Advanced Materials '93, VI / Frontiers in
Materials Science and Engineering, edited by S. Sōmiya et al.
Trans. Mat. Res. Soc. Jpn., Volume 19B
1994 Elsevier Science B.V.

Materials research in Japan

Masao Doyama
The Nishi Tokyo University, Uenohara, Yamanashi
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Materials research in Japan is reviewed. The Japanese government has issued many basic policies on materials R&D. The government is encoraging basic research. The statistics on research and development are based on "White Paper on Science and Technology" which was edited by the Science and Technology Agency.

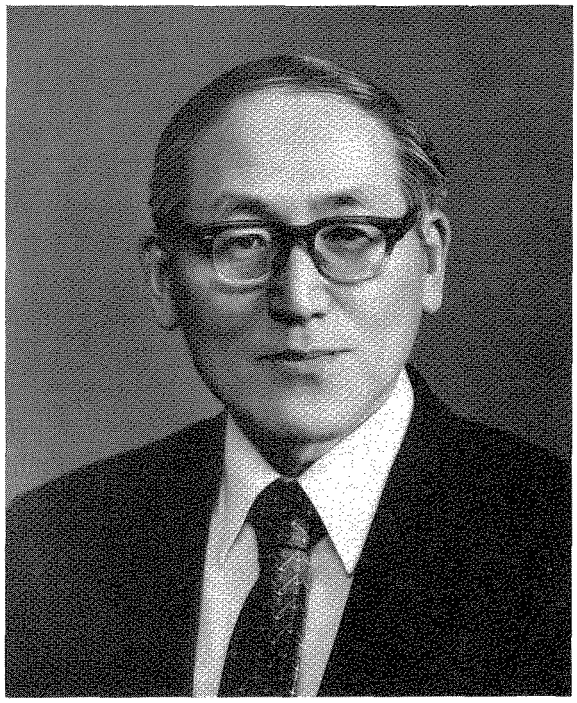
1. INTRODUCTION

The advancement of new materials removes obstacles for further development of advanced technology. For example, thermal efficiency of engines is the higher if the working temperature of the refractory materials is the higher. Electric conductor films or lead wires of VLSI should have high electrical conductivity because of the high density current passing through them. First wall of fusion reactors should stand for the damage due to fast neutrons and cyclic temperature shocks. Ceramic engines reduce weight and increase thermal efficiency. High temperature organic materials are important and easy to shape. The discovery of superconductors whose critical temperature is higher than room temperature definitly changes our daily lives. Advanced technolgy awaits the advent of new mateials.

2. MATERIALS SCIENCE IN JAPAN

The concept of materials science has started during World War II according to Professor Seitz. The real movement, however, started in the late 1950's in the United States. The movement in Japan followed that in the United States, but no positive movement had made. The departments of metallurgy at universities had not changed to department of materials science at that time. The reason was

1) Japanese metallurgical industry was rapidly expanding at that time. Departments of Metallurgy at universities in Japan expanded double to meet the demand for graduates from industry.



Graduated from the University of Tokyo,
Received M.S. in metallurgy from University of Notre Dame, M.S. and Ph.D. in physics from University o Illinois,
Research Associate at University of Illinois,
Residencial Research Associate and Associate Physicist at Argonne National Laboratory,
Associate Professor and Professor at the University of Tokyo
Professor at Nagoya University
Professor at the Nishi Tokyo University(present).

2) Lack of forsight by some leaders in metallurgy in Japan,
3) Myopic education system in Japan.

It is said that Japanese technology is weak in creative or original research. Japan has opened its port about 100 years ago after the Meiji Restoration. Japanese technology had to catch up the world standard. For this purpose Japan had to borrow Western science and technology and had to imitate them. It was critisized there is no originality. Now in some fields in technology Japan is leading the world. Many of the first inventions in these fields, however, originated in Western countries. The present problems at universities are how to foster originality in educational system. Japanese compamies are facing to the difficulty buying the patents from Western countries. We begin to realize that we must develop our own research. Recently Government is encoraging basic research emphasizing original research. Original research costs much more than following Western science and technology research, because much waste is inevitable. Along this tendency, many departments of metallurgy at universities changed to materials science and engineering in 1980's in Japan. Education in Japan deepens through students' narrow specialization. In the U. S. A. schooling widen students' knowledge.

In Japan, we have the field of material (not materials) science which emphasize the study of substance. This is a field of chemistry. Organic materials are often affected their molecular behavior.

3. JAPANESE GOVERNMENT POLICY ON SCIENCE AND TECHNOLOGY AND MATERIALS

The Japanese government begins to emphasize original research in its policy. The growth in the budget for basic research is increasing with a faster rate than the general budget increase.

The General Guideline for Science and Technology Policy was approved by the Cabinet in March, 1986, based on a recommendation submitted by the Council for Science and Technology in order to dynamically and organically promote Japanese science and tecnology from a longer-range standpoint [1]. The fundamental principles of science and technology policy are
1) Science and technology developement with originality,
2) Science and technology developement emphasized international relations,
3) Harmony with science and technology, human and society.

