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PREFACE

In line with the selected methodology, the Management and Technology area at IIASA decided to have the Innovation Management Task concentrate on sectors in an attempt to analyze the situation at this level of the economy before making any aggregations or conclusions relevant to management. In order to properly cover industry, it was suggested that branches that are at differing stages or that display different kinds of development be chosen for the study. Electrotechnology or power electrical engineering was one of the branches selected being an example of mature industry.

The task force meeting held in Leningrad from May 24-29, 1982, was the first attempt to scan problems in this branch and gain some kind of understanding as to the research that has been performed. The event was a multiobjective undertaking intended to identify the interest in this field, potential collaborators, and relevant issues.

Due to the unique opportunity of becoming acquainted with the work of Soviet scientists, the papers presented were not only by researchers and scholars in this field, but also by decision makers on the different levels of management. For the first time, several issues are exposed for the English speaker, thus, rendering a service to the English speaking community of researchers, and enhancing the contacts with collaborators in socialist countries.

The papers are arranged into four sections, each devoted to issues that can be viewed as interesting topics for further research.

The discussion, found in the back of the proceedings as Appendix A, reflects the character of the productive and creative environment at the meeting. The reader must bear in mind that this is only an attempt to reflect the "milieu" as accurately as possible. It almost seems impossible to express the true working atmosphere created by the participants.

The task force meeting was also the first attempt to see if IIASA could prepare a program of interest to representatives of industrial enterprises. Many questions were raised and discused. The reactions expressed by the participants at the meeting and later on significantly prove that the answer is generally positive.

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THE PRESENTATIONS

PART ONE

INNOVATION MANAGEMENT: SELECTED ISSUES

IIASA AND THE FUTURE DEVELOPMENT OF INNOVATION MANAGEMENT RESEARCH

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As simple as this title may sound, it may be a very difficult and risky undertaking under the circumstances that must be complied with. The institute is in the midst of a period of transformation, as is the draft research plan, which contains activities related to innovation management in revised form. Thus my task more resembles the proverbial problem of shooting at a moving target from a moving platform than it does a simple forecast based on extrapolations. The task is made even more difficult by the need to assess the future at the beginning of this conference so as to help focus the interests of the collaborators.

Systems science can be of help in identifying some system invariants on which one can base further analysis. The topics chosen continue to reflect the general theme man--nature--technology, which in the future could also accommodate innovation management. The basic issue will be to study systems not in an equilibrium state but in the process of adaptation to change and turbulence. Innovation, needless to say, is almost synonymous with change. Identifying this change in advance is a long-term if not eternal problem of innovation research. The impact of innovations (basic ones) has not only economic effects but more and more, societal ones as well, which retroactively affect the innovation process. Research in this area has not yet stabilized and cross country studies and comparisons are becoming increasingly important.

Another set of changes relevant to innovation management are those connected with the economic environment. The "turbulent" prices of energy and raw materials are one important element of this. Automation, CAD, and CAM have a disturbing effect on long-established economies of scale in production. Changes in economies of scale may eliminate price advantages, which in turn could generate radical changes in the comparative advantage of companies or even countries.

These changes are likely to have a decisive effect on the macroeconomic strategies of individual countries and their industries and also on the relative positions of individual branches. From the many publications emerging on this issue, one can conclude that their common context is a search for a new pattern of economic growth and a determination of the place of individual industries in this new pattern (Piatier 1981; Lafay 1980).

This situation requires new ways of making things, or as is quite often pointed out, new ways of thinking. The many training courses emerging at universities on the management of new technology (or sometimes the term "high technology" is used) point up the importance of the management of innovations. The important comparative advantage of IIASA will play a role in streamlining future activities.

One definite advantage is that IIASA is the only East-West institute of its kind. The usefulness of comparative East-West studies has been questioned often in the past for various reasons, prominent among them the differences in the
social systems of planned and market economies. These differences prevent any mechanical transfer of the results and methods of management systems from one country to another. Nonetheless even in the past "cross-fertilization" has taken place with greater intensity than is usually acknowledged. The well-known input-output economic analysis, for example has as one of its roots the methods of balance used for resource allocation decisions by the Soviet government (Batelle 1973). And the graphical methods for planning different projects widely used in socialist countries, have as a base the PERT, CPM, and/or other planning tools developed in the USA.

IIASA recently completed a joint study of systems of economic management and control in the USA and the USSR (Dill and Popov 1979). The study point out at least two problems relevent to the East-West comparisons of innovation management:

- innovation management is an integral part of the management of the national economy in general and of industry in particular;
- the meaning of the word "planning" is usually inconsistent not only between two countries, but even between two economists.

In combination, these problems can be seen in the fact that planning is often a highly structured activity with important "pre-planning" stages (assessing alternatives, forecasting future possible factors relevant to the planned activity, etc) that have to be performed before the decision on the planning goal formulation, irrespective of the organizational level. This is the area where strategic decisions and policy measure come into play and where much can be learned about how to improve the process of management of innovations, even for countries that abhor "central government planning" (See, for example, Rice 1976.) In this sense, the many improvements in managing innovations are resulting in innovation of management.

1. Innovation As We See It

The denotation of the term "innovation" has gone through many changes since it was used by Schumpeter in 1911. Numerous publications have been devoted to the many meanings and interpretations of the term (see Srnkova and Habva 1974).

Taking a broad sociological view, any change or novelty in habits, rituals, or behavior can be labeled as innovation. From an economic standpoint also the term "innovation" can be interpreted in myriad ways. One could perhaps start with Schumpeter's view of five situations that are conducive to innovation, a view that interprets innovation as being more than just technical progress. Another interpretation of innovation (and often of technical progress) may be found in economic growth theories, in which innovation plays an important role.

A third interpretation can be traced to the study of the general impact of science (the sociology of science). Some investigators feel that a theory of innovations is perhaps in the making. It would be premature to attempt to define the scope of this theory, but certainly mention should be made of work focusing on the identification and formal classification of innovation (Mansfield 1969; Langrish *et al.* 1972; Valenta 1969). The analysis of innovation is expanding. The relation of innovation to inventions, the utilization of innovations, and their economic and social impacts are being studied. In socialist countries many studies relate to the core concept of innovations, although the term "innovation" is not always used. Because innovation problems have been related to overall societal goals in socialist countries, terms like "scientific-technical revolution", "development", "new technology", and "technical progress" are often used. They are equivalent to the terms "technical change" and "innovation" found in Western literature.

In most studies innovations are considered to constitute an economic category of great importance and thus they are interpreted broadly. The management of innovation creates serious problems, most of which are common to many countries. In line with the goals of IIASA, "cross-fertilization" of ideas can improve our understanding of the issues.

Innovation has become an important issue in the political programs of many industrially developed countries, both market oriented and planned (Ramo 1981; Andics 1981). Widespread efforts are being made to identify and remove barriers to innovation, whether fiscal, technical, or organizational. In the following citation, Brezhnev (1981) talks about the challenge to those involved in innovation management:

> Everything that tends to make the process of introducing novelties difficult, slow, and painful has to be removed. Production has to be vitally interested in making quicker and better use of the fruits of the thought and work of scientists and designers. Solving this problem is, of course, not a simple matter--it requires breaking down outdated customs and indicators. But it is absolutely essestial for the country, for the people, for our future.

An analysis of potential barriers to innovation in socialist countries is underway (see Vecsenyi 1981; Lapin and Prigozhn 1980). The elimination of these barriers has been a leading theme in changes in the management of the national economies in socialist countries.

Efforts are also being made in Western countries to identify and remedy problems of innovation management. A recent National Academy of Engineering (NAE) report on tax policy and innovation described the problem in the follwing way:

> Many informed participants in the innovation process agree that innovative activity has recently declined, on the whole, in the United States. In addition, these observers have expressed concern about what they perceive to be corporate preferences for short-term, low-risk investment in marginal product improvements, rather than long-term, high-risk investment in major technological innovations.

Dr. Bueche, chairman of a steering committee of a wide-based study of the National Academy of Engineering, summarized the consensus of the studies and the panelists on the issue of knowledge imitations in his closing remarks. He said, "There is a lot we don't know about stimulating innovation." However, "There seemed to be agreement, based presumably more on faith than on mathematical models, that doing certain things would increase the rate of innovation." (See NAE 1980.) This passage, and the one above both allude to a common need: to create the right environment for stimulating innovation.

The study and management of industrial innovation in both market and planned economies involves the following issues:

- identification of dysfunctions at the level of the national economy
- identification of disincentives to organizations and individuals
- assessment of the social impact of innovation

Methods of aiding in the design of organizational and managerial systems that enhance innovation are also needed.

Despite the commonality of these issues in planned, market oriented, and mixed economies, problems of semantics can hinder joint efforts to resolve them. In various societies innovation problems have been approached through different disciplines, each with its own vocabulary. IIASA has made an attempt to clarify semantic questions by preparing a glossary of innovation terms in three languages (Haustein 1982).

2. Conclusion

I have tried to demonstrate the importance of innovation in economic policy, turn your attention to some problems that may emerge during the common study, and point out the advantages of IIASA for these studies. I am sure that this conference will reveal several issues that are important for our collaborators and on which the institute can focus future endeavors. For the case of electrotechnology, the issue paper by Levchuk *et al.* (1982) offers an impressive menu of problems to choose from. The scope of work on different issues will be determined by the resources available. In any case, the institute will always be ready to provide a platform for the exchange of research results and informal coordination of research activities in innovation management.

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TURBOGENERATORS AND HYDROGENERATORS: PROSPECTS FOR THE NEXT 10 TO 15 YEARS

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1. Introduction

Prospects for the development of generator technology are determined by forecasts of progress in power engineering. According to the data available, generation of electrical energy will reach 1550-1600 billion kWh in the year 1985, 220-225 billion kWh of which will come from nuclear power and 230-235 billion kWh from hydroelectric stations. A growth in energy generation of 20-25% is expected over the subsequent five years. Development of power engineering in the European part of the USSR will be provided for mainly by the construction of nuclear plants and in the Asian part, by the construction of coal-fired and hydroelectric plants.

The progress in turbogenerator technology is expected to correlate with the development of electrical power engineering. In the next years serial turbogenerators rated at 500 and 800 MW, 3000 rpm will be built for steam power stations using coal from the Ekibastussky and Kansko-Achinsky regions. European Siberia, which is endowed with natural gas deposits, will receive 800 and 1000 MW units. In the near future 800 and 1200 MW units are to be installed at nuclear plants, and later, sets with 1600-2000 MW ratings.

Hydrogenerators with ratings of up to 1000 MW are to be built for the large hydroelectric plants on the rivers of Siberia, the Far East, and Central Asia. Pump-storage projects are being planned for the European part of the USSR with a capacity of 200 MW in the first stage and a capacity of 300-350 MW in the succeeding stages. To make use of the water resources of small rivers, bulb type sets with 2-60 MW ratings are needed, and for tidal power, bulb sets rated at 30 MW.

2. Hydrogen-Cooled and Water-Cooled Turbogenerators

Turbogenerators with hydrogen cooling of the rotor windings and stator cores and water-cooled stator windings are being used extensively today. Turbogenerators of this types are referred to in the USSR as TVV (meaning hydrogen and water cooling). Among this class is the world's largest unit rated at 1200 MW, 3000 rpm, 24 kV, which is installed at the Kostromskaya power station. The rotor of this unique machine weighs 105 tons. It required a 230-ton ingot, which was forged by a press with a 12,000 ton capacity.

Development of the TVV series machines requires extensive theoretical and experimental studies of electromagnetic, thermal, and mechanical processes along with an investigation of electrotechnical and building materials. Based on this wide development program, units with low heat and vibration levels have been built; this undoubtedly contributed to the machine's higher reliability and longer service life.

The 1200 MW unit has the following parameters:

- peak to peak vibration of the stator end winding - 60 micron
- peak to peak vibration of the stator core - 30 micron
- peak to peak vibration of the machine frame - 10 micron
- temperature rises at rated load for the stator winding - 40°C
- temperature rises at rated load for the rotor winding - 36°C

On the basis of extensive studies, a brushless excitation system was developed for the 1200 MW unit. To improve its reliability, provision was made for parallel operation of both rectifiers using silicon diodes. The diodes are designed to operate at high accelerations of up to 8000 g, ("g" being the acceleration of gravity).

In the USSR two types of reactors are used for thermal neutron nuclear plants: a water-cooled power reactor (WCPR) of a double-loop type and a multichannel graphite-moderated reactor (GMR) of a single-loop type. The typical output of the GMR reactor is 1000 MW. A 1500 MW reactor is now being built. Two turbogenerators are provided for each of the reactors, for which sets rated at 500 and 800 MW, 3000 rpm are used. For the WCPR type, 1000 MW output is presently available, the reactor being operated in a single unit together with the turbine and generator.

Due to the low steam parameters of nuclear reactors (pressure: 7 MPa, temperature: 274°C) large units are built to run at 1500 rpm in the USSR and abroad. The turbine for such a unit has an efficiency somewhat higher than that of a 3000 rpm turbine. However, due to its lower speed, very heavy forgings are needed to manufacture the required rotors. Investigations of transient processes and the development of new excitation and regulating systems permitted an essential decrease in the demands placed on the parameters of the turbogenerators, which finally resulted in substantial reduction in the rotor weight. Thus a 1000 MW, 1500 rpm unit weighs 150 tons, which represents considerable progress for machines of that class. The forging is made of three parts welded together according to a special technological process.

In the USSR progress made in the field of turbogenerator manufacture has made it possible to build a 1000 MW, 3000 rpm turbine for nuclear plants. A high-speed turbogenerator rated at 1000 MW, 3000 rpm is to be built for this turbine in the near future. This generator is largely based on the basic design concepts for 800 and 1200 MW, 3000 rpm turbogenerators. Over the next 10 years the TVV-1000-2 type generator will be a typical design for installation at WCPR nuclear plants with ratings of 1000 MW.

The accumulation of practical experience, the development of improved calculating methods, and advances in materials have presented us with a complex task: the development of a unified series of turbogenerators with improved technical and economic characteristics for the most frequent output range of 63 to 800 MW. This series will be used for all plants in the USSR and will go into production within the next five years. Although the machines presently in service are highly reliable, the number of forced outage hours in the new series is to be reduced by half. The end parts of these machines will be considerably improved with a resultant increase in reactive loads at rated active loading. The turbogenerators are designed to operate under semi-peak loads.

3. A New Type of Turbogenerator with Full Water Cooling

With a view to the more distant future, extensive experiments have been conducted in the USSR for a number of years. These experiments, which are aimed at developing new and promising solutions for large output turbogenerators, are primarily concerned with water cooling for the rotor windings. So far, studies and experimental tests have been conducted for three different designs of turbogenerators rated at between 300 and 800 MW. In addition, considerable experimental work is being carried out on 300 and 500 MW units with oil cooling. The stator design, which involves placing a fiberglass segregating cylinder in the gap, will permit an increase in the generator voltage level and the use of simple paper-oil insulation. The experiments are also aimed at providing a calculation and design basis for development of the next output range.

Efforts are being concentrated on the use of water cooling because for conventional-design turbogenerators, water cooling is the only remaining option for increasing output without changing dimensions. Estimates have shown that the use of full water cooling for active and structural elements allows output to be increased by up to 30%.

The most complicated problem in obtaining water cooling for the rotor lies in the water feed and discharge. Generally, the water is fed into the rotor and discharged through the shaft. There are connecting tubes between the channels in the shaft and those in the winding. These mechanical connections can hinder a high reliability level and shorten service life.

An original solution permitting the elimination of mechanical connection has been suggested in the USSR. The water would move from a stationary tube onto the surface of the rotating ring and from there it would flow through the rotor channels. Here the rotor winding operates as a pump, throwing the water onto the inner surface of the second ring, which is larger in diameter. The resulting pressure overcomes the hydraulic connection in the winding channels. The winding thus operates practically without inner pressure, which eliminates the chance of moisture leaks, thus contributing to the greater reliability of the machine.

For reliable operation at non-symmetrical load (differing currents in the stator winding phases) without essential temperature increases in the rotor body, a damper winding is employed. Its conductors are placed below the slot wedges in slots over the rotor coils. The damper winding is made up of sections, each of which consists of two conductors placed in the adjacent slots. The supply and discharge of water is carried out in the same manner as for the rotor winding, the respective elements of the water flow circuit being arranged on the other side of the rotor. Since water is a better coolant than hydrogen, plane silumin coolers were developed to cool the stator core. The coolers, which are made up of constrictive copper tubes to channel the water, are installed between the core packages, which are made of sheet electrotechnical steel. As a result, the core is more monolithic than that of conventional machines with hydrogen cooling. This is due to the fact that in the hydrogen-cooled machines the cooling ducts in the stator core are formed by vent fingers. The greater core rigidity results in reduced vibration and noise.

As in conventional machines, the stator winding is cooled by water. The turbogenerator with full water cooling is referred to as T3V, meaning that the unit uses water in three places (rotor, stator winding, and stator core).

The turbogenerator can be filled with nitrogen or even with air, using low gauge pressure. The low pressure makes it possible to eliminate the shaft oil sealings needed for hydrogen-cooled machines, which use increased gauge pressure (0.3-0.5 MPa). Hence the fully water-cooled unit not only allows an increased output to be obtained with the same frame size, but eliminates the explosion hazard of hydrogen and the risk of fire from oil sealings.

It should be noted that the gas (nitrogen or air) in the high-voltage stator winding zone must be dry. For this purpose a closed ventilation circuit is used. The heated gas is picked up from the end parts of the machine by a blower, driven via a dehumidifier, and returned into the central portion of the turbogenerator. The dehumidifier is of a tubular construction and holds low-temperature water supplied from a refrigerator plant. The moisture settles on the outer surfaces of the dehumidifier tubes and then returns to the water cooling system of the machine.

The first turbogenerator with a full water cooling system was rated at 63 MW and was set into operation in 1969. The unit was installed in place of a conventional 25 MW machine. Its design was preceded by extensive studies of its component parts. Since 1969 three more such units have been built and put into service. A positive service experience and further development studies will permit construction of the largest generator, which preserves the dimensions of the TVV-type machines rated at 800 MW, 3000 rpm. The T3W-800-2 fully water-cooled unit was factory tested at the end of 1980 and put into service at the Ryazanskaya plant. Tests and studies have shown that the generator is capable of operating at 1000 MW load. The major specifications of a machine with this output are as follows: voltage - 24 kV; power factor - 0.9; specific consumption of materials - 0.56 kg/kVA.

Based on these fully water-cooled machines, turbogenerators rated at 1600-2000 MW are expected to be built for the next stage of output for nuclear plants.

4. Hydrogenerators for the Siberian Rivers

In the next 10-15 years unique types of hydrogenerators with unit ratings of 500-1000 MW will have to built for the Siberian rivers. The Turukhanskaya plant units on the Nizhnaya Tunguzka River will have the largest unit rating (1000 MW, 107 rpm). The Turukhanskaya plant hydrogenerators are to be built on the basis of experience gained in developing hydrogenerators for the Sayano-Shushenskaya power station, which have ratings of 640 MW, 142.8 rpm and a unique output per pole of 17.5 MVA. Their development required extensive studies, which were conducted on the Krasnoyarskaya station machines with ratings of 500 MW, 93.8 rpm, on generators of other stations, and on mock-ups and models.

Attention was focused on the assembling of the stator core into the ring. For this purpose new design and technological solutions were developed providing a pre-stressed state of the core in the stator frame. Special emphasis was placed on the design of an active zone, for which new methods were used to reduce stray losses and resultant local heat.

In the development of the Sayano-Shushenskaya station hydrogenerators, the end zones were constructed using non-magnetic clamping plates for the poles, in conjunction with baked packages, slit teeth, and non-magnetic spaces, making it possible to minimize the heating level in the end packages and increase the reliability of the stator.

Additional developmental work will be aimed at increasing the generator voltages to 20kV and reducing the thickness of the insulation. Further work will include the use of thin-sheet steel with a yield strength of $70 kg / mm^2$ for the rotor rims and an increase in the carrying capacity of the rims and pole support elements.

Characteristic of the Siberian hydrogenerators are high loads acting on thrust bearings. Thus consideration should be given to the development of thrust bearings with thrust loads of up to 7000 tons.

A specific problem for Siberia will be the development of hydrogenerators for the power stations, which are to be constructed in two stages. One of the stations, the Shulbinskaya plant, will be constructed in the next few years. A distinctive feature of these generators is that despite changes in the unit ratings and speeds during the development of the stations, their major assemblies are preserved.

An increase in the number of standardized assemblies and items will play an important role in developing generators with increased capacity. This represents a step toward the development of generators on the unit principle, i.e., by using various sets of standardized items and assemblies that have been proven both in service and in life expectancy tests.

In developing high speed hydrogenerators with rotor diameters of over 10 meters, a new approach based on correlation between the ductibilities of the rotor spider, rotor rim, and generator stator is to be used.

5. Hydrogenerators for Pumped-Storage Stations

The construction of pumped-storage stations is envisaged by a prospective plan for R & D in power engineering for 1982-1995. It is expected that the newly constructed stations will be equipped with standardized sets. In the first stage these will be generator motors of 200 MW, 150 rpm.

Initially, these sets will be installed at the Zagorskaya and Kayashadorskaya plants.

A distinctive feature of the Zagorskaya units is the requirement for the direct asynchronous starting of the sets from the line, whereby means are provided for reducing the starting currents to improve the support systems for the stator winding and core. In addition, to reduce the effect of the starting currents, the use of thyristor frequency converters is planned. In the next stages, it seems reasonable to use high speed sets with rotating speeds of 300-500(600) rpm rated at 300-400 MW.

6. Bulb-Type Hydrogenerators for Rivers with Small Head Drops

There is a great need for bulb generators with 2 to 60 MW output running at 60-100 rpm for use on rivers with small head drops. It seems reasonable to build a series of such machines. As a basic design for this series, the type of bulb generators used at the Jenpeg Station (Canada) rated at 28 MW, 62 rpm can be used. These generators have direct water cooling for the stator and rotor windings and rotor poles. For smaller machines, the use of air cooling looks promising. A peculiar feature of bulb generators is that their service should be automated. The tidal plants, whose construction is planned for after 1990, should also be equipped with bulb generators. Sets capable of operating under conditions of periodically changed heads will be built for these plants.

7. A New Type of Machine: Generators Using Superconducting Technology

In the future, the use of superconductivity could provide a radical solution to the output problem in power engineering. It is well known that at cryogenic temperatures certain alloys become superconductive. In this state current densities could be ten times greater than in conventional copper conductors. Studies of design possibilities support the construction of a rotor with a superconductive winding whose stator operates at room temperature. The most suitable superconductor at present is the alloy niobium-titanium, with liquid helium as a coolant.

Turbogenerators with superconductive field windings are opening up a combination of possibilities (rare in engineering) for reducing weight and size while concurrently increasing efficiency. Of particular scientific value at the present time is work related to specific problems of an electrophysical and thermophysical nature, along with mechanical processes in a rotating rotor-vessel at liquid helium temperatures. The use of superconductivity requires special measures for damping the rotor oscillation of superconductive generators during operation.

A research center of the industry VNII Electromash has developed and tested model superconductive generators with ratings of 0.018 and 1.2 MW. The studies performed on the models and mock-ups have made it possible to build a 20 MW, 3000 rpm superconducting generator. The first cycle of tests on this generator have now been completed.

In this generator, liquid helium is supplied to the rotor through a central hole in the shaft. From there it flows through the winding and is returned in a gaseous state via torque tube extensions and a channel with a ring section in the shaft. The rotor has a thermal radiation shield. The space between the outer and inner cylinders is vacuumed. In the end parts of the rotor are torque tube extensions and evacuated plugs. The electromagnetic capabilities of the rotor can be exploited only if there is a large amount of copper in the stator winding. Fastening and supporting the copper, which is placed in the air gap, presents a difficult technical and engineering problem.

The stator is designed to use freon for cooling. The machine has a segregating cylinder for this purpose.

A cryogenic environment for the field winding is maintained with liquid helium held at the boiling point. The principal thermal insulation of the low temperature zone is provided by two layers of vacuum spaces, one between the field winding torque tube and the thermal shield, and the second between the thermal shield and the supporting structure. The field winding is made of a niobium-titanium conductor placed in a copper matrix.

The field winding torque tube is constructed of stainless steel in order to withstand the centrifugal and electromagnetic forces acting on the winding. The torque type is made with extensions to permit a maximum diameter and higher effectiveness in preventing penetration of heat flux to the low temperature zone.

An outer cylinder made of a titanium alloy, to which a copper damper winding is attached, serves as the rotor's supporting shell. This support cylinder takes up the forces and torque exerted on the damper shield at abnormal loads.

The helium flow circuit is in the central axial duct of the rotor shaft, on the exciter side, and is terminated with a helium transfer coupling. The rotor is cooled according to a closed circuit scheme, which continuously forces helium into the rotor and returns it to a refrigerating plant.

The superconductive generator employs a slotless laminated stator with a ferromagnetic shield. The slotless design permits increased amounts of copper in the active zone, an increased average flux density value of the main field of the armature winding zone, the elimination of stray losses through slots in the stator, and simplified insulation for the winding bars. The stator is freon-cooled. The volume of the stator, which is enclosed by the frame, end shields, and a fiberglass cylinder, is filled with freon. The winding bars and ferromagnetic shield contain channels to permit the coolant to circulate.

The stator has a three-phase double-layer construction with diameter pitch. Each of the bars consists of a number of molded conductors of the "litza" type, arranged in two columns with a duct between them. The connections of the conductors are carried out so as to compensate completely for the circulating electromagnetic fields.

Support for the stator winding in the active zone is obtained by the wedge system. The end part is braced to the nonmetallic cone, enveloping it. The cone is rigidly fiexed in radial and tangential directions in relation to the frame, but can be moved tangentially in case of thermal deformations.

The generator has the following major specifications:

Voltage	6300V
Current	1835A
Power factor	0.8
Field current	1590A
Efficiency	98.2%

While in the development of this machine there was no particular objective to minimize weight, the machine's weight is 2.5 times less and 1.4 times more efficient than conventional units with the same rating.

After testing, the 20 MW unit will be used as a synchronous condenser. Based on the studies and tests, a 300 MW superconductive generator will be constructed by 1985.

The next stages in developing superconducting turbogenerators are expected to involve the development of 800-1000 MW machines by 1990 and 2000-2500 MW machines by 2000. It should be noted that with their increased efficiency and smaller sizes, superconductive designs are not limited to use in the largest machines. They are also suitable for those with a medium output.

THE ROLE OF INNOVATION MANAGEMENT IN THE OVERALL STRATEGIC MANAGEMENT OF ELECTROTECHNICAL FIRMS

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1. Present Conditions for the Management of Innovation Processes

In recent decades ever-stronger emphasis has been placed on the effective management of electrotechnical firms. This has been caused partly by gradual changes in production processes (i.e., the wide application of electronic elements in all electrotechnical production), and partly by the fact that in the future it wil not be possible to guarantee the rapid growth of electrotechnical production through a linear growth of input into production.

Also, in the vast majority of cases, the organizational and management structures of electrotechnical firms do not correspond in nature to the new conditions being created in response to high requirements for dynamics in electrotechnical product innovation, conditions which are caused above all by the application of the results of scientific and technological development in the basic branches.

At present, the electrotechnical industry must manage the development of a "new generation" of universal management elements–microprocessors–which can be applied highly effectively in various products designated for productive purposes, final use, and mass production. At the same time, it is necessary to bear in mind that the development of these elements is just beginning and is likely to have far-reaching effects. Microprocessors are creating the basis for management systems and also for traditional electrotechnical products. However, their concepts must be correspondingly modified in the very near future.

Nevertheless, when redesigning some "traditional" products, e.g., for superconductivity, cryo-techniques, opto-electronics, etc., the electrotechnical industry will soon have to absorb further qualitatively new principles. The production of energetic equipment will have to be oriented towards the use of new energy resources. Generally speaking, the development of all products will have to aim at a significant conservation of materials during production and towards energy conservation during operation.

In the national economy the electrotechnical industry will play an important role in the future robotization of production processes; this will inevitably require application of completely new conceptual approaches for the series of electrotechnical products. In addition, there will be requirements for a significant increase in robot production (with emphasis on a decrease in production costs). Many products will have to be produced on a larger scale, which is likely to influence their constructional designs.

Summing up, electrotechnical production is facing new realities, the reaction to which must be not only rapid, but also far-sighted enough to permanently meet their consequences. Of course, this will not be possible without a principal re-evaluation of the presently applied constructional designs of many traditional electrotechnical products and without principal innovations. It must be stressed that this process will not be a short-term one. On the contrary, it should be a continuous one, involving appropriate changes in the firms' management structures.

The resource requirements and relatively long periods necessary for providing the prerequisites for effectively operating the future reproduction process in a Production-Economic Unit (PEU) are in dialectic contradiction to the need for a flexible reaction to the quickening pace of scientific and technological development, and thus an even shorter innovation cycle. It will be necessary to foresee a large complex of problems and to meet the requirements for innovation policy in advance, so that the production process corresponds with the high level of manpower development. Here we have to stress that the effectiveness of social production requires a continual and long-term procedural balance between the progressive requirements for productive-technical and socio-economic running of a Production-Economic Unit and its management system, and the provision of resources. At the same time the dynamics of innovation development continue to gain speed, resulting not only in a growing number of new technological discoveries, but also in a shortening of the intervals between their development and practical implementation.

The effective long-term running of a Productive-Economic Unit should not be simply reduced to the often-mentioned requirement for keeping apace of, or even surpassing, other firms in the world in a comparison of technological and economic parameters of production. According to my experience it is appropriate to stress the system unity of these effectiveness parameters applied in the production process of a Production-Economic Unit, which then creates an integral part of the effectiveness of the national economy and social production.

2. Content, Time and Methodical Aspects of the Strategic Management of the Firm's Development

In the study "Strategic Management of a Productive-Economic Unit", published by the Management Institute in Prague in 1981, I described in full detail the problems related to the systematic concepts for the strategic management of a Productive-Economic Unit. I now allow myself to put aside more general methodological questions and concentrate on an explanation of the links between the strategic management complex and the decision-making processes applied in the areas of production and technology innovation as its dialectical components.

From an economic point of view the Production-Economic Unit is made up of three main characteristics:

a) content factor

b) time factor

c) methodological factor

The content factor defines important questions about the future development of the production process, i.e., the determination of long-term objectives and means and prerequisites for attaining them. In a larger sense, the content factor may include time-related and reversely-connected stages, namely:

- elaboration of prognoses for the given systems' development
- decision-making about the choice of prognoses and elaboration of development concepts
- incorporation of the concept into the complex of long-term development plans
- application of strategic management or its implementation based on a complex set of tactical plans.

The first two steps reflect the content of the strategic management in the narrower sense. Thus they include an analysis of the Production-Economic Unit development possibilities and the elaboration of a complex set of appropriate development objectives and the means toward their attainment. In this respect the innovation policy becomes part and parcel of a means for a timely and economic attainment of the above-mentioned development objectives.

From the time aspect, the strategic management is concerned with long-term development. In electrotechnical and machine industries this usually means a period exceeding the framework of the five-year plans, i.e., a period of 10-20 years. The selection of a concrete time factor depends on the specific conditions of a Production-Economic Unit management system and on the impact of its environment. Strategic management is determined above all by:

- type of production (production of industrial plants, individual, series, mass production, or combinations thereof);
- dynamics of the scientific and technological development of the production program (innovation cycles, assortment of products, service time of products, etc.);
- dynamics of the scientific and technological development of the production base and possibilities for its regulation (resource requirements, time factor, etc.);
- dynamics of stages (technology, construction, design).

