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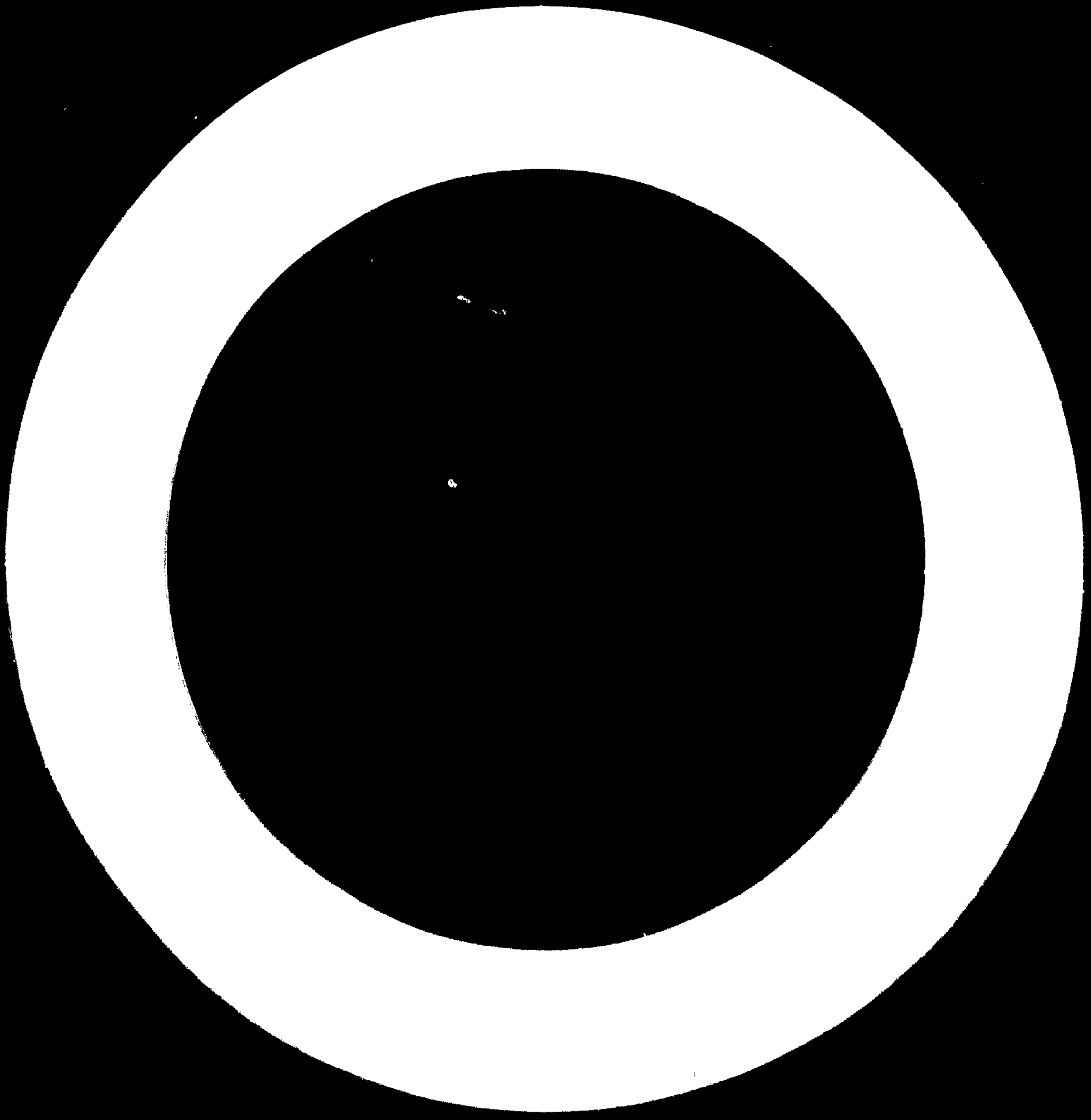

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CONTENTS

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Rise of the IC Industry

The first effect of transistors was to oust the familiar radio valve. Soon, however, a vista of entirely new possibilities opened up, including the possibility of manufacturing components in developing countries for domestic and export markets. This article was prepared for Asian Manufacturing *magazine and is reprinted by courtesy of the publishers*

THE invention of the transistor 25 years ago has had a great influence on the development of electronics and consequently on society as a whole.

Transistors are more compact than valves and require less power. They could, therefore, be fed from batteries and used in places where no mains supply of electricity was available.

By the 1950s there was considerable speculation about the desirability and possibility of accommodating entire circuits in a single piece of a semiconductor material and thus producing integrated circuits or ICs.

Apart from junction transistors of germanium (originally the transistor material par excellence), silicon transistor technology was investigated and developed.

For a number of reasons the issue was finally decided in favour of silicon. One very cogent reason was the fact that only three sources of germanium were known. Germanium transistors were also subject to aging effects caused by surface instabilities.

Superior material

Silicon, the preparation of which was a source of great problems in the early years, possesses good insulation and elevated-temperature properties, which is a great advantage, especially when high powers have to be handled.

Silicon proved to possess yet another trump card: it can be covered by an oxidation process with an oxide layer which possesses great adhesion, stabilizes the surface of the device and forms an excellent mask when the impurity layers needed for transistor operation are diffused on to the substrate. It was this property which gave rise to planar technology. The latter proved extremely suitable for the mass production of discrete junction transistors, enabling a large number of them to be made simultaneously in a single wafer of silicon.

A subsequent step consisted in the interconnection of various transistors. The evaporation-deposited metal wiring used for this purpose is separated from the silicon substrate by the layer of silicon oxide referred to above, which possesses excellent insulation properties.

To ensure that the various planar transistors are not mutually shorted *via* the (semiconducting) silicon substrate, each transistor must be surrounded, island-like, by an electrically insulating region. The fact that it is possible to grow a very thin single-crystal layer of N-type silicon epitaxially on a P-type silicon wafer offered a convenient solution: with an epitaxial structure, all that is necessary is to diffuse a P-type ring straight through the layer and to bias the resultant P-N junctions in the reverse direction. Epitaxial growth is defined as the growing of a single-crystal layer on a single-crystal substrate so that both have the same crystal structure and orientation. With epitaxial growth it is possible to apply to the surface of a crystal a layer of the opposite type of conductivity.

Meanwhile, many forms of field-effect transistors were exhaustively studied in addition to the junction transistor.

High surface stability

The high surface stability of the [illegible] used in planar technology rendered the [illegible] oxide-semiconductor) field-effect transistor [illegible]

Operation of this device is based on the [illegible] of charge at the silicon surface under the gate [illegible] For integration purposes the MOS [illegible] advantage over the junction transistor that no [illegible] layer and no insulation diffusion are necessary, with the result that the technology of MOS-ICs is relatively straightforward.

As a result of these various developments it became possible, as early as about 1960, to integrate some 10 transistors and other components on a single wafer so as to form a complete circuit. These first ICs marked the end of a period in which circuits comprising transistors, by now inexpensive, had to be wired and soldered together at great cost.

The desire for further cost reduction led in the second half of the 1960s to still more drastic integration techniques enabling some 100 components to be accommodated on a single silicon wafer.

The most recent advance is "large-scale integration", which was first introduced several years ago. This technique enables between a thousand and tens of thousands of components to be accommodated on a silicon wafer of several square millimetres or slightly larger.

At first, the military authorities were the main driving force behind this breathtaking development, but as time went on their role was taken over by space programmes and the computer industry, which demanded increasingly higher operating speeds and smaller dimensions, as well as lower power consumption and lower heat transfer.

Economy and reliability

Nevertheless, the chief criteria were economy and reliability. Needless to say, grateful use of this rapid progress in electronics was made in the development of professional equipment in sectors other than the two mentioned and for more "ordinary" applications.

As a result, applications such as traffic and automotive electronics, education and information *via* television, telephony plus television or page-printing and meetings *via* television or videophone are coming nearer and nearer to being a reality.

The miniaturization resulting from transistor and integrated-circuit technology have had positive consequences as regards environmental aspects.

Integrated circuits consist for easily the major part of silicon, which is obtained from silicon dioxide (quartz sand) and is required only in very small quantities. Copper wires and soldered joints have disappeared. Chassis, cabinets and spaces in them are only a fraction of the size they once had to be. Power consumption is [illegible]. A roomful of tube equipment devouring power by the kilowatt can now be replaced by a silicon single chip using something in the region of one watt. The [illegible] space and power they require cannot [illegible] restrict further extension of integrated-circuit applications.

Moreover, modern electronics can provide a solution to the problem arising from the increasing use of private transport which, in view of the limited space, the pollution aspects and steel and fuel reserves, is beginning to constitute a great threat to the quality of life. This undesirable development can be held in check by an advanced, properly functioning communications network.

Hyper-pure crystals

Almost all integrated circuits are made from silicon. The more complicated the circuits and the more of them there are on a silicon wafer, the more closely their electrical properties depend on the purity and structural perfection of the material.

A commonly-used technique for producing extremely pure single crystals of silicon – from which the crystal wafers are later sawn – is the floating-zone method, in which the crystal is grown from molten silicon which is not in contact with any other material.

Research at the Philips laboratories, for instance, showed that impurity of the silicon leads to the formation of vacancy clusters, i.e. conglomerations of empty crystal-lattice positions which can be fatal for the performance of the circuits formed on the wafer. Theoretical study of experimental data led to the conclusion that the clusters form at sites where oxygen occurs. On this basis it proved possible to devise two methods for eliminating the clusters.

One method is based on employing such a fast growth rate (5 mm/s) that the consequent rapid cooling prevents the formation of nuclei. In the second method, the growth process is carried out in a hydrogenous atmosphere. By interacting with the oxygen in the crystal, the hydrogen inhibits the formation of nuclei to such an extent that completely cluster-free material is obtained at growth rates as low as 3 mm/s.

Use of beams to determine purity

In recent years, scientists have come to realize that ion beams can be used not only to influence the properties of materials but also to determine the location and nature of foreign atoms in the crystal lattice of, for example, silicon.

If the atoms are heavier than those of silicon, the method employed is proton reflection. If they are lighter, the characteristic X-ray emission of protons [illegible] that occurs when protons collide with [illegible]

A new method has also been devised for obtaining a clear picture of the quality of an entire silicon wafer. The method consists in inserting the wafer as the target

Figure I. Silicon crystal with vacancy clusters

in a TV camera of the vidicon type. Inhomogeneities such as vacancy clusters and variations in the doping concentration are then clearly displayed on the TV screen [see figs. I and II]. It is important to eliminate these clusters if a defect-free silicon vidicon is to be achieved.

Figure II. Television picture of a silicon wafer. The circles indicate variation of the impurity concentration; the dots, vacancy clusters

LOCOS technology

LOCOS (LOCal Oxidation of Silicon) is the name which has been bestowed at the Philips research laboratories on a special method developed there for implanting integrated circuits (ICs) in a silicon crystal wafer [see fig. III].

Conventional techniques all feature an oxide layer which originally covers the entire wafer. Holes are then etched in that layer photolithically and chemically, and through these holes operations can be carried out on the exposed silicon.

For example, impurity concentrations needed for the formation of transistors, diodes, resistors etc., can be diffused locally into the wafer.

Since the dimensions and positions of these areas have to be kept within ever narrower limits as packing density increases, it is essential to keep the oxide layer very thin (up to about 1 μm). However, it is often desirable to have thicker layers because these layers are what separate the silicon wafer from the connecting and source leads, and unwanted capacitive effects must as far as possible be eliminated.

In LOCOS a thin layer of silicon nitride is used, the primary purpose of which is to act as a mask for the oxide layer. Thus the openings in the oxide layer, even when it is up to 2 μm thick, are accurately fixed by the thin silicon nitride pattern which can be removed separately by etching. The nitride pattern can also be used as a diffusion mask.

Formation of the thick oxide films can be so well controlled that, instead of projecting beyond the silicon surface, they can be deposited "flush" without too much difficulty. The metallization is then not required to span any steep steps, which appreciably reduces the possibility of undesirable breaks.

The LOCOS technique makes it possible to produce very compact ICs accommodating both MOS transistors suitable for high frequencies (with a P- or N-type channel) and bipolar transistors.

Charge transfer devices

Charge transfer devices (CTDs for short) can be used, *inter alia*, as delay lines (including delay lines for analogue signals), memories or filters.

The oldest representative of this family is the bucket-brigade device BBD. It owes its name to the fact that quantities of electric charge are passed on step by step like pails of water in the old method of fire-fighting.

