TRANSFER OF TECHNOLOGY

LISBOA, NOVEMBER 7. - 11., 1977

Technology acquisition and domestic technology development.

What are the governing factors affecting the decision to import technology rather than to rely on domestic R&D for military and/or commercial applications?

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THE INTER-DEPENDENCE BETWEEN MILITARY DEFENCE, MILITARY PRODUCTION AND COMMERCIAL INDUSTRY IN A SMALL COUNTRY

Gentlemen,

My comments are based on the experience from a company which is engaged both in military and commercial production.

Let us first look at the aspect inter-dependence between commercial and military production. The production of ammunition is a rather advanced sector of the workshop industry both concerning materials, processes and tools as well as the strict requirements as to product quality. We have found that the military production has had a strong influence on the development of the workshop industry in Norway as a result of

- outside orders for tools, materials and components,
- the experienced workers, engineers and scientists who have left us to work in other Norwegian companies.

Through participation in the US off-shore program in the 50's, our company was forced to introduce modern statistical quality control. Through us these systems were introduced to our sub-suppliers, and in that way spread out into the Norwegian commercial industry.

In most cases an order for military products includes an element of development work and will increase the supplier's capabilities. This effect may clearly be seen in development contracts where the objective is to develop new products or to improve existing ones, but even in an ordinary order for military products the development in production and quality control technology will usually include an effect of learning.

This element of learning and increased capability will always be paid by the customer. As this learning effect will increase the competitive ability of the national industry both concerning military production and commercial production, it is of the greatest importance for the industry in a country how the military agencies place their orders. - Even though it may be more expensive to place the orders within the country, this may be more than compensated by the increase in technology this gives to the local industry.

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Let us now look at the inter-dependence between the national defence and the

local military production. It is our experience that the close co-operation between the Norwegian defence forces and the local military production has contributed to build up and maintain a national know-how of great importance for the procurement of defence material both from sources in Norway and abroad.

The close co-operation concerning product development, production, quality control and maintenance of ammunition has also contributed to assure the necessary know-how to maintain the relatively lagre amounts of ammunition that the defence forces keep in store. Furthermore, the practical co-operation between the defence forces and our company concerning routine testing, maintenance and destruction of ammunition has resulted in an efficient maintenance system which contributes to extend the useful life for ammunition and thereby ensures a best possible use of the defence budget money used on ammunition.

The Norwegian defence forces do to a large extent use the same types of ammunition as one or more NATO-countries. Due to the special topography of Norway, it is, however, a certain demand for specialities. These particular solutions are difficult to achieve except through a close co-operation between the Norwegian defence forces and a local industrial company. Such co-operation concerning particular solutions both concerning the product specifications and product quality, is of extreme importance to give our armed forces personnel a safe feeling that their equipment and ammunition are of a type which is reliable under our local conditions in Norway.

It is equally important for an ammunition factory to have a close co-operation with the armed forces because this gives the advantages of increased know-how through mutual influence and also because such a co-operation gives the possibility to develop new types of material. For the armed forces a mutual co-operation necessitates a thorough analysis of their requirement for defence material.

Production of ammunition and other types of defence materials necessitates a continual activity if the experience and know-how is not to detoriate. In small countries this creates a certain difficulty as the renewal of material and ammunition usually is done cyclicly. We have found that the variations in yearly demand from the Norwegian armed forces are so large that we are totally dependent on a certain export to maintain our production capacity. To some extent the variations in demand for ammunition can be compensated by commercial

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maintain a local production of ammunition in Norway and in other small countries, there must be an open opportunity for export sales. Here there are two limiting factors, one has to do with local politics, as export licences are necessary for each individual sale, the second is the right to use US specifications and drawings for production to a third country. We are in particular concerned about the second question, as we have experienced a more restrictive attitude concerning the free right to produce and sell products according to US specifications outside of Norway.

In summing up, I would like emphasize that concerning military products it is not a question whether to rely on local or imported research and development. Both are necessary even in a small country. On one hand it would be an impossible task to develop all types of defence material and ammunition needed by the Norwegian armed forces, inside Norway. On the other hand to rely totally on designs developed in other countries would mean breaking off the close bonds between the armed forces and the military production in Norway. This would be a loss both for the Norwegian industry and for our armed forces.

In our experience military production in Norway has given a most important contribution for the development of commercial production. In my opinion it would be almost impossible to maintain a competitive industry in Norway without a certain military production. - This again underlines the importance of international and national procurement policy. Military production in smaller countries must be given a reasonable chance to obtain both ordinary production and development contracts.