Undoubtedly, the information system represents a further prerequisite for guaranteeing the strategic management processes. This includes above all the availability of complete, reliable, and up-to-date input information and the availability of input information for processing and evaluation (methods, data processing equipment). Furthermore, this includes the admittance of risk during the decision-making process and incorporation of the results into the subsequent stages of strategic management. This is primarily related to the stability and sensitivity of the managed processes in space and time, namely, sensitivity to changes occurring in the analysis of requirements and sensitivity to resource requirements, rate of possible balance between the deviations by means of time and space resource transferability, and the possibility to use reserves and tools for regulation of changes in the planning and implementation stage of the processes mentioned. The time horizon of strategic management should be appropriately divided into partial time intervals.

As far as the methodological aspect is concerned, the strategic management represents a selective management method with specific requirements for labor organization, personnel training, and information systems. In this connection the strategic management should be seen as part and parcel of the management system of a Production-Economic Unit as an entity and at the same time it should be closely linked to the strategic management system of the higher-level management system. (In our case, this means branch ministries, government.)

In order to complete the description of the three aspects of strategic management we have to mention the fact that, in practice, the Production-Economic Unit faces a series of problems resulting from the dynamics of development over a relatively long time horizon. Hence, it is necessary to work on the following problems:

- the risk factor as it relates to the future needs of a Production-Economic Unit and thus also to the potential requirements for the productive-economic activity of a unit;
- the difficulty of making complex forecasts of likely trends in dynamic aspects of the production process (scientific and technological developments, production innovation cycles, and means of implementing them);
- the uniqueness of some decision-making procedures;
- the difficulty of forecasting structural changes that disturb the continuity of the balanced development of a Production-Economic Unit management system (the impact of reorganization, changes in the management system at the macro-level, innovation leaps, etc.)

The economic importance of decision-making in the field of strategic management, the effects on the production process of a large number of gradually created prerequisites, and the long-time impact of the accepted decisions make necessary complex management of the main development areas in the Production-Economic Unit system as an entity. Thus, the appropriate linking of management sub-systems in various firm activities or the stages of the production process as an entity and the optimal use of its local functional possibilities must be ensured. The management of product and process innovations (especially technological innovations) represents another mutually linked and contingent factor of the strategic management of a firm's development.

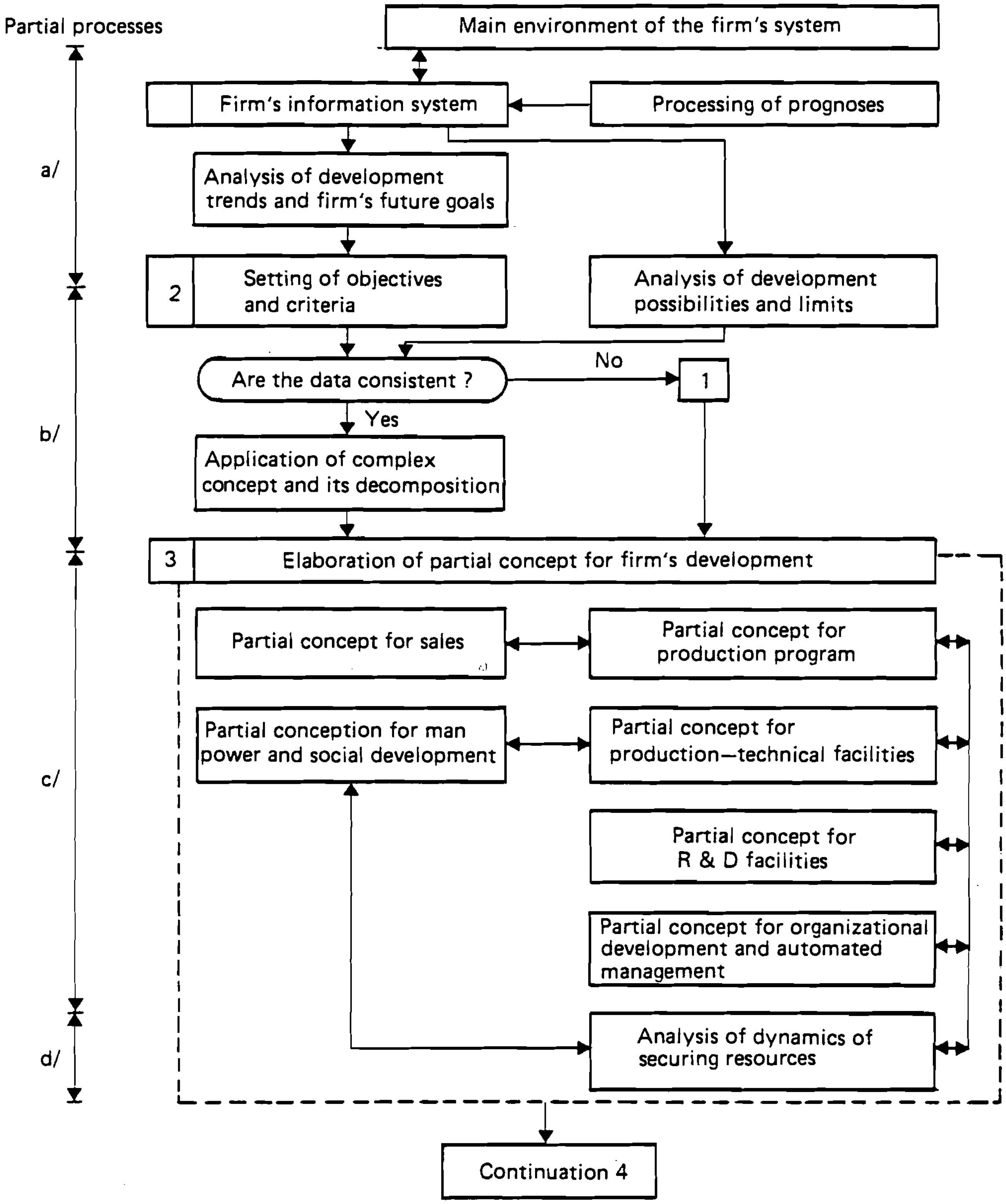
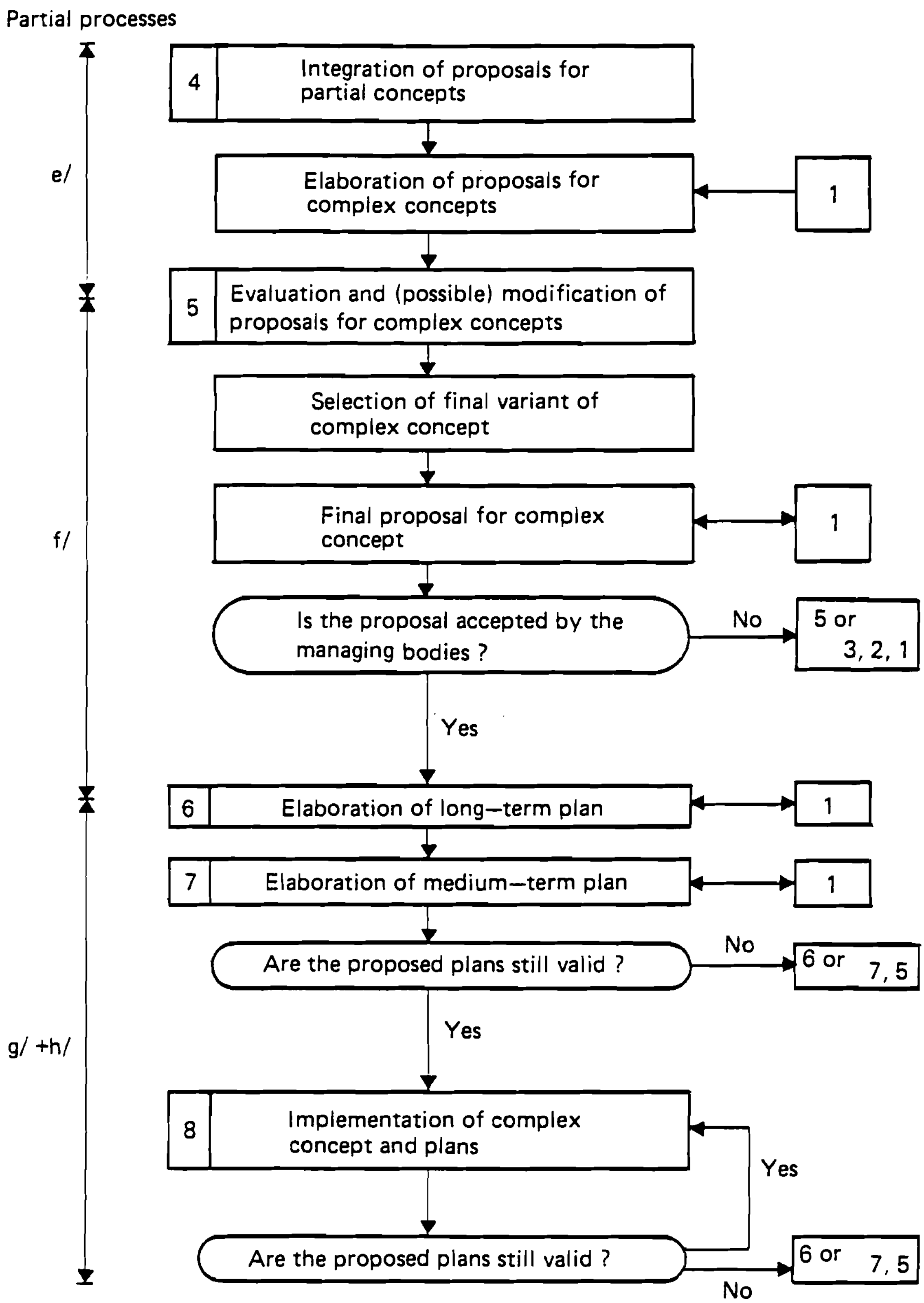


Figure 1. Creation and implementation of a complex concept for management system of a firm.

Figure 1. Continued.



3. Applying Decomposition to the Complex Concept for Strategic Management of a Firm's Development

The complexity of the management processes in the present large electrotechnical or engineering system practically excludes the possibility for an individual or group of individuals to work on the system's strategic management concept in the necessary depth. Here I mean the possibility for a one-stage solution to problems as is usual and possible in the decision-making procedure for smaller tactical problems. Experience shows that the large volume of information that must be processed when working on the development concept for a large organizational unit cannot be processed in one stage. Furthermore, when working on such a concept we also have to take into consideration time limits and the efficiency of exchanges of views among specialists at the various stages of the firm's production process. We then recognize the importance of major decomposition into a series of mutually linked and interdependent problems (see Figure 1). Coordination of decision-making about partial problems, reverse integration, and a complex solution for a Production-Economic Unit management strategy concept are unconditionally linked to the decomposition procedure.

While in the specialized literature there are many decomposition procedures and methods for the solution of mathematical models applied in decision-making, in practice the situation is quite different. It is true that in the CSSR we are trying to introduce and use mathematical models for the efficient solution of complex tasks, i.e., for their eventual decomposition and coordinated solution. However, these are more or less experiments. Based on my experience with practical managing activity in the Production-Economic Unit CKD in Prague and in several other Czechoslovak Production-Economic Units, I am of the opinion that when working on a strategic management concept it is primarily the content and qualitative character of many problems which make it possible for mathematical and other models to be widely applied to decompose the problems. Thus the decomposition of a complex concept for strategic management and the stages of its solution should be appropriately based on qualitative economic analysis and on non-formal procedures. The results of analyses carried out at our Institute have led to the conclusion that under present conditions the concept for strategic management should be decomposed into the following three aspects:

a) the content of the various decision-making procedures that create a base for the whole production process;

b) the decomposition of concepts applied in various subsystems of a Production-Economic Unit's organizational structure which guarantee a complex solution to a given problem;

c) the extent and importance of problems included in the complex concept for strategic management.

The tasks, which can be defined as partial concepts for strategic management to be applied in various areas of the entire Production-Economic Unit, appear to be the results of decomposition carried out from the point of view of content. The problem, which can be defined as forecasting studies of strategic management of a Production-Economic

Unit's partial organizational units (enterprises, plants), appears to be the result of decomposition carried out from the point of view of organizational structure. Hence, the forecasting study contains a proposal for working on the complex problem of strategic management in a subsystem, which is a part of the whole Production-Economic Unit.

During reverse synthesis, the partial concept has priority over the system of forecasting studies. The system of partial concepts may be defined as follows:

a) partial concept for production program development;

b) partial concept for production-technical facilities development;

c) partial concept for research and development facilities;

d) partial concept for marketing activities with special regard to export problems;

e) partial concept for manpower needs and problems related to social development

f) partial concept for organizational development and management automation.

These partial concepts were implemented in the Production-Economic Unit, CKD, Prague.

As will be seen later, the teams of experts working on partial concepts and the teams of experts working on forecasting studies on partial organizational units must be linked by means of an information system. This means communication between two levels of management, which may lead to a resolution of later conflicts. It is understandable that specific problems related to the strategic management of production process development in a firm's system may lead to modifications in the above-mentioned classification. Also, the possibility of highly expert studies appears to be relevant in this context. The content of partial concept can be characterized as follows.

3.1. Partial Concept for Production Program Development

Elaboration and critical analysis of a partial concept for production program development is relevant for clarification of a firm's management and the organizational units' attitude to probable future customer needs and possibilities for their timely and effective satisfaction. The partial concept for production program development includes first of all the following forecasting analyses:

- an analysis of the firm's production activity aimed at the satisfaction of customer needs within the national economy;
- an analyses of basic trends in the innovation development of the production program within the Production-Economic Unit, further definition and the expected development of the basic, ensuring, additional, and damping programs;
- an analysis of requirements for the development of production-technical facilities, including conditions for innovation in the production program;

- an analysis of requirements for scientific-technological facilities including conditions for innovation in the production program;
- an analysis of requirements for the numbers, skill structure, and social security of manpower;
- an analysis of requirements for modification of the management system and organization.

3.2. Partial Concept for Production-Technical Facilities Developments

Elaboration and critical analysis of a partial concept for production-technical facilities development is relevant for a clarification management's attitude to the necessary development of basic resources, equipment for productive and non-productive areas, materials, and energy. A partial concept for production-technical facilities development includes primarily the following forecasting analyses:

- an analysis and evaluation of existing production-technical facilities in various production units and their use;
- an analysis and evaluation of development possibilities of production-technical facilities in production units, including their further specialization, interdepartmental cooperation, and external cooperation;
- an analysis of development possibilities for timely and functional use of basic resources, as well as possibilities for their reconstruction and modernization;
- an analysis of initiation or transfer of production units, and possible liquidation of certain production capacities;
- case studies of higher-level innovations in production-technical facilities within the plants (innovations in production processes, organization of labor resources, labor tools, energy, manpower).

3.3. Partial Concept for the Development of Research and Development Facilities

Elaboration and critical analyses of a partial concept for the development of R & D facilities are relevant for clarification of a Production-Economic Unit's or its branches' management attitude to the application of science and research development, and represent the main driving force of innovation. Analogically, as in other partial concepts, we analyze partly the appropriate time development of applicable scientific and research studies, as well as their resource and organizational requirements under concrete conditions of time and space.

A partial concept for research and development facilities development includes mainly the following forecasting analyses:

- an analysis and evaluation of the existing research and development facilities that deal with applied research and development in plants and departments; also, the evaluation of their use for developing innovations for future production processes;

- an analysis and evaluation of the development possibilities of research and development facilities, including interdepartmental cooperation and external cooperation;
- an analysis of the application of existing research and development knowledge and techniques, technology and natural sciences in the production program and production-technical facilities, and comparison with results achieved abroad;
- a prognosis and analysis of possibilities for effective use of present and future scientific and technical knowledge in production program innovation and in the production-technical facilities, as well as basic possibilities for cooperation within and outside the firm (cooperation with external working places, possibilities for use of patents and licenses).

3.4. Partial Concept for Marketing Activities

The partial concept for marketing activities includes primarily the following forecasting analyses:

- active promotion of domestic and foreign sales;
- an analysis and evaluation of possibilities for future sales from present production programs and expected geographical destination, as well as comparison of the technico-economic level of our main products with that of foreign products;
- an analysis of prerequisites for effective satisfaction of sale possibilities important for national economy implemented in innovated products and by further appropriate production programs;
- an analysis of quantitative and qualitative sale aspects necessary for definition of basic development, additional and damping programs;
- an analysis of expected technico-economic parameters and evaluation of innovation level of given production programs, including comparison with the development of similar production programs of main foreign producers and with the services provided;
- an analysis of expected innovation cycles and service time cycles of main products, including the attitude toward the necessary growth of new products and elimination of obsolete ones;
- forecasts of the developments in the division of labor, division with the aim of guaranteeing necessary production programs;
- an analysis of possibilities for the sale of licenses for products and their components.

3.5. Partial Concept for Manpower Needs and Problems Related to Social Development

A partial concept for manpower needs includes mainly the following forecasting analyses:

- an analysis and evaluation of present age, skill level, and profession of personnel--necessary for guaranteeing all stages of a firm's production process;
- an analysis of resources expected to be necessary for meeting quantitative and qualitative needs in terms of number and structure of manpower; study of future requirements included in other partial concepts;
- an analysis of material and social requirements for guaranteeing stability of manpower in respective professions and qualification structures;
- an analysis and evaluation of present and proposed system for educating Production-Economic Unit workers, long term planned build-up of cadre reserves from the point of view of necessary age and differentiation by profession during their training;
- an analysis and evaluation of present and proposed future system of social-economic care, increase of living standard, and improvement of working conditions for firm employees from the point of view of the necessary age and professional differentiation;
- an analysis of expected basic development of premium system (as far as the wages and salaries are concerned) and the subsequent impact on manpower recruitment.

3.6. Partial Concept for Organizational Development and Management Automation

The elaboration and critical analysis of a partial concept for organizational development and management automation is relevant for clarification of efficient development of the organization structure and application areas, facilities and methods for introducing an automated management system into a Production-Economic Unit, and the automated management of production processes.

The recommended iterative approach to be applied in the creation of a complex concept for a firm's management system development is efficiently summed up in Figure 1. In addition, some partial processes of conceptual studies of strategic management may coincide chronologically.

An analysis of resource requirement dynamics that guarantee the development concept—including the complex of innovation processes—can be included into the planning process. Reversely, we may state that it is above all innovation processes which guarantee the necessary dynamics for the development of a given concept.

4. Conclusion

The development of up-to-date electrotechnical production presents not only challenging new questions but also new requirements for the organization and management of innovation processes. Consequently, it places high requirements on the "technology" of management. In this light the aim of my discourse was to sum up experience and views related to the appropriate incorporation of innovation policy into the concept of strategic management of a firm's development and their practical implementation in the management system.

PART TWO

MANAGEMENT PRACTICES IN ELECTROTECHNICAL CORPORATIONS

INNOVATION POLICY IN A LARGE ELECTRICAL ENGINEERING ENTERPRISE

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1. Introduction

The scientific and technological revolution has radically changed many traditional concepts in technology. It has brought about fundamentally new sources of energy, urged the updating of product designs, and widened the scope of knowledge about the potential of process technology. It has opened an era of computers, new materials, and industrial robots. At the same time, it has called for a number of stringent new restrictions aimed at ensuring environmental control and the appropriate use of mineral resources.

To keep pace with these changes, the technical world with its complex structure has concentrated its efforts on finding and implementing adequate forms of development and management involving the application of systems analysis.

We have been witnessing a rapid and effective development of national basic research management systems and a further expansion of international scientific cooperation. In many countries, after successful use of a systems approach to the organization of science, applied management systems--differing in details, but similarly oriented--have been created to control the technological progress within industrial sectors.

Following the introduction of sectoral management systems, there has been a speedy development of specific functional management systems, e.g., product quality management systems, etc. Moreover, special management systems for ensuring the fulfillment of goal-oriented programs are finding ever increasing and successful application. These systems are designed to achieve increased flexibility in the mechanisms for managing the development of new technology within a country, sector, or large group of cooperating enterprises.

The systems approach to management is becoming increasingly associated with technological change. Industry is taking a new step toward applying to R & D systems techniques that offer a new approach to innovation management as a whole. The area of research is widening (with respect to the problems handled) because in addition to the sector or field of science as object of investigation, the large enterprise with its specific problems is involved. The choice of a large research, development, and manufacturing firm as an object for a systems study with regard to innovation management, therefore, is not accidental and, no doubt, correct.

In a large firm holding a key position in the industry concerned, programs of all levels are coming together as if in optical focus. Here scientific ideas and designs are materialized into products, functional quality management systems, and coordinating programs for the development of new products and manufacturing techniques. At the same time, a large-scale research, design, and manufacturing firm whose activities span the entire cycle "R & D - design - manufacture" is essentially an independent system differing fundamentally in its methods from an industry or field of science.

In a large-scale firm, the way is open to a new process, which can be described briefly as an effective synthesis of scientific and technical ideas on the one hand, and factors related to their materialization on the other. Realization of an idea may be determined equally by the results of basic or applied research and any of a number of
features specific to the firm: timely updating of the production facilities, effectiveness of planning and management, availability of "brain" and skilled workers, as well as a highly developed infrastructure, the appropriate strategy and tactics for choosing and accomplishing the main objectives, flexibility in the economic mechanism, and the appropriate degree of computer application, along with other economic, mathematical and technical means, including a systems approach to choosing alternative decisions.

All the basic characteristics pertaining to the performance of a large-scale modern firm are extremely dynamic. Electrosila produces about 2,000 various machines and apparatus annually. At least 10 percent of these products are newly developed items whose manufacture involves new designs and new manufacturing techniques and materials. Moreover, the amalgamation's output grows one and a half times every decade.

To demonstrate the rate of innovation in the firm, suffice it to mention that the unit capacity of Electrosila-made large turbogenerators increased within the last decade from 500 to 800 MW, and then to 1200 MW, i.e., 2.4 times. Alone in the five-year period 1976 to 1980, three different rotor cooling systems were employed in Electrosila's large-output turbogenerators: traditional hydrogen cooling for machines with an ever-increasing capacity, water cooling for the 800 MW generator, and helium cooling for a superconducting generator (experimental prototype).

Computers and the systems approach are being used extensively for management organization, thus aiding the introduction of innovations in the amalgamation. Our aim in the management organization is to create an organizational structure that is flexible enough to adapt itself to frequent changes and to the growing complexity of the firm's objectives as well as to the introduction of advanced management techniques: wide-scale use of computers and man-machine interaction procedures for tackling managerial tasks of every kind. Computers are most effectively used for planning, pre-production, material management, personnel management, and for control over the execution of the administration's orders.

One of the most important tasks for proper coordination of the innovation process in a large-scale enterprise is relieving design and process engineers of the tedious, time-consuming chores that are part of their routine work; another is to apply systems analysis to the evaluation of design and technological solutions offered by the engineers. To cope with these tasks the development of a computer-aided design (CAD) system has been initiated and value engineering for main products is being gradually introduced.

In developing the CAD system, the firm's engineers have drawn on world experience in this field. Particularly, use has been made of the achievements of the well known enterprise CKD (Prague). CAD application has proved its utility through the use of standardized components, reduction in material expenditure, and acceleration of product manufacture.

An effective system for utilizing inventions has been developed and introduced at Electrosila. This system provides for quick identification of the most useful technical innovations in electrotechnology and promotes their rapid and extensive introduction by including them in R & D and production plans. In 1981 alone, the economic benefits gained from the utilization of 75 internal and external inventions exceeded 2 million roubles.

The problem of innovation management in a large electrical machine manufacturing firm is extremely complex and has many different aspects. It involves consistent development of design and manufacturing techniques, intersectoral relations of the firm and its cooperation with enterprises and R & D centers of allied industries and the region, a correct strategy and rational tactics for defining and achieving major goals, various organizational and social means of encouraging the initiative of the personnel engaged in solving the basic problems, a variety of economic and moral incentives to encourage creative endeavors, provision of proper working conditions, and satisfaction of social needs.

The primary task of the IIASA-sponsored innovation management project is to analyze the process of introducing innovations in large-scale electrical engineering companies in East and West. Every such company implements a number of innovation programs, which differ substantially in their nature and scope. With regard to Electrosila, it appears expedient to take its most significant program and use it to exemplify the organization of innovation management in the amalgamation.

2. Creation of Super-Large Hydroelectric Generators for the Sayano-Shushenskaya Hydroelectric Station

The recent development project that can best illustrate Electrosila's innovation activities is a project aimed at creating a series of unique hydroelectric generators for the Sayano-Shushenskaya Hydroelectric Station. This large hydroelectric project is of great significance for accomplishing one of the most important objectives of the USSR national economy—further development of the very rich natural resources of the Siberian region. Nearly all the basic electrical and construction parameters of this new giant hydroelectric project are unique. The height of the arched-gravity dam being built to obstruct the flow of the water course will be an unprecedented 245 meters. The storage reservoir will accommodate 31 cubic kilometers of water. The total load on the dam will exceed 16 million tons. During periods of high heads the dam spillway and the power station will be capable of accommodating flood flow of up to 13 thousand cubic meters per second. The energy of surplus water flowing through the dam spillway during floods may reach 29 million kilowatts and may indeed bring about a scouring of the solid river bed downstream of the station.

The construction of the giant new hydroelectric station on the River Yenisei marks not only a historical milestone in world hydrotechnical construction but also a significant contribution to the wealth of experience in developing the principle of territorial organization of the national economy on the basis of large regional integrated industrial complexes. Even in our age of technological progress we cannot but be impressed by the performance characteristics of the Sayano-Shushenskaya Hydroelectric Station: its ten hydrogenerators with their 6.4 million kilowatt total capacity will produce 23 billion kilowatt-hours of electrical energy annually. This power will be supplied to scores of mining, steel-making, chemical, machine-building, and transport enterprises, which will form the Sayansky Regional Integrated Industrial Complex, surpassing in capacity and in the variety of industries involved the world-famous Bratsky Complex. The social infrastructure of the complex will be formed by several newly built urban areas. Thus, the complex will represent a new milestone in solving the problem of rational distribution of the nation's productive forces.

One of the major tasks in creating this giant power station--to design and manufacture 10 hydrogenerators, each rated at 640 MW, with a possible increase in output of up to 720 MW--was assigned to Electrosila. The target dates for setting the hydro-units into operation, and consequently, the time limits for design, manufacture, and erection of the generators, were determined by the USSR national economic development plan. The choice of such a large unit capacity was to a great extent dictated by the huge power potential of the Yenisei River, by the site of the station near one of the narrowest places in the river's rocky course, and by the project's prospects for satisfying the future high demand for electric power after extensive development of the vast East Siberian region with its abundant natural resources.

In the shortest possible time, Electrosila had not only to find solutions to a number of fundamentally new engineering problems but also to devise new forms of R & D management that were consistent with the scope and complexity of this unique innovation. With this in view and in accordance with the decision of the firm's top management and professional staff, we proceeded in several major directions.

3. Internal R & D Management

First of all, we had to expand considerably our basic in-house research as well as studies being conducted jointly with electrical engineering research centers. The Sayano-Shushenskaya HS generators, hereafter called "Sayansk generators", were the first of their kind both in the USSR and abroad. They can be compared only with the 6 million kilowatt generators of the Bratskaya HS, the hydroelectric station built earlier on the Angara, another Siberian river. But the increase in capacity of the Bratskaya HS's 12 generators, each rated at 500 MW, called for a substantial improvement of their other essential characteristics, such as efficiency, weight-to-power ratio, etc.

At that time some organizational changes aimed at consolidation of the linkage between the R & D and production units were made. A leading department responsible for new technology development planning was expanded. Additional authority and functions were delegated to it, including the management of product quality and reliability. The firm's R & D center was relieved of a number of administrative and auxiliary functions (labor and wages, maintenance, metrological service), enabling the R & D center's top management to concentrate their efforts on problems pertaining to research and development proper. Development of the Sayano-Shushenskaya HS generators was assigned to special units set up within the hydrogenerator design department. The testing and laboratory facilities were improved so as to be able to perform additional tests. Mathematical and other types of modeling were widely used in many areas of research. A great deal of experimental and exploratory work was done both at Electrosila and at the power stations in commercial operation.

The research and design management was organized so that a specific task (defined as precisely as possible) was assigned to each of the design groups engaged in the development effort. These groups were also given possible alternative optimal solutions as well as criteria for their assessment and selection, with orientation toward the ultimate goals of the project as a whole.

To make the best use of experience acquired while creating and operating the largest hydrogenerators of the Bratskaya HS, Electrosila suggested setting up a Joint Scientific and Technical Board, made up of the representatives of the All-Union Electric Power Research Institute and the All-Union Electrical Machine Research Institute along with leading experts of the largest hydroelectric stations i.e., Bratskaya and Krasnoyarskaya. The board played an important role in the innovation project management. Some other forms of cooperative research were also used. As a result, the Sayansk giant hydrogenerator featured a good combination of new and proven-in-practice solutions.

New solutions--more effective but also more risky and labor-consuming as to development and implementation--were applied only in cases where the proven-in-practice solutions were insufficient for achieving the desired results. In all other cases, i.e., whenever the proven-in-practice design and technological solutions (e.g., with 500 MW hydrogenerators) were applicable, they were employed. This resulted in an increase in generator reliability and a reduction of the development cost and labor input.

Needless to say, the employment of proven solutions by no means dampened the creative activity of the task force: more than 20 improvements in the Sayansk hydrogenerator's construction and manufacturing techniques were recognized as inventions and were patented in the USA, France, the FRG, Japan, and other countries.

The Electrosila professional and managerial staff engaged in the development of the Sayansk hydrogenerators succeeded in fulfilling the major task of achieving a considerable increase in the hydrogenerator unit capacity and maximizing the possible economic benefits from the use of larger capacity machines. Thus, the Sayansk generator exceeds the Krasnoyarsk generator in capacity by 28 percent. Its power per pole is equal to the record value of 17.5 MVA owing to the unusually high peripheral speed of the rotor, the synchronous speed being 88.5 m/sec and the runway speed, 174 m/sec.

These speeds were obtained as a result of the use of high-strength sheet steel for the rotor rim, the yield strength of this steel being 1.7 times greater than that of the steel for the Krasnoyarsk generator rotors. The use of high-strength steel and other innovations made it possible to substantially reduce its physical size. As would be expected, a considerable gain was achieved with respect to specific power, i.e., weight-to-power ratio. This equals 2.75 kg/kVA which is lower than in all the earlier machines of this kind.

4. Intersectoral and Regional Aspects

Another important innovation management problem of the Sayansk hydrogenerator development project was to satisfy the needs of this unique project for more flexible forms of intersectoral and regional management. Within the framework of an integrated external management system it was necessary to coordinate the efforts of the amalgamation itself and enterprises in supplying unique forgings and special nonmagnetic rolled steel for the generator rotor. At the same time, close contacts had to be established with the turbine manufacturer, with experts in hydraulic engineering, with the design and civil construction people responsible for the optimal construction of the dam and powerhouse, with designers of the station's automatic control system and new water supply system, with designers of unique machine tools for those shops manufacturing critical generator components, etc.

The hydroelectric power station project was unique in that each organization engaged in its development posed a great number of engineering questions--substantive and operational--to scores of related organizations subordinate to other ministries and departments. The traditional procedure of intersectoral and interdepartmental coordination, generally quite reliable, often failed under these circumstances, resulting in wasted time and a devaluation of the decisions made.