In order to contribute to the comprehansive and systematic promotion activities in the future concerning materials science and technology, which have been rapidly progressing in recent years, a recommendation for Inquiry No. 14, Basic Plane for Research and Development in the field of Materials Science and Technology was approved by the government in 1987. The recommendation suggests significant R&D objectives and promotion measures for the next 10 years. A recommendation for Inquiry No. 15 "Basic Plan for R&D on Information/ Electronics Science and Technology" was made in March, 1989 [1]. In 1970's information and electronic technology has developed. In 1980's combination of information and computers was important.

The Science and Technology Agency is furthering common and basic research in materials science and technology. The Science and Technology Agency is investigating the feasibility study on many fields. The Ministry of International Trade and Industry is furthering R & D in advanced manufacturing technology under auspices of the Research and Development Program on Basic Technologies for Future Industries and the Large-Scale Industrial

Technology Development Program [1].
The Council for Aeronautics, Electronics and other advanced technologies established general guidelines for the advancement of materials science and technology.

Many Recommendations pursuant to inquiries concerning to materials have been issued;
1) Inquiry No.5, General R & D Promotion Policies for Advanced Materials Science and Technology and Associate materials science and technology,
2) Inquiry No. 7, General R&D promotion policies for the development and manufacture of new materials design,

3) Inquiry No. 9, important issues and guidelines for the promotion of improved measurement and control technologies related to new materials development,
4) Inquiry No. 13, Promotion of comprehensive research and development on the creation of new substances and materials with the ability respond to environmental conditions intelligently and manifest their functions,
5) Inqiry No.16, the advancement of analysis and evaluation technology in relation to materials development.

4. PROMOTION OF MATERIALS R&D

The Ministry of Education, Science Culture and Sports encoraging basic research in materials science and technology, as well as fostering creativity in the research environment. The Science and Technology Agency emphases common and basic research through research laboratories under the umbrella such as The National Institute for Research in Inorganic Materials and the National Research Institute for Metals. The Agency sponsors special coordination funds such as Exploretory Research for Advanced Technology (ERATO) and International Frontier Research Program.
Ministry of international Trade and Industry (MITI) is emphasizing R&D in advanced manufacturing technolgy.

Statistics in the research are mentioned in the following setions. These very much depend upon the White Paper on Science and Technology edited by the Science nad Technology Agency.

5. REASEARCH FUNDS IN SCIENCE AND TECHNOLOGY

The government research funds in Japan come from separate ministries. The Ministry of Education, Science, Culture and Sports is encoraging basic research in materials science and technology as well as fostering creativity in the research environment utilizing Grant-in-aid for scientific research.

Private industries in Japan are spending large amount of research funds. Figure 1 shows the R&D expenditures of selected countries in IMF exchange rateconversion. Because the IMF

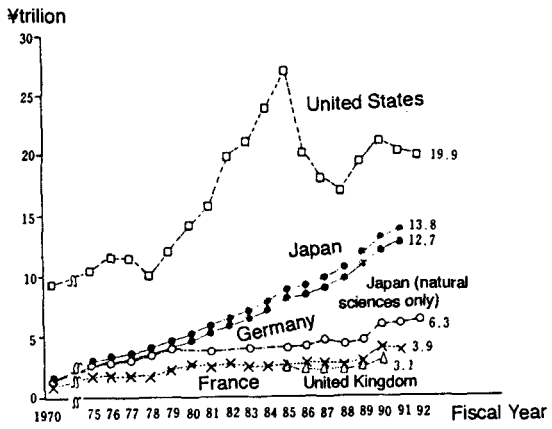


Fig. 1. Trends in R&D expenditures of selected countries - IMF exchnge rate conversion

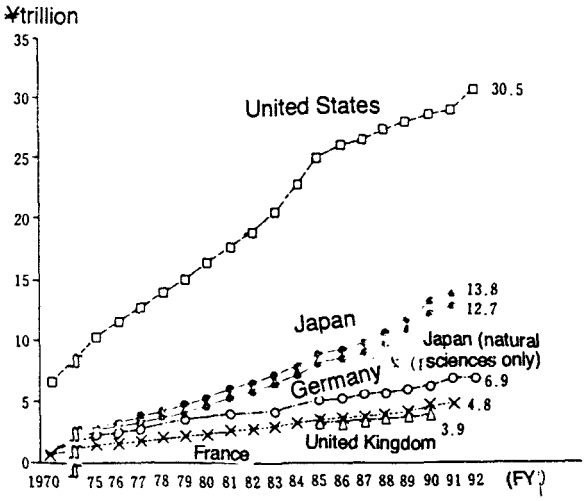


Fig. 2. Trends in R&D expenditures of selected countries - OECD purchasing power parity