TG N.L.

TECHNOLOGY TRANSFER IN INDUSTRIALIZED COUNTRIES

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7-11 Nov.1977

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THE ROLE OF THE EUROPEAN INDUSTRIAL RESEARCH MANAGEMENT ASSOCIATION IN TECHNOLOGY TRANSFER WITHIN EUROPEAN INDUSTRY

EIRMA TO-DAY

Origin

EIRMA has had its 10th anniversary in 1976. The idea to create an association of European industrial research managers goes back to the early 60's when there was much concern about the "technological gap" between Europe and the United States.

The specific proposal to create EIRMA was made at a European-North American conference in Monte-Carlo in 1965, organised by the O.E.C.D. EIRMA was established one year later with the aims and purpose set out in its statutes (DIAGRAM 1).

Objectives

The aims of the Association are thus :

- the study of industrial research problems,
- the application of better research management techniques,
- the furthering of a wider understanding of the place of research within the firm,
- furthering of a wider understanding among the members of the scientific and socio-economic environment which affects their work.

Functions

Membership in EIRMA is through companies which nominate an official representative, usually the research director or top technical officer, and two alternates. Participation in EIRMA work is through these or others nominated by them. This highly personalized system determines to a large extent the work methods and functioning of the association. Over the years, the work methods have developed and the functions increased. From a recent survey among members on the present and possible future role of EIRMA, the following list was distilled of what the Association could be or do in the opinion of our members (DIAGRAM 2).

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The first four points relate to contact, the next two to common work and the last three to external relations. EIRMA is expected to play a role along all these lines, excepting the last. Emphasis lies on the contact function and the educational aspects of EIRMA work. Regarding external relations, industry/university inter-actions and contacts with supranational bodies such as the OECD and the European Communities, find most interest, whereas relationships with governments and national organisations are rather seen as a matter of individual companies or national industry associations. But the EIRMA background ca can be useful here, too.

Membership

EIRMA membership has increased from 32 at the inaugural meeting in 1966 to 152 today (DIAGRAM 3). There seem to be two periods of flattening out of membership growth, from 1967-1969, and again since 1973. This could be due to the corresponding periods of economic recession, but one also has to keep in mind that a majority of the largest research intensive European companies are now actually members of EIRMA. It appears that at least two thirds of the European industrial R & D capacity belong to EIRMA members. On this basis, it has been suggested that an eventual membership of perhaps 200 firms would be both realistic and desirable from an organisational point of view.

EIRMA's member companies are from 15 European countries (DIAGRAM 4). It may appear that the distribution of members among the european countries is not quite balanced. The German representation, for instance, is not yet as complete as it could be and Italy, too, has scope for increased participation. Any EIRMA member must be engaged in manufacturing or the provision for services to a market. Any EIRMA member firm has to carry out a substantial amount of research and development and it is thus to be expected that representation from research intensive industrial branches should be high (DIAGRAM 5).

Although this may be regrettable, there is a natural tendency that EIRMA appeals to more larger companies than smaller. Related to the 500 largest European companies as listed by the Magazine "Vision", less than 20 % of our member companies are

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smaller. Some of these are in fact quite small, highly techno-

logy oriented companies. Of the 500 European largest, about 25 % are EIRMA members, but among the first 50, there are 33 members.

Activities

Work in EIRMA, which is always directed at the practical and not the academic aspects of a subject, falls into four broad categories :

- Internal R & D Management : e.g. "Research Planning Techniques"
- R & D Services : e.g. "Information and Documentation"
- R & D/Company interface : e.g. "The changing interface between R & D and Marketing"
- Interface with External Environment : e.g. "Industry-Government Relations in R & D".

Activities take the form of :

- The Annual Conference, combined with the General Assembly, adressed to the EIRMA representatives. Recent topics dealt with have been :
  - Industry-Government relations in R & D (1975)
  - The societal responsability of industrial research (1976)
  - Planning for Research and Develoment (1977)

  In 1978 the subject will be :
  - Industry's needs for basic research.

- Special conferences, usually on pressing problem of interest to both EIRMA members and top management from other functions. The last such conference was held in March 1974 on "European Industrial R & D faced with the energy crisis". I shall come back to another Special Conference, to be held in spring 1978.