All the personnel engaged in the project development became increasingly aware of the necessity to provide for a unified, well coordinated pace of work and closer contacts to eliminate departmental barriers. It is well known, however, how difficult this becomes when a joint project involves scores of enterprises and organizations that differ in product mix and sectoral subordination. However, the system of planned economy provides for such possibilities and in this case it was necessary to make full use of its advantages.

The solution involved setting up a full-fledged coordination board with very broad powers for operational management of the Sayano-Shushenskaya HS design and construction. The following example illustrates its span of authority.

When the board formulated its plan for the accelerated construction of the station, a special decision concerning this plan was adopted by the USSR Council of Ministries, which gave the board's decision the status of a national plan. The managers, leading experts, and scientists of all 28 organizations, industrial enterprises, and R & D centers engaged in the development of the Sayano-Shushenskaya HS became members of the coordination board. Two commissions were formed within the board: one for the hydroelectric station and one for the dam. The coordination board meets once every six months and the commission meets whenever necessary, but at least once every month. The Bureau of the Coordination Board was established in order to consider pressing engineering problems, while the current organizational functions were assigned to the Secretary of the Board and his office. Leningrad was chosen as the site for the board's headquarters, since 95% of the total volume of survey work, hydraulic engineering research, R & D, and design of the Sayano-Shushenskaya hydroelectric project were to be performed by the Leningrad research and design organizations, and because three-fourths of the equipment for the station were to be produced by Leningrad manufacturers. In addition to the intersectoral coordination, this measure did a lot toward solving the problem of regional management of the project.

The board had to cope with the task of determining a strict order of priority for hundreds of extremely complex jobs and coordinating activities for the scores of organizations concerned. A high technological level, a systems approach to decision-making, a minimum of costs, high efficiency, high reliability and a long service life of the structures, equipment and transmission lines--these were the major requirements to be met when the board and its bodies were making decisions on the pace of progress in the station development and construction.

The board worked out a master schedule for the work to be performed on the Sayano-Shushenskaya project. The following serves to illustrate the complexity of the preparation of this schedule: alone the number of Leningrad organizations that had to come into contact with others exceeded three thousand. It should be emphasized that the schedule covered only ad hoc (non-traditional) cooperation in order to avoid an overlap with those under the authority of the ministries involved.

The master schedule aided substantially in identifying work that was not covered by the preliminary plans. In many cases, the executing agencies needed urgently to be specified and in a number of cases there was a serious discrepancy between the targeted linking-up dates of separate stages. When preparing the schedule, the board did not restrict its task to coordination only. It virtually became the "brain" and organizational center of the project. Alternative solutions were discussed at the sessions of the board and commissions, especially when there were differences of opinion among scientists or leading experts and a decision had to be made by the top management of the project development and construction.

Whenever it was necessary to tackle a major problem, the board formed scores of task forces from among its members--managers of various enterprises and organizations. Hundreds of specialists--employees of the enterprises and institutes concerned--worked with these teams until the problem was solved. The secretariat of the board kept constant control over the progress of the work and submitted to the board, its bureau, and the committees preliminary versions of decisions aimed at a timely elimination of discrepancies. All the enterprises and organizations cooperating within the framework of the board saw how well coordinated the efforts of the partners and suppliers could be if their interrelations are properly organized and scientifically based.

It would be difficult to enumerate here the host of problems that the board discussed, finally finding for them sound and timely solutions; a number of them were the first of their kind in the world. As an example we can refer to the erection technique to be used for mounting the giant hydrogenerators at the station.

To achieve higher reliability of all the components of the Sayansk generator, whose frame was made 4 meters smaller in diameter than that of the Krasnoyarsk generator, the designers had to increase the machine's height. Its oversize ruled out transportation of some of its components by rail, and there were also difficulties connected within their transportation by water. Under these circumstances a fundamentally new solution was found to change the erection technique. Instead of erecting six traditional factory-wound stator sections at the site, it was decided to perform the winding on the assembled stator. The guaranteed gain in the generator reliability and service life easily compensated for the larger costs connected with the increase in the time erection. Thus the problem of transporting the oversized machine over a distance of thousands of miles, which earlier had seemed insurmountable, was solved.

In the process of work on the Sayano-Shushenskaya hydroelectric project, a number of other problems encountered in research, development, and production were solved in a similar manner. About 110 design and technological solutions based on bold but practically successful ideas were later recognized as inventions.

A paper of this length cannot cover such specific problems as changes in manufacturing techniques, updating of processes and equipment, pre-production, quality management, and measures for improving the reliability of the Sayansk generators, various material and moral incentives involved in the design and manufacture of the Sayansk generators, etc. The examples given exhibit the most interesting aspects of the innovative activity, especially, the intersectoral and regional coordination of the project and more effective methods of R & D management in solving radically new problems.

The innovative process is as infinite as development itself. Creation of a coherent theory of innovation management on the basis of research and systems study of diverse activities of different firms is one of the most important tasks of modern science and technology. IIASA's timely studies of innovative activity will contribute greatly to solving this problem.

THE MANAGEMENT OF INNOVATION ACTIVITY IN THE ORGANIZATION OF GANZ ELECTRIC WORKS

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1. Introduction

In a lecture entitled "Aims and Experiences of Innovation Activity at Ganz Electric Works," the general manager of Ganz Electric Works described the circumstances surrounding innovation activity, its aims, and the company's experiences over the last 20 years. The lecture reported on the product groups manufactured by the company. It mentioned the structure of production and stated that the company regards earlier targets as still valid for the future and thus intends to maintain them. In order to examine the organizational problems of innovation tasks and their role in the organization of the company, those developmental tendencies that are expected to be influential in the future, together with methods aiming at adapting to these tendencies, should be analyzed. The planned solution for organizing the innovation work can be summarized by concluding from earlier experiences and examinations.

2. Generally Experienced Main Tendencies That Influence Innovation Activity in the Electrotechnological Industry

On the basis of economic and technical analyses, it can be stated unambiguously that the role of the energy industry will continue to have major significance in the world economy and in that of individual countries. However, because of changes in price ratios, acquisitions, and the production of primary energy carriers, along with a vast increase in energy consumption, a tendency toward increased exploitation and efficiency has appeared. The role of electrical energy production has remained significant and will probably develop faster than total energy production, although compared to the extent of increase in the previous years or decades, both the increase in production and requirement for new equipment will be more moderate.

In the field of electrical energy use, there has been on the one hand an increase in efficiency, and on the other hand, increased automatization of the manufacturing processes in all branches of industry. Recently growth has slowed in terms of quantity, while the producing capacity of the world electrotechnological industry has prepared for higher production, and the result has been increased market competition. Thus a flexible industrial background is needed in order to meet the requirements of clients and users.

It can be concluded that in the manufacture of the electrical machines and equipment, which are among the product groups of Ganz Electric Works, we still expect continuous demand, although the appearance and load proportions of this demand will fluctuate depending on economic conditions. In some fields of innovation these general conditions have to be borne in mind and examined separately.

2.1. Marketing Activity

Marketing activity is concerned with drawing up proposals and making analyses on the basis of an examination of inquiries and market surveys which record expected tendencies and market demands, so that requirements related to products or production can be met. Thus this field of work determines the input data for the innovation activity of other special fields. In addition to data related to products, the market surveys gather commercial and commercial-political information in order to determine the character and range of needed services. Both users and clients require from manufacturers of electrical machines and equipment that, on the one hand, the products delivered should be as complete systems as possible, and on the other hand, that they should contain comprehensive information for the user in addition to merely supplying the product. Such information is either of a training nature or it is directed toward the conveyance of manufacturing procedures or information about product construction, to ensure problem-free utilization or to establish conditions for independent manufacture at a later date. Thus the expert establishing the marketing organization or making relevant proposals should himself fulfill several tasks an innovative nature.

2.2. Activities Related to Product Development

The conventional families of electrical machinery products can be counted among the well-proven ones, i.e., no decisively new solutions can be expected in the manufacture of electric rotating machines or transformers. The cryotechnical solutions, for example, because of their high costs and complexity, will be used less extensively to influence the direct innovation activity related to the production of the companies.

In the field of switchgears a basic change has occurred, which is expected to lead to the wide diffusion of the technology of gas-insulated metal-clad switchgears and the adaptation of vacuum techniques. Thus innovation activity also includes the establishment of or adaptation to significant technical novelties. The field of electronic control and regulation equipment is developing so rapidly that electronics are spreading quickly to the field of industrial process control. In the frame of this theme sudden changes may be expected and for this reason innovation management should be prepared for intensive progress.

2.3. The Development of Manufacturing

Apart from shortening the production time, there is long-term need to meet all other requirements of the customers. The frequent modification of products results in a decrease of the size of production series, parallel to the reduction of production time. Because of growing technical requirements, the accuracy and complexity of products are also increasing and so production conditions (machines, equipments, technical methods) must comply with demands for more precise operation. Since all these conditions constitute a need for more and more extensive training and adaptability on the part of experts working in production, the activities of such personnel with regard to these tasks should concentrate upon the creation and preparation of production conditions, while the demands on the personnel actually accomplishing the production are, or can be, limited. This tendency appears simultaneously with the need to reduce labor costs, with the common result that processes need to be automatized more than before. The trend in automatization differs from that of earlier years, in that rather than a mechanization of rigid processes, flexible automatic production needs to be realized.

2.4. Control Management

The improvement in control management should keep apace with the more rapid processing time, the frequent changes and improvements in products, the shorter series, and finally, with less-skilled personnel. Involved here are the revision of both incoming commercial and technical information, and production data related to all phases of manufacturing. In accordance with an increasingly explicit users demand, it will be necessary to supervise the entire manufacturing process, so that through representatives, even the user may inspect the different stages of manufacturing, keeping an eye on the fulfillment of the order on the one hand, and preparing for future application on the other hand.

2.5. Organization Management

Progressive tendencies and increasing requirements are necessitating a chronological coordination of aspects of each phase of realization with a view to creating clear and exact relationships and organizational forms in company management. The latter may also follow changes in technical or economical conditions. The demand for supervision also involves a need for easy orientation in company activities on the part of users, which similarly supports and necessitates the continuous and detailed elaboration of the relations between all business and manufacturing operations.

2.6. Other Tendencies

Parallel to the above-listed requirements, it is generally expected that documentation activity will have to go beyond merely producing documenting and control: it should promote on the one hand easy orientation for all experts doing the work, and on the other hand an easy survey of the situation on the part of the users.

The application of computer techniques appears to be a future requirement in all fields and will thus influence all management activities. Within the company, the adoption of computer techniques can assure shorter processing time and simpler execution of operations. Similarly, computer techniques are required for purposes of exact information and documentation. The user will prefer computer techniques for similar reasons: they allow more reliable operation, control, and information, free from subjective influences.

3. Viewpoints in Organizing Innovation Management

Based on trends and experiences of previous years, Ganz Electric Works strongly favors the application of computers and organizational processes that use computer techniques for all activities related to the innovation process. Naturally this cannot be realized immediately, but rather in steps. Nor can it occur to the same extent for each innovation activity, but rather as a function of the applicable background (machines, experts, data).

3.1. Organization of Marketing Processes

On the basis of the above tendencies, marketing involves various fields and cannot be accomplished alone by experts trained in commerce, sales, and techniques. For each order the necessary documentation and preparatory work with regard to bids, sales, and performance should be carried out by teams of experts selected from other special fields. As a result of this selection, from the point of view of organization, the marketing staff is made up of a basic group that deals continuously with commercial topics and acts mainly as an information collector, and other teams appointed specifically for each task. The compiled data are stored and processed for evaluation using computer techniques.

Later on during documentation of services (descriptions, instructions, plans) an increasing role is also allocated to the introduction of computer techniques. However, the proper computer background of design and manufacturing should work first as a developed solution.

3.2. Organization of Innovation in Design

The introduction of computer-aided design and drawing systems will improve design and speed up the introduction of new products. Experience shows that this system should be responsible for making approximately 8000 new drawings a year.

In the field of technical design, by relying on a background suitable for interactive, graphic, and calculation work, we deem it possible to meet the requirements involved. In this field activities of an organizational nature include the formation of structured product families—completely meeting the requirements of computation engineering--and the grouping and arrangement of the design activities in compliance with this structure. Ganz Electric Works possesses the empirical data and experience necessary for initiating the application of computer systems for technical calculations, design, and plotting.

3.3. Innovation in Manufacturing Technology

On the basis of several years of experience the factory intends to utilize, in three stages, several technical and organizational methods for innovation tasks involved in the manufacturing process. In connection with technical design activities, one step is to establish a technological designing system that also utilizes computation engineering tools and is not restricted to manufacturing processes that are automatized through the use of computers or by other means.

Simultaneously, the company intends to gradually automatize some parts of its electrotechnological manufacturing procedures, making use of possibilities afforded by product structures developed first for design purposes. In the automation of the individual operations of electrotechnology, robot techniques, which are spreading more and more in the field of mechanical engineering, will play an important role.

As a third step, for certain procedures that are economically justifiable by the range of products, the size of the series, or the character of servicing, the company intends to implement control of the manufacturing operations based on computers and robot techniques; this will involve a system of interconnected processes instead of individual technological procedures.

The company has several years' experience in making calculations and establishing an organizational background for computer-aided manufacturing and in establishing process control for certain electrotechnological procedures. Thus with a sufficient basis for the successful realization of the innovation process, it is assumed that this method will be continuously expended and developed in the future.

3.4. The Relationship Between Innovation and Control

Upgrading control procedures is considered as important as the development of design and manufacturing; particular regard should be paid to the organizational or computation-engineering methods for solving specific problems. This will involve further improvement of the company's existing quality control and quality assurance systems and the establishment of direct computer connections.

In addition to control, this solution will allow the company to furnish the client with continuously-updated information on the quality of the ordered product and the safety of its delivery.

3.5. Organization Supporting the Innovation Process

Improvements in the innovation process will necessitate corresponding reorganization of production control. For this, the preparation and management of production will be developed mainly by utilizing the existing computer infrastructure. As preliminary surveys show this task can be realized with the use of the production management systems developed for general application in mechanical engineering, but due to the specific nature of electrotechnology, the available systems will have to be largely redesigned.

4. Summary

The lecture summarizes the trends on the basis of the experience of Ganz Electric Works with the innovation process and its organization. It describes the planning and application of guiding principles and steps for fulfilling the tasks involved in the everyday work of the factory. According to professional information and literature data, these decisions do not deviate from changes generally experienced in industrial development; however, because of special conditions in the field of electrotechnology, they reflect aims that are less ambitious than those usually set. Therefore, we were glad to greet IIASA's initiative, which will make possible a more thorough elaboration of the developmental trends in electrotechnology by collecting the ideas and experiences of enterprises facing similar tasks and problems.

INNOVATION MANAGEMENT AT GANZ ELECTRIC WORKS: PAST EXPERIENCE AND FUTURE AIMS

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1. Introduction

At Ganz Electric Works all tasks and activities that (in connection with the production aims of the company) result in novelties affecting the whole work or a part of it are regarded as innovations. These activities include surveys of market conditions, analyses of economic concepts, and development of new product or constructions connected with product groups, changes in auxiliary activities, and coordination of management tasks. Innovation management means finding new solutions that deviate from previous routine work, exerting influence, and consciously checking that the tasks are completed.

The company manufactures many kinds of electrical engineering products, among them (in the order in which they were first produced):

- electric rotating machines, turbogenerators, high-output d.c. and a.c. machines
- network and industrial transformers
- network and industrial high-voltage switchgears
- electric railway vehicles and tram cars
- railway signaling and interlocking equipment
- electronic equipment for control engineering
- lifts
- low-voltage equipment mostly for railway vehicles and control engineering
- oil and gas burners

Naturally, in the course of the more than 100-year history of the company, in order to expand production, which has been diverse since the beginning, there has always been some kind of innovation activity. But conscious management activities belonging to the concept of innovation have mainly been underway during the last 20-25 years. We give an account of the experiences obtained, in this time because we feel that the aims and experiences of this period will provide useful information for summarizing future trends and work to be carried out both for our company and for other firms in the electric engineering industry.

To elucidate our activities and aims and describe our experiences we consider it necessary to review briefly our innovation activities and to sum up the economic conditions that played a decisive role in the determination of our earlier plans. On this basis, the management targets of the innovation activities and the results achieved are analyzed thoroughly.

2. Historical Background

The company, an electrical engineering industry founded in the last century, was a forerunner in the development of the electrical industry until the 1930s, both in Europe and the world, and its basic range of products was formed as early as that time. The company manufactured a very wide range of electric rotating machines, transformers, switchgears, and vehicles, adapting itself to existing requirements and development trends.

The company made initiatives in several fields which give us cause to be proud of the work of our predecessors. Among these products, we should mention the development of closed-core type transformers (developed at our factory), constructional and technological solutions for the manufacture of turbogenerators, and pioneering work in a.c. railway traction.

The Second World War interrupted the pace of development and the company was unable to keep its former position due to damages; therefore in the years since the war technical level has developed much more slowly than earlier.

Economic conditions of the post-war period have also contributed to a modification of developmental trends. The company functioned as part of a great industrial concern before the war, and thus it was possible at that time to directly utilize the technical possibilities and properties of other companies belonging to the concern, while after the war, according to the concept of industrial management, the concern was distributed to several large companies dealing with separate technical fields (carriage factory, shipyard, and electric factory). At the same time, the company had to fulfill its productive task according to the specifications of a strictly centralized industry management.

Reconstruction and quick industry development fully occupied the company and thus its innovation tasks were not influenced by economic or market conditions. However, analyses and evaluations of the technical level showed the consequences of the interruption caused by the war.

General post-war development trends in the energy industries showed unambiguously that it was necessary to catch up with the development that had been carried out in the meanwhile in Europe and throughout the world. In addition, as expected, after the forced development period in the Hungarian economy, the conscious introduction of new methods that could adapt themselves to economic and market conditions would have been taken into account.

3. Targets of the Innovation Activities of the Company

In the second half of the 1950s and the beginning of the 1960s, the company had to face the task of catching up with the general development in the electrical industry--primarily in the technical field--and the task of preparing for the realization of later economic progress. In this period, based on the leaping increase in the demand for electric and fossile energy carriers that are directly usable for many purposes, which has been a difficult economic problem all over the world, the company, in line with its wide range of products and character, added to the increase in the utilization of electric energy.

During this period, consumption doubled every ten years. Above all, there was an increasing demand for power generating machines (turbogenerators), for the extension of networks (transformers, switchgears), and in parallel to the general developments in the electric vehicles industry, motors, and other equipments. As could be expected, although demands could be foreseen, they were not immediately satisfied due to high investment and other costs; in every country development in each individual industrial field should be delayed until the available equipment hinders the futher development.

On the basis of these considerations the targets of the innovation activity of the company were as follows:

- Unlike specialization taking place in other branches of industry, the company should maintain all established manufacturing profiles and it should carry out development so that, independently of fluctuating demands, both the development work and the production could continue at as even rate as possible;
- As far as possible we had to realize development through our own efforts in fields of work where it was made feasible by the experience of our experts and research possibilities and furthermore when it was made possible through the utilization of results and knowledge gained earlier;
- In fields where the research possibilities of the company were limited or the demand for catching up with the technical progress calls for rapid, leaping changes, the company realizes its development program through the purchase of licences and "know-how";
- In fields where technical conditions make it possible, the company should apply the experiences and solutions of other companies with similar manufacturing scopes, finding its own solutions within the framework of cooperation;
- In addition to its existing profiles, the company should aim at extending its activity and product assortment using other complementary profiles; this should have a future role in equalizing the development and loads and could contribute to the further improvement of conventional products.

As can be seen from the above-mentioned points, the targets are decided related to aims for product development, improvement of the manufacturing processes, and extensive enlargement of the company. As expected, at the end of the 1960s and the beginning of the 1970s, due to the already-mentioned economic changes adaptation to economic and market conditions had gained more importance. Therefore, the purpose of innovation was extended to the task of adapting to prevailing market conditions.

Until 1979 innovation management was governed by the above targets. During this period the company's production output quadrupled and the originally manufactured product groups (rotating machines, transformers, switchgears, and vehicles) were expended considerably, partly within these product groups and partly by the introduction of new kinds of products. Among them were electronic control and regulation systems. These accompanied technical development and modernized our conventional products. They appeared in the form of excitation regulators of rotating machines and regulators for vehicles and were related to our earlier profile, but they had been developed for independent process control tasks and they are now used extensively in this field. In connection with industrial modernization, the company has begun manufacturing electric equipment for lifts and has taken over and improved the manufacture of railway signaling equipments and gas and oil burners.

In every product group the factory has purchased and introduced numerous licences and imparted or sold its own development results.

These developments could not be realized on the premises of the earlier factory. Therefore, the company built, bought, or took over new factories and plants. Instead of the original factory operating at a single plant, an enterprise employing some 7500 people and having four factories operating at six sites has been established. Besides its own plants, the factory cooperates with subcontractors. Development activity for the subcontractors is carried out by the factory so as to better support its own work and coordinate the individual tasks.

4. Experiences Gained From innovation Management

A look at the development of company products shows that the innovation aims have been fully achieved: in view of the possibilities available in Hungary in 1978-79, the company was able to catch up with the level dictated by technical development. Under the given technological possibilities, the production of rotating machines could reach the stage of manufacturing larger types of machines still feasible with the given technological potentials, and a reliable basis for technical development was created in the field of small and medium-sized rotating machines. In the production of transformers the company has attained and realized transformer types that fit the highest voltage level being used now in Europe, and in the production of electric equipment it has adopted and realized the manufacture of gas-filled metalclad switchgears fulfilling all networks and technical requirements in this special field.

The establishment of adapted or newly introduced profiles and product types has also given good results, which, especially with respect to the recent sudden development in low-current techniques and electronics, may be regarded as an important result.

The continuous development work and the possibility for gaining knowledge on more and more themes has resulted in the creation of an experienced, well-prepared designer-engineering staff, which several times has proved its ability in realizing smooth improvements of even well developed products taken over from other companies.

The introduction of new and more sophisticated product types was only possible by means of simultaneous development of technical and manufacturing conditions. The main accomplishments are summarized in the following:

- Adoption and introduction of manufacturing processes at the company and in new plants and factories;
- Training and continuous technical control of methods associated with certain manufacturing processes at subcontractors;
- Technological follow-up of product development pertaining to the traditional range of manufacture at the company itself with special regard to the introduction of licences attached to traditional profiles and to the adaptation or elaboration of their manufacturing processes;
- Creation and continuous improvement of the technical background for the new range of manufacture introduced by the factory.

The execution of the tasks has also resulted in the formation of a group of experts with extensive technical training in both theory and practice, which might later serve as a basis for both improvements and reliable production.

Since economical viewpoints are coming more and more to the forefront, especially with the expansion of the market, significant development work had to be carried out in the direction of sales, commerce, and management. These have also contributed to the fact that in addition to the original, relatively exclusive group of commercial experts, a technically trained staff of economic experts with considerable marketing experience has been formed.

The collection and improvement of technical experience was forced in all fields, due to the fact that a fluctuation of needs caused peak loading all the time in different profiles and so quick change was necessary. The exchange of technical experiences and licences, and the purchase of know-how provided an inside view of some solutions and technical methods used by other industrial companies, which, since they were entirely independent of each other, could have been generally adapted only after revision and coordination. Owing to this the innovation experts could make use of their own ideas even in adaptation works. This was further boosted by the successful results attained from realization of the company's self-developed products and manufacturing processes.

The comprehensive experience gained from the management tasks and innovation work and parallel development in a number of other profiles have proved the expectations both economically and in terms of realizing the development purposes. It was proven as well, that if the given development work was carried out by experts with the required practical experience and training, the team could fulfill its duty by concentrating only on these special tasks while a group of less-skilled experts could deal with the utilization of such improvements. Figure 1 is a simplified diagram of the company's organization, which was worked out for these tasks.

Based on the experiences gained, it seemed reasonable to create an organization wherein some groups are separated for innovation work in coordination with other business activities and for maintaining the methods mentioned previously in order to make it possible to keep up with future developments in electrotechnology.

5. Summary

This brief report has described the experiences and aims of innovation management at Ganz Electric Works during the past 20-25 years. Moreover, commenting upon the aforesaid, it gives a short account of the background upon which the management of innovation was worked out.

In the light of past experience, a separate innovation management activitity which is coordinated with other company tasks, and the interfirm exchange of experiences together with the company's own improvements have given very good results and offer a good basis for future development work.

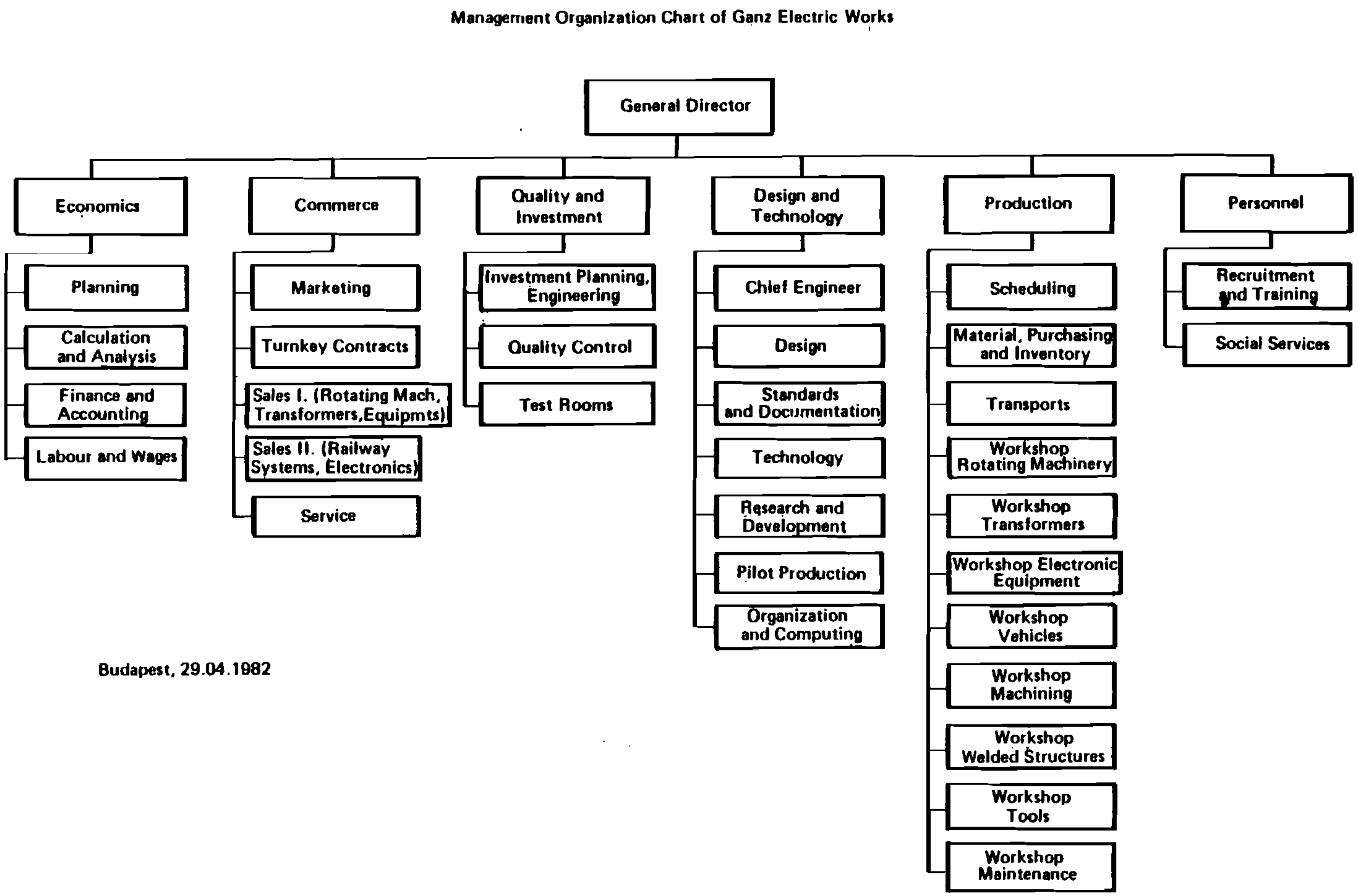

Figure 1. A management organization chart of Ganz Electric Works.

INNOVATION MAMAGEMENT AT OY STROEMBERG AB, AN ELECTRICAL ENGINEERING COMPANY IN FINLAND

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1. Introduction

Stroemberg has been manufacturing electrical equipment and electronics in Finland for over 90 years. Today the company employs 6500 persons and total sales in 1981 amounted to approximately 250 million dollars. The main product lines are heavy electrical equipment and systems and power electronics. The manufacturing program includes electric motors and generators of up to 20 Mw, transformers of up to 1200 Mva, switchgear, apparatus, and power electronics. As a special field the company widely applies AC-inverter technology for industry, electric vehicles, and ship propulsion. Approximately one third of production is exported.

Stroemberg's products are typically designed in-house. The advantages of this are that the products are well-known, the designs can be freely changed when desired, and there are no restrictions regarding product sales. However, extensive research and development work is needed for in-house design, and for a small company this can sometimes be a problem. On the other hand, smaller companies are more flexible than big ones in adopting new results and adapting the production program to them. The R & D work is limited mainly to applied research and development; basic research is only carried out in a few narrow special fields.

The company is divided into eleven profit centers. Each works independently in a separate factory building and is responsible for the design, production, and marketing of its products and also for research and development related to the product line.

The profit centers are:

- machines
- power electronics
- transformers
- apparatus
- switchgear
- electronics

- motors
- heating and cooking equipment
- installations
- service and repairs
- project sales

In addition to the research and development departments within the divisions, there is also a separate research center employing approximately 100 people. The research center is provided with extensive testing facilities, such as high voltage and high current equipment, cold rooms for large objects, material research facilities, etc.

A general principle of the company's research and development work is to bring the work as close as possible to everyday activities, business, and the customers. This makes it possible for the engineers to learn the real needs of the market and to be more market-oriented in their work.

Innovation management at Stroemberg can be discussed in two parts:

- management of the organization
- management of individual engineers

2. Management of the Organization

The research and development work is based on the real needs of the market on one hand, and on the strategic policy of the company on the other hand. Each profit center draws up a strategic plan, which is reviewed annually. An important part of this plan is the product policy, i.e., the consideration of new products and systems and the redesign of old products. In this way each profit center is forced to review its whole product line annually. The market potential and personnel resources are checked. After any necessary revisions the central management finally approves the strategic plans.

This method has been found successful. The strategic plans are made in the divisions as a team operation. Everybody can contribute to the proposal and everybody is informed of the accepted results. A great advantage of this is that the goals and principles of the division are clear to everybody, including those working in research and development.

Because of the nature of the electrical industry, a great part of the R & D work is carried out in response to actual orders. The development work is done in cooperation with the customer, whose assistance can be decisive. The benefits of the results can often be carried over to later orders. An example of this is electrical equipment for locomotives, trains, etc.

Many of the difficulties of innovation management arise in connection with the choice and selection of innovations to be realized. There are more innovations than can be taken into the program, as resources are limited. The economic profitability of the innovation is often the most important decision factor here.

A part of the R & D work is done in cooperation with outside organizations such as universities and institutes both in Finland and abroad.

3. Management of Individual Engineers

Even in large organizations the success of innovations is based on individual work. Only a small number of skilled persons is needed to bring about the best innovations. But this small number of persons must be well managed and the efficiency of their work must be high.

Good innovators should have good working conditions and the working atmosphere must be encouraging. They must have the feeling that they are working with the right type of projects to the benefit of the whole company.