In this type of IC the portions of charge, which represent samples of the signal to be processed, are stored in capacitors. Field effect transistors located between the capacitors act as switches which allow the charges to pass on to the next capacitor. The capacitors are connected alternately to a voltage [illegible]

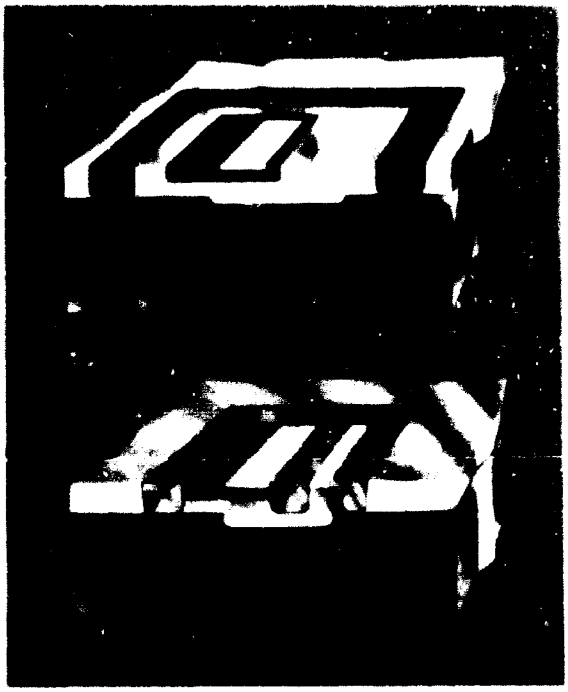

Figure III. *(a)* Integrated bipolar transistor (N^+—P—N^+) in which the insulation between the components is provided by P^+ depth diffusion regions (shown dark) in accordance with conventional techniques; *(b)* the same type of transistor made by LOCOS techniques, ideal insulation being assured by thick countersunk silicon-oxide regions (shown transparent), which can now be located in direct contact with the base region and the collector contact zone, with a resultant saving of space

representative of certain samples from the signal to be processed and a higher fixed reference voltage. Meanwhile, efforts are going on to further perfect the BBD principle, which, in essence, consists in the transfer, by means of a field effect, of portions of charges that are stored in a semiconductor.

Another version of CTD, which is based on the same principle, was mainly worked out in the United States of America and has been termed charge-coupled device (CCD); also here use is made of a series of electrodes fixed on to a wafer of oxidized silicon which forms the [illegible] electrode.

A greatly improved version, the peristaltic charge-coupled device (PCCD), was recently developed. In this PCCD the charge transfer from the input to the output is [illegible] greater perfection and at a greater [illegible] CTDs. In experimental PCCDs a [illegible] of over 99.99 per cent per step at a [illegible] has been measured, [illegible]

I^2 L, a breakthrough

In existing integrated circuits, particularly bipolar transistors, current-limiting resistors have to be inserted in the source leads to protect the transistors against overloading. These resistors require extra space, extra power and extra cooling capacity [see fig. IV].

Logic gate circuits (transistor circuits for computer applications) on an LSI scale have been developed.

The new technique has been named I^2L (or IIL, meaning integrated injection logic) because the bipolar transistors are powered individually by the injection of charge carriers from P-N diodes forming a single structural whole with the transistors. The local energy sources formed by these power-supply diodes operate at a level of 0.7 V, the forward voltage of a P-N junction. The power they deliver is naturally limited and renders the limiting resistors superfluous [see fig. V].

Using the I^2L technique, it proved possible several years ago to make more than a thousand gates in a crystal wafer of about 10 mm^2, a considerable advance in the LSI field. Recent research indicates that even larger numbers are possible. (The number of gates in large computers is expected to rise in the future from about 100,000 to 500,000.)

Power consumption of these circuits is now so small that it is comparable with the power consumed by the human brain. One of the ways in which this has been achieved is by "turning the circuits down" during quiet periods.

Figure IV. Part of an IC made by conventional techniques

[illegible]

Small wafers with large memories

One extremely important field in which integrated circuits find application is the computer. ICs have proved most suitable for the digital technique used in it.

A vital component of a computer is the memory, where data or the results of operations are stored provisionally or for an indefinite period. The efforts of the semiconductor industry to capture a large portion of the market for computer memories and oust the more conventional magnetic core storage has led to the development of memories with a large number of bits per unit of surface area and also a low cost per bit.

Research has been carried out for the purpose of developing a dynamic memory (i.e. a memory that can be "refreshed" electronically from time to time) with one MOS transistor per bit and a high packing density. In this type of memory the information is stored in the form of an electric charge in the slightly increased capacitance of the drain electrode of the MOS transistors which are used as switches.

The investigation has resulted in a prototype with 4,096 bits, each occupying only 825 μm^2, which corresponds to a bit density of 1,200 bits per mm^2.

This tiny bit area was achieved by using a combination of the LOCOS techniques described earlier and gates of polycrystalline silicon while, moreover, it was made possible by the great sensitivity of the part of the circuit that has to detect the stored charges.

The memory is also distinguished by the fact that it only needs one source voltage and that only one clock signal need be applied. From this signal the circuit itself derives a number of internal clock signals, which means that the circuit can be housed in a standard package with 18 connecting pins.

Data transmitter cut down to size

It is possible to have computers communicate with each other *via* existing telephone lines. The "language" in which they converse is made up of digits (data) instead of speech sounds.

The data transmission world is yet another in which great importance is attached to the miniaturization of circuits. In data transmitters, however, there was the difficulty that the filters, consisting of many coils and large capacitors, do not lend themselves to incorporation in integrated circuits.

In a new design [fig. VI] this problem has been overcome by using what are known as "digital" filter methods. The filters with their coils and capacitors have been replaced by shift registers, made up from logic elements, which can be readily produced in integrated form. Digital techniques are used even for the modulator needed in the data transmitter, so that it, too, can be constructed from computer elements which can be readily integrated.

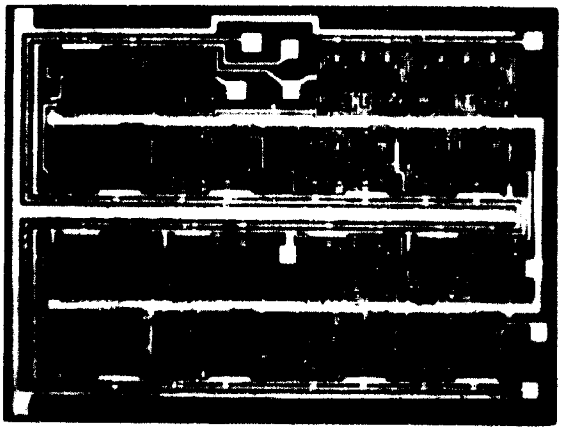

Figure VI. Complete digital data transmitter integrated in a crystal wafer of approximately 5 mm^2 area

In addition to specific IC advantages such as compactness and savings in material, power and costs, the integrated data transmitter, consisting of 400 components, also offers a certain degree of flexibility. For instance, its transmission speed can be modified with the aid of an external oscillator so that it is suitable for both narrow-band and wide-band telephone circuits.

Not coils but gyrators

As IC technology progresses there is an increasing need for a compact and integrable element which can perform the function of the coil, a component which is still comparatively bulky. Coils are still used on a fairly large scale, e.g. in telephone filters.

One of the possible solutions is the gyrator.

Like the transformer, the gyrator is a passive fourpole. The remarkable thing about the gyrator—and in this it differs entirely from the transformer—is that its output voltage depends entirely on its input current and its output current solely on its input voltage [see fig. VII]. This has a remarkable consequence: if the capacitor is connected to one pair of the gyrator's terminals, the same relationship is found between voltage and current at the other pair of terminals as in a coil [fig. VIII]. In short, a gyrator plus a capacitor stimulates self-inductance.

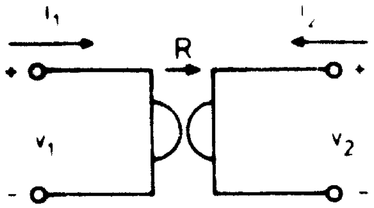

Figure VII. Symbol for a gyrator. Relevant formulae: $V_1 = -Ri_2$; $V_2 = Ri_1$

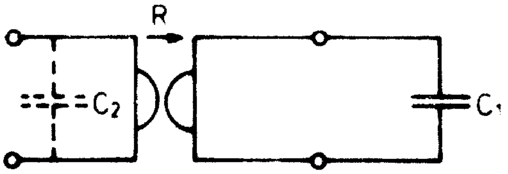

Figure VIII. Simulation, with the aid of a gyrator, of: *(a)* a coil with C_1; *(b)* a tuned circuit with C_1 and C_2

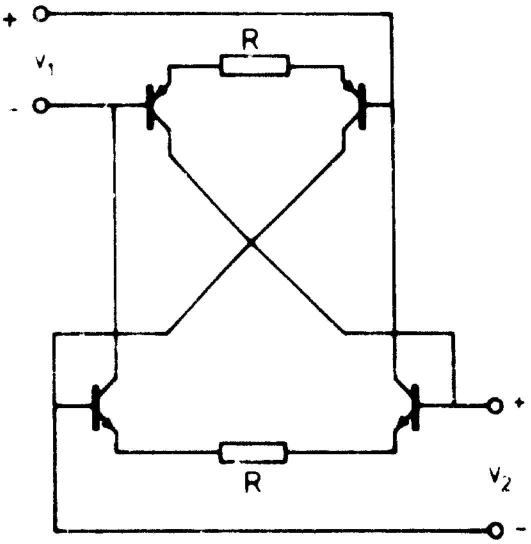

Figure IX. Circuit diagram of an integrable gyrator

Construction of a gyrator for low frequencies, however, did not become feasible until the advent of transistors and, more especially, of integrated circuits.

Research scientists succeeded, on the basis of a circuit containing four transistors and two resistors ("gyration" resistors) [fig. IX], in designing an integrable fourpole which satisfies the formulae given for the gyrator in figure VII.

The resultant integrated gyrator was successfully tested in telephone filters which, unlike conventional filters, do not need to be adjusted provided the gyration resistors and capacitors are sufficiently accurately dimensioned. The circuit can also be used for tunable filters, insulators, circulators, non-linear circuits and adaptive circuits.

Designing integrated circuits

As the number of components on crystal wafers has increased, the integrated circuit has become increasingly difficult to "take in" at a glance and its design has become more and more complicated. This problem occurs more especially in digital techniques, which usually demand many more components than are needed for analogue circuits.

Luckily, the computer has proved in many ways a valuable aid in designing circuits.

Researchers have for some considerable time been engaged not only in developing computer programmes for analysing and checking circuit diagrams on paper and locating subsequent faults occurring in the circuit but also in devising computer programmes for arranging circuit components and laying in the wiring.

Layouts are arrived at after "talks" between the designer and the computer—the latter acting as a kind of accurate, high-speed accountant who has been informed of certain commandments and prohibitions of general application to IC technology.

The computer "knows", for instance, what minimum spacing must be observed between leads and that leads must intersect as little as possible or not at all.

It has been found that the computer on its own cannot achieve absolutely optimum packing densities in the design of IC layouts. It can do so if the designer with his faculty of judgement intervenes during the computer's design procedure and gives instructions. This co-operation demands only a fraction of the manpower and time needed by conventional design methods.

It is hoped in the near future to design all layouts of digital LSI circuits by this interaction method.

06407

LOCATING INDUSTRY: ENVIRON

To protect and improve

OVER the past decade, realization has been growing that there is a vital need to protect and improve the environment of the world, that in order to meet the energy, air, water and living space requirements of a rapidly increasing population careful planning is essential.

This realization led to the convening in Stockholm in 1972 of the United Nations Conference on the Human Environment, which made 106 recommendations regarding the protection of the environment, and the subsequent forming of the United Nations Environment Programme (UNEP) to take action on those recommendations. UNEP, in conjunction with other United Nations agencies and several governmental and non-governmental bodies, developed a plan of action in which the recommendations were grouped into several broad areas.[1]

Three of these areas relate particularly to the location of industry and have been accorded high priority by the Governing Council of UNEP. They are:

- Human settlements, human health, habitat and well-being
- Land, water and desertification
- Trade economics and the transfer of technology

The reason underlying the assignment of this priority was expressed in a Declaration of Principles adopted by the Stockholm Conference. Principle No. 1 states: "Man has the fundamental right to freedom, equality and adequate condition of life, in an environment of a quality that permits a life of dignity and well being, and he bears a solemn responsibility to protect and improve the environment for present and future generations."[2]

However, while the economic advantages of correct location have long been recognized its importance with respect to the protection of the environment has not been given the attention it deserves.

During the growth of the industrialized societies little attention was paid to the effects of technology on the environment, either in choice of technology or location of industries. Social aspects, such as health and over-all community well-being, were subordinated or neglected, and in some cases deliberately exploited, in the drive to improve living standards, and, in spite of the social pressures and environmental awareness of today, this state of affairs continues to some extent.