- The system of Working Groups has developed into an original and dynamic element of the Association (DIAGRAM 6). Groups

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have about 15 to 30 members who meet regularly over a 2-3 year period. The aim is to bring together people from the staff of Member companies to exchange information and experience on a topic of wide interest to Members, to study the topic in depth and to produce a report for the benefit of the membership as a whole. Working Groups work on specific projects rather than on generalised studies and in EIRMA's first eleven years, 24 groups have been active. In selecting subjects for study, emphasis is placed on those topics for which no adequate platforms exist elsewhere. Besides providing valuable results, which are made available to all Members, Working Groups provide participants with a unique experience in an international environment, and thus contribute as a management education function.

- The results of a Working Group are disseminated in reports and through Seminars or other meetings. Having considered a subject in depth, the Working Group is in an excellent position to present its findings for discussion, and at the same time to test the Working Group conclusions against a wider cross-section of opinion and experience.

- Another feature of the EIRMA programme is the Round Table Meeting, the initiative for which usually comes from a Member company who would like to discuss informally with other Members of the Association a problem which is of current interest to them. Three to six such meetings, which may bring together 15-30 people for one day, are held each year.

- Even more informal are Special Interest Meetings which were started in 1977 to accommodate the wish of members for discussing in small groups of not more than 15 persons, R & D problems which may be specific to certain branches of industry or groups of specialists, but for which no other forum exists.

Communication

An essential function of EIRMA is to help in establishing personal international and inter-industry contacts, at all levels

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of R & D management, through participation in the different EIRMA activities. Direct contacts among the appointed representatives are moreover facilitated by the confidential Membership Directory, which describes Member companies' R & D functions, and lists all representatives and alternate representatives. A Directory of EIRMA Information Contacts fulfils a similar function for Member companies' Information and Documentation officers.

Close contacts are maintained with the Industrial Research Institute (IRI) of the United States, which was founded in 1938, and now has about 230 members. Reciprocal rights to participate at meetings and the availability of the membership directories contribute to direct links between senior R & D officers in Europe and the United States.

TRANSFER OF TECHNOLOGY AMONG EIRMA MEMBER COMPANIES

EIRMA was not created as an agent for technology transfer in the traditional sense. Nevertheless it seems obvious that the physical proximity of research managers in EIRMA favours direct technology transfer. There are a few members for whom this is actually the most important function of EIRMA. The possibility to test a research result on a colleague from a non-competing company or to sollicit advice in the informal atmosphere of the EIRMA "club" can be most valuable.

The official functions of EIRMA are nevertheless in the field of research management information and education. Stretching the term "transfer of technology" somewhat, one might say that the raison d'être of our Association is to "transfer technologies and know-how of innovation management" between its members. Technology Transfer in EIRMA is thus either concrete, in the usual sense, but informal, or abstract, relating to management techniques, during our formal meetings.

For the purpose of this conference, and in order to get my own mind clear, I have checked our experience against a list of Technology Transfer relationships established by H. Geschka.

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Slightly modified, he sees Technology Transfer as between (DIAGRAM 7) :

1 - companies with greater and lesser R & D experience (innovators and imitators),
2 - companies of different sectors of industry,
3 - licensors and licensees of industrial products and processes,
4 - suppliers and users of industrial products and processes,
5 - universities/research institutes and industry,
6 - industry and developing countries.

This classification leaves out one form of technology transfer which, for our members, is the most important one : i.e. transfer inside the company from Research to Development to Design to Manufacture to Marketing. Improving and rationalising transfer along this line has become a major objective of EIRMA in recent years and a good part of our work programme is devoted to these interface problems. At this meeting, however, I shall limit myself to the 6 relationships between the different partners listed above.

1.1 EIRMA members are more or less strongly innovation minded and may not want to be called "imitators". Nevertheless some will have greater concrete experience in a given field than others. I doubt, however, that, for competing companies in the same field, EIRMA constitutes a suitable forum for concrete technology transfer. The innovator/imitator relationships, as far as concrete products or processes are concerned, is weak. This does not exclude fruitful contacts between equals on subjects outside the domaine of business secrecy, and EIRMA may sometimes be a suitably neutral place for such contact, preferred to the more formal national or international industry associations.

1.2 The innovator/imitator relationship is very strong, however, as regards transfer of R & D management techniques. We are proud that this transfer functions smoothly between companies of different sectors, different size and different competence from 15 European countries. EIRMA has destroyed the barriers of secrecy which not long ago existed in Europe even over organisa-

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tional and management techniques and this is perhaps our greatest achievement.

