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17827-E

UNIDO

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.491/2
18 July 1989

ENGLIGH
ORIGINAL: FRENCH

First Consultation on the
Electronics Industry
Valetta, Malta, 6-10 November 1989

Issue paper No. 2

ELECTRONICS TECHNOLOGIES IN THE SERVICE OF INDUSTRIAL DEVELOPMENT

Prepared by the Secretariat of UNIDO

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Explanatory notes

Unless otherwise indicated, the dollar sign ($) means the United States dollar.

The following initials have been used in this report:

CAD	Computer-aided design
EEC	European Economic Community
MIT	Massachusetts Institute of Technology
NCMT	Numerically-controlled machine tool
OECD	Organization for Economic Co-operation and Development

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INTRODUCTION

The rise of electronics technologies marks the birth of a new industrial age. Ever less expensive, ever more compact and ever faster-operating electronics systems are being used at all stages of goods and services production.

The electronics systems forming the subject of this document are those involved in industrial development: computerization, specialized electronic equipment, electronic components and software. In addition, although services play a significant role in the economy, and the use and extension of computerization, both in public services and in banks, etc. represent very important phenomena, the present study will pay particular attention to the diffusion of these systems in industry.

An evaluation will be made first of the degree of penetration of electronics technologies in industry and then of the implications thereof for certain industries of special importance for industrial growth in the developing countries. This will make is possible to identify the various aspects to be taken into consideration when placing electronics technologies at the service of industrial development.

I. PENETRATION OF ELECTRONICS TECHNOLOGIES IN INDUSTRY

In the absence of more or less precise data on the incidence of various electronics systems in a group of industries with varying levels of development, reference must be made to more general or more specific studies in order to gain an idea of the degree of penetration of electronics technologies in industry.

In a general manner, use can be made for example of a study by the Organization for Economic Co-operation and Development (OECD), 1/ where it is stated that "since the mid-1970s and until 1985 ..., the internal demand (in OECD countries) for information technologies 2/ registered a growth in real terms of about 6 per cent per year, thus more than twice the mean growth rate for overall industrial production". According to the same document, the proportion of electronics technologies in the internal demand for manufactured goods increased from 5.5 per cent in 1975 to 7.4 per cent in 1983, compared with 9 per cent in connection with the demand for products of the automobile industry. Japan and the United States are the most advanced OECD countries and with them this proportion was, in 1983, 8 and 9 per cent respectively. These figures show the overall significance of the use of electronics technologies in the economy and the rapid growth of this use.

With more specific reference to the penetration of these techniques in industry in general, the OECD study in question gives, for a number of countries, an estimate of the demand by enterprises for information technologies as a proportion of gross fixed capital formation (see table 1: unfortunately there are no comparable statistical data available for the developing countries).

Table 1

The share of investment in information technologies in gross fixed capital formation for a number of countries
(in per cent)

	1984	1987
Germany, Federal Republic of	11.6	13.5
United States	14.6	18.1
France	9.0	9.7
Italy	8.8	10.6
Japan	6.9	8.3
United Kingdom	15.0	16.7

Source: OECD, Science and Technology Policy Outlook (Paris, 1988), pp. 105-106 (of the French text).

1/ Organization for Economic Co-operation and Development (OECD), Science and Technology Policy Outlook (Paris, 1988).

2/ The OECD and also the European Economic Community (EEC) have adopted the term "information technologies" for designating what is here defined as "electronics technologies".

These figures indicate powerful and dynamic penetration. Another study, in fairly general terms and dealing only with the United States, 3/ shows the trend since 1950 on the basis of data in constant 1982 dollars in the share accounted for by electronics systems in total new investments in capital goods and plant. This share increased from 7 per cent in 1950 to 10 per cent in 1960. It reached 20 per cent in 1978 and was more than 40 per cent in 1984. The reference here is to investments made by all producers of goods and services and this figure corresponds, in particular, to the important feature, already mentioned, of the significant degree of computerization of services. This is of direct concern to industry, having recourse to numerous external services, and its own activities, within enterprises, calling for services involving commercial management, personnel management, production management and so on.