The location problem

Environmental considerations with regard to the location of industry involve more than just the physical aspects of the matter; they must include the reason for establishing the industry. To exploit a natural resource? To expand a known market? To create employment? For political purposes? For national prestige? To exploit particular technical or manual skills? To take advantage of market proximity or geographical location? To attract foreign investment? To absorb excess local capital? All of these are plausible reasons for setting up an industry, the common factor being the improvement of living standards. In this connexion it is interesting to note the interrelationship between relative income and the acceptance of poor environmental conditions. In some developing countries whose populations are living near the subsistence level it is reasonable to expect that more importance should be

This article is based on a paper prepared by the secretariat of UNIDO for a meeting of the International Institute for Industrial Planning, held at Vienna in February 1974

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[1] See "The Environment Programme: approval of activities within the Environment Programme, in the light *inter alia* of their implications for the Fund Programme: report of the Executive Director" (UNEP/GC/14/Add.2).

[2] *Report of the United Nations Conference on the Human Environment* (United Nations publication, Sales No. 73.II.A.14), section II, principle 1.

MENTAL CONSIDERATIONS

placed upon the essentials of life—shelter, food and water—than upon atmospheric pollution and the destruction of flora and fauna. Experience has shown, however, that as economic conditions improve, awareness increases of the desirability of a clean environment and social pressure increases for a control on pollution. There is, it appears, a correlation between living standards and social pressures and studies are in progress to try to express this correlation in quantitative terms. Such information could, if used in the decision-making process, lead to great savings since the cost of adding pollution control equipment to an existing factory or plant is usually much higher than when it is included in the initial investment.

In developed and developing countries alike there is a tendency towards agglomeration in urban and industrial areas. This is a natural tendency since industry needs an infrastructure containing transport, labour, commercial banking and investment facilities, and proximity to raw materials and markets. However, while production costs can be kept down by establishing an industry where such an infrastructure already exists, this view may be found to be too narrow in the light of regional and national economic policies; the object must be to achieve a balance between social and economic profitability, two goals which, without consideration of all the parameters involved, may appear as conflicting.

The question of the optimum size of an agglomeration has not been fully investigated, but it is worthy of further study taking ecological aspects on an equal footing with economic considerations. Several of the larger cities of the world, whose location was based purely on trade convenience, are examples of unplanned siting which it would be preferable not to repeat.

Decentralization, on the other hand, while possibly desirable from the ecological point of view, is sometimes difficult to realise owing to the lack of infrastructure; it must, if it is to be successful, be the result of a planning operation which ensures provision of appropriate facilities and takes account of national or regional development requirements.

Decentralization policies are being carried out at present in a number of industrialized countries including the United Kingdom of Great Britain and Northern Ireland and the Federal Republic of Germany. Among other benefits of such a policy are the prevention of the further pollution of already polluted areas, the utilization of fully integrated systems of waste removal, sewage and water supply, and the more efficient utilization of existing transport systems (by reduction of local traffic volume and the integration of new systems into the existing network). Not only has this resulted in an improvement of the environment in these countries but there have also been economic advantages.

While the decentralization of industry is primarily of importance to the industrialized countries it is also of relevance to certain developing countries whose industrial systems were established by colonial administrations. India, with its large concentrations of industrial activity (notably at Bombay and Calcutta) is a good example. With regard to decentralization in developing countries there is, of course, the danger of spreading limited investment resources so thinly that they become ineffective.

When a country, either developed or developing, is considering decentralizing its industries, or establishing new ones, it is imperative that it have knowledge of the pollution potential of the technology involved; of the effectiveness of, and investment requirements of, pollution control equipment; of tolerable pollution levels, and of energy requirements.

While considerable information is available on the techno-economic aspects of most industries location studies are restricted by the fact that data on the wider external factors is not yet sufficiently well formulated to be of quantitative use. Several international organizations are trying to fill this gap, however. UNIDO, in conjunction with UNEP, is implementing a number of projects within the framework of an integrated programme of environmental work which should make a contribution to this field. Studies of existing plants are being carried out with a view to determining their over-all effect upon the environment. Since the mandate of UNIDO is to aid in the industrialization of the developing countries, the industries chosen for study are those which are particularly important to these countries, namely, the leather, rubber, textiles, iron and steel, cement, and basic chemicals industries. The methodology used in these projects is designed to provide information inputs for a UNIDO/UNEP study on a minimum-pollution integrated industrial complex (described below) and to endeavour to discover, through pattern recognition techniques, the necessary modification to the initial theories on the subject.

Minimizing pollution

In spite of the paucity of quantitative broad-based information considerable thought has been given to ways and means of achieving environmental cleanliness using the knowledge that is available. Two steps can be taken now reduce pollution from established plants or factories, and integrate complexes of low-pollution industries. The third step will be to identify the best possible locations for these complexes. This will call for the consideration of such parameters as geography, meteorology, labour potential, land use and the over-all characteristics of the ecosystem within which it is desired to create industry. A scheme for the investigation of such sites has not yet been formulated that is definite enough to allow discussion in this article.

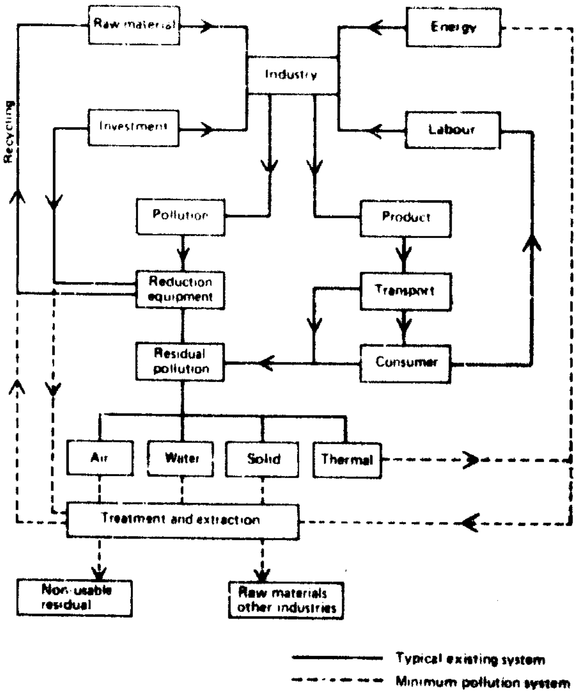

Figure I. The pollution cycle in a typical industrial system

The starting point in controlling the pollution from an industry is to determine the industry's pollution potential and what measures can be taken within the industry itself to correct this pollution.

Figure I shows a typical pollution cycle. It should be noted that, in addition to the industry itself, the system includes the transport factor and the contribution to over-all pollution by the consumer.

The dotted line shows feasible modifications to the system which could be carried out in order to achieve minimum pollution. The emphasis is on the recycling and utilization of wastes, simply removing or disposing of the pollutants from the system can only decrease the economic viability of the industry concerned.

The recycling of air, water and solid wastes is already reasonably well-established practice, but the problem of waste energy utilization, while the subject of a great deal of study, has not been completely solved. The importance of using this waste energy is clearly seen when it is realized that the average efficiency of thermal processes is only 35 per cent and that the remainder serves no useful purpose; in conventional fuels alone, some 3,900 million tons per annum serve only to heat the atmosphere.

The other final waste products of the cycle include a non-reusable residue, and by-products which could become raw materials for other industries. It is not realistic to assume that potential raw materials can be extracted from all pollutant residues; quantities and extraction costs may make the operation non-viable. The modified system does appear to be feasible, however, for large industries.

The non-reusable waste products would have to be treated by conventional methods: removal of harmful gases, neutralization of water prior to discharge into sewers or water courses, and controlled dumping, incineration and composting of solids. The technology of such treatment is still in its infancy, but it is expected that, in view of the present interest in recycling materials, the process will develop rapidly.

Minimum-pollution integrated industrial complex

A minimum-pollution integrated industrial complex is essentially an industrial estate in which some industries can:

- Utilize the products of other industries in the estate
- Utilize raw materials extracted from the waste of other industries
- Provide a neutralizing medium for the non-reusable waste of other industries

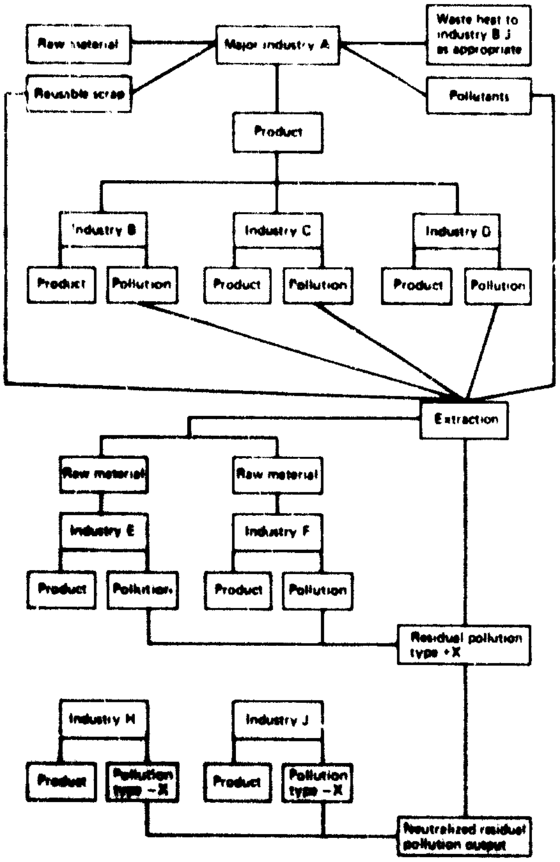

Figure II. **A minimum-pollution integrated industrial complex**

The concept (the subject of a major UNIDO/UNEP study) is illustrated in figure II. Although each of the industries shown has a pollution cycle similar to that in figure I, for the sake of clarity only simplified cycles have been used. It is assumed in this exercise that the complex is concentrated around a major industry, such as an iron and steel plant or a chemical works.

The major industry (A) feeds its products as raw materials to ancillary industries B, C and D. The pollutants from each of these four industries have a high degree of similarity and can be fed to a common extraction treatment plant.

The output from the treatment plant provides raw materials for industries E and F and leaves a pollutant residue which is added to that of industries A, B, C and D. This residue is designated type +X.

Industries H and J can be of any type producing a non-reusable residue (designated type −X) which will neutralize the non-reusable pollutants from plants A, B, C, D and E (type +X).

The system described here is, of course, very much oversimplified, but it is one which should lend itself well to systems analysis techniques.

It is realized that the difficulties involved in implementing such a scheme would be great; however, the advantages, even if the scheme were only partially realized, would make the attempt worthwhile. The main advantages are:

- **Minimum waste of resources**
- **Minimum residual treatment costs**
- **Reduction of transport costs and, provided the estate area is not too large, reduction in both traffic volume and pollution by utilization of non-polluting transport**
- **Creation of a commercial infrastructure of planned size and amenity**
- **Fullest exploitation of the labour market (because of the wide variety of industries)**

06408

IMPURITIES IN WATER:

some industrial implications and methods of removal

by Trevor D. Rees

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ALTHOUGH these comments are based mainly on experiences in the heavy chemical industry, many of them will be applicable to industry in general. Apart from the usual requirements for drinking and amenity use, water is also needed for process purposes, cooling and steam raising. It is important to stress at this point that water which is regarded as wholesome in the potable sense, i.e. water that is satisfactory from the point of view of odour, colour, taste, appearance and which can be consumed without risk from its chemical or bacterial content, is not necessarily suitable for many industrial uses without further treatment. In some areas cheaper alternative supplies of non-potable water are available and these can be attractive to industrial users particularly if the cost of any additional treatment is not too high and there is no, or very little, restriction on the quantity as is often the case with potable supplies. The various sources of water can be classified roughly into rainwater, ground water (from springs, shallow and deep wells) and surface water (from rivers, streams, ponds, lakes, impounding reservoirs and so on). It is the last type of water which is most likely to become polluted. Many of the impurities which can cause problems in industry are natural in origin, but as more complex collection schemes are devised and increasing use is made of rivers as aqueducts the effect of pollutants will increase in significance. In any case, the methods of treatment to be discussed are essentially the same irrespective of the source of impurity. These impurities can be grouped into suspended solids, dissolved solids and gases. On Teesside, for example, there is a potable supply arising from reservoirs in the catchment area, in upper Teesdale, i.e. from an area where pollution is not likely to occur. In addition to this there is a separate supply of industrial water which is extracted from the River Tees. This water is subject to variations in river flow and can also be polluted by discharges which flow into the river upstream of the abstraction point. Table 1 lists a number of the impurities in water and the problems they can create in industry.