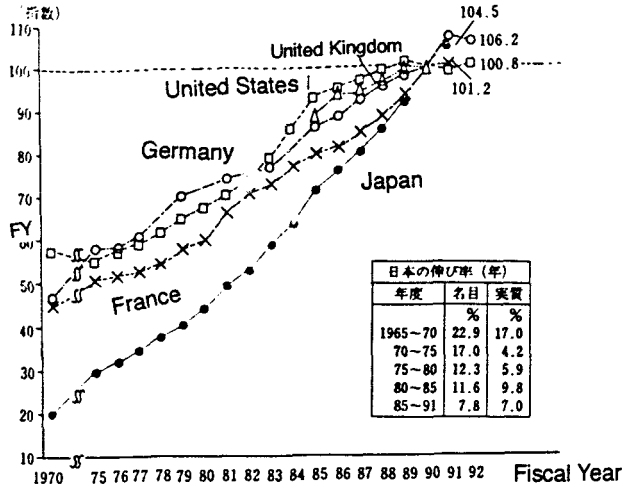


Fig. 3. Growth of R&D expenditures (in real terms) in selescted countries

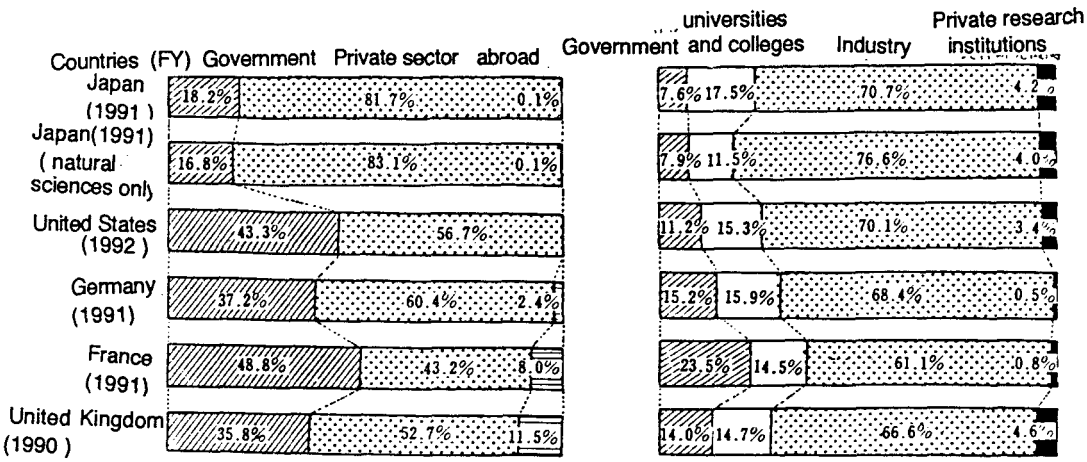


Fig. 4. Share of R&D expenditures financing and performance sector in selected countries.

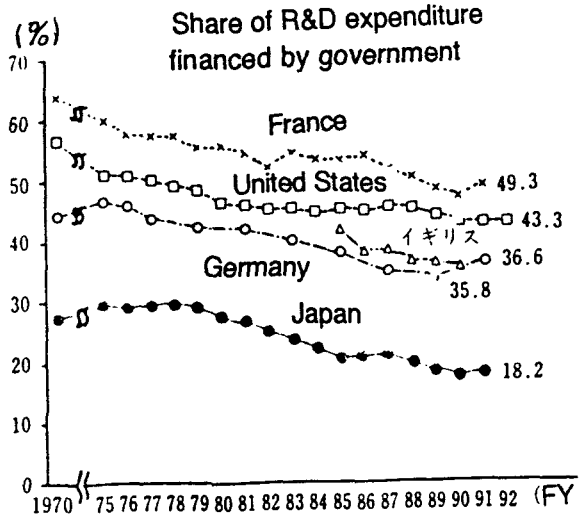


Fig. 5. Trends in government - financed for R&D expenditures in selected countries

exchange rate conversion to yen has changed, more appropriate measure may be in OECD purchasing power parity [Fig. 2]. U.S.$1 is Y104 as of March, 1994. Figure 3 shows the growth of R&D expenditures (in real terms) in selected countries. Figure 4 shows the share of R&D expenditures financing and performance sector in selected countries. Japanese government R&D expenditures percentage is lower than other countries listed. Japanese industries spend the highest percentage in the listed countries. The trends in government- financed for R&D expenditures are shown in Fig. 5. Figure 6 shows the R&D expenditures by industry (FY1991: Y9.74trillion). R&D expenditures for materials includes Chemicals(16.0%), iron and steel(3.7%), ceramics(2.7%), non-ferrous metals(1.5%), fabricated metal products(1.4%) rubber products (1.3%), plastics (1.3%), petrolem and coal products (0.9%), pulp and paper products