More detailed information 4/ on the penetration of electronics into the industry of three European countries - the Federal Republic of Germany, France and, in particular, the United Kingdom - makes possible a somewhat better localization of the sites and intensity of this penetration. The information given relates to two forms of penetration: the introduction of microelectronics into the products themselves and the use of electronics systems in the production processes. Between 40 and 50 per cent of the industrial undertakings in these three countries were using microelectronics in one form or another in 1984. All industrial sectors were affected to roughly the same extent, including the clothing and textiles sectors. There is, however, a difference that should be noted: with the exception of the engineering, the electrical and electronics, and the automobile sectors, there is virtually no introduction of electronics into the actual products. This of course follows from their nature: the time has not yet come when food commodities or the metal industry is stuffed with electronics.

The study on the United Kingdom 5/ gives an idea of the recent trend in this penetration. In 1978, hardly 7 per cent of United Kingdom enterprises were using microelectronics, while in 1987 the proportion was two thirds. As regards the sectoral distribution in terms of the two types of penetration, the same remarks apply, although the differences between the intensity of penetration into processes are reduced depending on the sector concerned. In enterprises introducing microelectronics into their output, 70 per cent use market microprocessors, while 18 per cent use integrated circuits made to order and 11 per cent pre-diffused circuits. Of the electronics systems introduced by undertakings into their production processes, programable automata are the most numerous: nearly 30 per cent of all industrial undertakings in the United Kingdom use them (i.e. about

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3/ "Technology and the American economic transition - choices for the future", Washington, GPD (OTAT, 1988), p. 16.

4/ The data are drawn from two studies: the first, published in 1985, concerns three European countries with respect to the years 1982 to 1984 (J. Northcott et al., "Microelectronics in industry: an international comparison: Britain, Germany, France" (January 1985, PSI-AGF)). The second study covers only the United Kingdom but provides data for 1987 (J. Northcott and A. Walling, "The impact of microelectronics" (PSI, 1988)).

5/ The United Kingdom data used describe a situation which doubtless approximates to that of the majority of market-economy industrialized countries.

110,000 automata). Slightly less than 30 per cent have recourse to CAD work stations. On the other hand, there is only one production unit in five which uses NCMTs (i.e. a total of about 42,000 units), and only 2 or 3 per cent of undertakings possess robots or manipulators.

The above figures highlight the extensive diffusion of electronics in all activities undertaken in the advanced countries, including industrial activities, even though factory workshops are still only rarely entirely automated. 6/ On the other hand, the few data available suggest that the penetration of electronics technologies in industry in the developing countries is much less strong. While some of those countries register a pronounced deficit in the marketing of electronic products, this is most frequently due to the impact of electronics for the man in the street or of computerization for government and other services. Thus it is rather those countries with "excess" electronics which have already introduced these technologies, for, as we have just seen in the case of the United Kingdom, electronics production is itself a significant employer of electronics techniques.

However to the extent, at world level, that the majority of industrial activities tend to make use of these technologies, the developing countries are affected by this use in connection with their industrial expansion, and should study the implications of this penetration by electronics techniques.

II. THE IMPLICATIONS OF THE INTRODUCTION OF ELECTRONICS TECHNOLOGIES IN CERTAIN SECTORS

In the light of the foregoing remarks, attention should be given to the implications of the introduction of electronics technologies in sectors characterized either by the use of electronics in production processes or by the introduction of electronics into products.

As regards the first category - since all sectors are now affected, at least in the advanced countries - it is important to choose those sectors of significance for the majority of developing countries, a significance associated with the position of the sector in question in the industrial structure of the country and in its foreign trade and which might be jeopardized without the use of electronics technologies. The textile and clothing industries would appear to meet this criterion. Since the developing countries are at present enjoying a relatively more favourable situation on the world market for clothing than on that for textiles, while the penetration of electronics has remained less intense in the case of clothing, this latter sector represents the most important field in terms of the potential implications of the introduction of electronics technologies for the developing countries.

The second category comprises in the main the electrical and electronics industry, the motor industry and the mechanical engineering industry. The electrical and electronics industry forms the subject of another issue at the present meeting (strategies for integrated development of the electronics industry

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6/ The number of workshops of this type known as "flexible shops" throughout the world was estimated at 3?0 in 1985 in a study by the Economic Commission for Europe (New York, 1986, pp. 29 and 42). Even assuming a very high rate of growth, this number is not likely to be more than 1,000 today.

including software). The automobile industry is an industry producing in the first instance consumer goods supplemented to some extent by industrial vehicles, whose importance in terms of capital goods production does not approach that of the mechanical engineering industry. To varying degrees, the latter affects virtually all the developing countries and hence all industrial activities. After considering the clothing industry, therefore, we shall turn to the mechanical engineering industry.