In many cases, it will be the smaller firm which profits from the experience and innovative know-how (on R & D management) of the larger companies. But these transfers are not uni-directional and I know that some of our largest members, through intensive participation in our work, reap large benefits from the exchange of experience with other large or with smaller companies.

2.1 The unofficial contacts in EIRMA leading to concrete transfer of technology and know-how are strongest between companies of different sectors of industry. EIRMA was not created for this purpose, but it favours personal contacts and friendship between research managers at all levels. These contacts can lead to fruitful exchanges on concrete technological problems, especially between non-competing firms in different branches of industry where the NIH-syndrom is weak and the possibilities of encountering unorthodox solutions greatest.

After ten years' existence, EIRMA has become largely representative of industrial research in Europe and the wealth of experience of its members makes it ideally suited for discussing concrete technological opportunities and trends with a view to cross-fertilisation of ideas from different disciplines and sectors. This being recognized, we are now preparing for a special Conference "Technology 88" where such exchange shall be officially organized for the first time.

The proposed Conference will not be futurologistic, but will focus on concrete industrial opportunities and constraints which, at a ten-year horizon, are already rather clearly perceived. The Conference will examine 8 major sectors, and for each of these one or several eminent EIRMA members will prepare :

- a brief review of technological progress in the sector during the last ten years ;
- a statement of the socio-economic-political context against which technological developments are seen for the coming decade ;

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- a concrete statement of technological progress-opportunities which seems likely during the next decade (which need not divulge commercial secrets) ;
- a concrete statement of technological requirements-contraints which are seen and the solution of which could lead to further technological progress during the next decade.

These statements will then be discussed in multi-disciplinary groups, in the hope of achieving maximum cross-fertilisation of ideas among our members.

2.2 Regarding transfer of management techniques and know-how, relations between companies of different sectors are at least as fruitful as between those of the same branch. The international diversity in EIRMA adds a dimension to the confrontation of differences in approach and thus gives additional opportunity for learning from each other.

3.1 I ignore how often contacts in EIRMA have actually lead to concrete licensing agreements and I regard this relationship as weak. The unofficial exchanges in EIRMA relate more to ideas, and it seems that such exchange of ideas can be more fruitful if the direct commercial motivation of the participants is low.

3.2 The patents and licensing functions are, however, of direct concern to the research manager. EIRMA has studied these fields, as they affect industrial R & D, for many years in two working groups, which have been good examples of interface contacts between R & D and other company functions.

4. Here, relations are similar to those between companies of different sectors, and I regard both the concrete and the abstract transfers as strong, again with the proviso that EIRMA was not set up to be a market place for industrial suppliers and users of processes and products.

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tional composition is actually a handicap, given the extreme variety of traditions and curriculae in European universities. We have not, for instance, been able to organise a system of visiting scientists between Universities and Industry as has been done by our US sister association, the I.R.I. Nevertheless, the subject of industry-university relations is being actively studied in EIRMA and our next Annual Conference, on "Industry's needs for basic research" should further sharpen the awareness of our members for the importance of the university contribution to their work. I therefore describe, with some regret, the technology transfer relations between EIRMA, as an Association, and the Universities as weak. Further efforts are called for in this field.

6. Lastly, what about EIRMA's role regarding transfers between industry and developing countries, which for many to-day rank first when thinking of technology transfer ? As far as I can judge, EIRMA has not yet been instrumental in bringing about concrete transfers of this type. On the other hand, there is a growing awareness of the importance of this field among our members and a feeling that EIRMA may have a role to play in facilitating such transfers through the discussion of problems and practical solutions. Our Working Group "Licenses" for example had a Sub-group on the thorny problem of licensing arrangements in developing countries. More recently, at the initiative of our President, U. Colombo of Montedison, we held a Round Table meeting devoted to the role of R & D in developing labour intensive - or appropriate - technologies. Considerable efforts are being undertaken by a number of member companies in this field and the communication of their experience has been valuable to others. Further work in this field is planned.

MAJOR PREOCCUPATIONS OF THE EUROPEAN R & D MANAGER TO-DAY

This could be a subject to fill a day or a week and I shall limit myself to presenting a list, probably too short, which at the same time is a reflection of the EIRMA work programme :

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- internally

  . the levelling-off in industrial R & D growth, often enhanced by lower industrial growth generally, and its consequences for the R & D function.

- at the R & D/company interface

  . closer integration of the R & D function with other functions and with corporate strategies generally.