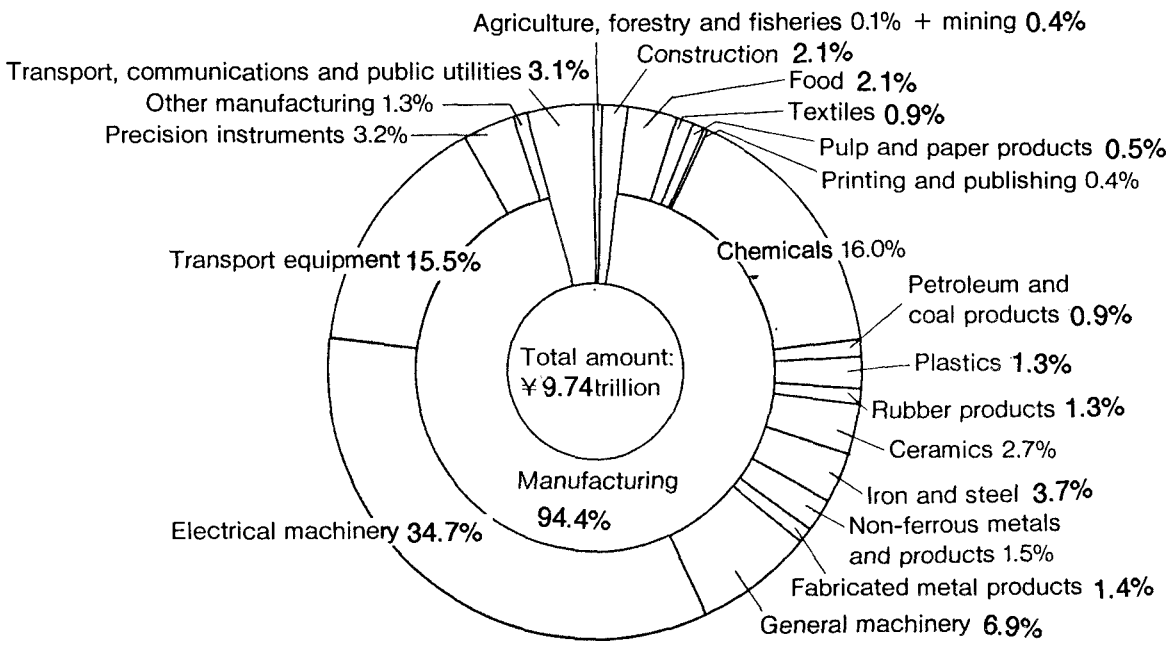


Fig. 6. R&D expenditures by industry (FY1991:9.74trillion)

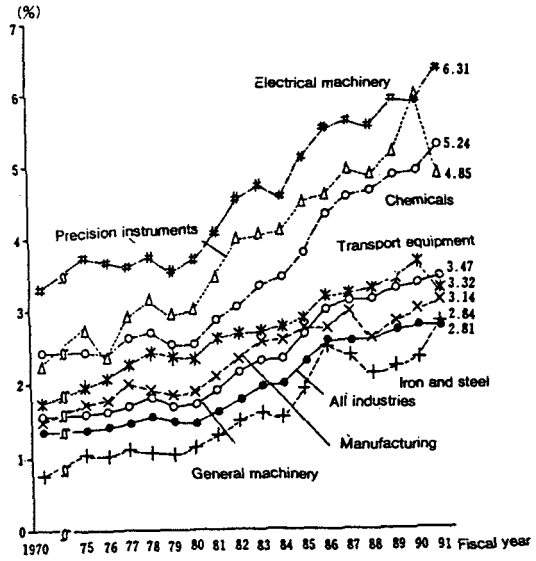
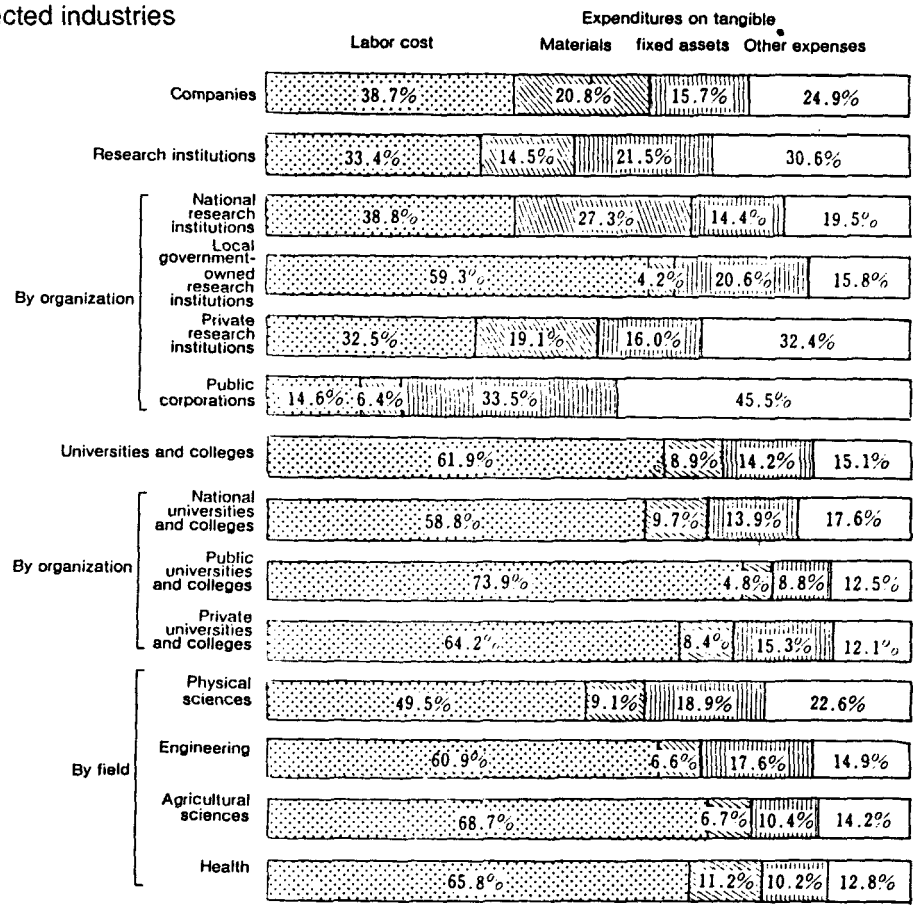