A. The clothing industry

The clothing industry is fairly internationalized with numerous interactions with other countries and substantial injections of foreign capital. In terms of their share of world production, the developing countries went from 8 per cent in 1953 to 25 per cent in 1975, 7/ a share which appears to have stabilized since. The share of the developing countries in world exports reaches nearly 50 per cent and represents more than 8 per cent of the total value of their own exports, or 14 per cent of their exports of manufactured goods. 8/ This shows the significance of this branch for industrial development.

In order to understand the problems associated with the introduction of electronics technologies into this industry, it is necessary to have an idea of the main characteristics of the production processes current in the clothing industry. Four stages can here be distinguished. The first two, in the context of traditional technology, call for highly skilled labour, whereas the qualifications required in the other two stages are much lower.

The stages in question are as follows:

- The "creation" which determines what the garment is going to be - as a function of current trends of fashion and the manufacturer's style - this design then undergoing the manufacturing process termed patterning;

- Grading, laying and cutting. Grading consists of determining, on the basis of the prototype garment, the features of the entire range of sizes in which the garment will be produced. Laying consists of determining the most suitable way in which to cut the cloth from which all the pieces intended for assembly into the garment are to be drawn. Cutting is an operation which is normally performed after folding, i.e. the superimposition of several folds of cloth for cutting;

- Assembly, a process which consists - using needle and thread as has been the case since the earliest times - of sewing the various parts together;

- Finishing: the pressing, folding and packing of the garment.

7/ Jacomet, "Le textile - habillement - une industrie de pointe" (Paris, Economica, 1987).

8/ It should be noted at the same time that three quarters of the exports of developing countries originate from four Asiatic countries: China, Hong Kong, the Republic of Korea and Taiwan (GATT, 1986/87).

At present, electronics technologies have been introduced in rather different ways, and a distinction can be made between what happens in the first two stages and what happens in the second two. These two categories will therefore be considered separately.

In the first category, it is computer-aided design tools which have appeared. Even for artists, graphics systems in colour facilitate layouts and their modifications, while grading becomes practically automatic. Equipment of this kind can be associated with cutting tools, which makes it possible to automate the whole of the first two stages of production. In 1982, nearly 20 per cent of the most important companies in the OECD area were equipped with CAD systems, while another 30 per cent were making preparations in this connection. 9/ The combination with cutting systems represents one of the most modern arrangements existing in batch-processing industries. Out of the potential market of about 1,000 large firms in the OECD area already disposing of a CAD system, about 18 per cent would appear already to have the combined equipment. According to K. Hoffman, the advantage over hand cutting could be significant. 10/ Thus, in the case of a firm with an annual turnover of $50 million, the saving in 10 years of operation would be some $3 million.

The impact on the organization of firms is important, particularly because it has a substantial effect on the kind of skills required. The highly qualified jobs of "grader", "layer" and "cutter" are completely changed. The job of grader virtually disappears, and in incompletely integrated systems the laying software is reciprocally acting and the layer retains a skilled job with a new skill at his disposal. The job of cutter does not disappear but becomes largely unskilled: three to five years are needed to train a manual cutter, whereas a few months are enough for him to learn to operate a numerically-controlled cutting machine.

The direct profits accruing to the enterprise basically consist of the saving in cloth, which may exceed 10 per cent, a far from negligible figure. The indirect gains relate to the flexibility and the speed with which new garments can be produced - a very important feature when it is necessary to follow the trends of fashion. On the other hand, new costs arise principally in the field of management and maintenance of these new systems, which require specialist personnel, while in order to derive profit from all the positive features it is necessary to improve stock management, and for increasing flexibility it is likewise appropriate to improve the management of relations with suppliers and customers.

It is at the third stage - that of assembly - that the introduction of electronics technologies causes a problem. This introduction has indeed been made by the use of sewing machines which may take the form of extremely fast numerically-controlled machines, but yielding very limited gains. The reason is that the time actually devoted to sewing in this stage represents only 10-30 per cent of the assembly cycle of an ordinary garment, 11/ the rest being devoted to handling of the cloth. But it is precisely this stage which calls for the most labour - in fact about 80 per cent of the total labour involved in the garment industry. 12/

9/ OECD, op. cit.