- at the interface with the socio-economic environment

  . societal pressures and the societal responsibility of industrial R & D
  . long-term energy and raw materials shortages
  . industry/university relations
  . industry's needs for basic research
  . industry/government relations

There may be opportunity to come back to some of these points during the discussion. Given the short time left, I would just like to give a few comments on the last item, industry-government relations.

This subject has been with us for at least four years, when EIRMA first set up a Working Group with this title. Emphasis was originally on the various tools and procedures used to regulate the direct financial relations with industrial R & D concerning project selection, form of contracts, project control, patent right arrangements and fiscal measures. But the Group also analysed more general aspects of industry-government relations and noted, in 1974, that :

"In Industry, opinions on the desirable extent, utility esseno[illegible] pu[illegible]se [illegible]ernmental influence on industrial R & D differ considerably.

One group considers the involvement of governments as a cumbersome interference with the independence of industrial activity. It takes the view that Industry should strive to avoid or to reduce these influences.

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One group considers the involvement of governments as a cumbersome interference with the independence of industrial activity. It takes the view that Industry should strive to avoid or to reduce these influences.

A second group accepts governmental influence as necessary and anticipates in the future an increasing public influence on industrial R & D activities.

For a third group, represented predominantly by mainly technology oriented companies, the financial contribution of governments is an important prerequisite for the realisation of its R & D programme".

In 1975, our Annual Conference was devoted to the general subject of industry-government relations in R & D and it became obvious that a merely defensive attitude of industry vis-à-vis growing government involvement was no longer tenable. It was recognised that,

- on the one hand roughly half of the total Western European R & D effort is funded by governments, of which in turn at least one half are channeled to industrial R & D
- on the other hand, indirect governmental influence through legislation and regulation is growing.

Under such conditions, only cooperation, based on understanding of the other's problems and motives, can be a fruitful policy for both sides. It was concluded that "it should become common practice for governments to turn to industry for advice and support in the early stages of policy-making and preparation of programmes and plans. In turn, industry has to take more initiative, and must be prepared to provide the scientific, technical and industrial expertise required by governments".

A more recent analysis in EIRMA of the industry government relations in R & D was given by Dr. Pannenborg, Vice-President of Phillips and EIRMA representative, at our 1977 Annual Conference in May, reproduced in N°.XIX of the series "EIRMA Conference Papers". Among the specific points made by Dr. Pannenborg, I should like to single out three with the hope of provoking some discussion at this conference.

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The first concerns the adverse effects of government subsidies to industrial R & D for international competition :

" In general it can be stated that Government measures taken on a national basis affecting or promoting R & D in industry, contribute to the distortion of free competition on the international scene. This certainly holds for explicit funding of development projects, but occurs - in the negative sense - also when repressive legislation,e.g. in the field of pollution control, is introduced in one country at an earlier point of time or with more severe requirements than in other countries. If we look at the effect of direct funding we find that it can be enormous. Notably in the USA there are multi-billion-dollar-companies which receive up to 60 % of their R & D expense under contract from the Government. This forceful mechanism in the USA undoubtedly was one of the factors leading to the discussion around the so-called technological gap".

Secondly, concerning the policy of the private enterprise vis-à-vis government funding :

"In general the management of a private enterprise will have the desire to minimize direct Government influence on its operations and on its policy and strategy. In these years of increase of direct funding of R & D in industry by government, it is important to observe that economically speaking the timely creation of a new demand through Government legislation or decision, is of more importance to the company than financial support for its R & D".

Lastly, his final remark closely joins the conlusion already endorsed by our Annual meeting in 1975 :

"For a believer in the system of free enterprise the increasing impact of Government on industry is not always regarded as a positive facet. One has to recognise, however, that the vastly increased complexity of society calls inevitably for regulatory power in certain areas, especially when the required economies of scale can no longer be achieved within the national boundaries. We from private industry should also realise how poorly

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Technology Transfer in Switzerland
An Industry Perspective

by Charles H. Tavel, Ph.D-Eng. ETHZ

To fully understand the position, policies and prospects of Swiss industry regarding the transfer of technology, it is necessary to take a look at its environment. Switzerland is a very small country. Its 6.2 million inhabitants do not provide a market of any size. As a consequence, all technologically advanced industries, even if they have foreign subsidiaries, export the greater part of their production. The watchmakers, for example, export 97 % of theirs.

A second economic constraint lies in the fact that Switzerland has practically no natural resources, if we except the natural beauty of its landscape which is the basis of its tourist income, and some hydroelectric power. That power should not be overestimated, however, since it represents only 13 % of the country's energy consumption. Consequently, all of the raw materials, 87 % of the energy and more than 50 % of the food the country needs have to be imported. It is therefore impossible for any heavy industry to survive. The country can only count on its human resources.

