response by the Japanese pulp and paper industry has been rather slow. The only exception is the

establishment of the Japan Pulp and Paper Research Institute, which is along the lines of this movement. JPRI is a joint enterprise established by Oji Paper Co., Jujo Paper Co., Honshu Paper Co., and Kanzaki Paper Co., in 1972. These paper companies are the successors of the former Oji Paper Co., which was dissolved in 1949 after the war. The former Oji Paper Co., was the oldest paper company in Japan, established in 1873, and produced more than 80% of the entire Japanese output before dissolution.

There was no common research institute for the Japanese pulp and paper industry before the establishment of JPRI. In 1970, the requirements of environmental protection became very severe. The research association was formed by the four companies mentioned above to study countermeasures to the odour problem caused by kraft pulping and to develop a "Pollution-Free" pulping process. JPRI was established on the basis of this research association. The notable development of JPRI is a pilot plant study of a non-sulphur closed pulping process with 10 ton/day capacity[11]. At present JPRI operates several laboratories in the University of Tokyo campus and does research under the guidance of the university professors. Construction of its own laboratory in Tsukuba Science Community in 1982 is in the planning stage. At the same time, plans for JPRI to become a truly national research institute are also under study.

The aim of JPRI is to carry out mission-orientated fundamental and applied research, and by doing so, to achieve technical revolutions in the pulp and paper industry. Also JPRI will become an information centre for the industry, and will play a liaison role between industry, university and governmental institutions, and between Japan and foreign research institutes as well.

2.5. Government Subsidy to Private Research and Development

Every ministry of the Japanese government subsidises, in many ways, scientific research and technological development, the

Table IX. Who Uses and Who Supplies R & D Funds in Selected Countries (12)

	Country (year)	Japan ('77)	Japan ('78)	U.S. ('77)	U.S. ('78)	U.K. ('75)	W. Germany ('77)	France ('77)
Users	Industry	65.2%	64.2%	69.7%	70.3%	62.7%	68.4%	60.3%
	Government	13.1	13.6	14.3	13.9	26.6	15.2	22.8
	Non-profit research institutes	2.2	2.3	3.3	3.2	2.4	0.2	1.4
	Universities etc.	19.5	20.0	12.7	12.6	8.4	16.2	15.5
Suppliers	Industry	65.8	65.0	46.0	46.1	40.8	55.6	41.1
	Government	27.4	28.0	50.5	50.4	51.7	41.3	52.7
	Non-profit research institutes	0.3	0.4	1.4	1.5	2.6	0.2	0.6
	Universities etc.	6.3	6.4	2.1	2.1		-	-
	From overseas	0.1	0.1	-	-	4.9	2.9	5.6

important ones being listed in Table VIII. For comparison, research and development funds in Japan are summarised in Figs. 10 and 11, and in Table IX. It can be seen from these figures and table that the proportion of governmental support is very small.

Government subsidies on R & D to all manufacturing industries are generally granted through the Agency of Industrial Science and technology, of the Ministry of International Trade and Industry (MITI). The aid comes in the form of the consignment development system administered by the Science and Technology Agency of the New Technology Development Corporation, and of the liability guarantee system given by The Centre for The Development of Research and Development Orientated Enterprises. Furthermore there is an R & D consignment system for the promotion of certain large-scale industrial

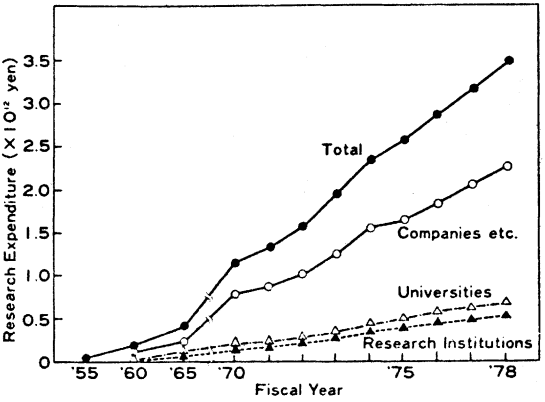

Fig 10—Changes in R & D expenditure by type of organization in Japan (12).