10/ K. Hoffman, Microelectronics and Clothing (New York, Praeger, 1988), p. 87.

11/ See Hoffman, op. cit.

12/ OECD, "Revivifier l'industrie par la technologie (Paris, 1988), p. 150 (of the French text).

Industrialists in this sector are well aware that it is here that the introduction of suitable electronic technologies could yield substantial gains in terms of competitiveness. 13/ This is a much discussed issue in several industrial countries, where the clothing sector includes numerous undertakings in difficulties. The research and development effort is, in spite of this, on a modest scale in these undertakings, since here, as in the textile industry, it is the manufacturers of machines who furnish technical progress. Since these manufacturers are independent, their machines are sold on the market and are available to anyone with the necessary financial resources.

At the same time, progress at the assembly stage is still awaited and the authorities in the industrialized countries are actively supporting research efforts in this direction. Thus, for example, in the United States the Department of Commerce is subsidizing a joint project conducted by textile fibre and clothing firms called "TC2", in Japan, the MIT is encouraging the "Technology research association of automated sewing systems" and under the BRITE programme the EEC is supporting research on the automatic maintenance of flexible equipment promoted by European sewing-machine manufacturers.

The developing countries thus retain a traditional advantage in this labour-intensive industry, until such time as radical progress is made in this phase of production. A study of the costs involved 14/ has shown that for manufacture of a good-quality cotton shirt the phase in question represented on average in a Far Eastern country 71 per cent of the cost price prevailing in a European country, the difference residing mainly in wages.

The impact on the developing countries of introducing electronics technologies into this industry would appear to be inevitable within a few years. ' number of developing countries have indeed already equipped themselves in this respect, either for technical reasons as when, for example, they purchase machines for sewing collars or pockets, which furnish work of an appearance different from that carried out by hand, or because they are in competition with other developing countries with lower labour costs than their own. Other countries, today, are investing in CAD systems because of the savings in cloth which can be effected, and then it becomes clear that the lower the labour costs, the higher equipment costs are going to appear.

B. Mechanical engineering

The mechanical engineering industry is here considered as one in which electronics systems are involved not only in the production process but also in the product itself, giving rise to what the Japanese have termed "mecatronics". This industry is of considerable importance because it supplies machinery for all manufacturing operations.

13/ See M. Dubois, "L'industrie de l'habillement. L'innovation face à la crise. Notes et études documentaires" (Paris, 1988).

14/ R. Vernet, "Likely technological developments in the textile industry and their potential impact on the future competitiveness of the industrialized countries", COMITEXTIL bulletin 85/5, according to OECD, op. cit., p. 148.

Consideration will first be given to machine tools operating by removing metal (as opposed to those which operate by shaping metal), and we shall observe the trend in the position among these tools held by those incorporating electronics systems and designated numerically-controlled machine tools, receiving their instructions from a computer which programs and monitors their work. In Japan, the proportion in question increased from 17.3 per cent to 51 per cent ot production (by value) between 1975 and 1981. The number of these NCMTs produced by the United States, France, Japan, the Federal Republic of Germany and the United Kingdom increased, by a factor of more than five between 1975 and 1983, going from 9,440 units to 48,500 units. Out of 2,000 Japanese firms manufacturing machine tools, about 150 were building these new machines in 1979. This is only a modest proportion, but the number of small manufacturers is very high. In the United States, out of 600 machine tool manufacturers, 20 per cent (including all the large ones) are making NCMTs using a number of instruments termed machining centres. 15/

These figures show the extent of the change and the way it is accelerating. Machine tool manufacturers are ever more obliged to offer products corresponding to the given state of technology, i.e. products incorporating electronics systems. Furthermore, these tools have themselves to be manufactured with the assistance of various NCMTs. It is indeed the mechanical engineering industry which is the one possessing the largest number of NCMTs. In the United States, in 1983, it held 51 per cent of all NCMTs (52,540 units) and 58 per cent of the machining centres (13,920 units). Comparable data are found for Japan in 1981: 44 per cent of NCMTs (11,000 units) were installed in mechanical engineering firms. 16/

Turning from this sectoral distribution of NCMTs, we may now consider their share in the total of machine tools operating by removal of metal; it emerges that the overall level of penetration remains relatively low. In the United States, in 1983, it amounted to 6 per cent of the total number, and in Japan to 4 per cent. But the total numbers involved are extremely large, with numerous types of machine tool. One of these types - lathes - is distinctly more penetrated by electronics technologies. See table 2.