Those resources are scarce, however, and expensive. The rate of unemployment is 0.3 % and Switzerland employs more than 600,000 foreigners, that is, roughly 25 % of its working population. On the other hand, as you know, the Swiss franc has been revalued against other currencies by about 55 % since 1971. As a consequence, Swiss labor has become probably the most expensive in the world. It is thus impossible for a Swiss manufacturer to compete internationally on a mere cost basis. The conclusions are, first, that technological innovation is a must, and second, that the types of production that do not enjoy a unique position either are being or ought to be transferred to less costly countries.

Turning now to technological innovation, you also know that it has become more and more costly. It may take $ 20 million or more nowadays to develop and market a new, original, pharmaceutical product. Twenty-five years ago it cost $ 1 million and 6 years ago around $ 10 million. It is thus imperative to spread the cost over as many units as possible, which means aiming for the world market.

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Now, the world is essentially divided between developed and developing countries, between the North and the South. It is of course very desirable to see that the developing countries really

develop. Even if we leave aside the political and moral considerations which argue pretty much in favor of our helping their development along, we must recognize that the Third World is by far the biggest potential market. The trouble is that it does not have the money to pay for its imports. Transferring technology, helping these countries to develop sound economies is thus an obvious solution. Unfortunately, the problem has become a political one. Although the only realistic approach to the concept of development resides in a partnership between the donors and receivers of technology, the governments of the developing countries have adopted a demanding attitude, giving short shrift to industrial property rights, denying patent protection and providing no guarantee of secrecy. This is of course very awkward, since nobody can compel private enterprise in the Western countries to deprive itself of its knowledge. The situation is actually a fairly recent one. A few years ago Swiss business had started investing in developing countries. But, shocked by the changes occurring in some of them, as well as in the World Industrial Property Organization (WIPO) and UNCTAD, it may soon switch the emphasis to transferring technology to developed countries, where patent laws are improving rather than deteriorating. That, of course, will very much depend on the positions taken individually by the developing countries themselves, since careful observation shows that bilateral negotiations might lead to results that are in complete contradiction with positions taken in multilateral negotiations.

Be that as it may, increased de facto technological interdependence between the developed countries is definitely in the offing. To illustrate this, let us take a recent example that shows the extent to which closer ties have developed not only between technologically advanced countries, but also between industries which up to now have had very little or no contact. For that purpose, I have chosen a typical Swiss industry, watchmaking, and more specifically the advent of the electronic watch.

Back in 1954, the Battelle Memorial Institute's subsidiary in Geneva started calling the watchmakers' attention to the fact that it should be possible to make an electronic watch. Some time later, it even secured a contract to do research on the subject. That work led to what today is probably the most accurate wristwatch in existence: Omega's Megaquartz, which has a maximum deviation of 12 seconds a year. The terms of the research contract, however, prevented Battelle from doing similar work for other firms, so the Federation of Swiss Watchmakers created a joint research lab in the form of a corporation with some 30 shareholders. Called the "Centre Electronique Horloger" it was incorporated on January 30, 1962.

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The lab was staffed essentially by Swiss scientists who had been educated in Switzerland but had gone to work in the United States (be cause their own country could provide very few opportunities in their

fields), and then came back to Switzerland when offered a challenging job. It is worth mentioning, however, that during their time in the U.S,, some of them had been very instrumental in developing production technology in microelectronics.

So we can see that the mobility of research people is a very important element in the transfer of technology, and one that works to the benefit of everyone concerned. It is a pity that this mobility is now strongly hampered by changes in the immigration laws, both in Switzerland and in the U.S. Only big multinational firms can, to some extent, overcome this difficulty.

In 1967, the Centre Electronique Horloger came out with the first prototype of a quartz watch. Tested in competition with others at the Neuchâtel and Geneva Observatories, it won all the prizes. The Japanese had produced a quartz watch too, but at that time it was still based on discrete elements whereas the Swiss prototype used bipolar integrated circuits.

The Centre Electronique Horloger started on the construction of an industrial timepiece in 1968. Called Beta 21, it was presented at the Basel Fair in April 1970. In 1967 the Federation of Swiss Watchmakers had already taken steps to create manufacturing facilities for the integrated circuits needed for the production of the quartz watch. Together with a few Swiss electronics firms, they set up, with Philips of Holland as technology donor and main shareholder, a firm in Zürich called "Faselec". So there we had a joint venture between a Dutch electronics firm at the forefront of microelectronics, and Swiss users, or potential users, of integrated circuits.