TABLE 1. SOME COMMON IMPURITIES FOUND IN RAW WATER AND THE PROBLEMS CREATED

Suspended solids	Unsightly appearance, deposits in pipes, boilers, process equipment and so on
Colour	May cause foaming in boilers; can stain process products and foul ion-exchange resins
Hardness salts	Cause scale in heat exchange equipment
Alkalinity	Decomposition of bicarbonates can give CO_2 in steam resulting in corrosion of condensate lines
Silica	Can volatilise in steam and deposit on turbine blades
Dissolved gases	Oxygen and carbon dioxide are agents in corrosion processes; hydrogen sulphide is a catalyst poison
Dissolved solids	Can cause foaming and scaling in boilers; a source of corrosion e.g. chlorides on stainless steel

Suspended solids can be naturally occurring silicates, or pollutants, for example, suspended oxides or fibres. Colour usually arises from naturally occurring humic and fulvic acids but equally important could be any organic matter e.g. detergents or oil. Each of these impurities is discussed later.

Process water

Process water is water which is an integral part of the process, either as liquid or steam. It is difficult to generalize on the effect of the impurities since much depends on the nature of the industry. At one end of the spectrum, water may be needed to remove massive impurities (solid, liquid or gaseous) from a crude product and for this purpose many available sources will be suitable without further treatment. On the other hand, in the pharmaceutical and transistor industries even trace impurities can have far-reaching effects. In table 2 a few examples are selected to illustrate this point.

TABLE 2. SOME PROCESS USES FOR WATER (AND STEAM)

Process	*Problem*	*Remedy*
Removal of ammonia from gas streams	Precipitation of hardness salts	Use softened water
Removal of impurities from dyestuffs	"Sulphated ash" clause in specification	Use water which will not give "sulphated ash"
Manufacture of rubber	Tight specification for Fe and Cu in final product	Use water which is low in Fe and Cu
Manufacture of nylon nitrocellulose and so on	Colour in final product	Use colourless water
Preparation of "high integrity" products	Removal of trace amounts of water-soluble impurities	Use demineralized water
Catalysis	Poisoning of catalyst (e.g. by Cl or S)	Use high quality water/steam

If one is removing ammonia from a gas stream, then as the pH rises any hardness salts in the water will precipitate out and cause problems. It is therefore necessary here to use softened water. In the manufacture of dyestuffs often a sulphated ash clause is involved and therefore softened water is unacceptable since it could leave a residue of sodium salts which would give a sulphated ash. In this case one would have to use demineralized water or possibly some [illegible] Also in the manufacture of rubber, copper and iron are very important, and one must choose carefully the source of water used. In the manufacture of nylon, nitrocellulose and fibres in general, colour in the final product is important and colourless water must be used. To render water colourless one can use techniques based on flocculation and filtration but sometimes even this is not good enough and treatment with activated charcoal is necessary. In the preparation of high integrity products such as catalysts and certain fillers even trace impurities can be very important and for this purpose demineralized water must be used. In catalytic processes, particularly such as steam reforming, small amounts of sulphides or chlorides can wreak havoc with the catalyst and therefore one must monitor and control the quality of the steam very carefully. If one is faced with the situation of having to use a raw water which may, due to anaerobic conditions contain hydrogen sulphide, for example, then this must be removed by one of the processes discussed later.

Cooling water

Although large quantities of cooling water are used in industry, the quality requirements are generally not very exacting. However, apart from getting the maximum use out of the water as a cooling medium, consideration must be given to problems of corrosion, scale formation and fouling of heat exchangers, all of which can prove very costly if neglected. There are basically three types of cooling systems which are used in industry. The water requirements and any ancillary treatment depends on the particular design:

1. *Closed cooling system*

Since there is no purge from this system it is possible to use a whole range of chemical inhibitors to combat corrosion even if they happen to be toxic e.g. high concentrations of chromate or nitrite/benzoate mixtures. Also, since the system once filled requires little "topping up", very good quality water can be used to prevent scaling.

2. *Once-through system*

The cooling duty is carried out by water which is often extracted from a river and then returned to the river without any pollution, except of course a temperature increase. Heat, however, is a pollutant which has to be controlled. Because of the large volumes involved, treatment is not usually desirable or practicable, but it may be necessary in some situations to filter the water first or occasionally add some polyelectrolytes to keep any insoluble solids in suspension. Biological control may also be necessary in some situations.

3. *Open evaporative recirculation system*

This is the most common form of system used in industry and is illustrated in figure I. Water from the bottom of the cooling pond is pumped back to the process and carries out a heat exchange duty. It is then returned to the hot well from which it is pumped to the top of the tower and in falling through the tower is cooled by two mechanisms: first by the latent heat of evaporation, and secondly by the transfer of sensible heat from the water to the air rising up the tower. This is a recirculating system and, because of evaporation, scale formation can occur during use. Therefore, a careful balance between the purge and the make-up water is required to arrive at an acceptable limit of concentration (concentration factor) vis-à-vis scaling, fouling and corrosion.

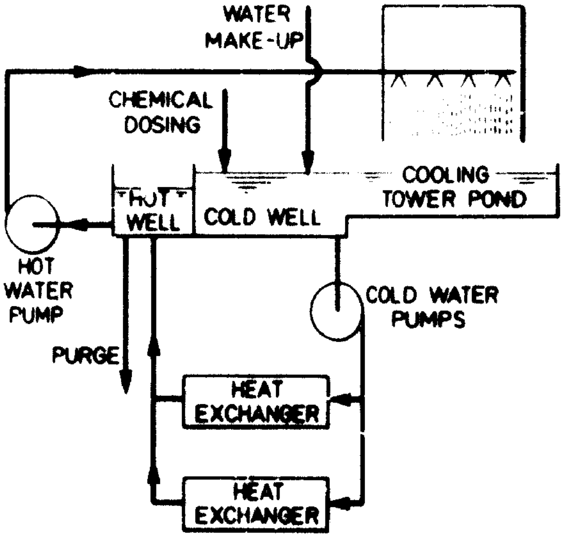
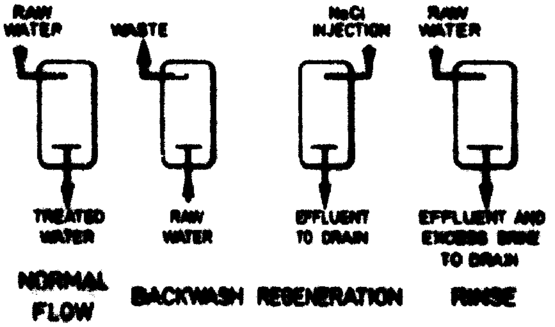


Figure I. Open evaporative recirculating system

Problems that can arise in cooling towers depend very much on the water used. For example, suspended solids, whether they are inherent in the raw water or result from atmospheric pick-up over the tower or corrosion within the system, are very undesirable. In regions of low water flow or high heat flux in particular, they tend to deposit and impair heat transfer processes. Suspended solids also encourage corrosion and add to pumping costs. Where there is a problem of this sort prior filtration of the make-up water may be necessary but this will obviously not suffice if the suspended solids originate in the system itself. In this case a proportion of the circulating water, usually 2-5 per cent, is passed through a side-stream filter in order to maintain an acceptable value for suspended solids in the system as a whole. In some situations the addition of chemical dispersants help to keep the insoluble matter in suspension and this is removed in the purge. Deposits can also occur in cooling systems due to biological activity. The lower forms of life such as algae, fungi and bacteria can give rise to growths in cooling towers altering the flow patterns over the tower packing. They can also produce slimes in heat exchangers which seriously interfere with the cooling process and also set up corrosion sites. Industrial waters which are unchlorinated and particularly those containing pollutants such as phosphates and ammonia, which act as nutrients, can be particularly troublesome. A biological control programme is usually carried out which often includes the regular use of chlorine, hypochlorite or a proprietary biocide. Deposits can arise from the crystallization of inorganic salts such as calcium carbonate, calcium sulphate and magnesium hydroxide. The skill in operating open evaporative systems is to optimize the use of water without running into this problem. If water is allowed to circulate and concentrate in these systems a time arises when crystallization begins. Calcium carbonate will normally deposit first, and the harder the water the sooner this point is reached. With some soft waters a concentration of say six to eight times is possible, but with many bore-hole and mine waters, which usually contain a large amount of bicarbonate hardness, even a twofold concentration causes problems. In practice, many of the waters are dosed with acids (sulphuric is usually employed for cheapness) so as to lower the pH and thus destroy the bicarbonates. This practice is limited because too low a pH gives rise to serious corrosion problems. Without discussing corrosion control in detail it may be said that where the use of a corrosion inhibitor is permitted (usually one based on chromate), by reducing the pH to about 6.5 it is possible virtually to eliminate scaling and at the same time reduce the risk of corrosion of mild steel to acceptable levels.

Steam

The production of steam, which is vital to most industries, depends very much on the purpose for which it is being used. It may be low pressure steam for space heating, evaporation and drying processes or very high pressure steam for power generation. Steam is also of course a raw material in many industrial processes. In order to produce it in the required quality, and at the same time minimize failures in steam-raising equipment, great care has to be taken in specifying and controlling the quality of boiler feed water. Irrespective of boiler pressure it is necessary to prevent the formation of scale on heat transfer surfaces. "Fur" in domestic kettles is an example of this. Some form of treatment is necessary to remove potential scale forming substances such as salts of calcium and magnesium. In low pressure boilers, the treatment is internal and chemicals are added which precipitate the hardness salts within the boiler in a fluidized form so that they can be removed in the "blow-down". In most situations, however, external treatment is practised. If the concentration of hardness salts is well in excess of say 100 ppm, partial softening with lime or lime soda is usually carried out. After this process the water may be suitable for feed to low pressure boilers, but since it is not possible to remove all the hardness further treatment is usually necessary and it is at this stage that one must consider ion exchange. Many modern ion exchange plants are fully automatic but this has only been made possible by the development of adequate monitoring devices. The simplest form of ion exchange is base exchange (fig. II). In this process the resin is a strongly acidic sulphonic acid resin in the sodium form. The time to regenerate the unit is usually decided by carrying out a hardness determination on the treated water. This can be done in the laboratory by titration with EDTA in the usual way, but there are of course on-line monitors to do this; some are based on colour reactions with dyes such as solochrome black, others are based on electrometric



BASE EXCHANGE: STRONGLY ACIDIC RESIN IN Na^+ FORM

SOFTENING CYCLE

$$2NaR + Ca(HCO_3)_2 \longrightarrow CaR_2 + 2NaHCO_3 \quad ①$$

$$2NaR + CaSO_4 \longrightarrow CaR_2 + Na_2SO_4 \quad ②$$

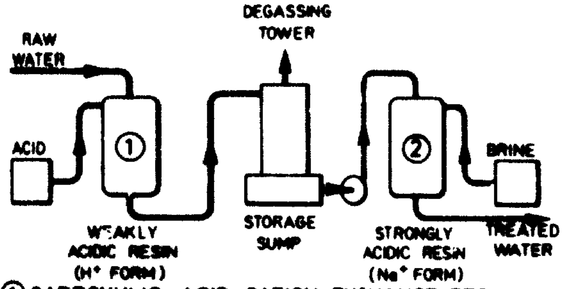
REGENERATION CYCLE

$$CaR_2 + 2NaCl \longrightarrow 2NaR + CaCl_2 \quad ③$$

Figure II. Base exchange unit

[illegible]. When the time to regenerate the unit is reached, [illegible] is a breakthrough of calcium or magnesium, the water is passed upwards through the [illegible]

sodium (therefore there is no decrease in the total dissolved solids) and brine is the regenerant. Although hardness salts are removed in this process, any bicarbonate still remains and if this water is fed to boilers the sodium bicarbonate decomposes giving CO_2 in the steam which in turn can cause severe corrosion when it comes into contact with mild steel. It is therefore very desirable to remove CO_2 after a base exchange process and this can be done by acidifying the water from this treatment process and blowing out the CO_2 with air or steam. This is not particularly attractive however and a dealkalization process is now available. This process is one in which upstream of the softening unit there is a dealkalization unit and a degassing tower (fig. III). The resin is a weakly acidic carboxylic acid resin in the hydrogen form which is only capable of removing calcium and magnesium from bicarbonates. What happens is that this calcium and magnesium are removed, the CO_2 produced is eliminated in a degassing tower and the water from the degasser sump is fed through a base exchange unit. In this process, not only does one obtain softened water but all the hardness and CO_2 present as temporary hardness is eliminated and there is a corresponding reduction in dissolved solids. To control this system the hardness is monitored at the exit of the base-exchange unit and CO_2 is determined in the base of the degassing tower by conventional methods e.g. barium hydroxide titrations or even a pCO_2 electrode is useful. To monitor the point at which breakthrough of alkalinity occurs, it is necessary to carry