Fig. 7. Ratio of R&D expenditures to sales figures in selected industries

Fig.8 R&D expenditures by sector and by consisting elements



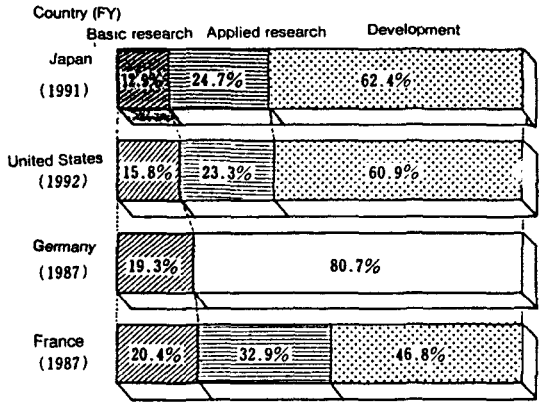


Fig.9. R&D expenditures by character of work in selected countries

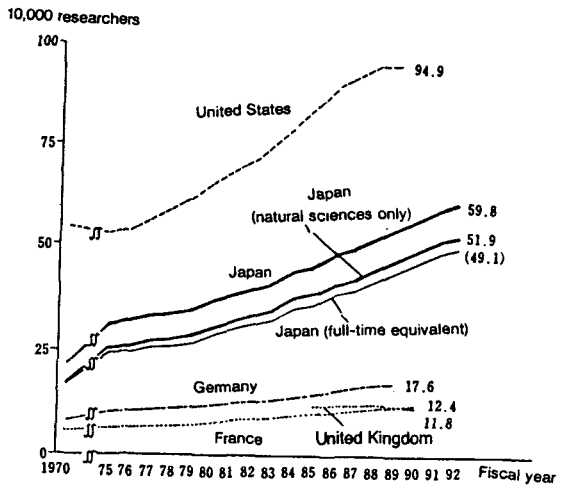


Fig. 10. Trends in number of researchers in selected countries.

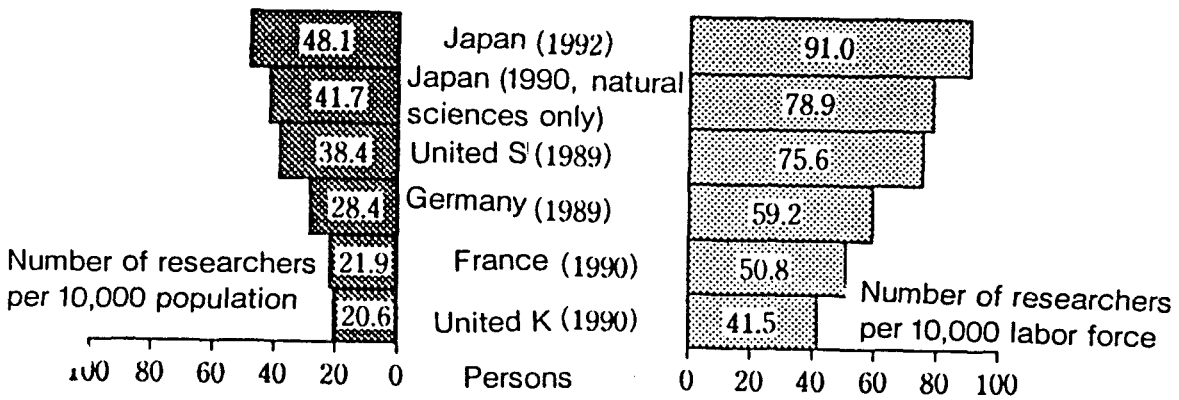


Fig. 11 Researchers per 10,000 population and 10,000 labor force.

(0.5%), textile (0.9%) and some of transport equipment, electrical machinery. About 30% or more of the total expenditures may be spent by materials R&D. Figure 7 is the ratio of R&D expenditures to sales figures in selected industries. Electrical machinery is the highest and the iron and steel is the lowest. Figure 8 is R&D expenditures by sector and by consisting elements, FY1991. Labor cost is the highest. Figure 9 shows the R&D expenditures by character of work in selected countries. Japan is still not spending much funds in basic research.

6. RESEARCH PERSONNEL

The number of researcher is shown in Fig. 10. Figure 11 shows the number of researchers per 10,000 population and 10,000 labor force. Japan has the highest number among these countries. Figure 12 shows the share of researchers by sector in selected countries. In Japan the researchers in universities and colleges are high but number of researchers at government research institution is the lowest.

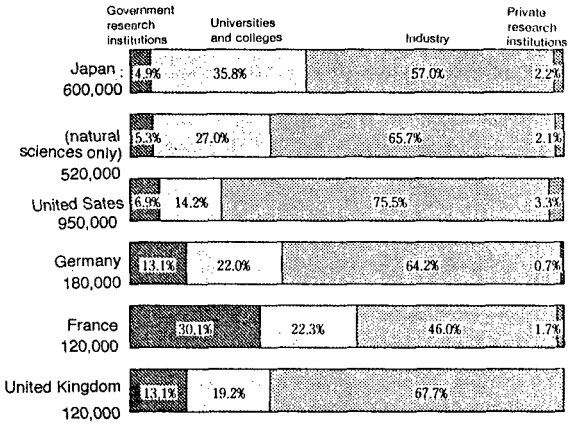


Fig.12. Share of researchers by selected countries.