The organization must be eager to accept new innovations and flexible enough to change the production program accordingly. Small companies often have an advantage over large organizations in this respect.

It is not enough that the company is favorably disposed to new innovations. The company must find customers who also are interested in and prepared to accept new products and new solutions. In a small country like Finland it is perhaps particularly easy to establish good cooperation between companies and customers as the people know each other well.

What can be done in order to improve the motivation of individual engineers?

- The research and development people, i.e., the innovators, must be well informed as to the company's basic policy and strategy so that they really know what the company wants to achieve.
- Goals and objectives must be set for the engineers' own work. In addition to the main goals, there must be intermediate goals.
- A time schedule must be set for the project. Research centers and institutes can work under less rigid schedules, but in business, a well-defined time schedule is important. The engineers must learn to respect time.
- The progress of the work must be followed and checked often enough. The management must show interest in the work's progress and not simply wait for the final results.
- Giving individual engineers more responsibility is a good way to improve motivation.
- The innovators must be encouraged to go outside the company to meet customers and to take part in conferences and seminars. In this way innovative thinking can be much improved.

It is important to understand that innovative, skilled people are needed at all technical levels. Not only doctors and high-level engineers, but also people with a lower level of technical education are needed in order to create a good innovative atmosphere and to produce the best final results.

MANAGEMENT OF THE INNOVATION POLICY IN THE COMPANY CKD PRAHA

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1. Introduction

The dynamics of the further successful development of the Czechoslovak socialist economy is largely depended on the flexible, rapid, and effective application of innovation policy to all stages and areas of production. The purpose of this paper is to give a brief summary of the practical knowledge gained from managing the innovation processes at CKD Praha. In view of the importance and key position of CKD's innovation policy *the attention is focused on the management of product innovations*.

1.1. The Conditions for Product Innovation

Last year CKD Praha celebrated the 110th anniversary of the foundation of its production base. Today the concern ranks among the largest production units in the Czechoslovak engineering industry, in terms of both the size of its production goal and the amount of manpower and other resources. The exigencies concerning technological and economic standards are emphasized by the fact that almost *two thirds of all commodities produced are intended for direct or indirect export; the rest are destined mainly for meeting key developmental goals of the Czechoslovak economy* and are specified as binding targets in the state plan.

The following production branches have primary positions in the production process of CKD Praha and thus for its innovation policy:

- diesel electric locomotives (more than 400 per year)
- tram cars (more than 1000 per year)
- high capacity piston compressors, turbo compressors, and cooling engineering systems
- semiconductor power components, including their industrial applications
- thryristor-fed electric drives, including static converters and transformers
- mobile cranes
- equipment for processing mineral materials and machines for producing building materials.

+ Professor Rychecky died on December 31, 1982.

The above-mentioned production lines also indicate prospects for developmental programs for the next 10-15 years. In addition to securing the needed technical and economic standard by means of the innovation policy we have to cope with further tasks of managing the economy. The primary problem is to cope with the tendencies of production and economic tasks under conditions of a scarcity of professionally suitable, qualified, and trained workers, and of certain materials, raw materials, fuels, and power. This leaves the problem of harmonizing with the possibilities given by the restricted investment policy, mainly as regards the needs of modernization and the reconstruction of machinery and metallurgy plants.

The all-round production of the CKD Praha from the viewpoint of the organizational structure is secured within the framework of the so-called branch enterprise with its subsidiary--enterprise Prerovske strojirny (Prerov Engineering Works). *An organizational affiliation of the company CKD Praha is the Foreign Trade Corporation Pragoinvest.*

The major part of the company CKD Praha--branch enterprise CKD Praha, comprises close to *twenty production plants and ten specialized purpose- units.*

The production set- up of CKD Praha corresponds to a relatively great extent to the principles of resource concentration and branch specialization, which has a positive effect on innovation policy. The exigency of the technology for final production, however, leads to a *tying up of a series of CKD plants by strong commitments of the inter- plant supplies and mutual cooperation*. For instance our final manufacturer of locomotives, CKD Lokomotivka-Sokolovo, receives complete diesel engines from CKD (W. Pieck and from CKD Hradec Kralove, and electric equipment from CKD Trakce, compressors for pneumatic systems from CKD Zandov, demiconductor components from CKD Polovodice, foundry semi-products from CKD Slevarny, etc. There are similar inter-plant relationships within the framework of the company among the branches for tram cars, compressors, complete electric drives, and machines for producing building material, etc.

The *special purpose units* carry out certain auxiliary and service activities for certain local groups of production plants, such as the Central Research Institute CKD, the general computing center, the projection institute, the organizational unit for supplies, or the unit for construction and power. Their activities are also essential for the effective realization of the innovation policy of the whole company, particularly from the viewpoint of a useful concentration of the necessary experts and resources, including the professional capacities of men and equipments in the field of metal and non-metal material research, testing, metrology, ecological parameters, acoustics, special electronics, measurement and computation techniques in the research institute and computing center. In this connection we must point out that the *specific branch research, development, projection and design are dislocated in the branch production plants.*

2. The Management of the Product Innovations

The complex innovation policy of the CKD Praha includes the production program (especially product innovations) as well as an effective development of the conditions for the reproduction process as a whole.

The top management of the company strive towards comprehensive *complex management of the innovation policy.* Above all this means:

- to set up a hierarchy of strategic goals for the company's development and to subordinate the partial innovation policy systems so that they will be consistent with overall company goals;
- to assess the differentiated weight and importance of the perspective innovation development in various production branches and to set a harmonized complex strategy for the growth priorities of the branches and thereby also for securing resources;
- to oversee mutual relations, e.g., to strike a balance between the available resources and the claims for them overall and for the development of innovation in the individual company branches as well;
- to try to ensure the parallel development of innovations or proportionality in the innovation development at substantial subcontractors who participate in securing of the entire effect of the innovation, etc.

In practice it is usually difficult to harmonize and secure the complex resources for the development of the productive and technological base, professionally qualified manpower, materials, and energy for the new production, and a system of organization and management in order to reach the required standard of the product innovations.

The determination of a system of strategic goals for product innovations for the whole concern together with the derived final technical and economic data for the individual production branches is a part of *the long- term development concept at CKD.* This *general concept* is disaggregated and detailed as needed into *partial perspective studies for development of the company's branch activities.*

The complex concept and the partial forecast studies are the result of a two-stage iteration process on the organizational levels "management of the concern–management of the branch or the organizational units of the company".

The system of conceptual management was introduced shortly after establishment of the present organizational form in 1957 and it has proved useful. It corresponds with the usual concept of making and improving the strategic management, i.e., in partial successive phases: forecasts-concept-system of long-term planning-system of middle-term planning.

Today's complex concept calls for solving the development problems by 1990 and in intentions as late as by 2000. It synthesizes the partial concepts for securing the development of various spheres of the reproduction process in the company:

- the production program
- the production-technological base
- research and development
- sales
- manpower and economic and social activities
- organization and management techniques (including computer technology).

The coordination of the company management with forecasting studies on the level of subordinate organizational units (mainly branch-works) is essential for the realization of product innovations and for their ultimate effectiveness. It is positively influenced by the application of the principles of planned socialist economics and by the relative stability of the long-term cooperation of the COMECON countries (for instance the influence of long-term agreements on the supply of locomotives, tram cars, compressors, or the influence of a long-term research and development cooperation, or the influence of cooperation and specialization agreements). It is negatively affected by the instability of the world economy, by difficulties associated with acquiring material and energy resources from abroad, by price fluctuations, etc.

Product innovations are selected on the basis of the development concept of the company and detailed forecasting studies. *The goals are differentiated for the branch and for the groups of products*, usually in the so-called basic sheets of product innovations. Our aim is rooted in our goals, which appear as a system covering objective technical parameters as well as economic, sales, and application data. Among these data are the deadlines for their accomplishment possibly including yet unmet prerequisites for their accomplishment (e.g., capital investments, imports). We strive to begin the production of innovated products promptly--either the year development is terminated or in year thereafter. Presently this is accomplished for about 60% of new products).

The accomplishment stage of the innovation policy is managed by a *long, middle and short term mutually interconnected system for planning research and development targets* (including their achieved outputs). We need not characterize the system in detail, as it is based on a methodology stipulated for the whole state. We stress, however, that the system uses a very elaborate two-stage checking system--which begins with an examination by experts before the inception of the task, continues by checking on its course, and concludes with the achieved checking output.

The majority of R & D targets are financed from corporate sources, i.e., from the so-called research and development fund (70-80% of expended financial means). This fund is for the most part acquired in the form of a so-called contingency fund from the production expenses of the company.

2.1. Principal Requirements on Realization of the Production Innovation

If we abstract from the specific nature of the individual production branches of CKD Praha (which are then expressed in concrete technical and economic product parameters), we find the following requirements to the innovation policy:

a. *To anticipate in good time the needs for and characteristic feature of the* future product innovation. Here prognostic studies in particular ought to be the basis for a timely development of work on the properly oriented innovation intention. From the standpoint of the company the intention is seen as a prospective, i.e., at the time of realization it may be evaluated according to its technological, economic, ecological, and other parameters. A long-term evaluation is aimed at. A good example of this might be our locomotives CME 3. The analyses of the above mentioned claim should be carried out from both the viewpoint of the mean periods for adopting the new finished products and that of the moral longevity of the innovation at the customer's end as well. The prospects for utilizing the product innovation at the selling stage is decisive for an evaluation of its effectiveness (the comparison of the innovation yields with the aggregate costs for its realization). In this connection, the duration of the innovation cycle is also relevant. At our company, this varies from 2-3 years to 8-10 years according to the production branch. Another index of the innovation effort is the share of products less than three years old, which at CKD Praha amounts to about 20% (fluctuating according to the weight of production volumes of the different branches) and the share of products in their first year of manufacture (in recent years about 8-9% of the aggregate commodity production for the entire year).

b. *To strive for the highest possible degree of innovation* and to make concessions regarding requirements only where a decisive economical evaluation have clearly shown that no optimal alternative exists, or possibly that eventually the resource allocation for the time period under consideration interval is not appropriate. In practice, we find that the best technological solutions (those with high operational reliability and required economic longevity) often result in the best economic effect. This effect is by means of a yield index (e.g., profit, marginal index of exports) applied to sales, while inside CKD Praha even the partial solution parameters are evaluated (e.g., decisive material savings, important reductions in weights and sizes, improvements in reliability and service life). Minimization of the total purchase costs and aggregate operational expenses for the planned service life, particularly in relation to the total gains of operational units production line, shop, plant) in which the machine or equipment is include, is normally the best aggregate expression of the effect at the customer's end.

c. *To endeavor toward resource substantiation* and economical realization of all the stages of the cycle "science-research-production-application". This is valid not only within the concern itself, but also at subcontractors within the action radius of the innovation. Of topical importance are also those problems of quality and overall control of the transfer of the innovation from the idea to its application. It is these very problems which frequently make it necessary to look for a replacement solution. There are problems with substitution of resources, problems of non-parallel innovation development at the level of the subcontractors, etc. The pre-production stages for becoming increasingly important for securing of valuable innovations. Reserve books of innovation solutions are being established (for which computer techniques are proving very useful).

d. For the complex management of the innovation policy *the influence on the long- term economic achievement of CKD Praha and its plants is of fundamental importance.* This refers both to the synthetic value indices of the 5-year and 1-year plans (profit, adapted own performances, indices of efficiency and volume of exports, etc.), and the indices which are essential for allowing future production development (work exigency, demand on material and power, etc.). The fulfillment of the named basic requirements for the realization of product innovations has become *a part of the managing system, especially for the organization of R & D by the general management of the company and in the individual production plants.* To this end the following systems and methods were worked out for the company a system of common and differentiated criteria for raising appreciation of the technical and economical standards of the innovation solutions (including the degree of innovation) methods for meeting product standards a system of selection and reviewing procedures before the tasks are incorporated into the R & D plan, a methodology for analysis and evaluation of achievements of R & D.

3. Conclusion

The management of CKD Praha assings primary importance to securing the innovation development of the reproduction process, particularly with regard to product innovations. By taking into account the traditions of the CKD staff, it continually endeavors to fulfill the aims laid out by the political and economical representative of or socialist state.

PART THREE

SOCIAL ASPECTS OF INNOVATION

INNOVATION POLICY AND NEEDS ANALYSIS

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1. Summary

This paper claims that innovation policy has placed too great an emphasis on technology and not enough on reasons for needing new technology. The evidence from studies of technological change is reviewed to show that the pressure from inventive activity has not been as important as the pressure from various kinds of needs. A method for studying needs is described. This method is called ***needs analysis***.

2. The Nature of Technological Change

2.1. Introduction

Any policy for innovation makes certain assumptions about the nature of technological change. Many people have assumed that technological change is the outcome of invention or science and that such change produces desirable effects. Inherent in words like 'progress' and concepts like 'removing barriers to progress' is the assumption that change is beneficial. In fact, many attempts at technological change have *not* been beneficial. Likewise, the assumption that technological change is the outcome of invention is *not* supported by the evidence that will be presented in section 2.2.

The assumption that change is caused by invention goes back to the Industrial Revolution and the many stories about great inventors and engineers of that time. Such an approach ignores the key question, "Why did one need inventions?" In Britain, the idea that change is caused by science goes back to the First World War when many 'modern' products apparently based on research in German universitites and industry were not available in Britain. This led the British Government in 1917 to establish the Department of Scientific and Industrial Research.

The Second World War provided a fresh stimulus to the belief that technological change is caused by science. Under the influence of innovation in the post-war period--atomic energy, antibiotics, radar synthetic fibres, thermoplastics, electronic computers, etc.--the governments of various countries (aiming at stimulating economic growth) and also private industry (led by the desire to maximise profit) decided to stimulate discovery by employing a growing number of scientists. In the post-war period there was a massive upsurge in scientific activity leading to the situation we have today in which around 90% of all the scientists in the entire history of science are now involved in active research (Price 1976).

This rapid growth of scientific activity, however, did not come about in a controlled manner. This was due partly to the belief that scientists can or should be left to their own activities until they produce something new. It was thought that the new idea, when it arrives, can be subjected to economic appraisal in order to see whether or not it would be worth the cost of its development. But the need to control the creative process itself was not acknowledged.

From the mid-1960s onwards, however, questions began to be asked as to the practical results of such very expensive research. The problem arose, for example, of explaining why countries such as Australia or Japan, which spend a low proportion of their GNPs on research, have a much higher rate of economic growth than England or the USA where the proportion of GNP spent on research is considerably higher (Williams 1964). Some unrest also arose amongst private firms as to whether the research departments built in the seclusion of the country, in an isolation akin to that of traditional universities, do or do not provide enough useful new ideas to justify the expense incurred in financing them.

When the first doubts about the usefulness of large scale research appeared, the answers initially provided were in terms of the 'barrier' hypothesis. According to this hypothesis, scientists *do* produce useful new ideas which are not fully made use of due to gaps in communication, lack of skills for using the new ideas, resistance to change, etc.

Although it took some time, eventually it did begin to emerge that if left to their own devices scientists do *not* produce useful new ideas. Those new ideas which had proved useful over the past ten or twenty years had been produced mainly by scientists who had either been told what lines they should think along, or by those who in addition to their scientific knowledge were aware of what was needed. So a new view of innovation began to emerge. Instead of it being seen as a second step after discovery, it became accepted that the process of innovation can start *before* the discovery. In other words, a need for change can be acknowledged first, and only then will the steps towards finding a solution be taken. The decision to invest resources in a particular line of research is an investment decision and can be taken *before* any discovery is made.

However attempts at making decisions about investment in R & D projects have not yet been very successful. This is partly because such decisions tend to be made on technical criteria rather than on a careful assessment of what is really needed.

2.2. Some Evidence

Most of the evidence about the nature of technological change is concerned with causes rather than effects. Studies aimed at defining the conditions for successful innovation have been financed by governments and private industry in the hope of increasing economic growth. Several of these studies have pointed to the importance of a knowledge of market needs for successful innovation (Freeman 1974). Utterback (1974) has compared the results of eight studies, covering different industries and countries. Table 1 shows his findings, which appear to corroborate the notion that innovations occur more often in response to some need than in response to the opportunity presented by some new technical concept. The studies listed in Table 1 were all concerned with examples of successful innovation. In some cases the quoted numbers represent Utterback's interpretation of the studies.

Table 1. Case studies of innovation.

Study	Proportion of innovations arising from market, mission or production needs %	Proportion arising from technical opportunities %
Baker et al.	77	23
Barter and Williams	73	27
Goldhar	69	31
Sherwin and Isenson	66	34
Langrish et al.	66	34
Myers and Marquis	78	22
Tannebaum et al.	90	10
Utterback	75	25

It should be noted that Utterback's concept of 'need' is not synonymous with 'demand.' He distinguishes three types of need:

1. Market need, reflected in customer choice
2. Mission need, which in the USA means a stated government requirement
3. Production need, which is an internal need to improve a production process.

The literature of economics provides further evidence that the process of technological change is a partly rational response to need. Although economists used to regard technological change as something outside the economic system, it has gradually been absorbed into economic rationality.

The first step in this absorption was the separation of invention from innovation in the manner of Schumpeter, who regarded invention as being outside economics, but described innovation as the process of investment in the results of invention and hence subject to economic forces.

The second step was to absorb invention within innovation. As invention and discovery became institutionalised in large R & D laboratories, it became possible to think of investment in research as a step before invention. Invention could then be seen as being inside an economically rational system of innovation and not a separate preceding step.

The research of Jacob Schmookler (1962) suggests that the rate of invention (as measured by patent statistics) in a given industry is governed by the demand for innovation in that industry. Since the effects of innovation are generated by the diffusion of an innovation and since the diffusion is the result of economic decisions either to invest in a new process or purchase a new product, Schmookler can claim that the effects of innovation are the result of two economic processes, one generating new technologies in response to demand and the other diffusing the new technology. This is almost the same as saying that when the effects of change are needed they can be produced.

A similar conclusion can draw support from economic history. For example, Habbakuk (1962), in comparing UK and US innovation in the nineteenth century, sees the greater degree of innovation in the US as being a response to the need for labour-saving devices. Although the details of his research have been disputed, it still seems reasonable to say the US obtained more innovation because people in a position to make decisions needed more.

Thus a case can be made for saying that necessity is the mother of invention and that the identification of a need (desired effect) followed by the allocation of resources to meet that need are the two crucial steps in innovation rather than other factors such as the date of a particular invention. An important point in support of this case is the realization of the existence of alternative technical solutions to specific problems. When there was need for developing transport from the East to the West coasts of America, there were various solutions available. If steam railways had not been invented, the history of air, road and water transport would have been different, but the need would have been met.

When the growing automobile industry produced a demand for more rubber, various solutions were available. If rubber plantations had not been established in European colonies then synthetic rubber would have been manufactured much earlier.

It would seem therefore, that the absence of a particular invention or discovery need not prevent needs from being met, because there is always more than one potential technical solution to a given need. Which solution is adopted is partly chance and partly a matter of resource allocation.

2.3. Some Problems

However, it is not just a matter of identifying needs and allocating resources to needs according to priority. Unfortunately there are some problems:

1. Not all needs can be met by allocating resources. A good example of this is the drive to find a 'cure' for cancer. This can be seen as a case where the need has been incorrectly described. The real need is to get rid of cancer; this can be done either through prevention or by cure. It so happens that the needs of industry to operate efficiently are in conflict with the preventative approach, so much effort has been put into finding a "cure,"

which if it existed, would be highly profitable for the pharmaceutical industry. This is also an example of the second problem.

2. Innovation is a complex process involving many inputs. Very often, technological change involves more than one need, so there has to be a 'coincidence of needs' before change takes place. In the case of cancer, the needs of society for better health and the needs of industry to make profits coincide in the search for a cure. The needs do not coincide in attempts to prevent cancer by reducing exposure to various chemicals.
3. A third problem is that there may be more than one mechanism resulting in technological change. There is some evidence that the very small number of innovations that have large effects involving the setting up of completely new industries are rather different from the large number of innovations that have smaller effects.

Several writers have described different types of innovation. For example, Nikolayev (1975) describes two kinds of inventive activity:

- "Exploratory inventive activity yielding fundamentally new product lines whose manufacture involves the establishment of new industries or the replacement of an active part of fixed assets with a long turnover period;
- "Inventive activity producting modifications of existing products and new product lines whose production does not involve the replacement of fixed assets with a long turnover period."

Nikolayev claims that:

> "Inventive activity of the first type, while creating the technical possibility for replacing fixed capital and the advent of radically new product lines and new industries, develops particularly rapidly when the existing means of production, techniques and consumer goods formed objectively at every given stage of social development no longer perform their functions effectively."

and

> "On the scale of state-monopoly capital, powerful stimuli to inventive activity of the first type begin to work also when competition and struggle on the international scene become more intensive."

In other words, it might be that most innovation is in response to a need, but that some change is forced by competition and in an extreme case a technological determinist mechanism may be operating.

This author has suggested elsewhere (Langrish and Poznanski 1979) that there may be two types of innovation: major changes which take place rarely (possibly in cycles of 55 years) and minor change happening all the time. The major changes may be so important that once one country has developed them, others are forced to follow. However, the 'normal' type of change should be in response to some clearly identified need or group of needs, otherwise the change is change for the sake of change without benefits being obtained.

3. Needs Analysis

3.1. Electrical Engineering Research in the UK

Having attempted to demonstrate the importance of needs in innovation policy, it is necessary to discuss how needs can be fed into practical policy decisions and how needs can be identified. One way of introducing this topic is by a discussion of electrical-engineering research in the UK.

Since Rothschild introduced the idea of the 'customer-contractor' into UK government research, government is supposed to state its needs through research requirement boards. In the case of electrical engineering, the Electrical Technology Requirements Board was set up to fund specific research projects. A strategy document (ETRB 1979) defined technical areas where funding would be provided. However, this is *not* needs analysis because its concentration is on specific areas of technical expertise rather than on problems.

This concentration on technical areas is illustrated by the strategy of the Electrical Research Association (ERA), which defines key areas for research. One such area is the electrical-machines programme (Rudge 1982), which is sub-divided into three major themes. The first is concerned with the provision of new data for the design of induction motors, in particular, those data relating to thermal and ventilation aspects. New data will be obtained from laboratory work, which will be incorporated into improved mathematical design models, also being developed. The second theme relates to the interaction of electric motors and solid-state controllers, and the implications on the design of both components. The third theme deals with the application of electric motors in industry and is concerned with techniques to monitor the condition of electric motors in service.

In the UK, the generation and transmission of electricity is controlled by the Central Electricity Generating Board (CEGB), which has its own research organizations. Research carried out by the CEGB is more problem oriented and is much closer to the needs analysis approach.

One major need of the CEGB is reliability and this need is an important factor in decision making as illustrated by the following extracts from a paper by the Board's Chairman (England 1982):

> "The breakdown of a single 660 MW AGR nuclear unit will add about £200,000 to system operating costs for each day it is out of service. This is because its running costs are so low and a plant with much higher fuel costs would have to run in its place. Problems which incur cost penalities of this magnitude require a rapid response. We aim to achieve this with considerable help from scientific services laboratories in each of our five operating regions, backed up by three larger central laboratories.
>
> "Although a wide spectrum of developments can be studied at the research stage, only a very limited number can be chosen for ultimate exploitation. In making such choices, it is important to compare the future potential, from steady evolution, of

> existing technologies with the step change possible by adopting major innovations. For example, we are exploring with manufacturers whether the benefits from the development and introduction of superconducting generators would justify the launching costs involved, bearing in mind that a small reduction in plant reliability would wipe out the advantages of lower generator cost and lower losses."

To use a need-oriented approach requires a change of attitudes amongst certain scientists and engineers. It is much easier to organise research into areas of technical specialism than into problem solving or need-oriented groups. It is easier to study super-conductivity than it is to study reliability, and yet there is more scientific prestige attached to the former than the latter.

The normal scientific approach is analytical—breaking down the problem into component parts for separate study. The new needs approach is synthetic--putting together knowledge from different technologies in the light of different economic, social and operating requirements.

This new approach requires interdisciplinary teams of people trained to collaborate with people from different backgrounds. Such an approach also has educational implications, as traditional science and technology education is very specialist oriented.

3.2. Steps in Needs Analysis

The Institute of Advanced Studies at Manchester, UK is an interdisciplinary research center. Its approach to needs analysis can be explained by the following plan for a needs analysis of Prestel.

Prestel is a new information system linking a computer with television sets via the public telephone system. Prestel is interactive, i.e., the receiver can send messages to the computer. The information base is provided by many independant information providers (IPs). The question is: Who needs this new system and how will it evolve in response to different needs?

Step 1. Initial open-ended gathering of facts, fantasies and future predictions.

a) From the extensive literature on micro-electronics, telecommunications, etc.

b) From the small but growing literature on Prestel

c) From discussions with collaborators

d) From a non-critical brain storming session. Some 40 pertinent aspects have been isolated, including such items as:
   - the effects on different social groups;
   - the potential of Prestel as a channel for market research and opinion/political polls;
   - the effect on education in the home and in schools;

- the effects of electronic funds transfer;
- the possible adverse effect on traditional publishing if more people make use of Prestel;
- the effect of page formatting and design on reading and information location;
- use of Prestel as an intermediary for access to data bases held outside it;
- effect on the deaf.

Step 2. Primary Needs Analysis.

a) Identification of primary needs. Needs of manufacturers to make profits, customers information needs, needs of IPs, etc.

b) Economic, technical and social analysis of the likelihood that these needs will actually be met by Prestel.

c) Determination of the relative importance of primary needs. These are to be assessed through joint discussion between academic and collaborators. It might emerge, for example, that the need of hardware producers to manufacture the modified TV sets is quite small at present. This in itself would not stop the development of Prestel; it would just delay it until the apparent market size persuades someone that their need for a good return on capital can be met by the efficient manufacture of low cost hardware. If, however, the needs of the consumer for prestige, novelty, practical information systems, etc., are not likely to be met by Prestel, then it has little future.

Step 3. Secondary Needs Analysis.

a) From the above two sections it should be possible to identify some important secondary needs that are likely to lead to a variety of impacts. For example, if the present user trials being carried out by the Post Office indicate that members of the public are likely to queue up to obtain Prestel as a replacement for normal advertised sources of information (cars, houses, holidays, mail order catalogues, etc.) then the secondary needs to be investigated will be different from the case which would exist if the Post Office found that it had to go in search of other needs to satisfy. (This latter case often exists with new technology. The manufacturers of Hovercraft, for example, in their desperate search for someone who needs it, are currently looking at its use as an ice-breaker.)

Depending on the requirements of the need analysis, the kinds of activities that the researcher might be involved within this part of the study could include

- Expose groups of people to Prestel and record their ways of using it and any difficulties encountered;

- Establish what services are most used;
- Investigate the provision of helpful aids to users;
- Study householders who have Prestel to find out how the service alters their pattern of life and leisure time;
- Advertisers, publishers, travel and advisory agencies, etc., could be interviewed around a structured set of questions on what these groups use Prestel for, what are the shortcomings of the Prestel service at present and what changes are needed to make it more useful for them.

b) More detailed studies. If, for example, the previous analysis suggests that Prestel is likely to replace some traditional advertising, then cut-price electrical retailers, house agents, etc., will have a need to gain access to the new system. If large enough, they could become IPs, but more likely they will work through a new type of agency. One way of exploring the implications is to provide assistance to such an agency in such matters as informtion systems, visual presentation of information and use of colour. Such involvement could produce further needs requiring specific studies, e.g., a carefully controlled evaluation of the relationship between colour coding and information transmission, making use of expertise in both psychology and graphic design.

4. Conclusion

A ***needs analysis*** is not easy to carry out. It requires an interdisciplinary, open-ended approach which probes into the real needs of people, organisations and sub-groups. However, studies of this kind are required if greater benefits are to be obtained from new technology.

The alternative is to leave benefits to chance, trying out various new technologies and seeing which ones survive through Darwinian-type evolution. The greatest challenge to rational thinking is to do better than chance.

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HUMAN FACTORS IN INNOVATION AND PRODUCTIVITY

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Though innovation and productivity are often considered to be private or national economic concerns, many of the factors determining success or failure represent issues common to societies around the world. Many of these also can be traced to threads of thought on human motivation and organization which have run through history at least since the industrial revolution. Thus I feel that this international comparative discussion of modern innovation management is especially significant, and provides a real opportunity for me to bring back to my country valuable lessons from the theory and experience of other nations. It is also a particularly good forum in which to exchange ideas related to the human factor in innovation and productivity strategies, since the human element in industrial activities gives societies around the world a commonality which transcends differences between financial, social, or industrial organization.

We are seeing, in current U.S. innovation strategies, a rebirth of attention to the motivation and mobilization of human resources. Since international trade competition began to raise innovation and productivity concerns in our country to the level of a national crisis in the mid-seventies, U.S. policy makers have concentrated heavily on capital formation, financial and organizational techniques, patent policy, and research and development investment as the keys to improved competitive performance. We are now renewing our awareness, however, that none of these financial and organizational schemes can reach their true potential unless they tap the full creativity and workplace experience of workers in both assembly line and managerial positions.

Professional and popular literature is filling with articles focusing on behavioral aspects of management and worker performance. Attention in the U.S. Congress has begun to shift to the human dimension of the productivity problem, with extensive interest in hearings and colloquia in my own Subcommittee on Science, Research and Technology (The Human Factor in Innovation and Productivity 1981, Seminar on Research, Productivity, and the national Economy 1980), as well as in related legislation and hearings in other Committees (National Productivity and Quality of Working Life 1975, The Productivity Incentive Act of 1982, The Productivity and Human Investment Act of 1982).

In this paper I will discuss some of the ways the awareness of the human factor is being expressed in innovation in innovation thinking in the United States and a few other countries, along with problems being faced in trying to change deeply-rooted habits and attitudes. Our experience may not have direct parallels in the issues faced by other nations represented in this international innovation task force, but will hopefully provide a point of comparison from which participants can extract some useful lessons, or ideas on which to build.

Much of the attention in the U.S. centers around re-learning concepts which go back at least to the Hawthorne studies of worker motivation in the 1930's (French 1964), and include the quality control ideas of W. Edwards Deming and Joseph Juran. These were well developed at least thirty years ago: Deming first brought these nations to Japan when he traveled there in 1950 as a consultant to the Union of Japanese Scientists and Engineers (Nation's Business 1981). Apropos of this IIASA task force's focus on the heavy electrical industry, one of the early awards for achievement under the Deming-designed quality improvement program was the 1952 prize to the Furukawa Electric Company for improvement in cable quality. Juran's handbook on quality control was published in 1951 (Iron Age 224 1981), and had wide influence in Japan. A powerful theme that emerged from the work of Juran and Deming at that time was the notion that steady improvement in the quality and reliability of a product line was the key to systematic market penetration for industrial products. Most importantly, training, motivating, and fully using the onsite eyes, ears and minds of the workforce was the key to efficient and economical achievement of these quality goals.

In a contemporary re-emergence of this line of thinking, there is now wide recognition in the U.S. that by the late 1970's we had gotten into serious trouble due to shortcomings in our use and development of human resources (Business Week 1980). There were many signs of this, but prominent among them were the absenteeism which plagued the auto and other heavy industries, the relatively high rejection and scrap rates in U.S. manufacturing plants, and difficulties in finding a workforce ready and able to adapt to the new skills of measurement and computer control which were needed in automated modern industrial techniques. It was clear that in many key areas the workforce was not considered as a reservoir of skill and imagination for problem-solving, but its characteristics were instead viewed as a significant part of the productivity problem itself.