① CARBOXYLIC ACID CATION EXCHANGE RESIN IN H^+ FORM

$$2RH + Ca(HCO_3)_2 \longrightarrow R_2Ca + 2H_2CO_3$$

(PERMANENT HARDNESS UNAFFECTED BY THIS RESIN)

② SULPHONIC ACID CATION EXCHANGE RESIN IN Na^+ FORM

$$2RNa + CaSO_4 \longrightarrow R_2Ca + Na_2SO_4$$

(REMOVAL OF PERMANENT HARDNESS)

Figure III. Dealkalization plus base-exchange process

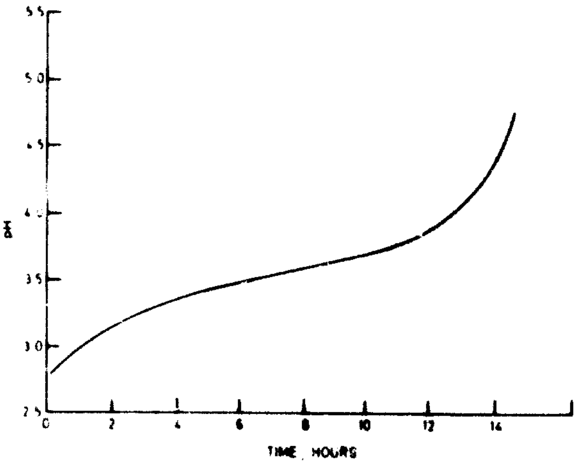
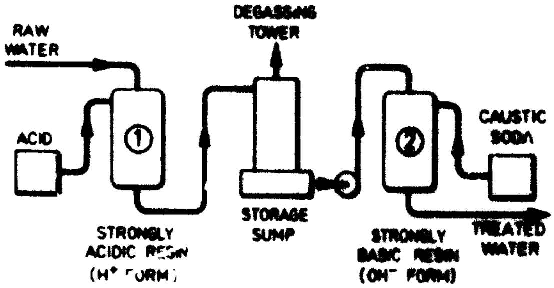


Figure IV. Change with time of pH of treated water from the dealkalization resin

out pH determinations (fig. IV). As can be seen during the normal course of events the pH is well below 4.5 but as the sodium or calcium bicarbonate tends to break through, the pH rises. At some predetermined value, based on alkalinity requirements, the pH value is chosen and regeneration takes place at this point. Neither of these ion exchange processes remove anions other than CO_2 and they are therefore inadequate for high pressure boilers, above about 800 lb/in², which require demineralized water for feed. As mentioned earlier, many industrial processes also require demineralized water. The reason why high pressure boilers need demineralized water is that solutes increase the risk of corrosion at the higher operating temperatures and silica in particular begins to volatilize in the steam. Many costly failures have been due to this silica redepositing on turbine blades from the vapour phase. In order to demineralize water it is necessary to use anion as well as cation exchange resins. Figure V illustrates a very simplified version of a demineralization plant which contains a strongly acidic resin in the hydrogen form, and a strongly basic resin in the hydroxide form. In the cation exchange process any cations are removed and anions, including bicarbonates, converted into their equivalent amount of free acid. Carbon dioxide is removed in the degassing tower and the silica plus mineral acids which remain are then taken out on the anion exchange resin in the hydroxide form. To control the operation of this plant it is necessary at the end of the process to determine the conductivity which is very low with an efficient process. Conductivity measurements detect any leakage of ionized species but do not detect silica, and it is therefore usually necessary in these operations to have also a silica monitor. "Silicometers" can be obtained commercially or one can use an "AutoAnalyser" system, based on the colour measurement of the blue reduced silico-molybdate complex. Carbon dioxide is determined by standard methods and the operation of the cation exchange unit is normally controlled by the break-through of sodium ions. These are the first to break through from this unit and some years ago they were largely determined by flame-photometers; a sodium responsive electrode (pNa) is now normally used. These sodium electrodes will also respond to hydrogen ions and it is therefore necessary to make quite sure the pH is adjusted to a value above 8, usually by introducing ammonia before the treated water stream is monitored. In demineralization processes all undesirable impurities, including less common contaminants such as heavy metals, ammonia, fluoride, phosphates, sulphides and so on, can be removed provided they are ionized. Problems can arise with non-ionic materials such as organic matter, including non-ionic detergents, and colloidal forms of silica. These materials may not be retained on the resin in which case they will go through the demineralization process and cause problems, for example, in the boilers. If they are retained on the resin it will be by a physical rather than a chemical process and there is no guarantee that they would be removed in the normal regeneration process. The resins thus gradually become fouled and their performance impaired. With many waters, therefore, it is necessary to install, ahead of the demineralization plant, a clarification process which usually combines flocculation with filtration. The most widely used flocculating agents are aluminium and ferric salts. Under correct pH conditions these give large gelatinous flocs on which the non-ionic impurities are adsorbed. Small additions of polyelectrolytes sometimes help. To assess the efficiency of the clarification process, the water coming from the flocculator and/or the filters is normally examined for colour, suspended matter, residual iron or aluminium as the case may be, and



① CATION EXCHANGE RESIN IN H^+ FORM

$$RH + NaCl \longrightarrow RNa + HCl$$

② ANION EXCHANGE RESIN IN OH^- FORM

$$ROH + HCl \longrightarrow RCl + H_2O$$

Figure V. Demineralization unit

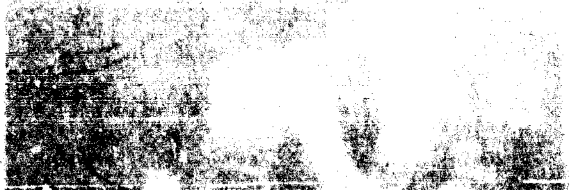
organic matter. To help in deciding the best design parameters for a flocculation process, it is possible to carry out laboratory experiments using a flocculation device. Various quantities of the primary flocculant are added, the pH is varied and the results with and without polyelectrolyte are studied. From these results one can quite often closely predict what will happen on the large scale unit.

Deaeration

In view of the concern expressed when natural water supplies become anaerobic it may appear paradoxical to state that oxygen is a very undesirable impurity in boiler feed water. The concentration of oxygen is in fact a very significant factor in the corrosion of iron and steel and often results in a highly dangerous localized form of corrosion known as "pitting". In order to reduce this corrosion it is necessary to deaerate the water before feeding to the boiler. The removal of oxygen is normally done in a pressure or vacuum deaerator. This will reduce the concentration from 10 to the order of 0.05 ppm but it is then often necessary to add a small amount of a chemical scavenger such as sodium sulphite or hydrazine, to remove the last traces.

Reuse, recycling and use of inferior waters

In some areas the supply of water is restricted and its use must be optimized; in other situations, pure economics demand that this is done. By reuse of water is meant the successive use of a given source of water for various purposes. Condensed steam from some processes, for example, contains impurities which make it unsuitable for recycling back to the boiler without some form of costly treatment. In other respects it may be good quality and may be used as make up for cooling towers. Sometimes, saline water such as boiler blow down or water from mining operations is used as feed to evaporators which then produce high quality steam condensate. Condensed steam itself is also often used to dissolve chemicals such as ammonia and nitric acid. By recycling is meant the successive use of water for the same purpose, for example, in the operation of open recirculating cooling systems. Recycling of condensed steam for further use as boiler feed is another example, but considerable care must be taken to ensure that its quality is satisfactory. Even if the steam has been used solely for driving turbines it can become contaminated by machine oil, corrosion products and the inferior water which is used in turbine cooling. Normally some system of monitoring such as conductivity measurement is carried out continuously but as it is difficult to detect trace impurities such as oil and suspended matter all the condensate is usually passed through a filter which might include powdered ion exchange resins for the removal of solutes. When steam has been used for purposes other than power generation such as drying and evaporation of chemical products, the risk of contamination is much higher and more elaborate monitoring devices are necessary. In one situation the author has experienced there may be contamination by methanol and in this case a special gas chromatographic apparatus had to be devised for monitoring purposes. Reference has already been made to the move in some areas to offer cheaper but inferior supplies of water to industry. One of the problems facing industry will be to equate the cost of any additional treatment with the reduced cost of the raw water and there would appear to be some challenging problems ahead for industrial water chemists. Inferior water can be used for cooling purposes but if this should be a sewage effluent the relatively high concentration of phosphates and ammonia would encourage biological growths and high concentrations of salts could enhance corrosion problems. Developments in the field of specific biocides, dispersant chemicals and corrosion inhibitors will no doubt help to overcome these problems. Looking further ahead, techniques such as reverse osmosis and electrodialysis will probably play an increasingly important role. Whatever chemicals are used, however, the industrial chemist has to bear in mind that he must pay due regard to his effluent control problems.



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06409

PLASTICS MAKE SIMPLER SAND MOULDS

Plastics are finding increasing use in the production of foundry sand moulds as a result of a shortage of craftsmen for the traditional wood pattern moulds. Several research and development centres have been experimenting with these materials since the 1950s and have accumulated considerable expertise in the field. This article deals with some aspects of plastics in patternmaking, based on one company's experience, and is reprinted, by courtesy of the editor, from the August 1973 issue of Asian Manufacturing

THE most important item in the production of sand moulds in the foundry is the pattern which is used at the very beginning of the process. It is usually made of wood, but the making of wooden patterns requires a high degree of craftsmanship. A shortage of qualified personnel in this field in recent years has compelled manufacturers to experiment with new materials and production techniques previously unknown in the pattern shop. The rapid increase in the use of plastics for patternmaking is therefore a logical and understandable development.

Plastics have now passed through the trial phase and earned recognition as acceptable and proven design materials. Their consumption in patternmaking has risen sharply in recent years. One of the main factors responsible for this growth is their multi-faceted application, another is their exceptional resistance to wear.

The use of plastics in patternmaking began with a synthetic resin pattern varnish. This was followed by synthetic resin fillers, cements and glue. In 1956, as the cold-setting resins appeared on the market, they began to use them to make core boxes and supplementary patterns: in those days a technique completely new to the pattern shop. Only when moulding equipment was produced with the pattern and pattern plate in single piece, however, did the consumption of synthetic resin begin to soar. The fact that plastics are usable not only as the actual raw material but also in many cases as an accessory to simplify the work helped to accelerate the swing towards plastics in the pattern shop.

Reliable assertions on the profitability of plastics in patternmaking can only be made by considering the specific application.

The main types of plastic used in patternmaking are: thermoplastics, elastomers, and thermosetting types.

Thermoplastics

Of the thermoplastics, the most suitable for patternmaking is polystyrene foam, because of its good machinability. But it is also an attractive material from the cost standpoint. The advantages of polystyrene foam lie in a significant simplification of the work of making the pattern—the pattern-maker no longer has to pay any attention to tapering the pattern so that it can be stripped from the mould.

Polystyrene patterns are used primarily for one-off pieces, casting systems and demonstration patterns [see fig. 1]. In the training of apprentices, polystyrene has provided welcome assistance. Often a complicated pattern is first formed from this material as a type of three-dimensional sketch to make the presentation more vivid. It is also a very effective teaching medium for improving the student's ability to read engineering drawings. In contrast to polystyrene, experimentation

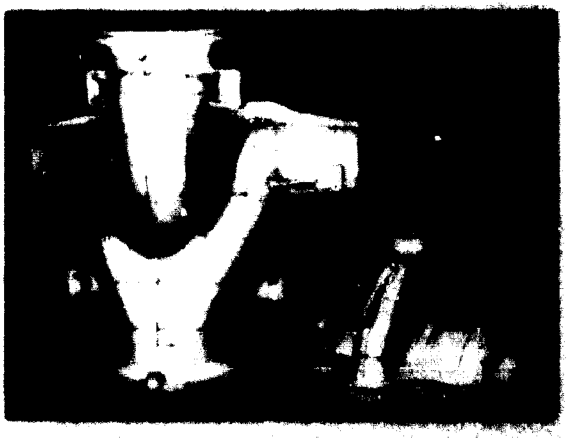


Figure 1. Foam [illegible] for a pump casing

with plexiglas has proved relatively unsuccessful because of its high coefficient of thermal expansion. Plexiglas can therefore only be used for patternmaking under certain conditions.

Elastomers

Polyurethane foam is an elastomer, being a cold-setting foam produced from a two-component resin. It is relatively simple to work with and its good machinability permits the fitting operation to be efficiently achieved.

Thermosetting plastics

The thermosetting plastics used in patternmaking include epoxy resins, polyesters and phenolic resins. The materials used most are epoxy resin and polyurethane resin, the latter coming from the polyester group. Recently, phenolics have begun to be used as coatings for coated plates in core boxes.

These various types of resins used with the several techniques mentioned below enable the building of patterns or tools of differing sizes.