As will be seen from this table, the market for lathes other than numerically-controlled instruments sagged considerably between 1975 and 1984, and in order to survive manufacturers have therefore to consider ways and means of modifying their product. Overall, in 1984, three quarters of the world production of lathes in the market-economy countries were represented, in terms of value, by numerically-controlled lathes.

15/ All these data are taken from a report by the Economic Commission for Europe entitled "Recent trends in flexible manufacturing", United Nations, New York. Unfortunately there are no equivalent data for other groups of countries, and in particular very few relating to developing countries.

16/ Data provided by the Economic Commission for Europe, op. cit., pp. [illegible]-54. In the case of Japan, only firms with more than 50 employees are considered.

Table 2

The share of numerically-controlled lathes in the total investment in lathes in a number of countries
(in per cent)

Year	Federal Republic of Germany	United States	France	Japan	United Kingdom	Sweden
1975	26	17	23	43	19	No data
1984	85	59	71	83	83	73

Source: CECIMO and MBTBA as reported by S. Jacobson, Electronics and Industrial Policy (London, Allen and Unwin, 1986), p. 13.

This remarkable trend has not occurred without affecting the industry world wide. Japanese firms have been the driving force behind the change, manufacturing relatively simple and cheap lathes in large numbers and exporting them to a great extent. In 1984, every second numerically-controlled lathe sold outside Japan was a Japanese product. Japan holds 54 per cent of the world market, in terms of value, exporting 69 per cent of its output in 1981. 17/

The impact on the organization of enterprises manufacturing conventional lathes is of course considerable. In the first place, in this case and in that of all articles where electronics have to be introduced into the product itself, the traditional skill and know-how are no longer sufficient and the qualifications required are not to be found within the profession itself. Certainly, the first NCMTs used by a firm may be conventional machines only slightly modified, to which bought-out numerical control devices have been added. While purchasers of this type of hybrid could be found at the beginning of the 1970s, this is no longer the case.

The very design of the item must be completely rethought, on the basis of knowledge of which at least half is entirely new for the firm. It is necessary therefore either to establish a close association with an electronics supplier and bring together teams from the two firms, or to recruit new staff and organize the dialogue within one's own enterprise. Furthermore, electronics technologies are changing very rapidly and mecatronics is still a new industry, which means that an innovative mentality must be developed.

The new series of numerically-controlled lathes which will be appearing on the market will have a very limited lifetime, not comparable with preceding generations. This lifetime is becoming even shorter: it was estimated at eight years in 1974, five years in 1978 and three years in 1983. The research and development costs for a range of numerically-controlled lathes are nevertheless high - of the order of $500,000 to $1 million. 18/

17/ See Jacobson, op. cit.

18/ See Jacobson, op. cit.

These research and development costs, which as we have said are extremely high for a short product life, make it necessary to reduce production costs and increase sales. Most experts 19/ agree that marketing and after-sales service, along with the numerical control faculty, constitute the principal source of economies of scale, which may mean as much as 30 to 40 per cent reduction of costs, subject to an annual production of about 800 units.

In order to reduce these costs in larger production runs, most of the major manufacturers have begun to introduce flexible workshops. Thus, for example, the Japanese firm Yamazaki 20/ has established such a workshop whose productivity is three times that of a conventional shop: the overall cycle needed to produce a lathe lasts four weeks instead of 12, and the number of operators is reduced from 195 to 39. Such results are the outcome both of the machines installed and of the manner in which they are integrated into a new form of organization of work.

It is evident that the world industry is greatly perturbed by these developments, and that, among firms which survive, the problems of reorganization of work and the introduction of new management and production methods are considerable: all observers stress the difficulties inherent in optimizing the operation of totally or partially flexible shops for reasons which are essentially of an organizational nature, relating to logistics and "human resources".