In retrospect, the origins of this difficulty in the U.S. are relatively clear. The reliance on market forces as determinants of industrial decision-making leads naturally to a tendency to view labor as an oversimplified commodity in an economic equation. In the short-term this can lead to efficiency in staffing levels and streamlined deployment of the work force. In the longer-term, however, it leads to underinvestment in training, and in building identity with the goals of the employer. The natural mobility of the U.S. population, geographically, occupationally, and socially, amplifies the "labor as a simple commodity" pressure of the market system. The longer-term view, that skilled and motivated labor and managers are an essential infrastructure for industrial success, tends to receive inadequate attention. In the absence of concerted incentives for longer-term thinking, the errors of short-term expediency dominate.

Similarly, our well-known distrust of national scale planning and investment often makes local economic conditions the chief determining factor in guiding investment in human resources. The local view once again introduces some efficiencies and responsiveness to change, but also further increases the transient pressures of the market economy. The long-term investments in education and training which could be justified in a national-scale innovation and productivity strategy are difficult to justify on a local basis.

Last, the distinctive "cowboy mentality" of U.S. individualism frustrates many traditional strategies of organizing, motivating, and training manufacturing and managerial workers. Group or national benefits are not generally sufficient incentives to channel the energy of the individual U.S. worker. In contrast, intra-company adversarial relationships between individuals, labor and management, or other subunits of an industrial organization, drive the system to self-defeating internal struggles even though they may also create beneficial competitive drives for efficiency and achievement. Inter-firm, inter-industry, or inter-regional adversarial tendencies inject, on a broader scale, the same dual pressures for wasteful struggle and healthy competition.

It is easy to see that both the strengths and the weaknesses of the U.S. system of handling the "human factor" in innovation and productivity originate from the same underlying attitudes. The inextricable linkage of strengths and weaknesses to a common underlying characteristic is, of course, common to many complex systems, social or mechanical. The problem is, then, not to change the basic character of a society's view of human resources and organization, but to create institutions and incentives that overcome the inherent weaknesses without sapping the natural strengths.

An example of this approach is the "re-discovery" of the Deming system of worker participation in quality and production control. The Japanese view of Deming's contribution is symbolized by the fact that the highest Japanese national award for success in improving product quality is named not after a Japanese, but after the American Deming himself, the coveted "Deming Prize" (Nation's Business 1981). In the Deming system, heavy investment is made in training assembly workers in statistics relating to quality control, as well as to timing and smooth functioning of production lines. Record keeping and monitoring are emphasized, carried out at the site where the work is done, by those who are doing it. Unusual events or difficulties are noted as soon as they emerge from the record, and become the subject of prompt worker/management discussion to find ways to solve the problem or take advantage of opportunity.

It is easy to see the relationship of this approach to simple control theory. By putting the control function directly at the work station, the feedback loop and response time to errors is much shortened. It contrasts with traditional systems where specialized individuals from a "quality control department" come in from outside the workplace, or even the plant, and use distant computers to process production figure which generally have become aggregated in such a way that vital information is lost. The additional emphasis on bringing in the immediate attention of management addresses the crucial observation that in typical production processes, 85% of manufacturing failures represent not random worker error, but instead systematic failure of components of the process itself (Nation's Business 1981). Only prompt attention by management can remove the causes of these systematic process failures, and create conditions where low failure rates are possible.

More basically, systems like Deming's are designed to involve the worker directly in the planning, supervision and management of the enterprise. Workers are no longer thought of as essentially blind tools to carry out pre-programmed mechanical functions, but become a sophisticated sensory mechanism and source of ideas to detect and act on both failures and opportunities at the working level. Management's role is not the detailed management of system components, for which they must rely on the on-site workforce, but instead to focus on overall system organization in response to information which suggests pathways for improvement. For many traditional management approaches in the U.S., this represents a new conception of the relationship between management and the assembly-level worker, or between upper and lower management levels. In analogy to the neural-muscular control systems of animals, the Deming system makes efficient use of the ability to do a large amount of information processing and integration at the working level, without involvement of a slow and distant "brain". That central "brain" capacity is thereby released for broader and vitally important long-term functions of optimizing the over-all system design.

The views of skeptics and critics of these ideas are not surprising. There is a hesitancy to believe that ordinary workers can be trained and relied on sufficiently to be given the work station monitoring responsibilities envisioned. Similarly, there is doubt that management will be able or willing to respond quickly enough, or with sufficient spirit of partnership and mutual respect, to worker-detected system failures. The only way these misgivings will be answered is, of course, with a body of actual experience which measures the effectiveness of the approach over an extended period. However, for immediate purposes, I would call your attention to a very popular and familiar example ouside of the manufacturing domain. It is the pervasive use of detailed statistics and "worker-management" discussions in improving team performance in sports. Many fields of sports represent outstanding examples of a steady increase in productivity without, in general, any technology breakthrough. Instead, there is the extensive system of detailed statistical monitoring which brings to spectator, performer, and management attention facts like: "how many successful left-handed shots basketball player X makes during the last two minutes of a game". As ridiculously detailed as these may sometimes appear to be, they have provided a kind of "biofeedback" that coaches and players feel has provided vital information about crucial weak spots, as well as about areas of strength. This information has been the key to steady improvement of over-all performance. The analogy to the Deming system can be carried further by noting that in the most successful applications, sports statistics are as much in daily consciousness and use by the active players, from secondary school students through veteran professional, as they are by the coaching (managerial) class.

Further, listening in on sideline huddles in team sports quickly teaches that it is the working level team members who are often bringing key observations to the discussion along with ideas for improvement; the coach's role is to blend this input into a successful revision of the over-all system. Sports occasionally provides an interesting laboratory for experiments in management and building motivation. The field is highly success oriented, with diverse systems in simultaneous competitive operation. Moreover, an experimental tradition exists, with openness to unusual approaches as long as well-known indicators of success show that progress is being made. These are conditions which spawn rapid and creative adaptation to new challenges and opportunities.

We need not rely, however, on indirect indications of the promise of the worker-management cooperation to build in quality. Major Japanese companies achieved major savings after first adopting Deming's social and organizational technology. The Furukawa Electric Co. had reduced rework and in-plant accidents to 10% of their previous base. A steel firm saved 28% on coal consumption per ton of steel produced, and a pharmaceutical firm tripled output without new labor or equipment investment (Nation's Business 1981). In the U.S. much less experience has accumulated, but the Nashua Corporation, a large conglomerate making copier and computer equipment, and complete copiers, credits Deming's methods with revolutionizing their own manufacturing capabilities. Their chairman and president, William E. Conway, summed up his experience by stating: "There is no doubt in my mind that this whole use of statistical analysis to solve the problems of production and service is the third wave (of the industrial revolution) (Nation's Business 1981). In the largest experiment to date, the Ford Motor company first applied the approach to reestablish the viability of their production of compressors for air-conditioning units, a function nearly taken over by foreign subcontractors. Following success in this area, key elements of the Deming method are now being implemented in a comprehensive way in all Ford manufacturing operations, and has become part of the public image through the "Quality is Job 1" advertising campaign (see Figure 1). Early results have been sufficiently successful that each of the large American auto manufacturing companies have now followed suit with a "built in" quality program as a key part of both the substance and the advertising image of their manufacturing process.

Everybody talks about quality, Ford people make it happen.

Every step in building a car requires careful preparation. Before the exterior trim can be applied, for example, any rough edges left by welding have to be smoothed out so the trim will fit the car as designed. Anita Tholen knows that quality comes from doing her job just right. So the next person on the line can do the job right too.

This dedication to quality at Ford Motor Company is paying off. Latest results show a 48% average improvement in quality over 1980 models as reported by new car owners.

Visit a Ford or Lincoln-Mercury dealer and take a close look at what total employee, management, union and supplier involvement can achieve.

At Ford Motor Company, Quality is Job 1!

Ford
Mercury
Lincoln
Ford Trucks
Ford Tractors

Figure 1. Quality as a key advertising thrust of a major U.S. auto manufacturer. (The Ford program is based on many of the Deming statistical monitoring ideas.)

Despite the appealing theory and early practical results of these approaches to optimizing the "human factor" in innovation, there are obviously problems in application. Most basically, all systems involving human behavior are complex and are strongly affected by the environment and historical background against which they operate. Practitioners must be prepared for failure as an unpleasant, but necessary, step to eventual success. Patience will be a necessity as old habits are slowly discarded. Naive over-enthusiasm, already evident in simplistic hopes to mimic Japanese quality circles and other techniques in a completely different American cultural environment, can be the worst enemy of investment in sustained effort (Klein 1981).

In more detail, the training needed to bring workers to the ideal level of competence allows few short-cuts, and can represent an expensive initial investment burden. The very high work force mobility in the U.S. makes such investment hard to justify for a single firm, or even state or local government. Paradoxically, training initiatives in one region, operating against a background of underinvestment on a national basis, can be self-defeating by only facilitating the mobility of trained workers away from the investing region.

Another major barrier is the adversary attitudes that has so strongly characterized U.S. labor-management relations since the emergence of the union movement in the early part of this century. The success of a concept of worker and management partnership in improving manufacturing systems will depend on demonstrating to each side that change in the status quo can bring mutual benefits, instead of opportunities to take advantage or be taken advantage of. Investment in building a climate of mutual trust will be needed before either side will be convinced to accept ideas from the other without suspicion as the dominant initial reaction.

A fundamental problem related to the suspicion of innovation strategies throughout traditional sectors of the U.S. economy is the absence of "dislocation mitigation" mechanisms. By these I mean arrangements to buffer individuals, parts of industrial enterprises, existing firms, economic sectors, or even geographical regions against the short term disruptive effects which can be brought even by beneficial technological change. If workers and management are expected to look at proposals for technological change in terms of benefits for the whole system, instead of purely in the framework of local and short-term well-being, such buffering mechanisms must be provided.

Obviously, providing dislocation mitigation is a fundamental problem for a system which is largely designed to take advantage of the strong points of reliance on market forces. Yet these mitigation mechanisms are crucial to facilitate and remove barriers to the adaptation of the new technology so necessary to compete in world markets. A variety of approaches have been used in the U.S. on an ad-hoc basis in cases where major labor displacement has been experienced, such as the consolidation of railroads in the pre-and post-war periods, introduction of a new shipping technology in the 1960's, and recent airline deregulation (Miller 1979). However, these mechanisms have generally been restricted to either governmentally regulated industries, or disputes in which the government was a party or the public sector was otherwise heavily involved. The precedents and procedures for displacement mitigation are much less developed in the non-regulated manufacturing industry. The primitiveness of our efforts is measured by the weakness of that which does exist: rules for lay-off notices in many industries typically involve notice as short as a few hours or days (Miller 1979). When change is seen as bearing the potential for this kind of personal diaster, it is not surprising that attitudes of suspicion have been so strongly built up toward the introduction of new technology. Until we can create confidence that this suspicion is not warranted, there will always be major inhibitions in communications and cooperation between U.S. workers and management in the introduction of improvements in manufacturing technology.

In an even broader sense, progress toward fully utilizing the human potential for progress in innovation may depend, in our country, on the development of improved planning mechanisms which primarily emphasize communication among workers and different levels of the management structure. Such mechanisms are necessary to provide a natural framework for the trust and mutual respect for full utilization of the human potential in enhancing innovation and productivity. In the U.S. we are coming from the far end of the spectrum of general distrust of planning mechanisms, especially at the national and governmental level. Our particular allergy to national planning comes from some empirically based concerns: fear of the tendencies toward centralization inherent in many planning mechanisms, fear of the inflexibility to external change which they often bring, and fear of the bias toward conservative strategies which is inherent in planning based on incremental perturbation of past practice (Moss 1982).

Much of this phobia can be overcome, however, by putting less stress on the conventional view that a plan is a way of determining actual goals and monitoring their fulfillment. Indeed, in high technology based industries, there can be so many unexpected developments and opportunities that long-term plans become, in detail, rapidly outdated. However, the process of forming the plan, wisely done, can be the kind of internal communication mechanism which is crucial to enabling an organization to mobilize all its resources for common goals. The process can be used to build the kind of common understanding which can minimize confused internal contradiction or conflict. Whatever the applicability of the plan's strategy for the shifting circumstances of the future, it can serve at a given point in time as a clear definition as to how the enterprise's values and goals would lead it to act under an assumed set of future conditions. It can also allow members to participate in refining that definitions, and to signal their concurrence in the goals. These are necessary conditions for the full utilization of human resources.

It is always a challenging problem, in a system as decentralized as that in the U.S., to create planning systems which serve to give some coherence of goals and yet preserve flexibility toward change and room for initiative. Yet even in the more centrally organized economics, as notions of independent "profit centers" become prevalent, similar problems will be faced. In the extremely decentralized U.S. private and public sectors we clearly have to face the fact that highly independent and individualistic planning will inevitably take place at the sub-unit level. Our only hope for coherence is to provide incentives for building networks of strong communication links and cooperative habits among the subunits, instead of trying to impose a central direction. Once more, patience will be needed as trust is gradually established in the mutual benefit of such linkages. Adaptive styles of planning must provide the needed flexibility, in which plans are more intended to highlight assumptions and alert planners to future changes in circumstances than they are to providing rigid roadmaps and schedules. The feedback mechanism, which allows continual adjustment of the plan in response to new information, will be more crucial than the original plan itself. The feedback system for plan adjustment is a continuation of the vital internal communication process which begins with the initial plan formation.

In all of the human factor issues of innovation discussed, labor management cooperation, dislocation mitigation, and participatory planning, it is clear that experimentation will be the key to success. We are dealing with the behavior of individuals and groups which are shaped by complex forces of culture, history, and local circumstances. No one system of participatory planning, for example, is likely to be successful in the diverse societies all grappling with the need to stimulate industrial innovation and productivity. These goals are only likely to be reached if managers and workers can see rewards in social and organizational risk-taking, even to the extent that a reasonable rate of organizational or social failure is accepted as an indication of a healthy experimental attitude.

It is in the spirit of this experimental process that I believe it will be so fruitful to use international working groups such as this to share and analyze comparative experience. The industrial world is changing very rapidly, in terms of technology, communication and marketing, competitive trade pressures, and the social structure of management and of work. One example among many is the impact of microprocessor-based computer and communication technology on industrial management systems. Many choices are newly presented: should the new technology be used for more extensive monitoring and greater central or hierachical control? Or should the information dissemination capabilities be used to broaden the base of leadership, and understanding of an enterprise's strategies and goals?

These technological changes present adaptation challenges to traditional institutions and patterns of industrial organization and management. They are occurring so rapidly that no single society will have the chance to experiment with the full variety of incentives and new organizational approaches which can be conceived. Yet there are in any case innumerable parallel experiments going on around the world, as each society and industrial organization tries whatever adaptation approach seems best for it at a given moment. The crucial need now is to fully use the knowledge and insight that these social and organizational experiments are bringing. This will require, first, the concerted exchange of experience among the industrial countries, and second, an emphasis in that exchange which stresses open discussion and adaptive learning, from mistakes and failures as much as from proud success. In this spirit, in this International Innovation Task Force and in society as a whole, we will be able to count ourselves fortunate to be active at a time when there is such great stimulus and incentive for the most creative of human organizational thinking.

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TRAINING FOR INNOVATIVE ACTIVITY

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1. Introduction

Successful innovative activities assure not only a corporation's future, but also its growth rate, and have a significant influence on industry as a whole. Innovators in many industrial enterprises, universities, and research institutes round the world are working on projects in numerous and varied sectors, each with different objectives. Thus the systematic exchange of progress reports and the resulting cross-fertilization of ideas is becoming more important than ever before. Innovative activities, therefore, should be focused mainly on sectors in which cooperation between interdisciplinary project teams promises to stimulate innovation. The results of innovative activity can then be rapidly and purposefully channeled into market-oriented development projects.

Innovation is the hallmark of all vital developments. New ideas, experiments, and discoveries deepen scientific knowledge and stimulate further technical progress. As technology comes to permeate all realms of life, an increasing number of problems must be solved by electrical engineering, which provides us with light, power, and warmth, allows intensive worldwide communication, and assures the smooth running of industry.

Innovation in electrical engineering is bringing about a continuous improvement of products and equipment, and above all, improvements in production processes, instrumentation, and process-control, while at the same time increasing the power of computers and data processing systems. The innovative activities of many of the present large electrotechnological enterprises began with the primary innovation of Werner von Siemens, whose needle telegraph greatly stimulated communications engineering. His paper "On the Transformation of Working Power into Electrical Current Without Permanent Magnets", in which he defined the dynamo-electric principle, was to provide the basis for power engineering.

Selective innovative activities provide the groundwork for the entire business effort of any large electrotechnological enterprise. Only through generic or product-oriented innovation can an enterprise assert its position in the main branches of electrical engineering on the world market.

The very diverse spectrum of electrical engineering products makes it necessary to review at regular intervals the principal directions of innovative activities and future prospects on the home and world markets. Efforts also have to be made to foresee in broad outline which technological trends are, sooner or later, likely to become firmly established.

It is necessary to consider very carefully whether each research or development project will be likely to yield a result which will find acceptance on the home or world market. And since innovations inevitably help to shape human living and working conditions, it is also necessary to show that the public interest is being served.

The limitations of industrial civilization are becoming increasingly evident, as basic raw materials become depleted and further industrial growth threatens to conflict with the ecological balance. But humanity today is living in an environment that takes its bearings from science and technology. Without technology, modern life would be inconceivable. Technical development shows, moreover, that many problems can only be solved by further selective innovative activities.

From the very outset the electrical industry has placed great value on realizing high energy conversion efficiency for generators and plants. In doing so, however, it does not rely on generators, transformers, power cables, switching galleries, and motors alone. Since the distribution and conversion of energy are complex processes which need to be optimized in the interest of overall efficiency, the electrical industry has developed automatic feedback control equipment and systems that enable the supervisor to make the most efficient use of the available electrical energy.

And so most of today's electrical innovations are occurring in process engineering, communications, and data processing. New instruments are monitoring the concentration of pollutants in the atmosphere. New techniques are helping to conserve raw materials and energy. The efficiency of material processing and energy conversion is being progressively improved with the aid of electrical engineering and electronics. In all branches of industry, electrical engineering is promoting qualitative rather than quantitative growth (Figure 1).

2. Behind the Front Lines of Development

Behind the front lines of development, new ideas and concepts must be tested for their technical applicability. Because modern electrical engineering relies more than ever before on knowledge gained through scientific research, basic studies of physical effects, materials, system principles, and software problems are essential in developing new technologies, equipment, and systems.

The strategies for all innovative product or process activities should be based on a policy of consolidating and advancing technical progress in all key fields of activity through continuous development. In line with this general policy, it is the responsibility of the central laboratories of a large technological enterprise to keep abreast of the latest developments in all branches of electrical engineering through contact with outside research institutes, and to remain in close cooperation with the various groups of their own enterprise and their development laboratories. In this way, the large electrotechnological enterprise can be assured that it will always operate according to the latest and highest standards.

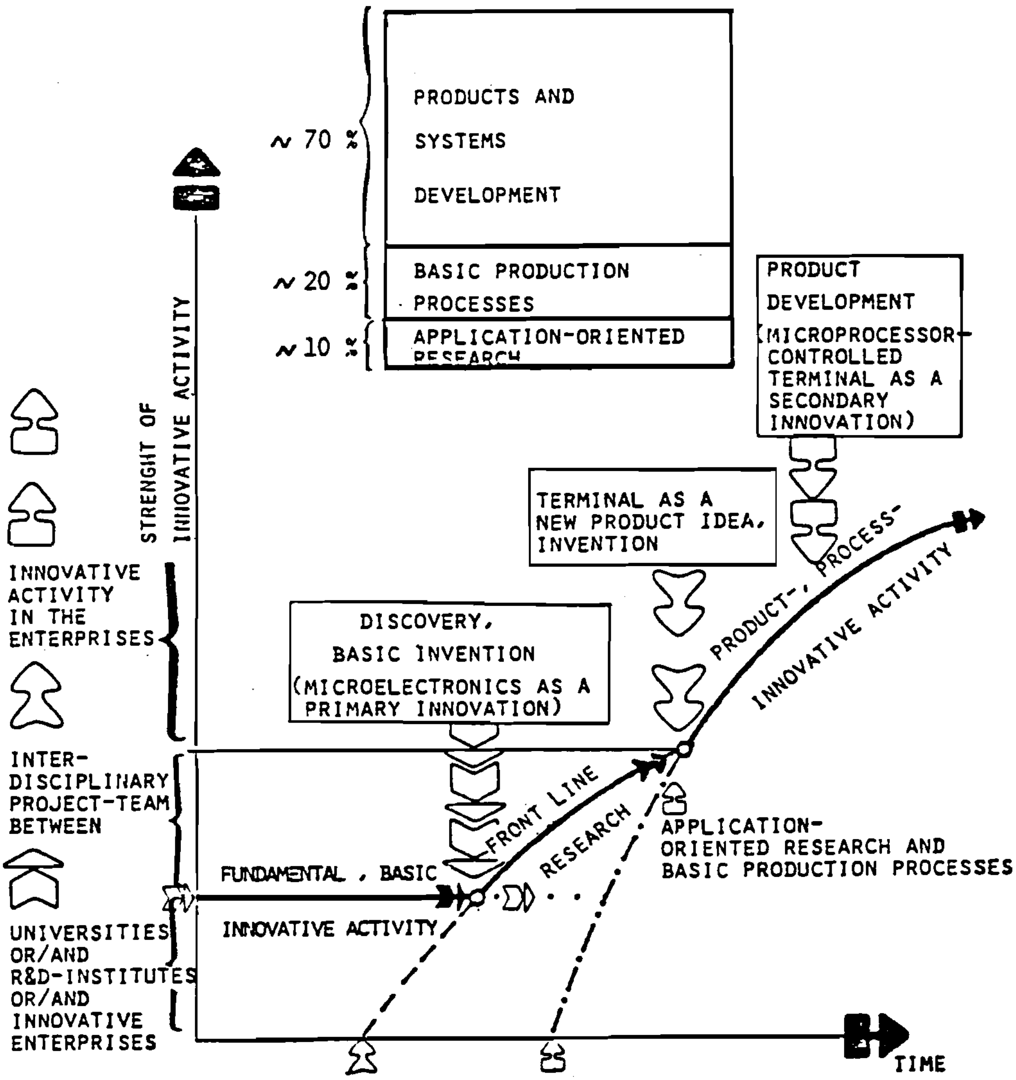


Figure 1. Distribution of innovative activities in large electrotechnological enterprises and large industry and the possible relationship between the universities, R & D institutes, and industry.

3. Structural Change Through Innovation

Innovation frequently leads to changes in working conditions. The modification of a production process or the introduction of improved techniques into established branches of industry invariably change the kind of work that needs to be done.

Innovations are prompted on the one hand by an increasing multitude of new human needs, and on the other, by new discoveries in natural science. In electrical engineering, new approaches have resulted in advances in material science, a broader application of machine intelligence, and advances in system-oriented conceptualization.

We should be fully aware that in some branches of industry, technical advances eliminate jobs. We should also be aware, however, that every successful innovation creates numerous new types of work in the areas of organization, basic production planning, and quality control. To a large extent, the resulting structural change means a shift from lower to higher grade jobs.

4. Microelectronics as a Primary Innovation

The changes brought about by a primary innovation can make it possible:

- to renew existing technologies, products, methods, and qualifications
- to create new technologies, products, methods, and qualifications
- to eliminate complex and unmethodical forms of organization
- to overcome the barriers resulting from technical and scientific specialization
- to prevent the isolation of specialized areas
- to meet an enterprise's targets with regard to results and development
- to release staff within a short period
- to guarantee full employment and continuing social progress (Figure 2).

The advent of microelectronics has marked a technical evolution of the first rank. Microelectronics may be seen as a primary innovation, destined to inspire a multitude of secondary innovations in practically all branches of engineering. In the same way that electrical appliances relieve human beings of mechanical chores, microelectronic circuits will relieve them to an increasing degree, of routine brainwork. Microelectronics are likely to prove to be a worldwide basic invention and primary innovation, penetrating through diverse economic and social spheres.

5. Behind the Front lines of production

The implementation and further development of appropriate process technologies is today the primary responsibility of product engineering. The increasing precision and performance required by new products imposes exacting demands on all production processes and quality

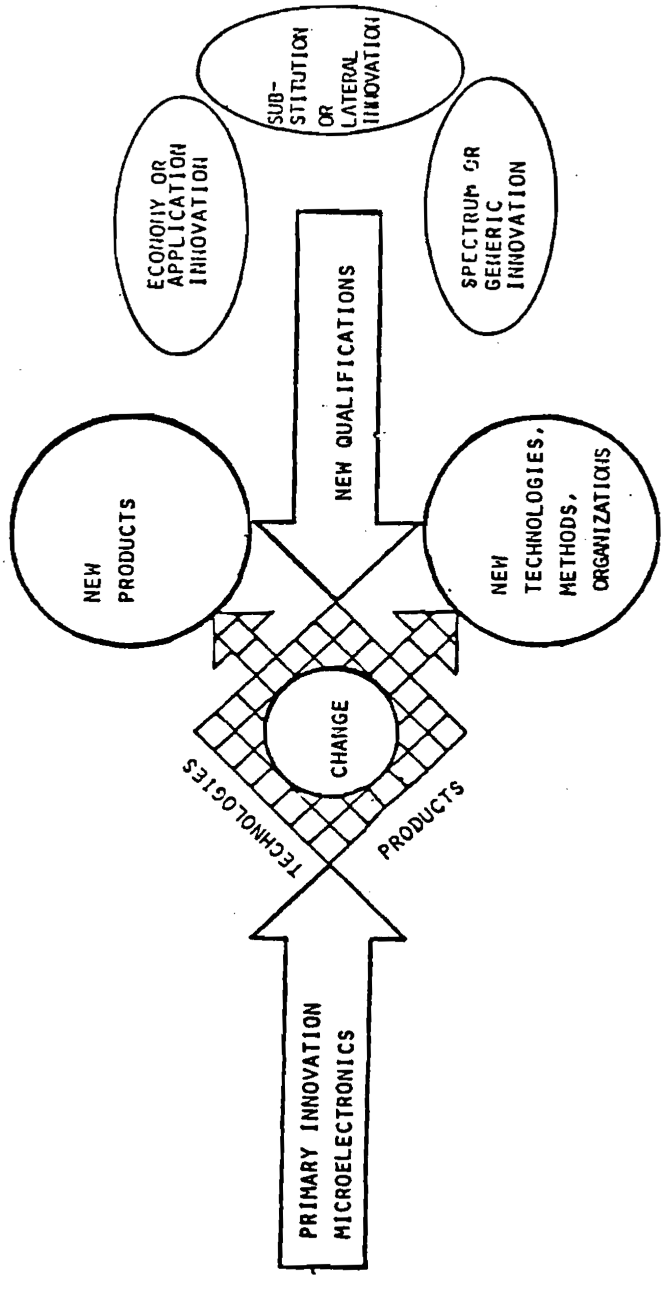


Figure 2. Possible changes induced by microelectronics as a primary innovation: technologies, products, methods, and qualifications.

control procedures.

Technology, organization, and productivity improved continually. New materials and technologies have to be studied and refined to the point where they can be used for large-scale production.

Conventional mechanical engineering and precision mechanics must be further developed, as do new physical and chemical processes, such as laser-beam lithography, film deposition, photographic technology, and precision electro-plating. The same is true of new plastic materials for improved insulation, microscopic inspection with electronic eyes, and sensors that increase production flexibility (Figure 3).

6. Innovation Promotes a Balanced World Economy

Technical development in industry should be seen primarily with a view to increasing global integration. For international cooperation to flourish, it must rely on the coordinated exploitation of all available capacities. Many worldwide development projects are justifiable only in the light of an international division of labor and economic integration. The highly industrialized countries in East and West have the important obligation of technology transfer to the developing countries in the South.

At this point a short review may help to underline the fact that precaution is necessary in efforts to meet economic and social targets. Figure 4 shows the primary innovations that have changed work, technologies, working methods, enterprises, and society more than once in the last 200 years (Figure 4).

We will continue to need technical progress in the future for a number of reasons:

- First, to support the individual, the enterprise, industry, economy, and society, and to help in their development.
- Second, to maintain a high standard of living and the prosperity achieved so far by technical civilization.
- Third, to help other people as well, especially those 80% of the world's population who have come off so badly and who are claiming their rights and their shares.

In his book *The Great Hope of the 20th Century*, Fourastie (year????) spoke of an increase in product output per unit of raw material or working hours, referring to satisfying the needs of the greatest possible number of human beings.

A retrospective view makes it clear: the enterprise's interest should always concentrate on the primary innovation and key new technologies. Exact knowledge of the technology itself and of its particular range of application are essential.

In particular, primary innovations compel us to try to meet future demand by means of a continual increase of professional knowledge--well-planned and with an end in view. Through an increase in efficiency and shedding the load of relief of the demand for primary innovations and key technologies, microelectronics, are today encouraging inventions all over the world, which will lead to the development of new technologies, products and methods (Figure 5).

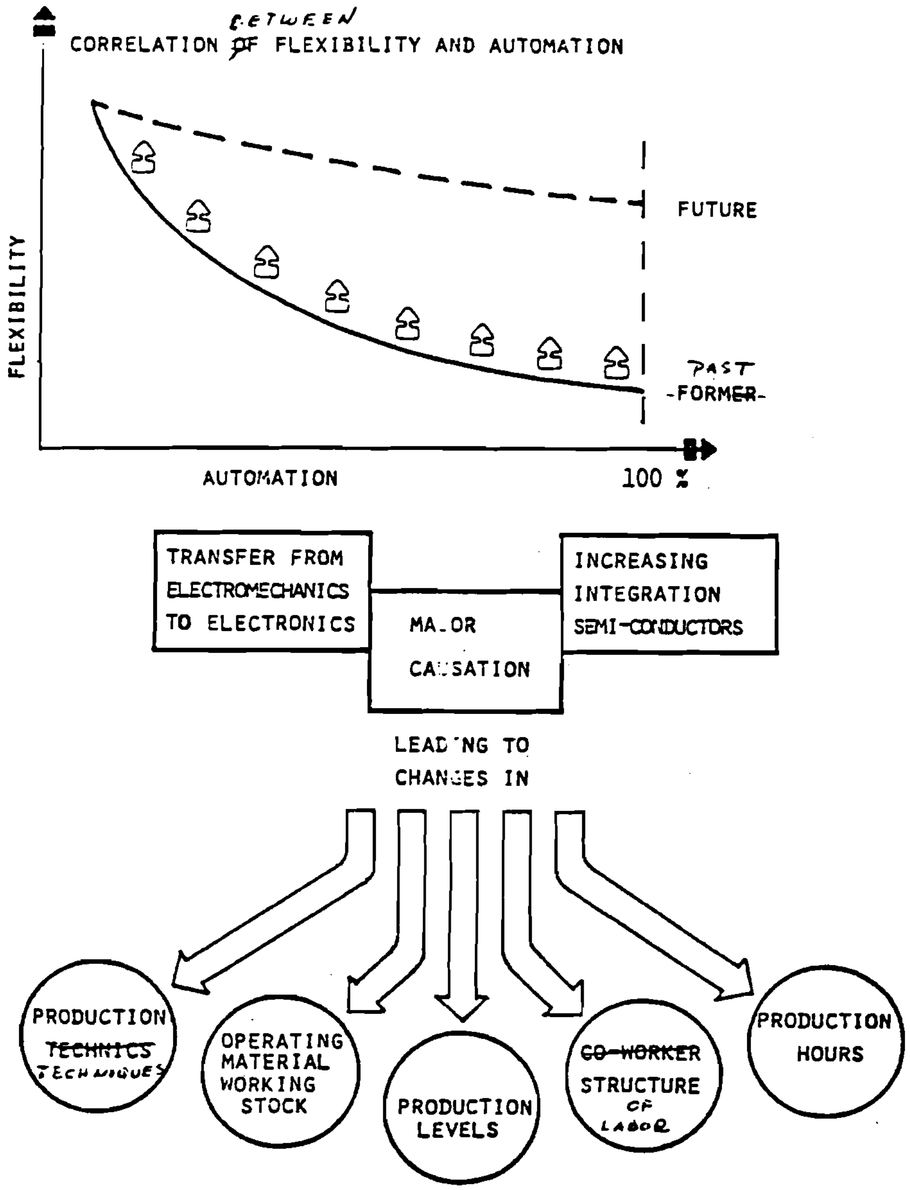


Figure 3. Behind the front lines of production—new qualifications are necessary to develop new technologies and new organization for new products.