Techniques

Six basic techniques are used in patternmaking, the choice of technique being determined by the type of workpiece and the stressing to which it is subjected (see fig. II). These are: priming, back filling, casting, modelling, laminating, and machining. Casting, laminating and back-filling require master patterns made of conventional materials.

Priming

Priming refers to a surface layer a few tenths of a millimetre thick. It is normally coloured, serving to indicate areas subject to wear. The layer used may be hard or brittle, medium hard or soft, depending on the requirement: high-pressure moulding patterns, slinger patterns or blown-core boxes. Patterns having to meet lesser quality requirements are made without a priming layer.

Casting

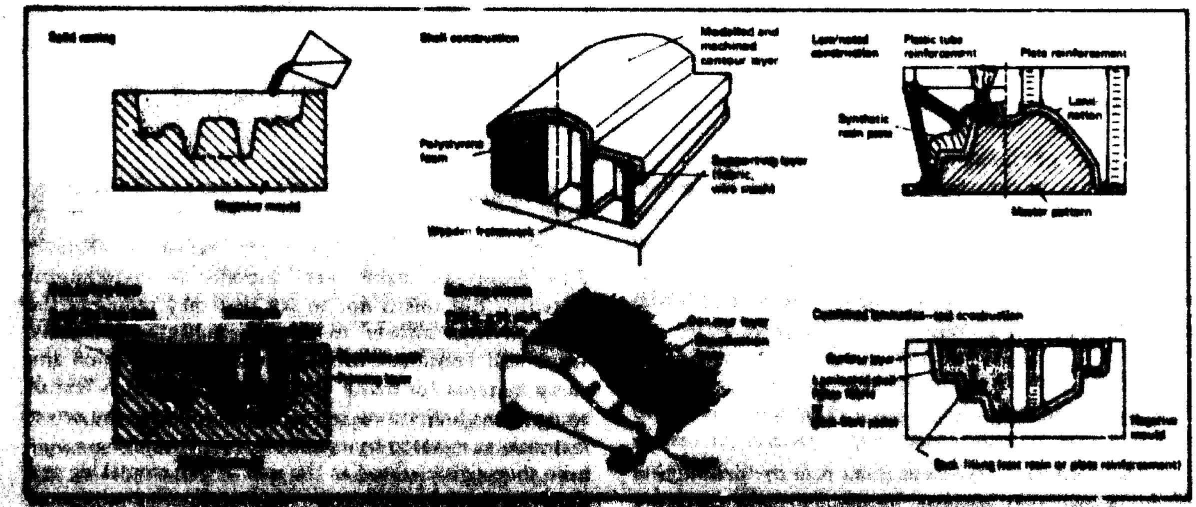
Change pattern plates are cast by efficient volume-production methods and this system is used in the company's high-pressure moulding plant.

Laminating

This is the name for the method by which resin-impregnated glass fabric is laid up to form a so-called laminated shell. In place of the conventional hand lay-up method a synthetic resin paste has recently been used, consisting of a mixture of chopped glass fibres and a two-component resin. This has considerably cut down the expensive manual labour. For high-strength, low-weight patterns, however, the relatively labour-intensive laminating method is the most advantageous.

Back-filling

When it is necessary to reinforce a laminated shell and/or a surface layer, back filling is carried out using a synthetic resin extended with filler materials, the choice of the most suitable fillers being a matter of experience.



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Modelling

A framework made of wooden sections based on the drawing is built up on a plate. Wire mesh is then stretched between the sections to support the synthetic resin layer, or the space between them is filled with polystyrene foam. Finally, a synthetic resin paste is modelled on this to form the contour.

Machining

Polystyrene foam and Polylite (a polyester filled with water) are purchased as blocks and are worked on machine tools in much the same manner as wood.

Applications of synthetic resins

Often the same contours are repeated on different castings. In such cases, it is often possible to use synthetic resins and copying methods to make significant reductions in the labour required for the pattern equipment and thus in the cost of the pattern set. There has been considerable activity in this direction for quite some time, with successful results.

Examples

A so-called composite pattern construction (repetitive, heavy-use pattern components) is copied in synthetic resin and employed in combination with other pattern materials to make a core box or a pattern. This procedure was first used in producing pattern equipment for a cylinder block. Breaking down complicated patterns into component parts makes it possible to cut manual labour down to a minimum.

Simplification in the case of impellers

Instead of building an entire blade insert the patternmaker builds only a segment of it. This segment is then used as a master pattern to produce the required number of segments as synthetic resin duplicates. Alternatively, the patternmaker can produce a negative, which is then used to cast the required number of blades on to the supporting body.

Preparation of duplicate pattern sets

The main use of synthetic resins is in the production of duplicate sets of patterns, identical to, and therefore interchangeable with, the originals (e.g. for licensees).

Plastic/metal combinations

This procedure involves a basic metal unit with the difficult to machine pattern/core box contour clad with synthetic resin by casting.

Precise checking of dimensions with plastic core boxes

In the case of castings with complex core work, pattern inspection by conventional methods is very troublesome and reliable inspection results can often only be obtained by cutting specimen castings apart. Since the advent of synthetic resins in patternmaking, this aspect of production has become more economic [see fig. III].

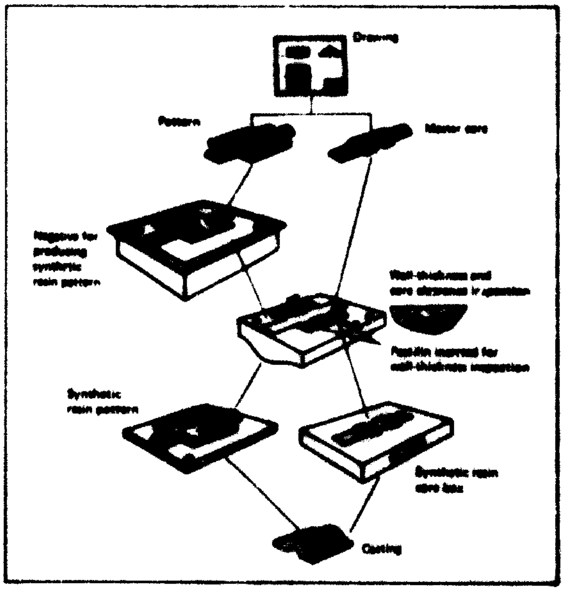

Figure III. Inspection plan for epoxy resin castings

Potential

Plastics are being used in patternmaking wherever their properties make them superior to conventional materials. But this is not to say that they represent the sole and final answer to all patternmaking problems. Wood still continues to be an exceptionally good and cheap material for many applications. It is important to recognize its limitations and to use it alongside the newer materials as dictated by commonsense. Plastics have now been thoroughly tested in the role of patternmaking and their successful application has assured a continued expansion of their range of uses in the future.

PAPER CAN KILL

06410

by Lee Grossman

Mr. Grossman is a regular contributor to Industrial World magazine, from which this article is reprinted with the publisher's permission

INDUSTRY around the world shares a common problem—too much paper work. Increased paper work is symptomatic of increased industrial activity but much of the paper work is sheer waste. A lot of it comes from stale procedures. A company president asks for a report on something and it becomes a fixture in the company for the next five years until somebody realizes it is useless.

Although much of the paper work generated by [illegible]

interest in them? Is it really necessary for a salesman to spend a quarter of his time filling out reports? Would not the payoff be greater if he spent more time selling and less time reporting? What would happen if we just stopped producing reports?

Many companies are attempting to answer questions like these. In so doing they are struggling with paper work systems that have grown too fat. Ponderous piles of paper; bulging files and cabinet drawers; an endless stream of memos, reports and copies are the signs of a company in need of paper diet.

Like their human counterparts, middle-aged companies are the most susceptible to overweight. As a lean and trim company matures, paper piles up until one day the company finds itself fat with too many reports, memos and statistical analyses.

In the corporate aging process people come and go, and each adds his own flourish. The new traffic manager adds paper to track shipments, the new controller adds controls and some forms, the new credit manager adds his forms, the new production manager his statistics. And so it goes, each department adds its little bit to the steadily growing pile. Over the years each successive office holder adds his contribution to the increasing pile until the cumulative effect is fat paper.

Results in lethargy

What is wrong with fat paper? It is costly in many ways but its greatest threat is that it reduces a company's life span.

Just as too much weight is dangerous for human health, it is also bad for a company. Companies with too much paper work have a low survival rate; they are lethargic, bound up in red tape and resistant to change. In a rapidly changing world the company that stands still today will not be still standing tomorrow.

To fight fat paper some companies go on a crash diet, lose some of their fat only to have it reappear sometime later as big as ever. In such campaigns some obsolete paper is eliminated. But such efforts do nothing about the causes of fat paper—the things that generate superfluous paper in the first place.

Reasons for too much paper

Poorly conceived diets will not work for humans and they will not work for companies hoping to trim fat paper. What kind of diet will work? Before you can arrive at a diet that will have some lasting effect you have to understand the underlying causes for fat paper.

Psychologists tell us people overeat and get fat because they are trying to compensate for some lack in their life. Many companies have too much paper for the same reason; they are compensating for something they are missing. Fat paper compensates for a lack of management ability, a lack of employee security, a lack of more productive things to do.

Many managers use paper as a substitute for management know-how. Running a company solely by paper work systems just does not work. Such systems are crutches for lack of management skill or the exercise of managerial discipline.

Systems cannot run a company; only capable managers can. Systems can help, but they cannot replace management. If they could, computer systems would have taken over management's job long ago.

For example, a statistical system that controls labour utilization and productivity (commonly referred to as a labour reporting system) is simply a useless collection of information and data until management interprets what the information means and does something about the figures on the paper. It is the action of doing something to improve labour productivity that makes the system worthwhile. Action is important, not the paper that merely reports the need for it.

In a small business little or no paper work is needed to alert management because they are already out there where the action is and they know what needs to be done. As a company grows and layers of management are added, layers of paper work are also added. These layers of paper serve to insulate top management from reality. The more direct the paper work system is, the better the chance that management will react.

It is the inept manager who adds fat reports. He wrongly believes that he can substitute paper systems for managerial ability. When it does not work he piles on more reports in the hope that the sheer bulk of the apparatus will control things.

Soon, more time and effort is spent controlling the paper work than in controlling the thing the paper work was intended to control in the first place.

There is security in paper

Some managers encourage fat paper work systems to protect their companies from occasional risks. They overcontrol to the point where the controls are more costly than the possible loss being prevented by the paper work.

These managers are compensating for fear of failure, fear of exposure or fear of the unknown loss. Such fears are usually out of proportion to the realities of life.

When the problem or loss does finally occur the paper systems are rarely accurate enough to substantiate anything. With all the paper floating around no one can find the right document anyway. It is the fear of the unknown that builds until the system overcompensates, becomes top heavy and finally crumbles from disuse.

The cause of excessive paper work is not limited to the managerial ranks. Excessive paper work is often the symptom of insecure workers. It is their insecurity that causes them to seek "paper protection" and so they willingly join the ranks of paper shufflers, churning out more and more paper. Workers who get little satisfaction from their jobs or those without enough work to keep them busy will add even more to the paper mountain.

Written reports can only follow events. They are often inaccurate and omit important details. Preoccupation with such reports may mean a neglect of the realities of corporate life. Reports can never give you a "gut feel" of what is happening. Over-reliance on reporting systems is one way to the corporate graveyard.

Here are seven ways to cut your paperwork

Here are seven ways to trim the fat off your paper work. Each takes management willpower to make it work.

1. **Get more from your paper.** Assign an individual or department the job of paper controller. The Systems and Procedures Department in large companies usually fills this role.

First, each report and form is scrutinized to be sure it is necessary. Second, it is determined if various forms can be combined by analysing where each goes and the kinds of information it contains. Then it is determined if the number of copies of each form can be reduced by making the remaining ones do multiple duty.

For example, one copy of a purchase order receiving record can be used by the receiving department to record the receipt of a shipment. The quality control department can record its acceptance of the shipment on the same copy. Next, it is sent to record the receipt for inventory records. Finally, it is sent to accounts payable to await the vendor's invoice. Notice that one piece of paper did four jobs.

Left to their own devices, each department in this example would insist on keeping a file copy of the receiving record. A powerful central systems group makes it difficult for departments to add paper fat for their own needs. A central group designs comprehensive and integrated systems that meet the needs of all departments without overcompensating for some imagined need.

2. **Create less paper in the first place**—Management can set the tone by demanding less paper themselves. By getting out where the action is they will observe more and read less. On-the-spot observations are invaluable because written reports filter out undesirable information. Once management sets the tone, the rest of the company will follow.

Every member of management can fight the inclination to "put things in writing". Some things should be written but many more things should not. Overly detailed procedures manuals, corporate objectives, departmental goals, job descriptions and comprehensive organization charts may be the early symptoms of a dying company. Growing companies are too dynamic to be able to document such things with any degree of accuracy.