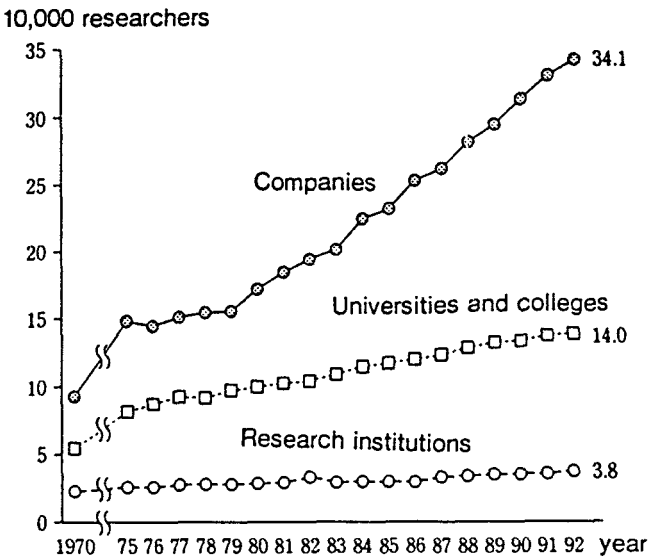


Fig.13. Trends in number of researchers by sector in Japan.

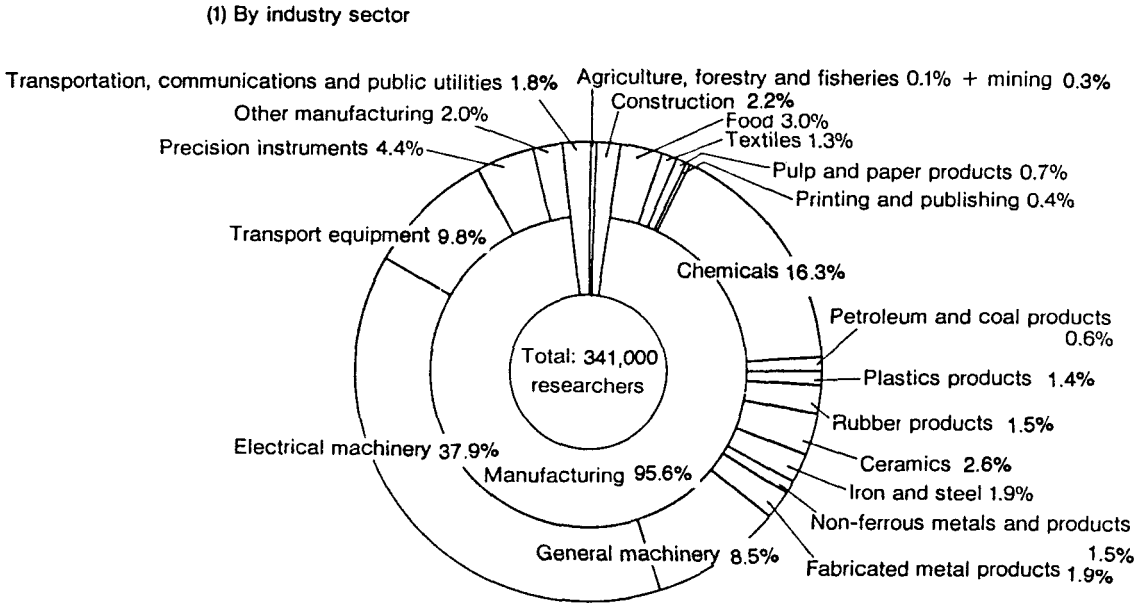


Fig.14. Number of company researchers by industry sector.