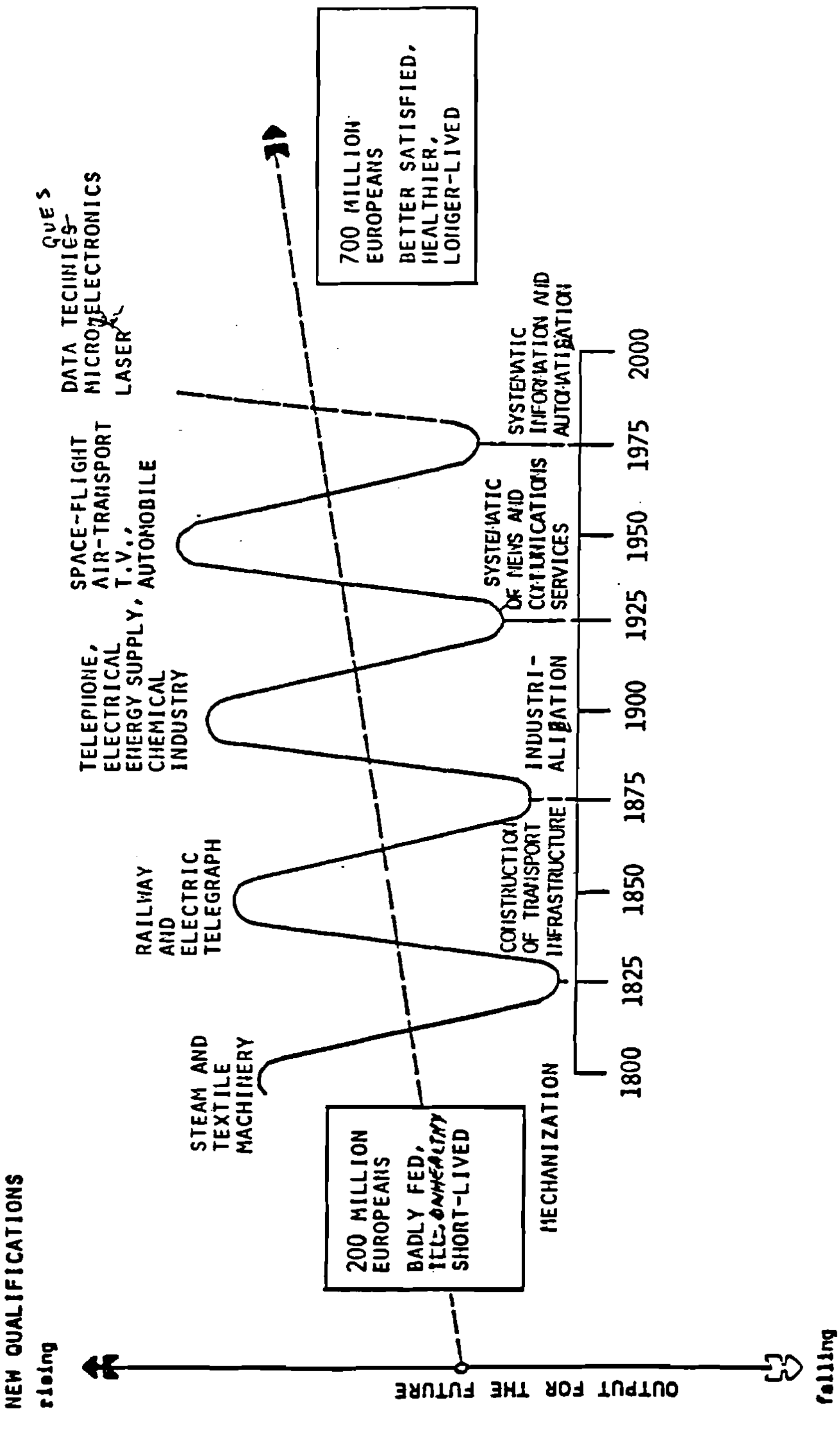


Figure 4. Primary innovations that have changed work, technologies working methods enterprises and societies during the last 200 years.

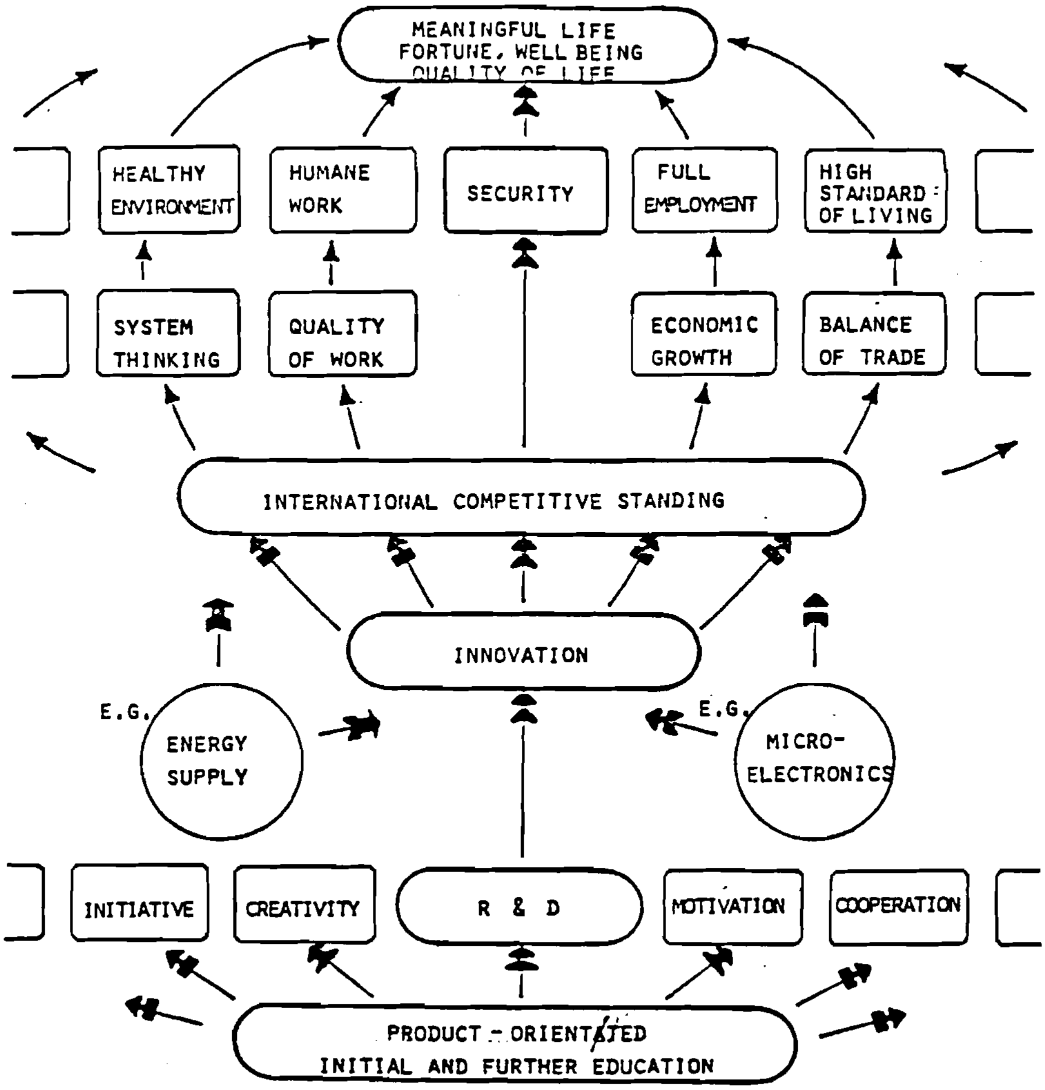


Figure 5. Innovation as the basis for international competitive standing.

7. Trends in Production

Industry today can only operate productively by employing the most advanced machines and technologies. And productivity depends heavily on the level of mechanization and automation. Here electrical engineering and electronics are setting the pace of progress. Increasing automation and complexity in industrial processes is being accompanied by the need to invest ever greater engineering effort into systems development. (As an example, automatic feedback control is being increasingly integrated with power engineering.) Complex process technologies require effective monitoring: every abnormal condition must be recognized instantly and intelligibly so that fast remedial action can be initiated.

More clarity in production allows fast, selective intervention during machine loading, material flow, inventory building, or balancing the workload among personnel. In this way production is made more efficient, machine tools can be optimally loaded, power, raw materials, and storage space are conserved, and the quality of the finished product is improved.

Another important trend in products is the increased use of numerical control of machine tools, which has gained a time-honored place in medium-quantity production runs for parts manufacture. Its advantages are the constant high quality of the finished parts and shortened machine-loading and production times. The result has been an increase of 100% or moreover that of conventional machines.

Modern numerical controls are so compact that they can be accommodated for inside the machines themselves. Mechanical machine tolerances are electronically compensated for. The new numerical controls herald a new phase in automation in the sense that they encompass the entire spectrum of small and large, simple and complex machine tools, **while at the same time they are of interest to small production runs and** even individual production of parts.

8. Training: Possibly the Most Effective Tool for Solving Programs and Promoting Innovative Activities

"The Glossary of Training Terms" published by the UK Department of Employment defines training as "the systematic development of the attitude, knowledge, skill-pattern, required by an individual in order to perform a given task or job. This is often integrated with further education." (See Figure 6.) They then define a ccompany's training need as "the difference between actual and required performance in some specific area of ccompany operation, where improvement through training is the most economical way of eliminating the difference."

This is the area in which each enterprise should be most interested--the most economical method of bridging the performance gap. Technical development requires a new way of thinking, especially in the field of education and further education. Professional qualification, being a production factor of the highest order, will gain more importance, as demands for qualification rise simultaneously with technical, economic, and social progress. This means that all who have already learned a lot, will have to learn even more to bring their knowledge up to date.

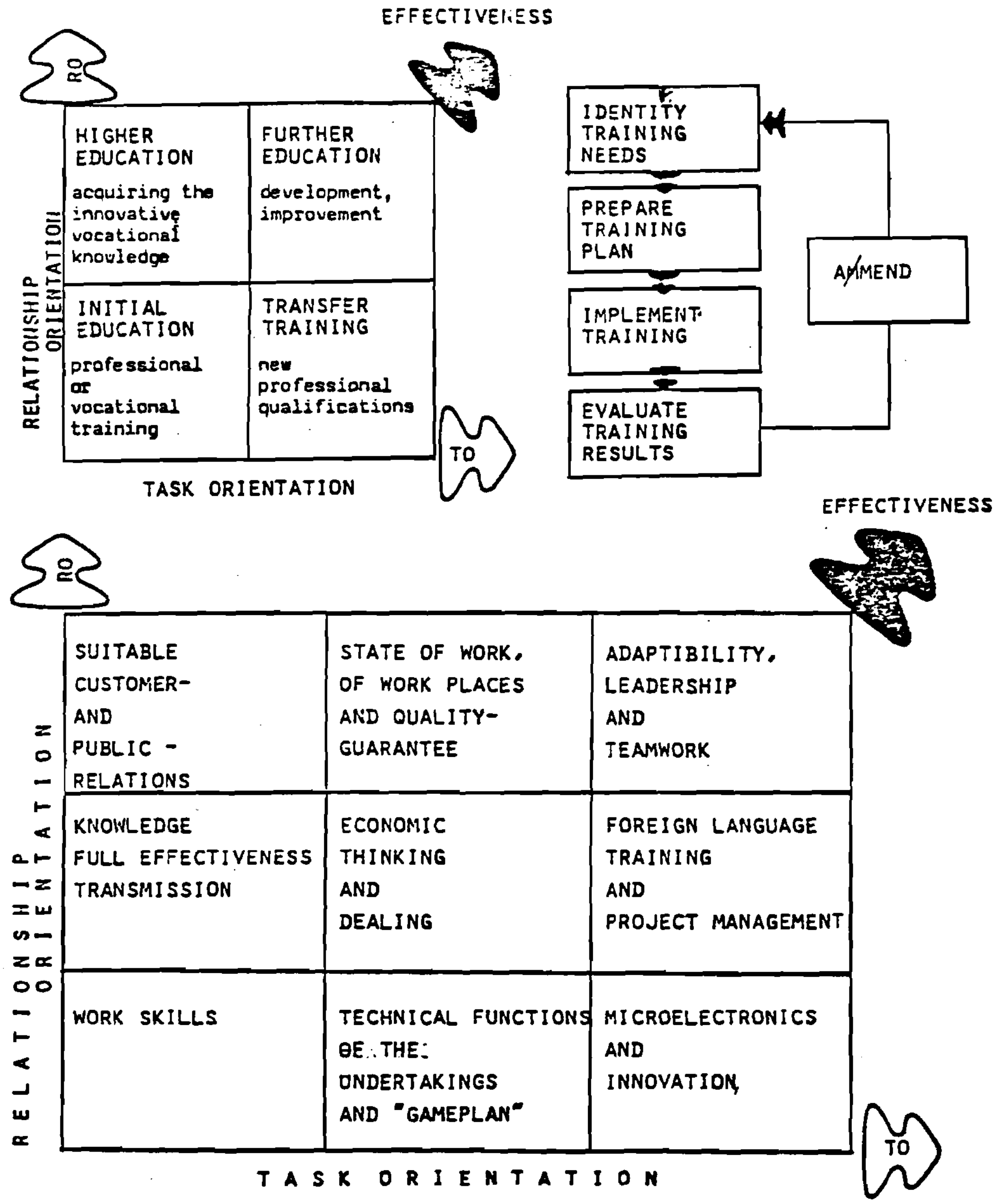


Figure 6. Training—the most economical method for bridging the performance gap.

There are basically four areas to look at in order to identify training needs:

1. The strategic planning of a technology-based enterprise
2. Problems associated with work tasks
3. Problems associated with manpower turnover
4. Problems associated with the organizational structure. (See Figure 7.)

9. An Example of a Transfer-Training Program: From Mechanic to Microelectronics Technician

Within the production methods, microelectronics have created a new relationship between workmen, who are called now "microelectronics technicians", and their implements and machine tools, we should like to make two brief comments about the trend toward increased rationalization. First, machinery--'intelligent' or not--will always take a subordinate place in the relationship between man and machinery. Now and again, conjectures are made about this, but the 'intelligence' of data processing is preliminary and predisposing, not dominant and sovereign. Second, unemployment can be avoided through new products and accomplishments, rather than by less rationalization. A loss of market threatens full employment far more than a well-calculated reduction of staff by rationalization ever can. The opening-up of new markets by means of economic and technical innovation is essential, if economic modernization is expected to be conducive to employment conditions.

Towards the end of 1977, an Austrian electronic enterprise initiated a one-year transfer-training program. Mechanics were retrained as microelectronics technicians in the fields of digital techniques, microminiature electronics, and their application. Since then, workmen from research and development departments, from production, distribution, installation, and service are being trained for new positions. The need for training 'micro-miniature' electronics technicians', resulted from a visible lack of qualification on the part of the present mechanics with professional experience, who in the future, will be held fully responsible for the operation of numerically-controlled machinery, inclusive of programming. (See Figure 8.)

Consideration of alternative solutions led to the decision that mechanics should be retrained as qualified microelectronics technicians. The mechanic attains the technical level of a certified engineer in a very special field, and is appointed to a position for which his mechanical skill together with his newly-acquired qualification (programming) is required. Retraining is in five to seven dual stages and lasts one year. The use of modern adult teaching methods makes it possible to address all channels of human receptivity (Figure 9).

10. Microelectronics: A Challenge to Initial and Further Education As Well As to Transfer-Training in the 1980s

NO.	ITEMS WHICH INDICATE POSSIBLE TRAINING NEEDS	CATEGORY OF TRAINING NEEDS	POSSIBLE TRAINING SOLUTIONS
1 A	The introduction of an advanced production process	What training will be required by the - production operators? - supervisory personnel? - maintenance personnel?	Run a transfer training programme for mechanics to microelectronic technicians
1 B 1 C	The enterprise will in future enter a new market with new products	What training will be required by the - innovation project managers? - R & D personnel? - sales personnel? Is it an overseas market?	Training in - strategic planning - managerial effectiveness - problem solving methods - creativity technics - leadership and decision making - product and system knowledge - project language etc.
2 A 2 B	Quality problems	Are we getting the help from all areas to produce the highest possible quality level? What training will be required by - managers - supervisory personnel - production operators etc.	Run a training programme for managers and supervisory personnel in - value analysis - zero based budgeting - management by objectives - quality control circle "Jishu Kanri"
3 A	A large number of new entrants leave after a short period	- Poor introduction training? - Recruiting the wrong people?	- Run an introduction programme - training in recruiting and selection methods
3 B 3 C	Graduates and specialized staff don't work effectively	- Lack of development possibilities? - salary conflicts? - problems in task and relationship orientation?	- Job development-, rotation- and enrichment programme - training to introduce a scheme of job evaluation - cooperation training programme
4 A	Bad relationship between departments	Lack of proper job specifications	Course on situation analysis and writing "effectiveness-areas"
4 B	Problems in getting answers	Lack of concrete decisions and/or management always changing their mind	Training in - Management by Objectives - Managerial Effectiveness - Problem solving methods
4 C 4 D	Feeling that there is too much favouritism	To introduce an objective appraisal system	Course on appraisal techniques

Figure 7. Examples for possible training needs and solutions.

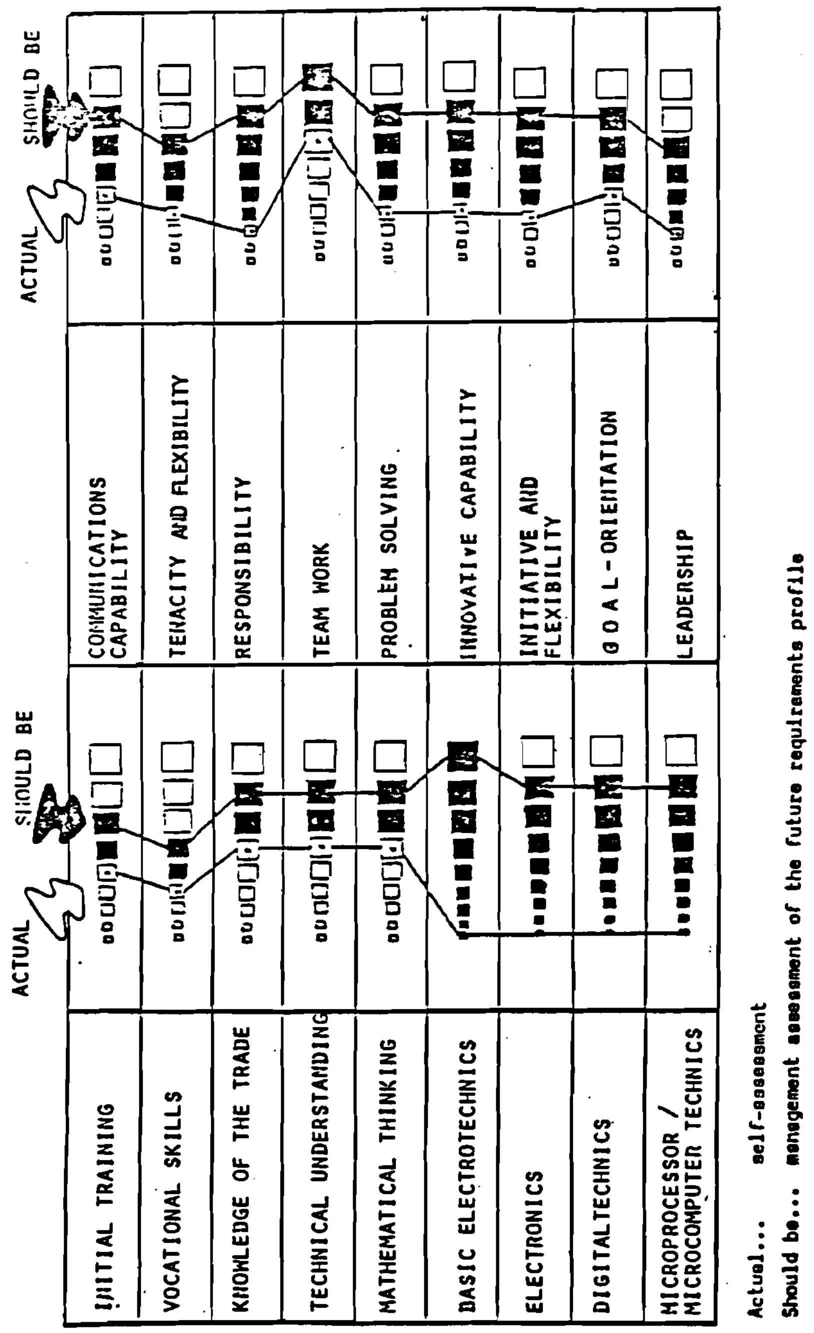


Figure 8. New requirement and qualification profile difference between mechanic and microelectronics technician.

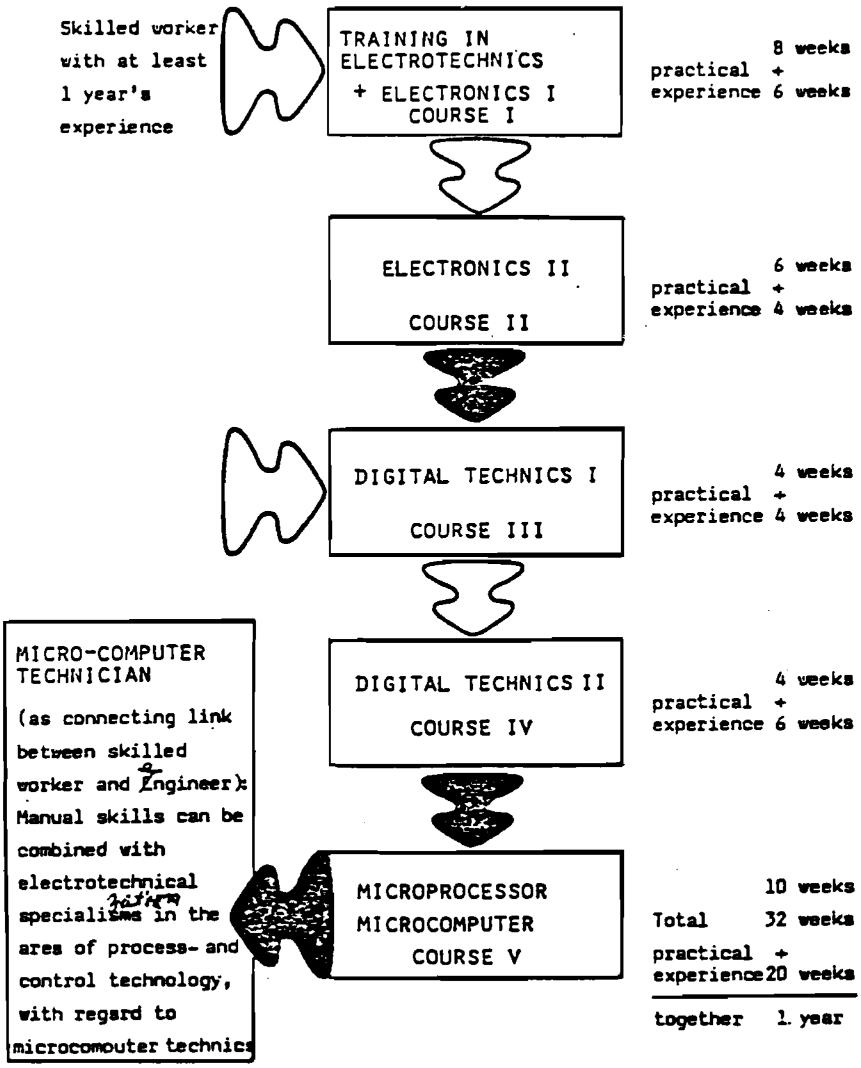


Figure 9. A transfer-training program: from mechanics to microelectronics technicians.

Microelectronics are likely to be the key technology of the 1980s worldwide. The current situation is as follows: some million jobs actually make use of instruments and implements that have been constructed at some 100,000 jobs, from elements which, in turn, originated from some 10,000 jobs.

A decade ago, 75% of the products now constructed at those 100,000 jobs did not exist at all. Daily life is being changed by an estimated 25,000 new products--in households, in traffic, on the production line. And there are a good many products we do not even know about yet (Figure 10).

Knowledge accumulates from many different fields. In view of the thousands of years during which only ordinary tools were used, the consequences of this newly-grown data processing 'brain' tool need to be understood--in fact, more than any previous historical evolution--or we shall be at its mercy, for it cannot be stopped.

Until recently mechanization has been restricted to mass production. Earlier technology did not permit brisk adaptation to changing market conditions. Microelectronic movement-control mechanisms are expected to promote high-grade flexibility in automatic production within small-scale manufacturing operations. (See Figure 10.)

Demand for newly qualified staff who are trained in the use of microminiature electronics will increase in the future.

Management and workers, teachers and students will have to cope more and more with "soft" immaterial technologies, for the software technologies--based on microelectronics,--have started to become essential for future products and methods. (See Figure 11.)

11. All-Round Problem-Solving Through Integrated Systems

In the future, system-oriented conceptualization will influence innovations to an ever-increasing degree. Any technical problem needing a solution that is favorable both technically and economically should necessarily be considered within the context of all the given boundary conditions, and treated as a system. This applies to all industrial processes, from energy conversion to telecommunications.

Materials research, computerization, and system-oriented conceptualization represent a general trend that can be expected to influence the innovations of electrical engineering in the coming years. (See Figure 12.)

The following list shows some of the areas in which innovative activity is currently taking place:

Energy

- Conversion of primary sources of energy
- Electricity and gas from a combined distribution network
- Current switching *in vacuo*- - compact-style switching stations for extra-high voltage
- Space heating as an integrated system

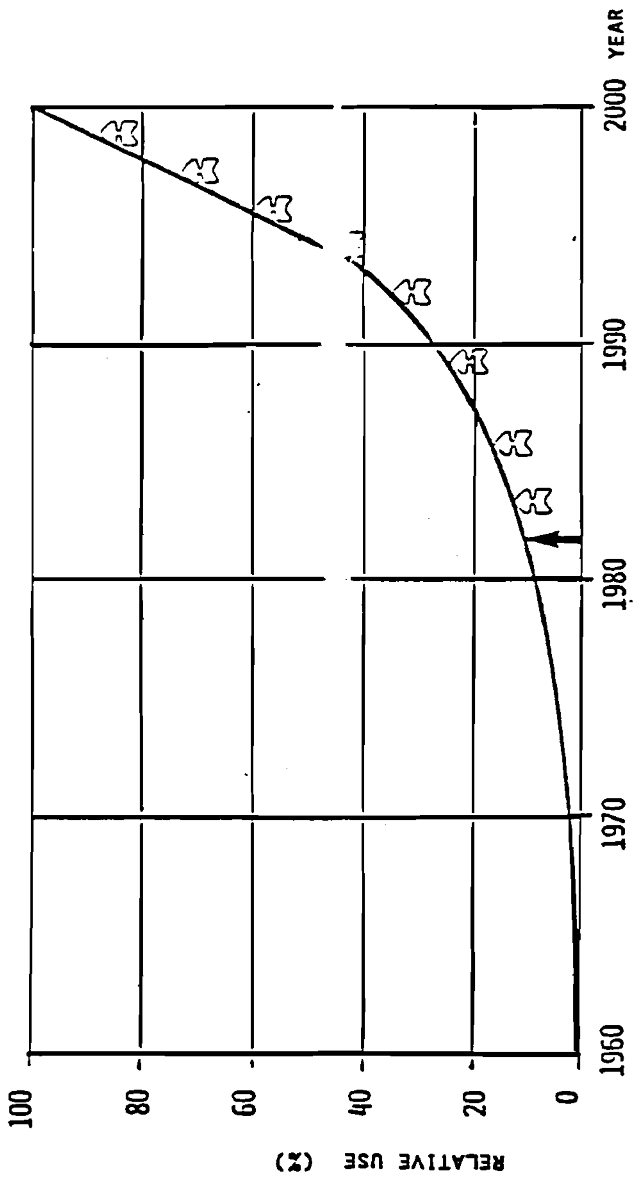


Figure 10. Use of microelectronics relative to possible use in the year 2000.

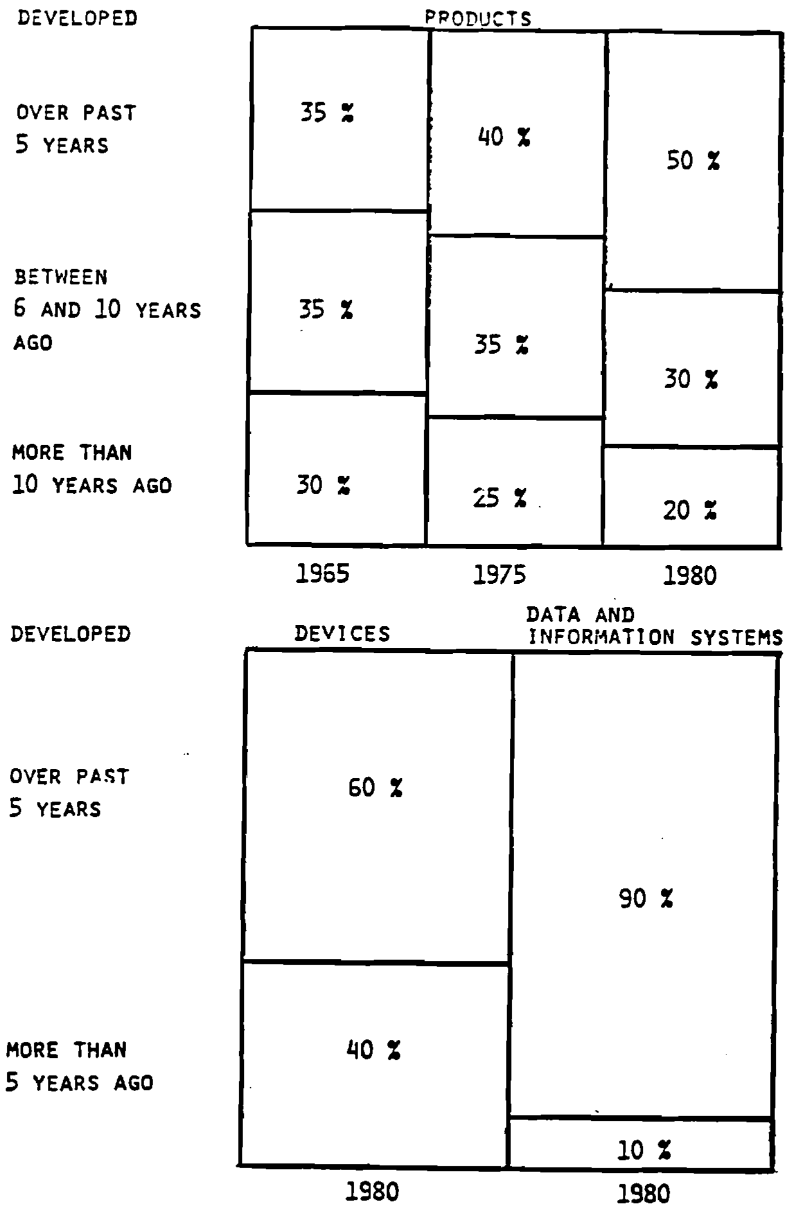


Figure 11. Average sales breakdown of large electrotechnological enterprises: products, devices, data, and information systems developed over the past 5 years/ 6-10 years ago/ more than 10 years ago.