The developing countries are affected by this trend in two ways: as users of lathes and as producers of lathes. The price of numerically-controlled lathes was very high 15 years ago or so, but this is no longer the case. Whereas in 1974 Japanese prices 21/ were more than eight times higher than for conventional lathes, the difference had been reduced to a factor of 3.5 to 1 by 1984 and is tending to drop still further for machines which are also as a rule faster and more accurate. This might encourage the developing countries to purchase NCMTs for their metalworking and mechanical engineering activities.

There are also about a dozen developing countries manufacturing machine tools, and in particular conventional lathes. All these countries have already been obliged to undertake the manufacture of numerically-controlled lathes. Apart from an impact of the kind felt by any conventional manufacturer and described above, a firm in a developing country may find itself unable to solve the problem of purchasing the electronics know-how locally, in its efforts to proceed from mechanics to mecatronics.

In the case of Brazil and India, F. Erber considers 22/ that these countries are experiencing difficulties in effecting the technological transformation.

19/ Economic Commission for Europe and BCG "Strategic study of the machine tool industry" (1985).

20/ See UNIDO, "Global study of world electronics" (ID/WG.478/2(SPEC.), 1988), p. 108.

21/ See Jacobson, op. cit.

22/ "Capital goods in industry and the dynamics of economic development in LDCs: the case of Brazil", in M. Fransman, ed., Machinery and Economic Development (Macmillan, 1986), pp. 215-245.

Their market is too small and their customers, including public undertakings, tend to prefer imported products, thus depriving them of a period and a sphere of apprenticeship based on imported technologies.

The position of countries such as the Republic of Korea, having a greater electronics technology potential, is very different; nevertheless, numerous problems still arise. According to S. Jacobson, the strategy of all manufacturers in the most advanced developing countries has consisted of producing the least sophisticated and the cheapest types of lathe. This strategy will not work in the long term; at best it can provide an interim period for re-learning. In the medium and long term it will be necessary, in order to remain an effective lathe manufacturer, to launch out into the production of the types for which there is the greatest demand. Here it seems essential that the public authorities in the developing countries concerned should adopt strong support measures and lay down a clear strategy. This undoubtedly requires thorough study.

III. ASPECTS TO BE CONSIDERED FOR PLACING ELECTRONICS TECHNOLOGIES AT THE SERVICE OF INDUSTRIAL DEVELOPMENT

A. The ability of electronics technologies to promote industrial development

In most spheres, the penetration of electronics technologies has been slower than was believed at the beginning of the 1980s. It was thought at that time that the advantages accruing from labour costs and enjoyed by the developing countries would soon disappear and that production based on these advantages would revert to the more industrialized countries. In fact, a considerable range of industrial operations may continue to be carried out in developing countries using conventional techniques.

The developing countries may choose activities in which they wish to promote the penetration of electronics on the basis not only of benefits in terms of productivity, quality and specificity of product, but also of advantages enabling them to structure their industrial production apparatus in the way which will be necessary at the start of the third millenium.

B. Socio-economic adjustments implied by the use of electronics technologies

The examples represented by the clothing and machine-tool industries have clearly shown that, at micro-economic level, the user of electronics technologies was able to reduce the number of workplaces without necessarily lowering employment at the firm or group level. Most of the studies conducted in industrialized countries show that the macro-economic results are not negative. This does not mean that the macro-economic result is spontaneous, but it indicates rather that supporting policies of an institutional and financial nature are necessary in order to facilitate the reorganization of the socio-economic system.

These examples demonstrate the need to reorganize operations in the widest sense, within the enterprise. The skills required for former jobs are modified, others disappear altogether, and new ones become necessary. The old kinds of know-how are no longer suitable or must be combined with others which may be available in the enterprises with which co-operation must be pursued. In addition, the necessary intra-enterprise co-operation on the part of workers and a display of interest in the organization of the work in progress seem to play more important roles than formerly. 23/ We are clearly faced with a new concept of labour, which calls for substantial socio-economic adjustments characterized by greater job flexibility and greater worker participation.

C. Training requirements for mastering electronics technologies

Training is of course one of the most important requirements. Whereas a number of traditional jobs disappear or no longer call for special skills, new jobs requiring moderately or highly skilled personnel are necessary to implement and master electronics technologies.