After having presented their quartz watch, however, the Swiss watchmakers decided that it was nothing but a gadget and that the mechanical watch had attained such a state of perfection that it could not be beaten by electronics. The electronic watch's great precision, which was such a compelling argument in its favor, was simply discounted as not needed or even desired by the consumer. Quartz watches were offered for sale as an expensive sideline. No mass production was planned and Faselec had to survive by producing discrete components and hybrid circuits.

And then came 1974, with the recession, a Swiss franc that had appreciated 55 % in three years, and the massive appearance on the American market of the digital watch coupled with increasing Japanese competition. This had severe repercussions on the business of the Swiss watchmakers, who started losing very sizable amounts of money. Employment in the industry dropped 28 % in 2 years. Although the recession and the revaluation of the franc were the main causes, this shows how fast a fundamental change in technology can hit an old and seemingly very solidly based business. The Swiss had to do something and do it quickly. They started by buying their integrated circuits and

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first (LED) displays from the United States. Then they pushed ahead at full speed on the production of integrated circuits. Faselec had the technology from Philips but the main producer of watch components, ASUAG, wanted to build its own circuits too. Pressed for time, it did so by buying Hughes's production technology, which was a second form of transfer from a foreign source and from another industry.

The story doesn't stop there, though. American digital watches were essentially based on Light Emitting Diode (LED) displays. Such displays, however, are impractical. They consume so much power that a button must be pushed to read the time. The LED display is therefore most probably going to be fully replaced by the Liquid Crystal Display (LCD). The origin of the LCD can probably be traced back to the laboratories of the Swiss chemical firm Hoffmann-La Roche. Roche took out a basic patent on the use of liquid crystals and put it into a joint venture with Brown Boveri, aimed at developing medical electronics. Brown Boveri in turn developed the production of the displays and is now the world's largest producer of them. Its biggest customer is the watch industry. We thus have a transfer of technology from a chemical to an electrical engineering firm, with the main customer being not the electronics but the watchmaking industry. The development of this technology will in turn have an influence on the American market.

At the same time, the Centre Electronique Horloger, which had continued to work on integrated circuits for watches, that is, circuits with low consumption and high speed, is now licensing the results of its research to American electronics firms. And you can be sure that the pendulum is going to keep swinging back and forth between the Japanese, the Americans and the Swiss - and maybe some others. The moral of this story is that today there is no assurance of stability anymore. Yet the major revolutions are predictable. Strategic planning is not an impossibility. The advent of the electronic watch had been foreseen 20 years before it actually came out.It is at the tactical level that the pendulum really swings. Technology is the main troublemaker and nobody can be sure of being a winner for very long. "Nothing is permanently lost, nothing is permanently won" is the President of the Swiss Watchmakers' motto.

The second lesson is that a number of mechanisms have to be used simultaneously or successively to transfer technology. Let us just mention in passing the obvious importance of scientific documentation, congresses, symposiums and personal visits, as well as the mobility of scientific and technical staffs.

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however, and one of two other mechanisms may have to be chosen : licensing or the establishment of subsidiaries. Leaving aside the developing countries, let us briefly state the reasons which compel the Swiss to switch, often grudgingly, to one of these two forms of technology transfer :

- the cost of producing in Switzerland with its high-priced currency.
- the lack of manpower, which has been and may again become the most powerful motivation.
- the need to be close to a big market.
- customs tariffs. Those with the European Community have disappeared but they are still noticeable in the U.S. and Japan.
- non-tariff barriers, which comprise all forms of protectionism, including, in certain countries and for certain products, still vigorous forms of nationalism. This is especially true if the buyer is a public agency.

If we now try to analyze which form of transfer is best in a given case, we find that it depends very much on the nature of the technology and the size of the firm. Small firms usually have no other choice than to license production in countries to which they cannot export. Big and financially powerful firms will react differently depending on their type of activity. The pharmaceutical industry, for instance, does not seem to be interested in licensing. Royalties, which are on the order of 4 to 6 % of sales, are too low even to pay for the research costs, which run between 10 and 15 %. These firms license only when they are forced to,either by antitrust laws or by compulsory licensing. The dye, herbicide and pesticide producers will not license either, but they may practice cross licensing in order to have a complete product range. In Switzerland, petrochemicals, artificial fibers and paint are in the hands of smaller firms which currently practice licensing both as receivers and donors of technology.