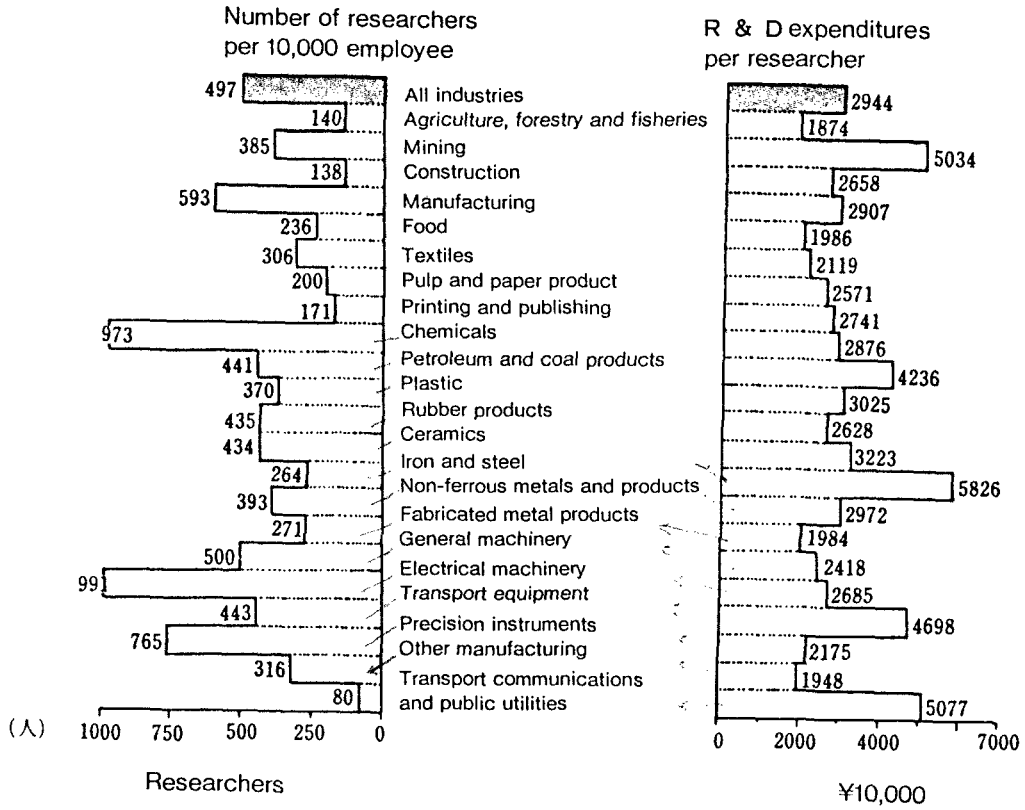


Fig.15. Number of Researchers per 10,000 employees and R&D expenditures per resesearcher in companies.

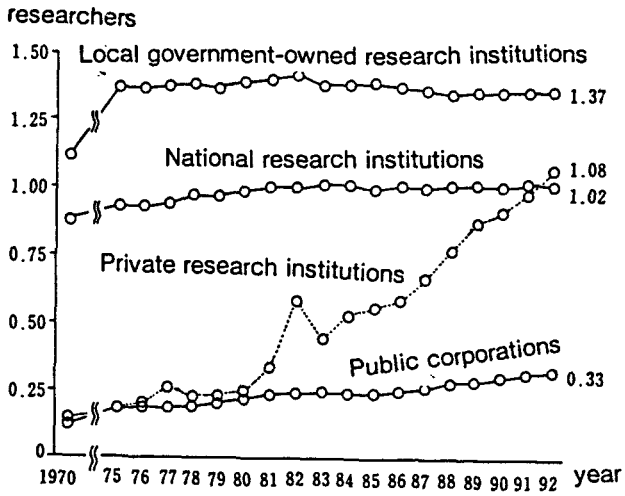


Fig.16. Trends in number of researchers in research institutions.

products (1.9%), non-ferrous metals and products (1.5%), rubber products (1.5%), plastic products (1.4%), textiles (1.3%), pulp and paper products (0.7%), petroleum and coal products (0.6%) and some of electrical machinery, general machinery and transport equipment. Figure 15 shows the number of researchers per 10,000 employees and R&D expenditures per researcher in companies. As for the number of researchers per 10,000 employees, eletrical machinaery is the highest. It is interesting to note that ceramics field is the second highest. This may be due to the boom of recent new ceramics and high temperature superconductor R&D. Iron and steel industry shows again the lowest. It is worth while to mention that the R&D expenditures per

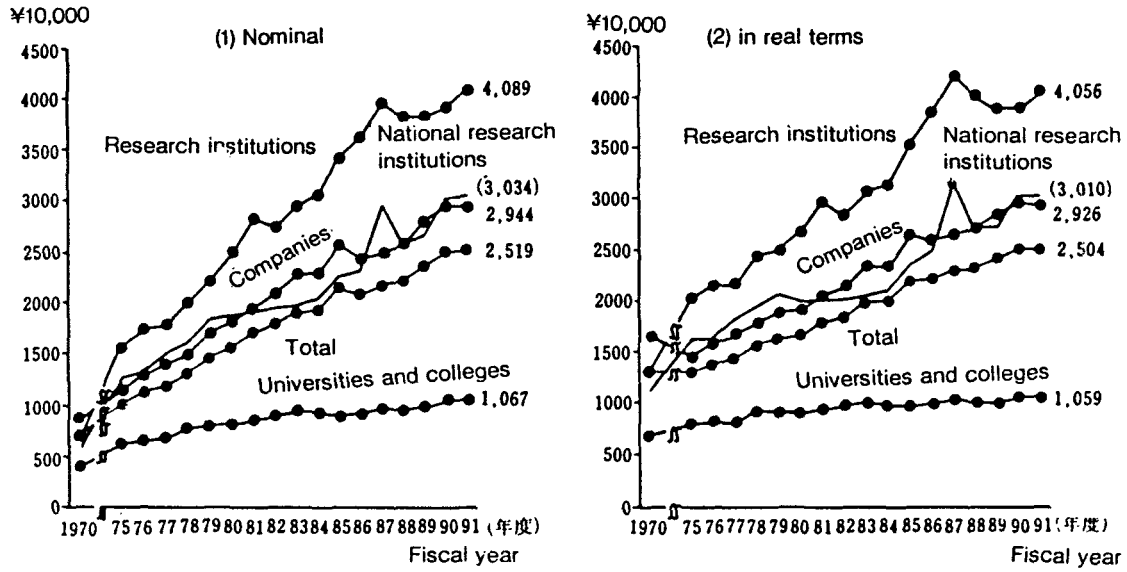


Fig.17. Trends in R&D expenditures per researcher.