It is sometimes thought that the developing countries have available abundant skilled labour. One would do well to ponder this affirmation, in view of the fact that the obstacle most frequently mentioned in the industrialized countries in connection with the introduction of electronics technologies in a firm is shortage of staff skilled in electronics. 24/ The new skills called for by problems of production and labour organization should also not be forgotten.

D. The need to develop repair and maintenance capabilities appropriate to the new equipment

One of the most common dangers lying in wait for the potential user of new equipment, whose manufacturer is not close at hand or only whose base purchase has been financed, is that the equipment may soon break down or even may never function.

Most electronics systems require after-sales service and systematic maintenance, normally offered by the manufacturer or by specialized service companies. These operations are expensive and it is normally preferable that companies should carry them out themselves, at least to some extent. But even current maintenance and small-scale repairs, in the case of this type of equipment, still require skilled staff and suitable facilities.

The repair and maintenance of such equipment in some ways also provides technological apprenticeship. These operations can thus contribute to industrial development.

E. The importance of regional and international co-operation

Regional or international co-operation concerned with the use of electronics technologies in industrial production should concentrate on the transfer of the experience gained from such use. Through highlighting the basic problems to be solved, co-operation could lead to a reduction of the difficulties, particularly of an organizational kind, which emerge during introduction of electronics technologies.

23/ See J. C. Neffa, "Proceso de trabajo, nuevas tecnologías informatizadas y condiciones y medio ambiente de trabajo en Argentina" (Buenos Aires, Friedrich Ebert, 1988).

24/ See Northcott, op. cit.

As regards training, and during the first stages of introduction of the new technologies, regional training centres and international agreements would be in a position to launch a process which is difficult to initiate at national level owing to the shortage of instructors.

Similarly, the use of various items of equipment at least to some extent not locally produced and involving entirely new electronics technologies gives rise to repair and maintenance problems which are also, in the early stages, training problems where regional and international co-operation has its part to play. The establishment of spare parts stocks or of remote control maintenance centres (by telecommunications) is a further matter for regional co-operation.

IV. FINAL CONSIDERATIONS

The world technological and industrial transformation is causing practically all countries to aim at "modernizing" their industrial production apparatus, in order to keep pace with the electronics age. The background, procedures and implications of the spread of electronics technologies as described in this document would suggest that discussions aimed at reaching conclusions and drafting recommendations should be organized on the following subjects:

Impact of the diffusion of electronics technologies on industrial activities as a whole

- All industrial sectors are concerned, in terms either of production processes (automation) or of products incorporating ever more electronics. The developing countries should therefore pay attention to these developments and consider their consequences.

- The automation occurring in industrialized countries may progressively undermine the favourable position won by the developing countries in certain sectors of the world market; this is particularly so in the clothing industry, mechanical engineering, automobile component manufacture, machine tools and the electronics industry itself.

The choice between conventional processes and automated processes in the developing countries

The decisions here should be made gradually, taking into simultaneous consideration:

- The advantages offered by automation as regards improvement of productivity and of quality;

- The implications in terms of maintenance and repair of the new equipment installed;

- The position of the sector in question against the background of international competition: automation should start with those sectors which are the most exposed to competition (on the local or world market) and those in which national production is not sufficient to meet local demand;

- The possibility of simultaneously shaping their production structure in the way which will be necessary in order to meet the technological challenges of the third millenium.

Socio-economic adjustments

The public authorities should anticipate and give support to the restructuring operations which will certainly ensue from the introduction of electronics into various industrial sectors:

- By offsetting the negative effects of this restructuring (disappearance of jobs or of skills) through institutional or financial measures;

- By promoting the exchange of information (at national and regional levels) and making enterprises aware of the organizational difficulties which will undoubtedly afflict them as a result of automation (changes in skills needed, new forms of co-operation between various jobs, and between design offices and operators). This pooling of experience will make it possible to find solutions to palliate the difficulties.

Training requirements to master electronics technologies

Action to be taken in this field comprises:

- Identification of the new skills required by the introduction of electronics and the reorganization of work;

- Promotion of national and regional training centres in the context of international co-operation.

Development of repair and maintenance capabilities

This should be regarded as a priority calling for:

- The promotion of training in the conduct of current maintenance;

- Study of the advisability of regional co-operation which could take the form of a maintenance centre remotely controlled by telecommunication, or of the establishment of a stock of spare parts.