The machinery and electrical equipment industries also recognize that the income from licensing very rarely covers R & D costs. They therefore consider the licensing they do to be only a supplement to actual production. They mostly use licensing in cases where a patent covers only part of a production process, where the investment required to go into production abroad would be disproportionately large, or where their financial resources are limited.

Turning now to the second form of transfer, the establishment of foreign affiliates still appears to be a desirable option in spite of the growing criticism of the multinational industries. Actually, that criticism comes mostly from the developing countries.

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very extensive or highly complicated. In fact, it is by far the most efficient channel of technology transfer. It will also be a necessary option when forms of nationalism affect the choice of suppliers, when the technology is not very sophisticated and when the product is bulky.

Multinational involvement is furthermore very frequent in the types of industries which base their activities on research (chemicals, pharmaceuticals and food, for example). The dynamic medium-sized firm which bases its growth on a specialty program will also probably choose to go multinational.

There is in fact a widespread belief that multinationalism is an unavoidable and even desirable form of technology transfer. One reason is that the cost of creating technology has become so tremendous that ways have to be found to exploit its results worldwide. Another is that it is definitely the most efficient form of technology transfer. Still another is that it is to every country's advantage to have technology exploited everywhere in the most effective way - and that implies worldwide cooperation among everyone involved in production. As it happens, cooperation can best be achieved within the framework of a multinational firm.

It can be expected, however, that some changes will take place in the multinatonal concept itself. It used to be that managers were nationals of the home country. That is now no longer the case. A second characteristic was that the subsidiaries in the host countries were wholly owned by the parent company. That is also changing, and twenty years from now more than half of the capital of affiliates will, in most cases, probably be in the hands of the host country. What, then, is going to be the cement holding together this loose tissue of firms ? The answer is technology development and transfer. The role of the parent company will thus mainly be to see that the group stays in the forefront of technology. That will mean both conducting research and making sure that innovations made anywhere in the world will be made available to all the members of the multinational family.

This is a healthy development, but it definitely requires that government intervention be kept at the lowest possible level. Right now, though, the trend is rather disturbing. We have seen for example that the cost of creating technology has become so great that it must be borne by the world market. Now, one of the big assets of the multinational firm is its ability to concentrate its research activites. Since the results of its research are shared by all, the cost obviously must also be borne by all. But that is becoming more and more difficult. A number of governments are tending to impose undue restrictions on the financial transfers made to pay for R. & D. They

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each demand that their own country get its share of R & D operations. But there is a definite limit to such deconcentration. This limit depends of course on the type of activity. The investment in research facilities has become quite considerable for most industries and it can hardly be doubled, let alone tripled or quadrupled. Coordination costs an enormous amount of money, is rarely efficient and never easy. Although research has already been partly decentralized in many Swiss multinational firms, there is bound to be a limit to how far they can go.

There are other difficulties too, like parallel imports of pharmaceuticals in the European Community. Yet, though very disturbing, these obstacles are not really too fundamental or universal.

One potentially severe impediment to a swift development of technology transfer may be caused by "technology assessment". If every country imposes different standards for every product, as is now done in the case of food and drugs, manufacturers will be confronted with one of the worst forms of nontariff barriers. It is highly desirable, therefore, that international agreements determine common norms of acceptability for technical products. But it would be most unfortunate if a mammoth suprational organization were to be given the job. The solution to an inescapable problem still lies somewhere in the future.

We have yet to mention a form of technology transfer which is bound to become more and more important : the delivery of turnkey plants. That can also be expected to foster international cooperation within the framework of international consortia. Let us also mention in passing the role played by joint ventures, just to say that such ventures are not easy to operate and that 50/50 deals are best avoided.

In closing, I would like to call your attention to a very important form of technology transfer, one whose potentialities have yet to be fully realized : that is the transfer from universities to industries. Switzerland's chemical industry has brilliantly explored this possibility and may be held up as an example of what can be achieved. The thermodynamic and electrical engineering industries have also made a stab at it. But there is still much progress to be made along these lines.

Assessing the prospects of Swiss industry has thus led us to stress the considerable interdependence among countries on a world market that has come to be everyone's arena. The interflow of technology is becoming one of its main characteristics. The prosperity of all countries, developed or developing, and perhaps even world peace, will be closely related to how free that interflow is allowed to be. Let us hope that governments will not try to solve their internal difficulties by severing the commercial and technological ties which have begun to be woven around the world. Nothing can be gained by protectionism. But much could be destroyed.

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