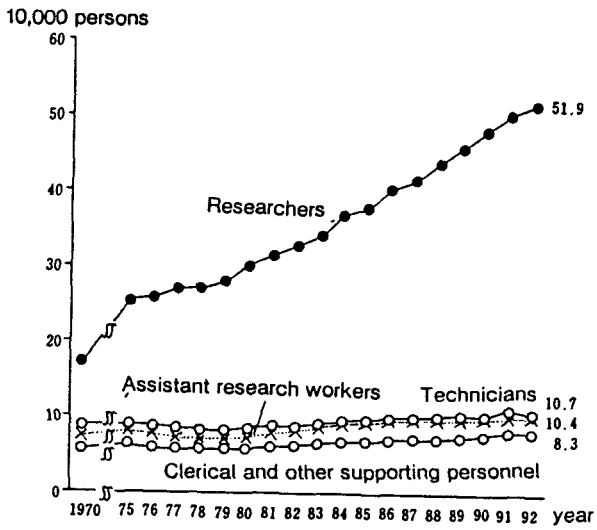


Fig.18. Trends in persons engaged in R&D in Japan.

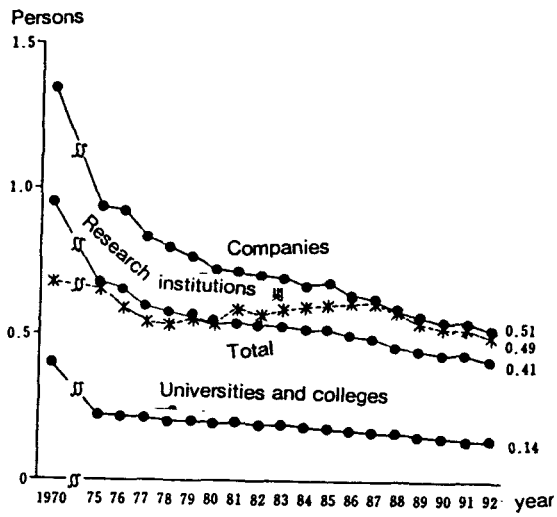


Fig. 19. Trends in number of assistant research workers and technicians per researcher in Japan.

researcher, however, the highest in iron and steel industry. Let us look at Fig. 16 which shows the trends in number of researchers in research institutions. At local government-owned research institutions, national research institutions and public corporation show the number of researchers are saturated, but at private research institutions the numbers are rapidly increasing. Figure 17 shows the trends in R&D expenditures per researcher in Japan. Research institutions are the highest but the universities and colleges are the lowest..

Research facilities at Japanese universities inferier to those of industrical laboratories and government laboratories. Another point inJapan is shown in Fig. 18 which shows the trends in persons engaged in R&D in Japan. The number of technicians, assistant researchers clercal and other supporting personnels do not increase but only researchers rapidly increasing. This forces for researchers to do work for supporting personnels. This is shown clearly in Fig. 19 which is the trends in number of assistant researcher workers and technicians per researcher in Japan. Researchers in Japan are spending much time in doing secretarial and technical work.

In Japan, there are almost none of temporay positions. All government employees have tenior in Japan. The total number of government employees are reduced every year. This looses the flexibility of employment.

7. SUMMERY AND CONCLUSION

In the materials research in Japan, the research funds are improving, but because of the currency conversion rate, the statistisc show reseasonable numbers, but the real spending power is not large as shown in the figures. Number of supporting personnel is decreasing, so the efficiency of researchers is not large as shown in the figures. The Japanese

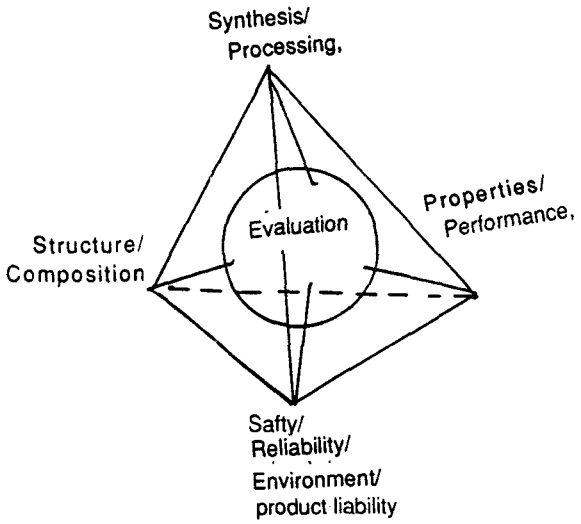


Fig.20. Five elements in materials science.

government is encoraging basic research to share the agony of the original research.

Paradome of science and technology is changing from quantity to quality.

Economy is changing from national to global (Globalizaion). International adjustment is becoming important such as GATT, SUMIT Meetings. We begin to realize that resources, energy and market are not infinite. Technological transfer to developng countries are becoming important. We begin to realize that science and technology must harmonize with environment.

Materials science and technology covers wide field of materials, from processing to materials physics, from materials science to materials engineering. There are five elements of materials science, (1) Synthesis/Processing, (2) Structure/Composition, (3) Properties/ Performance, (4) Safty/ Environment/ Reliability/ product liability and Evaluation [Fig.20]. Micro-composite materials, intelligent materials, nano-structured materials, hierachical structured materials and hybrid materials will be important. The development of materials in future, however. should be made from the wide view and should be useful to mankind and globale environment.

ACKNOWLEDGEMENT

The author expresses his thanks to refering the White Paper on Science and Technology (Japanese and English editions). Many of the figures are from these papers.

REFERENCES

[1] White Paper on Sciend and Technology, edited by the Science and Technology Agency.