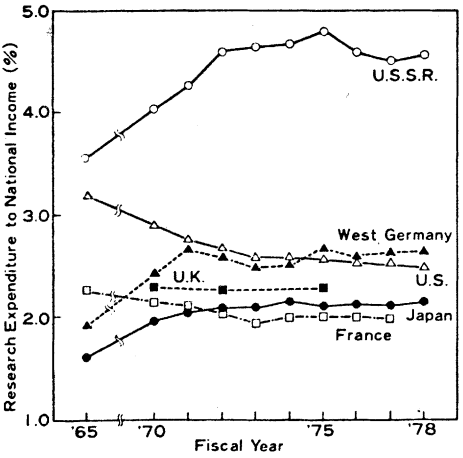

Fig 11—Ratio of R & D expenditure to national income for various countries (12).

Table X. Technical Development Tasks in Japanese Pulp & Paper Industry

Raw Materials	Effective Use of Tropical Hard Woods Mechanical Pulping of Hard Woods Pulping of Non-woods Fiber Resources Prevention of Chip Decay Expanding Utilization of Recycled Paper
Pulping and Bleaching	Yield Increase of Chemical Pulp Energy Conservation of Mechanical Pulping Biological Pulping Process Hydrogen Pulping Pulping Process without Caustizing Lignin-preserving Bleaching
Papermaking and Processing	High Consistency Forming Neutral to Alkaline Papermaking High Filler Papermaking Simultaneous Multiply Forming Dry Forming Beating Method Simultaneous Coating of Both Side Dry Coating
Environmental Protection and Energy	Enclosing Process Water in Pulp & Papermaking High Efficiency Dewatering of Sludge Reuse of Waste as Resources Practical Use of Low-quality Energy
Others	Bio-mass (Comprehensive Use of Plant Materials)

technology developments, energy-saving technology and new energy source development.

Subsidy from the Agency of Industrial Science and technology, MITI, is given in five categories. Firstly, a part of the expense of key technological development by the industry is defrayed by the government. Of course such development must be in accordance with government policy on science and technology, which is announced every year. Secondly, it is given for R & D into the technical development of new energy sources to substitute oil, on subjects to be designated by the government. The third type of subsidy comes as a form of tax concession for R & D expenditure. The fourth subsidy is made in the form of low interest-rate loans from the Japan Development Bank and the Small Business Finance Corporation. This applies to projects such as the industrialisation of new technology, construction of large-scale pilot plant, test production of machinery, etc., which are recommended by MITI for the promotion of technology developed in Japan. The fifth and the last subsidy is the aid given to the technical research association of mining and manufacturing industries. This system allows that a research association for a specific project can be formed by several companies. If approved by MITI, they may be granted a subsidy and also given a special preferential tax measure.

The Japanese pulp and paper industry has not made effective use of these except in the development of the "Pollution-Free" pulping process carried out by JPRI.

Anticipation of Crisis and Challenge in the Future

When the Japanese government wants to introduce a new measure, it devotes considerable effort to getting a consensus amongst the Japanese people. To this end there is a number of councils, appointed by appropriate ministers to co-ordinate opinion on the inquiry made by the ministers.

The largest and most authoritative council for industrial policy is the "Industrial Structure Council" (ISC), composed of

about 130 members selected from various sectors of the Japanese people, excluding politicians. The council was asked "What should be the policy of industry and trade for the 1980s" by the minister of MITI on August 24, 1979. In response, the council set up the ad-hoc council on the policy of 1980s, and the report was submitted on March 17, 1980. The ad-hoc council was made up of 38 experienced persons, consisting of 9 university professors, 9 representatives from industry, 5 senior staff members of industrial associations, 4 journalists, 3 bankers, 2 each from housewives, labour unions and research institutes, and one from local government. In addition a well-known Japanese SF-novelist, Sakyo Komatsu, is also in this council.