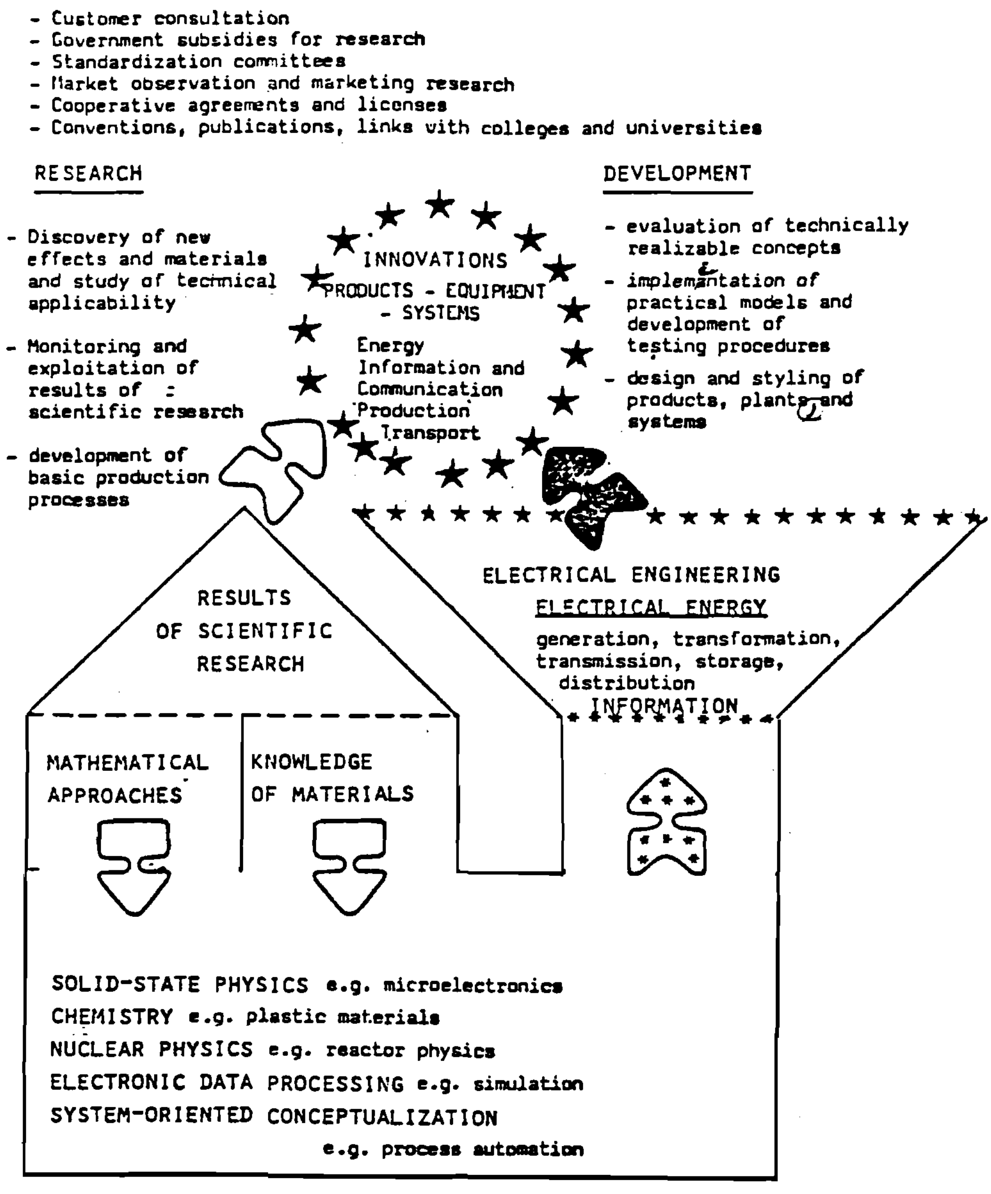


Figure 12. Innovative activities and responsibilities in a large electrotechnical enterprise.

- Large superconducting magnets for nuclear fusion

Information and Communication:

- Additional services through electronic switching systems
- More digital technology for more additional versatility in the telecommunications network
- More adaptable and flexible computers
- Light as a communication medium

Production:

- Increased automatic feedback control
- New process technologies that conserve both material and power
- Broadened application of process control through microelectronics
- Increased automation in industry

Transport

- Better coordination of traffic flow
- New very fast railway systems
- Flexible control in short-haul and long-haul public transportation
- Automated site determination and vehicle identification in road traffic
- Increased safety in rail traffic through distributed automation
- Transportation without noise or poisonous fumes in conurbations.

12. Innovations Past, Present, and Future

Each large electrotechnological enterprise has had milestones in its development, in the form of scientific discoveries, basic inventions and patents, primary and secondary innovations, novel equipment and systems, etc. Thus development, which is based on the continuous growth of knowledge, is backed by countless smaller discoveries and innovations in constructional design and production processing.

In a dynamic and changing world, a large electrotechnological enterprise can find and keep its balance only through continuous innovation. (See Figure 2?????.) Effective research and development should be based on a meaningful strategic planning concept. At the outset of the strategic planning process the answers must be found to the key question, "Which technologies should we be involved in and which technological opportunities should we pursue?" These questions may be answered through a process of deliberate exploration and planning, or in a considerably less systematic way. But whatever the answers, they will have strong implications for all the enterprise's research and development efforts, its operations, its competitive position, and its ultimate well-being. (See Figure 13.)

Figure 13 shows the complex interrelations involved in the origination and development of an innovation. The figure shows that the innovation process runs parallel to the process of strategic planning; creative ideas, which flow continually into the enterprise from the market and from technology, are selected and put into effect with the aid of strategic methods. The introduction of the element of strategic planning into innovative activity requires that, through organizational measures, a continuous dialog be established between those responsible for research and development, construction, production and marketing, and the management of the enterprise. Even in the technical sphere, new projects and driving-forces capable of changing the strategic framework within which enterprise operates arise frequently.

13. Training for Innovative Activity and Managerial Effectiveness

In the recent past there has been a growing awareness of the need to better integrate training for innovative activity with other top management tasks. The aim of training for innovative activity is to make managers and their organizations more effective.

Managerial effectiveness is the extent to which a manager achieves the position's requirements for output. A manager's job--his only job--is to be effective. Managerial effectiveness must be defined in terms of output rather than input, i.e., by what a manager achieves rather than by what he does. Effectiveness is best seen as something a manager produces from a situation by managing it in an appropriate way. Every management job has effectiveness standards associated with it. They may not be written down, or even known, but they are always there. NH 1
Goals, Control, and Management

A manager's job can be viewed as a sequentially integrated series of steps. Goals for the organization and its employees need to be set, results need to be measured, and managerial action needs to be taken in response to those results. These steps are shown in the acccompanying figure (Figure 14), in which the solid linking lines indicate the basic control steps.

As the figure shows, the evaluation of results normally takes into account both expected and actual results. Management's next step is to attempt to reinforce satisfactory performance with rewards, or to correct unsatisfactory performance with penalties or training. The managerial response may also include a revision of goals to reflect changed expectations as a result of recent experience. Every manager is responsible for the execution of the basic steps shown in the figure. However, the ways in which managerial control functions are conducted can vary greatly.

14. The Effectiveness of Innovation Management

The effectiveness of innovation management is the extent to which managers of innovations and their organizations achieve the goals set by themselves and their organization. The managers and the organization, as well as the prescribed goals, should be innovative and effective. Innovation is one of the control issues in management. The limiting factors, such as knowledge, intent, or lack of external persuasion alone are not sufficient to be innovative. The main limiting factor is often a behavioral

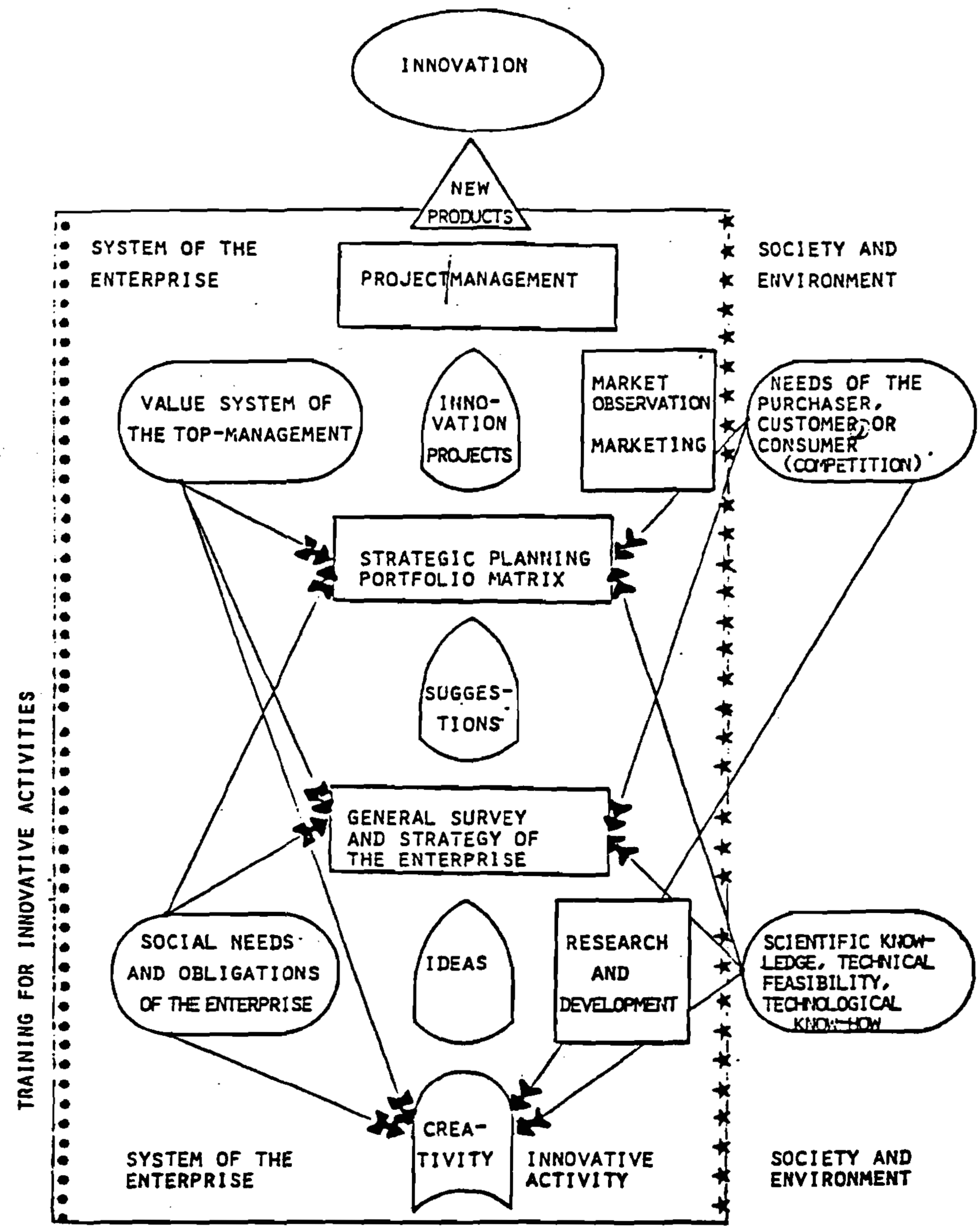
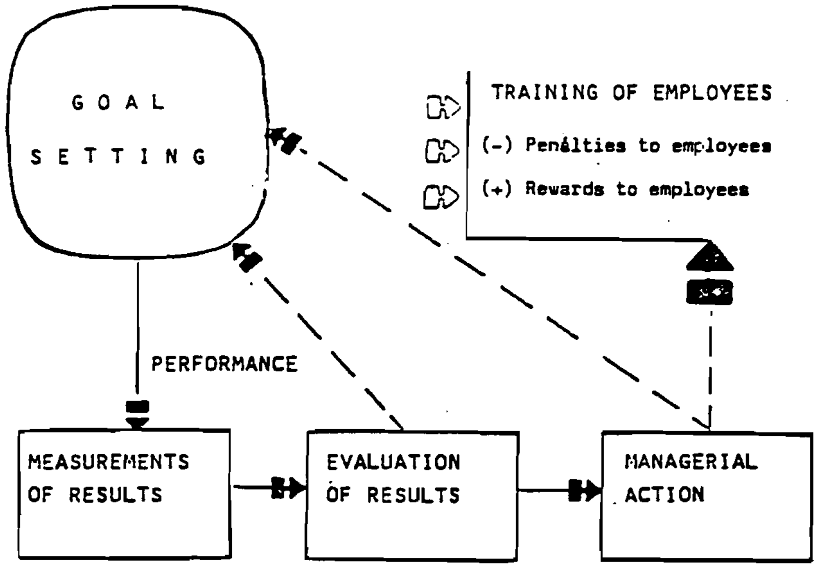


Figure 13. Basic schedule of the innovation process for new product.



"In the grammar of social institutions the word "controls" is not the plural of the word "control". Not only do more "controls" not necessarily give more "control" - the two words, in the context of social institutions, have different meanings altogether. The synonyms for "controls" are measurement and information. The synonym for "control" is direction. "Controls" pertain to means, "control" to an end. "Controls" deal with facts, that is with events of the past. "Control" deals with expectations, that is with future. "Controls" are analytical and operational, concerned with what was and is. "Control" is normative, concerned with what ought to be, with significance rather than with meaning.

If we deal with a human being in a social institution, "controls" must become personal motivation to lead to "control".

Peter F.Drucker

Figure 14. Controls, controls, and management.

one.

Innovative managers in the 1980s need to learn how to manage social systems, and how to manage themselves in them. Managers generally know what actions will improve things, but they often do not take them (Figure 14a).

An innovation manager's job is concerned with handling a number of different and often complex situations. Each managerial situation is different; it places different demands on the manager. There is no set formula for solving each situation that arises. Therefore, being able to diagnose situations is a most useful managerial skill.

15. Training Guidelines for Innovative Activity

A training program for innovative activity is based on two factors which make up all managerial behavior:

- getting the innovative task done
- teamwork with other people to improve innovative activity.

Any behavior exhibited by an innovation manager is to some degree concerned with one or the other, or both (Figure 15).

We can describe behavior concerned with task-orientation as the extent to which a manager directs his own and his subordinates' efforts, characterized by initiating, organizing and control. And we can describe teamwork orientation as the extent to which a manager has personal job relationships characterized by innovation, listening, trusting, and encouraging.

Innovation effectiveness results when the appropriate basic style of management is used. A situation involving an innovation manager can be broken down into five elements which contain all aspects of this style:

- technology
- organization
- superiors
- co-workers
- subordinates (See Figure 16).

The organization, the superior, the co-workers, and subordinates demand that the innovation manager uses a certain basic style. For instance, certain innovation managers expect their team-members to manage with a high degree of task-orientation, while others expect a high degree of team-orientation, or some combination of the two. In the same manner, an innovation manager's team-members expect him to manage in a particular way.

16. Methods of Effective Innovation Management

Since innovation is a complex process which over time involves the interaction of many different corporate functions, it can only adequately studied and analyzed within comprehensively defined units.

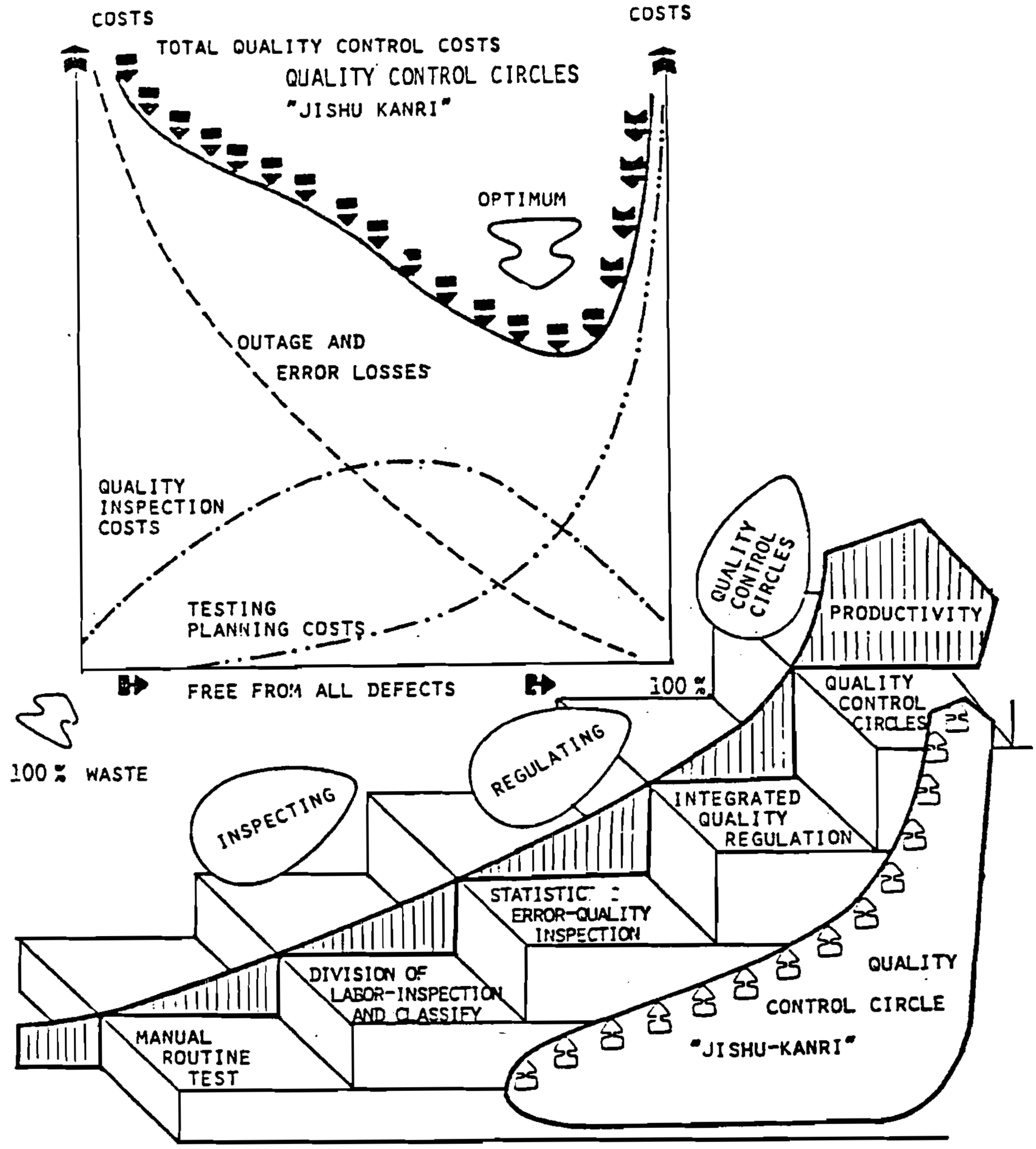


Figure 14a. Quality control and operation improvement for more effective quality control.

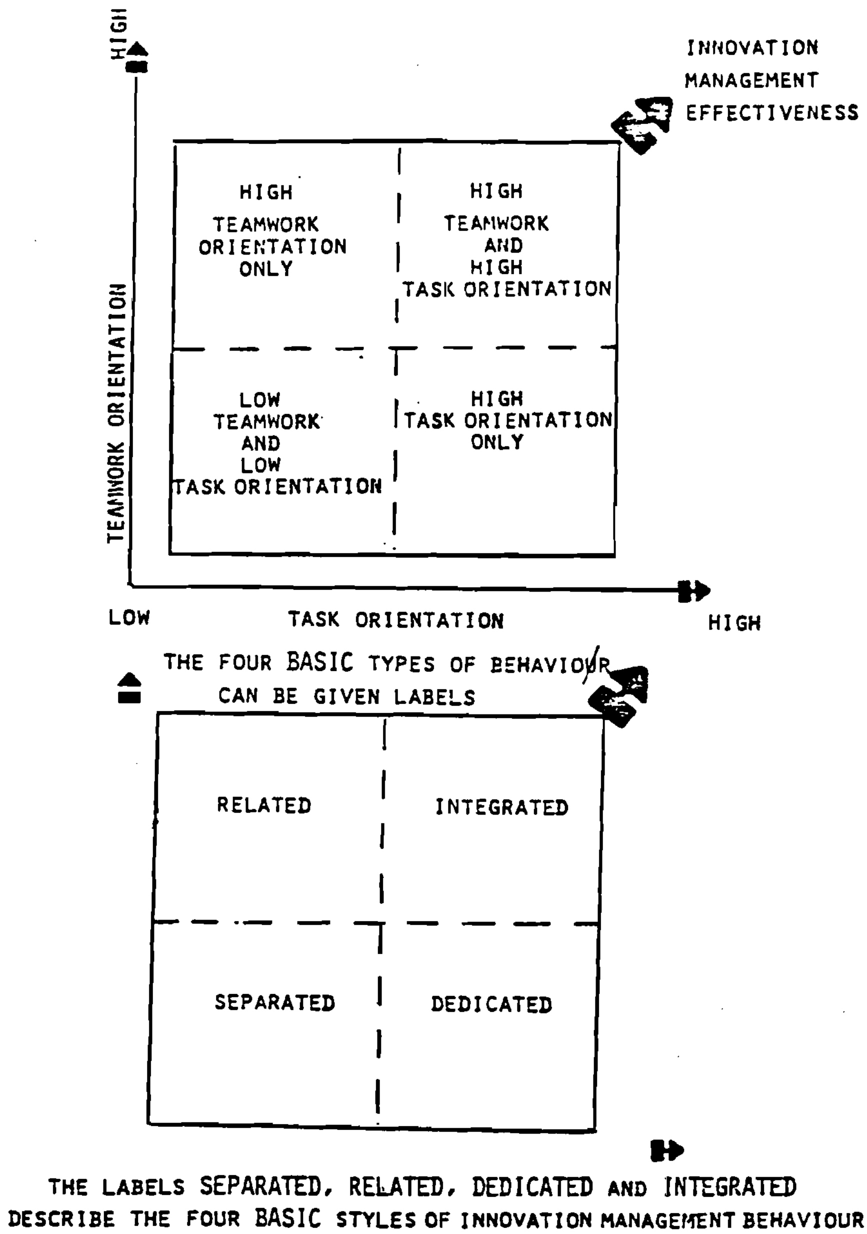
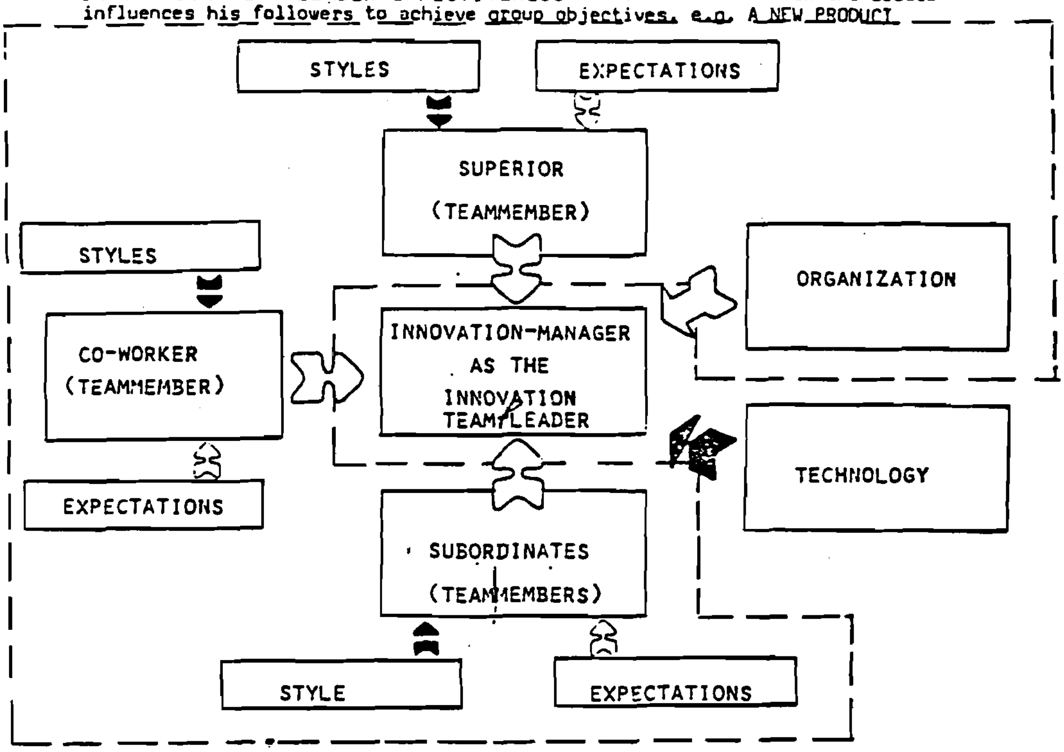


Figure 15. Four types of innovation management behavior in order to be more effective in any given innovation situation.

INNOVATION MANAGER AS THE "INNOVATION TEAM" LEADER

A manager seen by others as being primarily responsible for achieving group objectives, e.g. a specific INNOVATION GOAL

INNOVATION TEAM LEADER EFFECTIVENESS - The extent to which the leader influences his followers to achieve group objectives, e.g. A NEW PRODUCT



TECHNOLOGY - The way work may be done to achieve managerial effectiveness

ORGANIZATION - All the factors which influence behavior within a social system that are common to essentially unrelated positions

SUPERIOR - A person having authority over a manager and responsibility for his work

COWORKER - A person with whom a manager works who is neither his superior nor a subordinate

SUBORDINATE - A person over whom a manager has authority and for whose work he is responsible

MANAGER - A person occupying a position in a formal organization who is responsible for the work of at least one other person and who has formal authority over that person

Figure 16. Five situational elements a situation manager must recognize, respond to, or change.

A strategic product/technology unit comprises a product and its underlying technology, the associated production facilities, research and development which support the product, and technology and the marketing and service function (Figure 17).

17. Market-Pulled vs. Technology-Pushed Innovations

There exists a well-established distinction between technological innovations that are 'pulled' by the market, and those which are 'pushed' by technology. The former are innovations for which a market need has been perceived. A technological means is sought for making possible the design and manufacture of a product that satisfies that need. In contrast, technology-pushed innovations are driven by a technological capability in search of an application that serves some useful consumer need. In this case, technology is the driving factor.

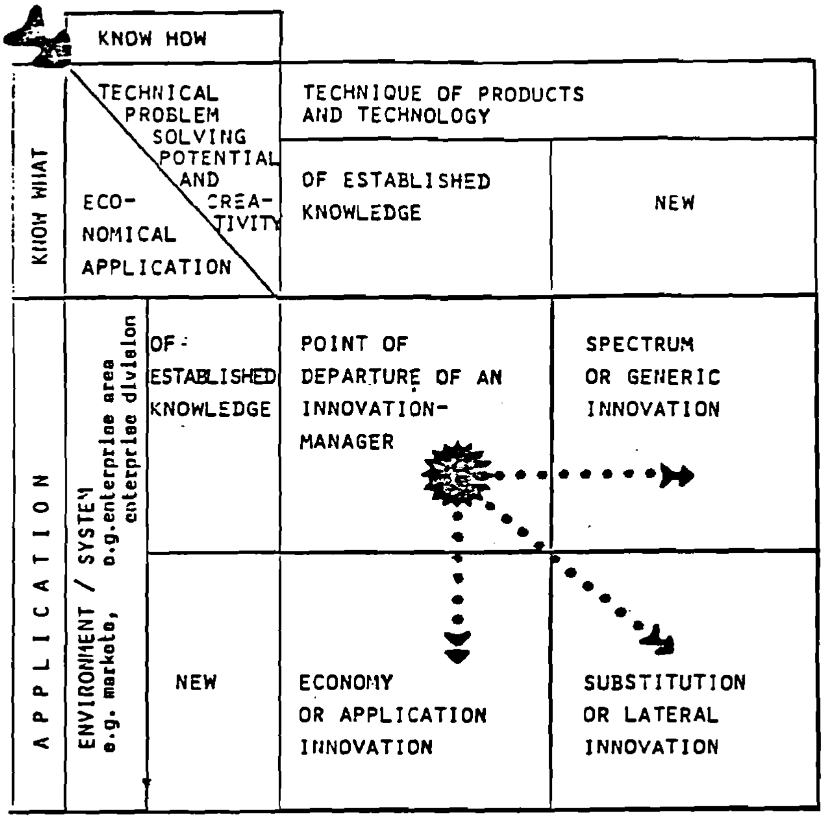
Since the two types of innovation are driven by different forces, one could reasonably expect life-cycles to be somewhat different. In the case of technology-driven innovations, for instance, it is quite feasible not to consider the life-cycle of a product, but rather to analyze the dynamic development and maturing of the generic technology which underlies it. This underlying generic technology may move in and out of a given product and may have application in a variety of other products.

When analyzing market-pulled innovations, it seems more appropriate to look at the product life-cycle, and to analyze the development of a product concept and its associated product specifications and performance criteria. In the course of the development of such a product concept, different technologies may be used; in the late 1950s and early 1960s, for example, transistor technology began to replace electron tube technology in computers.

Below we shall describe two life cycles: one for the development and maturing of generic technologies, and one for product concepts. These two life cycles are characteristic of the two principle forces which govern technological innovation: market pull and technology push. It must be kept in mind, however, that a product is a true combination of a market need and a technological feasibility: product concept and technology interrelate closely. In fact, a product can alternate between being pulled by the market and pushed by technology, as happened in the development of semiconductors. The interaction of technology and product concept can itself become a dynamic factor. The well-known product life cycle concept has been widely used, yet its benefit as a planning tool has repearedly been called into question because literal adherence to the concept may simply make it a self-fulfilling prophecy (Dhalla and Yuseph, 1976).

Three phases in a product's life cycle, analogous to the decision-making process, can be distinguished:

- Innovation period
- Maturity period



- MICROELECTRONICS ENABLES ALL THREE KINDS OF INNOVATIVE PROCESS TO TAKE PLACE.

SCHUMPETER EMPHASIZED THE ROLE OF THE INNOVATIVE MANAGER (THE INNOVATOR, THE DEVELOPER, THE PROMOTOR...) AS THE MAN WHO INITIATES AND RECOGNIZES TECHNICAL IMPROVEMENTS AND WHO SUCCEEDS IN GETTING THEM INTRODUCED.

Figure 17. Direction matrix of a possible innovation.

- Period of decline.

The level of activity is normally highest in the innovation period; it drops during the maturity period and sometimes rises again during the period of decline.