3. **Check procedures periodically**—In our ever changing business world procedures are rapidly outmoded and hence need periodic evaluation. Check your procedures periodically to see if they are still relevant to today's needs.

4. **Use value analysis.** How much of your paper is only marginally useful? Does each piece of paper have essential value? If so, does the recipient use the information and how is it used? What would happen if the recipient did not receive it?

Keep only those papers that have real value. Eliminate "the nice to have" reports. Try cutting the distribution of reports and memos to see who screams the loudest. Put back only what you have to. Limit memo distribution to a "need to know basis". For general announcements, use your company bulletin board.

5. **Keep it simple.** Avoid embellishments and frills. If it can be done by simple machines, avoid complex computers. Do not fall in love with systems that generate paper lest they become the rationale for new systems and more paper.

6. **Try trust, not paper**—A 237 store chain that covers the British Isles was able to streamline its procedures based on trust—not paper. Eliminating the need for receipts, signed documents and operations manuals the company was able to cut 26 million forms weighing 120 tons, and 8,000 out of 28,000 jobs. Not everyone can do what they did but the opportunity exists in similar proportions in every business.

Too often paper controls are set up for insignificant reasons. Consider the propensity to cheat and only control the significant steps where cheating is likely to occur. Consider your risk exposure and then make your control consistent with the risk.

7. **Eliminate the cause**—The previous steps will help you trim paper, but will your reports remain thin? When you strengthen a manager's abilities he will not need to rely on paper as a crutch. When you develop a secure company climate managers will not feel the need to overcontrol with paper and employees will not need paper protection for their jobs. When workers have enough satisfying and productive work they will not seek busy work.

06411

COMPUTERIZED AUTOMATI

INDUSTRIAL automation is hardly new. The concept began with the Industrial Revolution, yet automated equipment and procedures have changed relatively little over the years. For the most part, human workers still guide the machines, carry the parts from one machine to another, keep track of what each machine is doing, test and assemble the parts and inspect the finished products.

Worker dissatisfaction widespread

Many of these jobs are as mindless and tiresome as Charlie Chaplin's was in *Modern Times* nearly 40 years ago. Worker dissatisfaction with these dull, repetitive chores is widespread. Even generally high wages and fears of recession have not quieted labour unrest in many plants. The work stoppages, slowdowns and absenteeism that have often resulted from this dissatisfaction have led to decreased output, poor product quality and thus to escalating production and repair costs.

Most of these routine jobs could be done by computer, says Dr. Charles A. Rosen, Staff Scientist, who has been developing computer-based automation systems at Stanford Research Institute (SRI) for several years.

"This could eliminate many undesirable jobs", he says, "and provide new man-machine relationships requiring more human intelligence and thus restoring man's purpose and dignity."

He visualizes factories in which many repetitive jobs would be done by computer-controlled machines supervised by a smaller but more highly trained work force than is used today. The workers would be capable of setting up (i.e., programming) each job, modifying procedures, changing over for new models or batches, maintaining the equipment, and using their intelligence to cope with stoppages and breakdowns. Thus, in effect, they would be "time-sharing" their capabilities among many machines.

Freed from the relatively low-level jobs that can best be done by machines, the human workers would be able to devote their time to those more challenging tasks that now either cannot be done by machine at all or can be done only with inordinately expensive computer hardware and software. Such jobs would include programming the assembly, inspection and materials handling systems as well as repair and maintenance of the systems.

The seeds of this dream exist today. Already, computer control is widespread in chemical processing and some segments of the automotive industry. It is rapidly invading the petroleum industry, particularly oil production, and the aerospace, communications and electronics industries. As electronics takes over more and more functions that have historically been performed mechanically or electromechanically, computerized automation is spreading to the manufacture of such equipment as calculators and automotive parts as well.

Low cost computers

This rapid growth is sparked by plummeting computer costs and the spread of electronic control systems, which are cheaper, more reliable and faster than electromechanical or mechanical controls. A minicomputer-based control system that cost $100,000 five years ago would now come to about $25,000. David Penning, Senior Industrial Economist at SRI, whose background combines several years in computer production with extensive long-range technoeconomic planning experience, predicts that by 1980 the price of such a computer control system may have dropped to between $5,000 and $10,000.

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ON TAKES OFF

Figure I

The prototype vision system (fig. I) developed at SRI is part of the materials handling system shown in figure II. The vision system recognizes an object and determines its position and orientation on a moving belt. With this information, the industrial manipulator (fig. II) is able to grasp the object and move it to some desired location

Electronics spearheads automation

Penning expects the electronics industry (including communications) to be a spearhead for automation because this industry is familiar with computer-based electronic control techniques and therefore has the ability to adapt such techniques easily to production requirements. Also, electronic products tend to be functionally so complex that only a computer can test them rapidly enough to make testing economically feasible.

Moreover, electronic products are subject to rapid obsolescence. Television, for example, has gone from vacuum tube parts to transistors and on to integrated circuits in about ten years. This rapid product evolution makes it feasible for the electronics manufacturer to consider changes in production equipment as soon as his product becomes obsolete rather than waiting until his equipment wears out.

For the electronic manufacturer, therefore, computer-based automation makes economic sense today. Penning points out that in 1972 one television manufacturer increased its profits 55 per cent and its sales 30 per cent by automating its production line.

Now, the computer is extensively used for testing electronic products. In addition, it is beginning to take over metal cutting and fabrication in many industries. In the so-called "direct numerical control" (DNC), one computer controls many machine tools. In "computer numerical control" (CNC), each machine has its own small dedicated computer to guide it through the machining of complex contoured parts made of exotic metals.

Computer to monitor equipment

By 1980, Penning expects that computerized manufacturing will have penetrated further into a variety of industries. Not only will electronic testing and machine tooling be more extensively computerized than currently but also the computer will be used to monitor

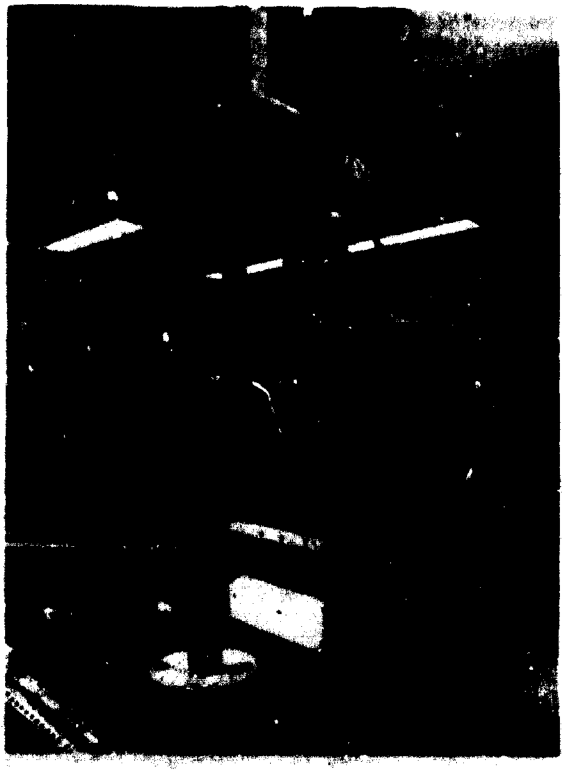


Figure II

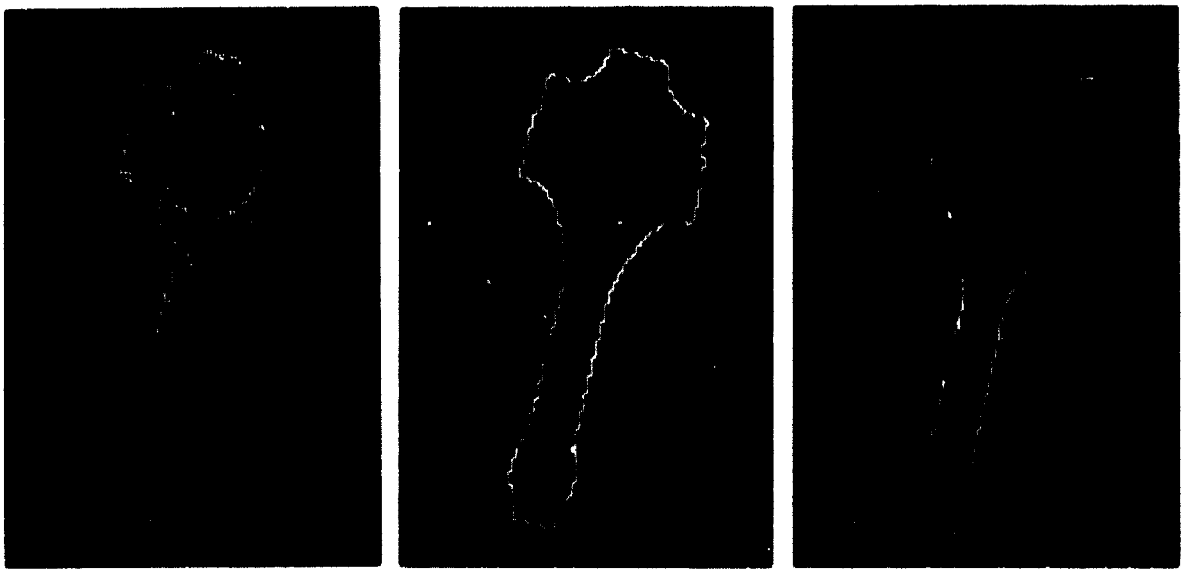


Figure III

Figure IV

Figure V

The system can be programmed to recognize and manipulate a particular object in a desired way by means of an interactive programming routine using TV displays of the object (figs. III, IV and V). For example, by means of a light pen, the programmer moves certain lines displayed in figure V to the points where he wants the manipulator to grasp the object

equipment and collect data as to which machines are doing what chores and how efficiently. Without a computer, it is difficult for a plant manager to keep current information on these operations.

Penning points out that in a recent survey managers in various manufacturing and process industries said they intended to automate equipment monitoring and data collection at the same time that they automate the test and fabrication operations.

Major operations still to be taken over by the computer are programmed materials handling, inspection and assembly. These would be systems that could be easily programmed to perform a variety of operations on objects of different sizes and shapes. Typical operations would include moving parts from one place to another, remembering where they are located, picking them up off a conveyor belt while they are in motion, inspecting them for completeness, damage, spots and stains, making sure their dimensions are within tolerance, and putting them together to make a finished product, which is then further inspected.

Enter the robot

Materials handling operations are beginning to be done in some factories with simple programmable manipulators, sometimes called robots. They are used for such jobs as loading and unloading presses, stacking parts, spot welding and paint spraying. But these devices have as yet no more than rudimentary sensory equipment, such as a photocell. As a result, they can only manipulate objects that are fixed in a precisely predetermined position. They lack the sensory feedback as well as the hardware and software capabilities needed to perform two-handed operations. However, they can be programmed to perform a wide variety of simple tasks involving certain specified movements.

A human worker programs the manipulator by moving it through the desired motions once, then going back and making small changes in its sequence of operations until he is satisfied with its performance. An average production worker can acquire the skill needed to do this in a month or two.

Programming the assembly line

Computer-controlled inspection and assembly systems are further over the horizon. Virtually the only ones now in use are single-purpose systems that can sense such characteristics as dimensions or colour but cannot be programmed to do more than one task. Programmable systems will be difficult to implement because of the almost infinite variety of objects to be assembled and operations to be performed. The objects may range from nails to automobiles, while the operations to be performed on them may range from measuring the length of the nail to putting tires on the automobile.

The equipment that could sense and manipulate such a variety of objects has not been developed yet. Two-handed operations, such as putting a tire on a vehicle as it moves down a production line, can be performed in the laboratory, but the systems are not yet practical. The manipulators will have to be improved and the software refined and simplified so that it can be incorporated into a small computer. Moreover, it will be necessary to develop higher level computer languages close to the spoken language so that someone who is not a programmer can program the system to do different jobs.

Talking to computers

Until recently, higher level computer languages were not practical to use with minicomputers because of their limited memory capabilities. In order to translate the languages into voltage levels, which the computer can understand, a great deal of computer memory is required. With the rapidly falling cost of computer memory, however, the situation has begun to change. As a result, it would be feasible to trade off computer memory for ease of programming, if the programs were available.

Rosen heads a group of scientists at SRI who are developing both programs and hardware for a variety of programmable systems under a contract with the National Science Foundation. The objectives of the two-year program are to develop easily programmable manipulating, visual sensing and inspection systems and, finally, an integrated assembly and inspection system that incorporates materials handling, acquisition, assembly and inspection operations, all easily programmable and potentially cost-effective.