The Report of the ISC entitled "The Vision of MITI Policies in the 1980s" is published by the government and will be summarised in the following: "Japan is at present at a turning point. She must prepare for the possibility of crisis and challenge in the future, positively and creatively."

That Japan is at a turning point is apparent from the following facts. We are entering an age of diversification of energy, of multipolarised and pluralistic world politics and economics. Japan has finally attained the level of western developed countries in many respects. She conducts about 10% of world economic activity, and her population is rapidly shifting towards an older age group. ISC proposes three long-term targets in order to solve these problems:

(1) Japan must establish economic security by contributing to world economic stability and development and to world peace, using her economic potential.

(2) It is necessary to promote the development of creative own-technology in order to maintain and increase Japanese economic ability in a country of poor natural resources. At the same time the effort must be made to develop new energy sources to substitute oil, and to change to an energy preserving society.

(3) There must be co-existence of the affluent society with industrial activity. The report also proposes various specific measures and policies to achieve these goals.

Against the background of this general report, the specific problems of each industry are dealt with by the sub-councils. Under the pulp and paper sub-council, there are three sub-committees covering: (1) the distribution system: (2) the security and development of wood resources: and (3) technical development. The sub-council consists of 26 members, of which 7 are from the pulp and paper industry, 5 from associations relating to the industry, 6 from banks, 2 each from universities, the press and labour unions, one housewife, and one from a trading company.

In view of the forecast for 1990 on pulp and paper supply and demand (See Fig. 12), and to respond to long-term goals proposed by the ISC, the pulp and paper sub-council is presently working to draft the report, which will be available by the time of this symposium, but is not at the time of writing this manuscript.

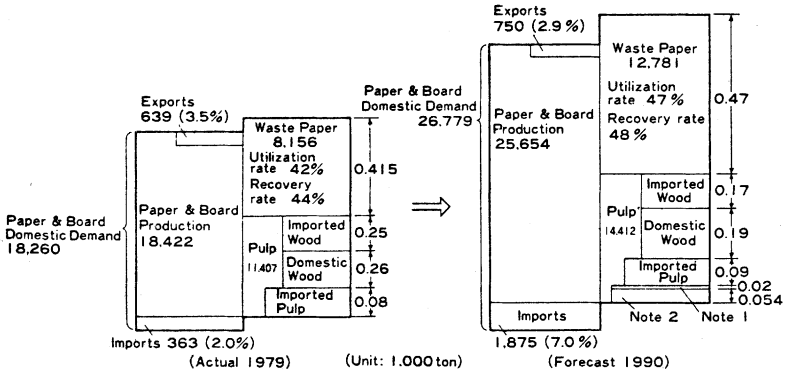

Fig 12—Forecast on supply and demand of pulp and paper in Japan (13).
Note 1: Increased amounts of domestic woods by promotion of lumbering.
2: Increased amounts of imported pulp by development in overseas countries, other than spontaneous increase.

The recommendations of the pre-publication (i.e. unofficial) version may be summarised as follows:-

(1) A stable supply of raw materials such as wood chips and pulps must be ensured.
(2) The use of recycled paper must be increased, by enhancing the collection system, and balancing supply and demand.
(3) Energy saving and the use of energy sources other than oil must be encouraged.
(4) Product ranges for the international market and international capital exchange must be diversified.
(5) Creative research and development must be promoted.
(6) There must be establishment of the supply system and replenishment of industrial bases.
(7) The function of the distribution system must be substantiated.

The technical developments needed to achieve these tasks are listed in Table X.

Among those listed, the following projects will be given high priority;

Effective use of tropical hard woods,
Pulping of non-wood fibre resources,
Energy conservation in mechanical pulping,
Improvement in sheet formation and water removal,
Enclosing the process water in pulp and paper-making,
Breeding of suitable woods for pulping,
Comprehensive use of woods and non-wood plants.

To carry out these projects, it is pointed out that there is a need for good information exchange amongst industries and for common research systems including industry, university and government. There will be some concrete measures in this direction in the near future.

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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.