This traditional analysis is only applicable to long product-life cycles. Most modern products, mainly because of the introduction of microelectronics, have shortened the time necessary for innovation and production. Therefore one must be prepared to analyze each and every day or week in the life of a product from the original idea to the beginning of mass production.

A strict analysis of the product's value and all this involves the highest positional value, both technically and from the point of view of marketing. If the uncertainty should be too great, the production development should be broken off. The same is true if it appears that the product carries too high a risk-factor (Figure 18).

The critical point is when sufficient resources are made available at each stage for production and preparation for production. At this point, a quarter of the planned outlay is allocated to R & D. Decisive project-testing must now take place. The green light for following-up a project from this point means an increasing necessity, and also a moral obligation, to follow it up at least to the pre-production stage--with all the associated costs.

Life-cycle considerations identify and analyze a general pattern of development which allows one to put the ccompany's situation in context. Having identified a technology's or product concept's stage of development, within a general, well-understood pattern, allows the decision-maker to gain a deeper contextual understanding of the situation, and at the same time gain a long-term perspective, which is essential in the management of technical innovation.

One can readily distinguish five stages of development in the course of the lifetime of a generic technology (Figure 19).

17.1. Formative Stage

A necessary precursor of the formation of a generic technology is the discovery and scientific understanding of physical phenomena that can eventually be put to technical use. Determining the feasibility of a generic technology requires additional, often intense research. This phase in the life of a generic technology, which takes place in a ccompany's R & D laboratories, requires the allocation of adequate resources.

17.2. Exploration and Validation

Once a new generic technology has been conceived, product (or process) concepts need to be found which will allow the advantageous use of the new technology in an advantageous way. The most common pattern in the introduction of a new technology is its utilization in existing products, where the new technology helps to perform traditional, well-understood, and well-defined functions better, more cheaply, or more effectively. The identification of appropriate application areas is a task that lies beyond the capabilities of the R & D department and requires

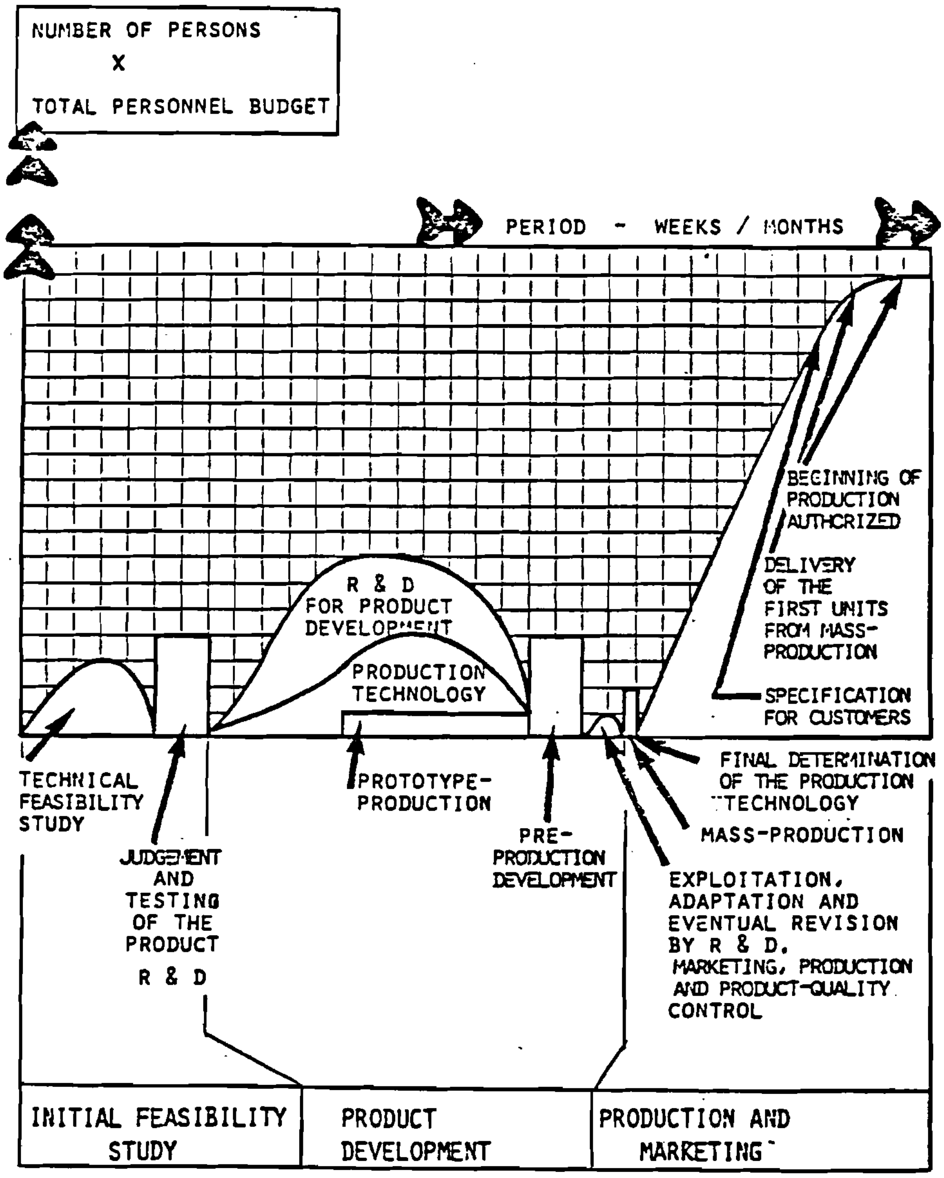


Figure 18. Innovation period of a new product.

Generic Technology (potential innovation)	Product Concept (application innovation)
1) Formative Stage body of scientific knowledge plus technical use generic technology feasibility investigations	1) Seed Stage need identification and translation into product concept identification or development of suitable technology
2) Exploration and Validation establishment of applications criteria identification of broad applications areas and of research and development needs	2) Introducotory Stage intense learning: need/concept concept implementation technology "dominant design" clear understanding of market potential
3) Technology Development provide broad technological knowledge base develop technology to point of application specific opportunities are identified in the process	3) Established Product Stage competition: process innovation becomes more important R&D: improve product find new, superior technologies to implement proven product concept
4) Introduction learning from actual use efficient user - engineer feedback 5) Maturity technology well-understood broad range of applications	4) Maturity - technical "blind alley" - generation phenomenon

Figure 19. Life cycles: generic technology and product concept.

substantial input from the areas of marketing and possibly also manufacturing. Furthermore, conformity with the enterprise's current strategic policy must be kept in mind. Therefore this phase requires considerable interaction and coordination between various corporate functions.

17.3. Technological Development

Once major commitment to a new technology has been made, a knowledge base must be built up to allow the elimination of problems and difficulties that stand in the way of its application. Building this foundation may require a considerable research effort. Not only must a solid scientific and technological knowledge base be built, but in the course of the work specific application opportunities have to be identified.

17.4. Introduction Phase

A great deal of learning takes place during a new technology's introductory phase. Since application and use rapidly uncover shortcomings and opportunities for improvement--particularly in the early stages--it is essential that there be a direct link between those who use the new product or process, and the R & D engineers.

At this stage the ccompany needs to maintain a considerable degree of flexibility, because rapid learning about how the customer actually uses the product or process and learning about the technology itself make necessary frequent changes in the actual product.

17.5. Mature Phase

By the mature phase, the new technology is well-mastered and understood, and has proven itself useful in one or more successful applications. It can subsequently be used in a potentially wide range of applications, and its integration into existing products may create new generations of those products. In this stage there is a series of applications of the new technology, some of which may stimulate new technological progress. The technology has become part of the general body of technical know-how.

Texas Instruments, strongly committed to semiconductor technology, found successful product concepts, e.g., in the pocket calculator and the electronic watch.

18. Techniques for Innovative Activities

Innovative activity can be described as the process of identifying a problem that was previously unrecognized, or identifying a new solution to a problem, i.e., a solution that is beyond the prior experience of those involved. We can say that innovative activity is at the opposite end of the spectrum from conformity. Experts on creativity have made numerous efforts to reduce conformity in order to create conditions in which innovations can more easily occur. See, for example:

- on managerial effectiveness: (Reddin 1970)

- on the managerial grid: (Blake and Mouton 1964)
- on project management: (Archibald 1976)
- on the rational manager: (Kepner and Tregoe 1965)
- on management by objectives: (Odiorne 1973)
- on approaches to improving productivity: (Blake and Mouton 1981)

Forecasting and Creativity Techniques:

- The Delphi Approach: (Intuitive Thinking Subgroup, Helmer Gordon, Rand Corporation 1966)
- Brainstorming: (Osborn 1953)
- Historical Analogies: (Gordon 1956, 1961)
- Morphological Research: (Zwicky 1950)
- Relevance Trees
- Systems Analysis
- Synapse: (Aznar 1966, 1971)

Problem solving and decision making methodology:

- situation analysis
- problem analysis (detecting causes)
- decision analysis (preparing decisions)
- potential problem analysis

Further methods and techniques:

- Network plans
- Gap analysis
- Misfit analysis
- **Portfolio analysis**
- Life cycle analysis
- Value analysis
- Quality control cycles
- Zero base budgeting
- Workshops, etc.

19. One Example

The training for and practical application of 'A Systematic Approach to Problem Solving and Decision Making'. This enables all managerial staff to:

- check and systemize their thinking habits
- deal with situations, tasks and innovative activities in the same language
- use a precise questioning technique to find out all important information and to evaluate it

- become more secure in decision making, to prepare and make decisions systematically
- direct spheres of innovative activity better, without having to know all technical details
- arrive at solutions faster and save time and money
- ensure the successful carrying out of a plan (safeguard program). (See Figure 20.)

20. Conclusion

Every day we observe managers and employees being far less productive and innovative than they could be. We see waste, inferior products, and people chatting about matters that have no bearing on their output. Yet often we see the opposite--people applying themselves with enthusiastic effort. We see high output with lean manning, and we see other manifestations of excellent innovation management. What makes the difference?

There are many explanations. Some say that unproductive and uncreative people lack goals; that those who are committed share a dedicated sense of purpose. Others blame bosses for having an adverse effect on innovative activity. Still others say that bosses use their power and authority to promote excellence.

However, nothing in the industrial setting is more important than improving productivity by innovative activity. There are many reasons for this. One is that productivity by innovation permits higher wages and salaries, and these in turn are the basis for a better standard of living. Beyond that, improved productivity by innovation keeps an enterprise and a society afloat and competitive in the international sphere.

The third reason is that innovative and productive people are happy people. They are satisfied; they find reward in their own effort, and satisfaction is certainly one of the important ingredients in mental health.

Given the central role of innovation and productivity in the design of a modern enterprise and also a modern society, it is not surprising that there are so many ways of trying to increase it. Some are practically worthless, while others make a very substantial contribution.

Every innovative activity is a combination of two considerations. One is the best technical system for being productive. The other is the best social organization to make human resources effective by innovative activity. I hope I have been able to give some useful examples.

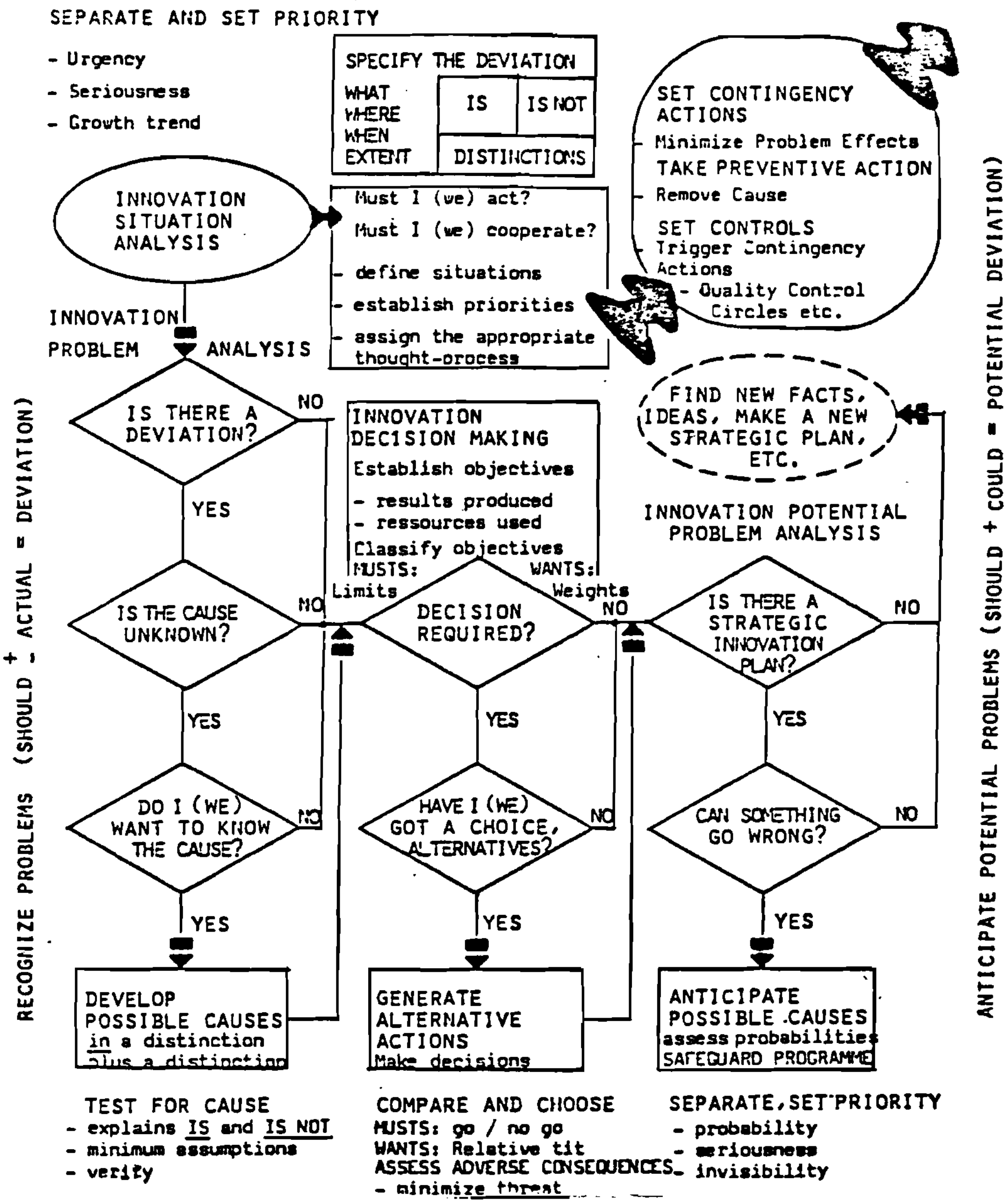


Figure 20. Implement plan new ways of operating for innovative activity.

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APPENDIXES

APPENDIX A

Discussion

General Summary

The presentations covered a wide spectrum of topics,including applied research in electrical engineering, government participation in innovation management, and practical experience with innovation management at different firms. There were a multitude of questions, responses, remarks, suggestions, etc., which indicated an active interest on the part of participants. The questions concerned specific aspects of electrical engineering (e.g., storage of energy, development of new electric motors, the degree of computer application in electrical engineering, consumer goods produced by the firm in addition to the main items, achievements in computer-aided design, present and future application of flexible automation), economics and management (e.g., steps towards final delivery, cost of reconstructing and retooling for innovation, control of competition between different profit centers inside a corporation, how to involve all levels of enterprise in innovative activities, how allied industries are encouraged to be innovative, etc.), as well as more general and social aspects (e.g., systems of stimulations and sanctions, personnel training, etc.).

The specific questions received specific answers concerning the basic research in resins and steel being carried out by Stromberg, Electrosila's application of a line of 8-9 robots engaged in extrusion of plastic mass parts, product development teams including marketing personnel to ensure the innovation's success with the consumer in Cze+choslovakia. Analyzing the aspects of innovation management reflected in the discussion, one can see that most of them concerned the people involved:

a) It was pointed out that, at IBM, for example, to improve understanding and cooperation among divisions (profit centers and R & D units, for example) people are moved from one division to another for a certain period of time;

b) At Electrosila, to guarantee a smooth and effective relationship between the groups participating in an innovation, a Council of Directors elaborates a single policy.

The participants made a number of remarks related to the complex nature of innovations, which arise either as a reaction to societal needs or as a result of the curiosity of human intellect. Sometimes innovations arise much before the societal needs for them. It was emphasized that innovations always involve risk but, "Where would we be if we never anticipated needs but only responded to them?" The evoking of needs is interactive by producing something you produce new needs. Most of the time we not only measure our activity by the cost of resources we use up in inputs, but by what use values we have to deliver that are difficult to assess and measure.

In the subsequent discussion the participants touched upon theoretical and practical aspects of innovation management.

Wishing to bring clarity to the concept of organizational models referred to at the meeting, *B. Milner* (USSR) spoke of the employment of line and functional structures at different organizations. The Finnish company Stromberg, for instance, has a typical functional structure: its eleven profit centers have relative economic and organizational independence. When Electrosila was discussed, one might have received the impression that organizational design is to some extent in opposition to the functional structure. But this is not so. In discussing Electrosila we were referring not to its organizational structure but to its management system. All the enterprises incorporated in the amalgamation Electrosila have relative economic and organizational independence; they are self-supporting and their performance is evaluated by their labor productivity and profitability. The management system consists of functional blocks—economic, marketing, R & D-- that function within a line structure. Nor is this a question of varying degrees of centralization. Communication between the blocks within the management system is not effected strictly through the top level of the hierarchy.

We are becoming increasingly aware that the line structure is not obsolete as an organizational form. But it should correspond to the objective requirements of production. We can speak of its inadequacy only in connection with its orientation toward single products. With modern complex and diversified production this structure should be substantially complemented: the vertical lines of power (which will never be abolished) are complemented by horizontal lines with decision-making authority delegated to ad hoc bodies, like coordination commissions, production councils, etc. Such forms are abundant. Let us take General Electric, for instance. On first sight, it seems to display an authoritarian structure, but in fact the structure has many complementary forms dictated by the objective requirements of current production. We must look at this in terms of other colors too not only black and white. In the USSR the concentration of production and management into amalgamations (there are 4,000 amalgamations incorporating 18,000 enterprises) has only become possible because the line and functional structure is complemented by other forms that allow the decision-making authority to be delegated to lower levels.

T. Moss (USA) expressed the belief that no matter how a company is organized, the most important thing is its built-in healing mechanism found in some form or other in every organization. As to the transfer of experience, it is best done by people.

Speaking of how innovations influence the manner of production, *D. Krook* (USSR) pointed out that the process of innovation management has a multi-faceted and multi-level nature, which includes:

a. the technological aspect;

b. the production aspect (it is not enough to introduce innovations--one has also to maintain the level of production);

c. the economic aspect (minimization of costs, division of labor, specialization, cooperation);

d. the financial aspect (where finances come from, i.e., from internal or external sources);

e. the social aspect (increasing importance of human factor).

Due to innovations, the production management process acquires speeds, and the earlier structures do not work. Current studies on innovation management in the USSR are mainly oriented towards two objectives:

1. To elaborate a basis for a scientifically valid policy on investments;
2. To identify the effect of innovations on the management process.

D. Krook also spoke of the results of a study involving electrical engineering and some other industries which might permit broader conclusions. 40 commodity groups were analyzed (each comprising 20 items). The conclusions were as follows:

1. The average time that the item remained in production was:

Before 1925	34-38 years
From 1926 to 1951	22-25 years
1952 to 1965	10-12 years
1966 to the present	5-6 years

It is predicted that further reductions will occur but at a slower pace.

2. The official list of manufactured items nearly doubles every 10 years.

3. Fifteen years ago, 22 percent of manufactured units were serial-produced; now the figure is only 13 percent.

Papp (Hungary) pointed out that it is impossible to find topics in electrical engineering that are equally interesting to all participants. A company's interest depends on its economic circumstances. For example, the enterprise GANZ is trying to solve the problem of how to innovate while working out new markets for new products. This poses several problems both to a company and its enterprises. These problems differ from enterprise to enterprise, but one could learn from each other. For instance, a rotor ring was developed, and for a year it was a problem. Maybe for somebody else it was not a problem. It is difficult to find common points of interest among different companies.

2. I do not believe that firms using certain organizational forms, such as profit centers, will change their structure to adopt the recommended innovation management scheme. But I do think that small-scale firms like GANZ need the work initiated by IIASA as we do not have access to as much information as the multi-national corporations (Siemens, General Electric, etc.).

I would suggest three topics for common work:

1. Energy-saving technologies in electrical engineering;
2. Problems of quality and reliability (both from the producer's and the consumer's points of view);
3. Team work (groups of experts) to work out some proposals for IIASA. Maybe it would be useful to elaborate a questionnaire to give the participants a chance to choose proposals.

Francic (Yugoslavia) told the participants about RADE CONCAR, the largest electrical engineering firm in Yugoslavia, which employs 22,000 people. It has 40 profit centers, an R & D center, and an engineering organization. Some incorporated enterprises have their own R & D units. The majority of the enterprises manufacture final products and have a direct connection with the market. 60 percent of the innovations implemented come from the R & D center; the remaining 40 percent from the R & D units. The real problem lies in the effective management of such a system and thus the present discussion is interesting and useful. The problem of effective management boils down to how to coordinate the work of different teams, as well as the relationship between the R & D and production units, as there are objective incompatibilities in their programs:

1. the program oriented toward an unknown user (marketing),
2. joint (R & D and consumer) elaboration of parameters.

Electronics now represents not only a means of working but is also part of a finished product, and it considerably influences working techniques. It is very important to investigate the methodologies of different teams.

The system of innovation management should be two-dimensional: vertical (organizations responsible for certain products) and horizontal (enterprise level) and it should have integrated programs beyond the normal profit center hierarchy.

B. Sazonov (USSR) spoke of the importance of methodology. The methodology is agreed upon while studying the problems and not before the study. In particular, innovation problems can be solved during and as a result of the studies, because the terminological problem is not the only one. Differences in terminology come from differences in innovation concepts, and that will remain. We can, however, turn it to our use, as it is very useful to get acquainted with different concepts of a thing or phenomenon.

It is not necessary that every enterprise in the electrical engineering industry be innovative, but then there arises the problem of transfer of a unique experience to other surroundings. This is a methodological problem. Methodological problems are very serious and require joint effort.

Evstafiev (UNIDO) told the participants about the directions of activity in his organization and pointed out that the problems discussed at the meeting will be very useful for developing countries, and that UNIDO will explore the possibility of contributng to further events in this direction.

T. Vasko (IIASA) talked about what IIASA can do to further investigations along this line. An interactive process of problem selection should be developed, involving: a) problems of technical policy; b) problems of motivation (not much has been done so far on social aspects of the problem); c) problems of productivity (in the loose sense of the word) and new production technologies.

Using input from the collaborating countries, IIASA can generalize, filter, and give back the information that is applicable universally. In analyzing the data we can use systems methodology and then diffuse the resulting knowledge.

IIASA carried out penetration studies on robot diffusion. What factors influence robot diffusion if we correlate it with the hourly wages? We found that there is a good correlation in several countries, but some countries defy this relation (e.g., Sweden and Japan). Trying to determine the ratios between working places taken by robots and all working places that could be used by robots, they arrived at curves that show saturation in diffusion of robots (of second generation). There are several publications available at IIASA for more details.

SUMMARIES BY THE CHAIRMEN OF THE SESSIONS

Summary by B. Milner

The session I chaired reflected the common character of enterprises in different countries (CKD, Stromberg, Electrosila). It can be concluded that there are five areas around which general problems of innovations are focused:

1. the product itself (goal)
2. the means (technology)
3. resources of all kinds
4. manpower (personnel)
5. organization.

The reports pointed to differences in ways of solving these problems: through finding an appropriate organizational design, through forms of motivation, and by evaluating performance. The usefulness of the joint work lies in the exchange of views on how to solve the same problem. Here we observed the formation of a common basis for a case study to be organized by IIASA despite the organizational difficulties IIASA is now facing. Contacts with industry and with concrete means of industrial development (innovations) should help and invigorate IIASA. Experience shows that theoretical and applied studies should run parallel, and the more IIASA is oriented toward applied research, the better and more stable its position will be.

The following recommendations were suggested at the session:

1. The participants of the meeting should request IIASA representatives to give a full report to the directorate and Council of IIASA, including a report on the general opinion voiced in the reports and discussions.
2. It would be appropriate to start thinking about a new seminar focusing on a narrower range of topics.
3. Publication of the proceedings of this meeting would be extremely useful.

Summary by J. Langrish

Many problems of mutual interest have not yet been talked about. There is no shortage of problems to study--the question is how to study them (i.e., the methodology of research into research). We hear descriptions of different organizational structures or training schemes but what comes next? Methods of comparative analysis are not very satisfactory in connection with human organizations because of differences in terminology. Thus before beginning any comparison one has to agree on terminology.

One has to be careful with evaluation too. What organizational structures are best? This is difficult to judge. We can agree on physical things (weight, distance), but not on things with abstract value (logical problems). These difficulties can be overcome if people are aware of them.

What can be recommended? International groups should be created to agree on words. As to the evaluation problem, one can do the following. We can take some technological change as an example and let people of different countries evaluate it. Then we could see if it agrees with the organizational chart, the size of the organization, etc. A lot of variables could be involved. At certain stages it is not useful to say: "We do this in Moscow", or "We do not do this in Finland". There has got to be some scheme of comparison, with some agreement about terms and values first.

Response by T. Moss to J. Langrish

Certainly, we need to assure the use of common terms. But talking in different frameworks is also useful because in one's home surroundings it is almost impossible to imagine a completely different situation and ways of dealing with it. Inherently, certain kinds of innovations can proceed only in nonintegrated fashion. There are two different mechanisms: (1) value enhancements, and (2) creating new products.

Summary of B. Benda Presented by T. Vasko

1. Glebov's and Nikitin's papers treat prospects for industrial development (electrical engineering). This is extremely important as an input for our future activities and for forecasts of innovations. Academician Benda expressed the opinion that in the future it would be very useful to present lectures on selected topics.
2. Following some suggestions by Academician Glebov, IIASA could ask specialists to come to IIASA for a small workshop to discuss problems of energy accumulation through superconductivity. Though IIASA does not investigate physical problems, it can provide a forum (6 years ago it provided a forum on @CO sub 2@). I may not have final answers to the problems mentioned here. Let me start with the key issues of many papers. They fall into two groups:
   (a) The process of stimulating innovation activities--social, managerial, etc.
   (b) Importance of quality and value enhancement in recent industrial production (in at least four papers).

These two issues create a focus and encompass many related activities. My statement concurs with much in Levchuk's report. As I see it, every speaker found the exchange of knowledge and practices useful. In the recommendations we should point out this fact. Maybe in the future some focal topic could be suggested to IIASA.

Summary by G. Wolf

A new product (innovation) is an object of investigation for innovation management studies, and a cooperative goal. It is also important to study the facilities at hand before an innovation is adopted as well as the life of a product from the birth of an idea (maybe a comparision within the framework of IIASA). That means optimization of a feasibility studies.

APPENDIX B

The Agenda

MONDAY, MAY 24

13:00	Lunch
14:30	Registration
15:00	Introductory Session Chairman: V. Goncharov (IIASA/USSR) Opening Address B. Fomin USSR B. Milner USSR T. Vasko (IIASA/Czechoslovakia): IIASA and Future Development of Innovation Management Research
16:00-17:30	Plenary Session Chairman: B. Benda (Czechoslovakia) Co-chairman: D. Levchuk (USSR) Yu. Nikitin (USSR): Scientific-Technological Progress and the USSR Electrotechnology Development Perspectives (Delivered by O. Fedorov) I. Glebov (USSR/CIGRE): Development Prospects of a Large-Scale Electrical Machine Building in the USSR for a Period of 10-15 Years
19:00	Dinner (Hosted by IIASA) "Pulkovskaya" Hotel Restaurant

TUESDAY, MAY 25

9:30-11:00	Plenary Session Chairman: B. Milner (USSR) Co-chairman: L. Vodachek (Czechoslovakia) R. Rychecky (Czechoslovakia): Management of the Innovation Policy in the CKD Praha Company (Delivered by L. Vodachek) A. Potila (Finland): Management of Research and Product Development in an Electrical Company (Stroemberg)
11:00	Coffee Break

11:30-13:00	Plenary Session (Cont.) G. Papp (Hungary): Aims and Experiences on Innovation Management at Ganz Electric Works B. Fomin (USSR): Innovation Policy in an Electrical Engineering Enterprise (Electrosila) Discussants: R. Tuuli (Finland) B. Francic (Yugoslavia)
13:00	Lunch
14:00-15:30	Plenary Session Chairman: T. Vasko (IIASA/Czechoslovakia) Co-chairman: V. Okorokov (USSR) V. Pokrovsky (USSR): Development of the Influence of the State Administration System on the R & D Policy of Amalgamation, Enterprises and Organizations in the USSR J. Langrish (UK): Innovation Policy and Needs Analysis
15:30	Coffee Break
16:00-17:30	Plenary Session (Cont.) O. Federov (USSR): Organization and Implementation of the Technological Change in the Management of Electrical Engineering Industry M. Holec (Czechoslovakia): Innovation Processes in the Strategic Management of Electrical Firms Discussants: Dr. Francic (Yugoslavia) D. Krouk (USSR)
19:00	Visit to the Circus

WEDNESDAY, MAY 26

9:30-11:00	Plenary Session Chairman: J. Langrish (UK) Co-chairman: A. Evstafiev (UNIDO/USSR) J. Hrabeczy (Hungary): Innovation in the Management Organization of Ganz Electric Works A. Maratch (USSR): Influence of Innovations on the Organizational Design of a Large-Scale Research and Production Amalgamation V. Okorokov (USSR): Adaptive Organization Structures in the Management of an Amalgamation (Firm)
11:00	Coffee Break

11:30-13:00	Plenary Session (Cont.) I. Kotek (Czechoslovakia): The Role of Computer Application and of Information Systems in Decision-Making Processes Relating to the Formulation of Strategies of Technological and Innovation Policy (Delivered by J. Grof) T. Moss (USA): Human Factors in Innovation G. Wolf (Austria): Training for Innovative Activity V. Kabakov (USSR): Problems of Development of Organizational Structures in Industry Discussants: M. Holec (Czechoslovakia) B. Milner (USSR)
13:00	Lunch
14:00-15:30	Plenary Session Chairman: G. Wolf (Austria) Co-chairman: V. Pokrovsky (USSR) E. Kurochka (USSR): Basic Principles of Innovation Management at Electrosila Under Renewal of Products D. Levchuk (USSR): Organization of Applied Comparative Research of Innovation Management in electrotechnology Reports from Chairmen of the Sessions Recommendations and Discussions Future Research Plans
15:30	Coffee Break
16:00-17:00	Plenary Session (Cont.) Continuation of the Session Discussions
20:00	Cultural Program and Dinner on Board the Ship "Kronwerk"

THURSDAY, MAY 27

9:30-13:00	Visit to Electrosila
13:30-14:30	Lunch
15:30-18:00	Visit to the Hermitage
19:00	Visit to the Leningrad Music Hall

FRIDAY, MAY 28

9:30	Sightseeing of Historical Places in Leningrad (Hermitage, Isaak, Cathedral, etc.)
14:00-18:00	Visit Pushkin
19:00	Dinner (Hosted by the Organizers of the Meeting) "Leningrad" Hotel Restaurant

SATURDAY, MAY 29

9:30	Sightseeing of Historical Places Outside Leningrad (Petrodvoretz)

APPENDIX C

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