In December, 1973, at the end of the first six months of the program, the group had completed a materials handling system with visual and touch sensing (figs. I-VI). For the visual sensing, both a television camera and an array of linear diodes are being used. Both visual sensors convert the optical image to electronic signals. These signals are processed by the computer, which then identifies any of six or seven different objects and directs the manipulator to pick them up and place them in a specified location. Tactile sensing is done by the "hand" and "fingers" shown in figure VII. Light detectors sense the movement of the fingers, and the computer relates this movement to the amount of pressure applied by the fingers. The system can identify and pick up objects in motion.

"It is not very good at this yet," says Rosen, "but it is getting better."

He points out that none of the systems thus far developed at SRI would be cost-effective in a factory because they require the capabilities of a large computer. Even if the computer were time-shared among many different factory operations to bring down the cost per operation, the system would not be practical in the factory. The whole factory would have to shut down if the computer failed. Within two years, however, Rosen expects to have simplified and streamlined the software enough so that it could be used in a self-standing minicomputer-controlled system that would be cost-effective in the factory.

Long-term goals of the project include the development of a system that could respond to voice commands such as "a little higher", "two inches to the left", etc.

Figure VI. This computer-controlled turntable can rotate a part into a known orientation. The four pistons then push the part against the adjustable pins, holding it in position

Figure VII. Instrumented "hand" or end effector with arrays of tactile sensors in the "fingers" as well as torque and force sensors in the "wrist"

06412

Low-cost Automation

by G. P. Kearney

The author: G. P. Kearney is a research worker and consultant in machine tools and automation. In 1967 he set up the first low-cost automation centre in England. He has also worked as a consultant on behalf of UNIDO (in Sri Lanka, Singapore and Turkey), and the United Nations Educational, Scientific and Cultural Organization (UNESCO). The original version of this article first appeared in the Turkish language in the quarterly review Verimlilik, *published by the Turkish Productivity Centre at Ankara*

LOW-COST automation might better be termed "do-it-yourself automation"; it is fitted or custom-made to the conditions of the particular factory and the particular machine, and since this requires intimate knowledge of the factory and the process, it must usually be applied in the factory by the factory's engineers.

Low-cost automation is not low cost in the absolute sense but in the comparative sense. The costs are generally recouped within a short time, so that relative to the savings obtained, the cost is small even though the amount of money spent may have been high. For instance, if work-handling devices are added to an expensive machine, raising its output by 30 per cent, and if the labour and capital charges for the machine are $10,000 per year, the saving is $3,000 per year. If $1,000 were spent on the work-handling device, the money would be recouped within four months. On the other hand, if $1,000 were spent on an accessory for an inexpensive machine which only increased its output by 5 per cent it would take five years to recoup the cost. The first instance is low-cost automation; the second is a question of buying equipment which should be amortized, an investment decision.

The growth in production of standard units, such as pneumatic components and work-handling devices, made in bulk by specialized firms, has helped to spread the use of this type of automation in industry. The task of the factory engineer is to incorporate these units into a mechanical structure which he designs for the purpose, and then to design control circuits in pneumatics or electronics. Even control circuit problems have been eased by the availability of easily used and inexpensive electronic units.

Application of low-cost automation

The first problem in applying low-cost automation is to decide where it will be valuable, where the cost of the equipment can be quickly recouped from savings, and where it is technically feasible. The main possibilities for application lie in routine operations and operations that need force and power not already provided by machinery. As routine operations are easier to automate than very complex ones, they are an obvious target for low-cost automation. Work that needs the continuous application of strength and power is frequently done manually; as the day wears on, however, the labourer becomes fatigued, and his productivity drops. Often, heavy weights have to be moved by several workers; but a power device for lifting could be operated by one man, keeping labour costs down, lowering fatigue, and frequently increasing the speed of the handling operation because of the greater compactness of the lifting device.

Another area to look into is that of simple monitoring; quantity inspection tasks, for example, often lend themselves to automation. On the other hand, automating the inspection of the paint finish on a refrigerator is almost impossible since the detection of faults requires highly sophisticated human visual inspection.

Economics of low-cost automation

Low-cost automation saves money by increasing the productivity of the workers, by saving the labour costs in a particular operation, and by increasing the productivity of capital equipment. Minor savings can be effected by using devices designed to safeguard workers and equipment, and improvement in quality can be obtained through more thorough inspection.

Increasing the productivity of a machine and its operator by adding low-cost automation will compensate for the cost of the automation device. The more expensive the machine and the more skilled the operator, the greater the saving. Furthermore, if the machine is always fully loaded, machines (and operators) that have a subsidiary function in the production process do not stand idle. This factor is often hidden in cost calculations, but it means that priority in automation should be given to machines for which a high loading is required.

Reducing the number of workers in a particular operation obviously saves money, but it can introduce other difficulties. Terminating a worker can cause unrest and hinder future co-operation in introducing automation. Where savings can be made by eliminating the services of a worker, it is advisable to make sure that a need for the worker exists elsewhere in the factory. In this way, expansion in the need for labour can be met, not by new recruitment but by automation. The benefits are also long-term since the cost of labour is rising. In addition, once the costs of the low-cost automation are recouped, the firm is in a much better position to resist a slump in trade; it can let stand idle any equipment which has been paid for, whereas if it has to lay off workers a subsequent increase in the market after a recession will involve all the difficulties of recruitment and re-training.

Commercially available devices

Low-cost automation is largely possible and economical because the number of manufacturers specializing in automation devices has increased and these manufacturers sell at prices that are only possible through large-scale production. Using these devices, the factory engineer can automate his factory at reasonable cost.

There are three main requirements in low-cost automation: power, monitoring and control. Devices may be pneumatic or hydraulic, electronic or electrical, or mechanical. Power and force are best supplied through pneumatic devices such as pneumatic cylinders controlled by pneumatic or electro-pneumatic valves and circuits. As the pneumatic cylinder can deliver a high force in relation to its size it can be built into a small space. This is a great advantage because many automation devices need to operate in the confined loading or unloading space of a machine and must not restrict the capacity of the machine by encroaching into the working area. If the sequence of operations of the pneumatic cylinders is simple, control can usually be

[illegible]

arranged through a pneumatic circuit. If it is more complex, electrical or electronic control circuits may be needed to control the cylinders through electro-pneumatic valves. Speed control of pneumatic cylinders is poor, and an improvement can be obtained by using hydraulic cylinders. For both pneumatic and hydraulic cylinders there is a difficulty in getting long travels, and electrical drives through gearing can then be useful. Close control of speed also needs electrical drives or rotary hydraulic motors. Also useful are a wide range of clamps and fixtures operated pneumatically, which may be linked in a machine by the machine structure and controlled from the central control circuit. Air devices, using fluidic principles at low air pressures, are useful for monitoring as these provide very cheap detection transducers. Even control circuits may be built from fluidic units, although the cheapness of modern integrated circuit electronics often makes them uneconomic.

Electronic transducers can assist in monitoring and in detection although they tend to be expensive in relation to fluidic devices. The great value of electronics for low-cost automation lies mainly in their use in logic control circuits. Electronic logic devices are now very cheap and are extremely reliable under a wide range of industrial conditions. They are easy to build into circuits, even by those not particularly skilled in electronics.

Mechanical, electro-mechanical and pneumatic-mechanical units are widely available, particularly to assist with the mechanical handling problems of transfer and orientation. Bowl feeders of various types can be used to orient small parts preparatory to transfer into a machine. Standard units for transfer machining are also widely available. With these, as with other units, there is always the possibility of re-use for different automation arrangements, if the initial arrangement becomes obsolete through a change in design or product.

Useful techniques

Since low-cost automation is used mainly by factory engineers it might be wondered whether these engineers can be taught the techniques in a reasonably short time. The main techniques used, that is techniques with wide generality, are related to pneumatic and hydraulic circuitry, to combination and sequence logic, and to mechanical design. As most of the power and force needs in low-cost automation are met by pneumatic circuits, this, obviously, is one of the techniques that are necessary to learn. Pneumatic circuit principles are largely common to hydraulic circuits and with a little extra work hydraulic circuit principles can also be learned.

Logic, using electronic or other devices, is very useful in designing the control circuits of automation equipment. For slightly complex circuits, logic is an essential technique, but it is fairly easy to learn in a short time. It enables simple solutions to be found for apparently complex problems (such as conditional responses and sequencing) of the control circuits. Logic is not needed for simpler controls, which can probably be done by pneumatics, or for controls that are similar to conventional relay circuits.

Mechanical design is essential since most automation equipment must be built and designed in the factory, but this is part of the regular training of mechanical engineers.

Above all, the main requirement of the factory engineer undertaking low-cost automation is the firm intention to automate; this will keep him on the alert to opportunities to automate, aware of the need to keep up to date regarding the availability of commercial units to assist automation, and concerned with following other reported applications of low-cost automation in trade literature.

Training a factory engineer in the techniques of low-cost automation is easy; provided that he already has some background in factory experience he can be given good basic training in two to three weeks full time. After such training, the most urgent need is the opportunity to practise the techniques that have been learnt by undertaking simple, and later more complex, projects within the factory.

Problems of introducing low-cost automation

Low-cost automation may be described as an attitude of mind for management, for technologists, and for labour. Generating the proper attitude of mind in management requires a process of education and publicity as to the value and feasibility of low-cost automation in order to establish an environment in which low-cost automation projects can flourish. The success of this environment will depend on: the firmness of the intention to expand production; the readiness to provide funds for the purchase of automation devices on the advice of engineers, for the training of engineers in the techniques of low-cost automation, and for the in-factory training of workers; and the willingness to employ engineers not only for routine tasks but also for the development of increased production through low-cost automation. Once managers can be convinced of the advantages and feasibility of low-cost automation it is only necessary to ensure the availability of training for engineers and the supply of automation devices. This process of manager education, for example, has been introduced by automation centres in the United Kingdom of Great Britain and Northern Ireland and in the Netherlands.

Once an automation centre is established it can easily provide training facilities for engineers, together with advisory and information services. The centre need not be a separate institution; it can be part of a larger engineering institution or government department, with initial staffing of three or four engineers.

The second prerequisite of the introduction of low-cost automation, the availability of automation devices, is more difficult to arrange. A wide variety of equipment is available in Europe, but stockists in most developing countries are loath to build up large supplies for a market that does not yet exist and that would require publicity in its development. On the other hand, if a large market did develop it would be necessary, in the interest of the economy in general, to encourage the manufacture of the more common items domestically.

Automation and employment

The introduction of any form of automation causes fear of employment because of the belief that as automation improves efficiency the same amount of work can be produced by fewer workers. This, however, is untrue, for while low-cost automation increases the productivity of machinery that already exists on the factory floor, the automation will be uneconomic unless this extra production can be sold. Before introducing low-cost automation it must be ascertained that there is a need to increase the volume of production through the factory. It may not be necessary to delay automation of a particular operation until there is a need for more production from it, because the labour saved on the operation may be diverted elsewhere. Nevertheless, quicker returns on investment will be realized if operations that normally present bottlenecks are automated.

Taking a wider view of the effects of automation on employment it is seen that the choice is not between automating and not automating but between the methods of automation. If a factory chooses not to use automation it is choosing lower productivity on both machinery and labour. It may be argued that this can be compensated by lower labour costs, but this means that the lower wages paid to the worker must compensate not only for his own lower productivity but also for the lower productivity of the machinery which he is operating. It is even possible that if a worker worked for nothing his products would be more expensive than if automation were being used. Finally, it must also be realized that failure to introduce automation condemns workers to remaining at low salary levels, which get even lower as international competitors increase their levels of automation.

06413

Industrial Technology in Brazil: Ideology, Methodology and Action

by Luiz C. Corrêa da Silva

The Ministry of Industry and Commerce of Brazil is implementing a comprehensive programme designed to stimulate the development and application of industrial technology in that country. A special Secretariat for Industrial Technology has been created in the Ministry to control the programme, for which some $90 million has been appropriated for 1973-1974.

This article presents an outline of the ideology and methodology adopted, and the action taken, in the Secretariat's first year of operation. It gives an idea of the technological challenge facing Brazil, and is a case study which might be found useful by other countries with development problems similar to those of Brazil. The article is the revised version of a paper presented in 1973 at a management development workshop organized by the Instituto de Pesquisas Tecnológicas of São Paulo and the Denver Research Institute, by Luis C. Corrêa da Silva, who was Secretary for Industrial Technology in Brazil at that time

National technological planning

WHEN tackling the problems of know-how absorption and production, it is important that developing countries clearly establish their technological ideology, methodology and machinery for implementation. It is also important that they be pragmatic regarding technology: goals should be increased production and productivity and improved quality. Technology is the key to the achievement of these goals.

Solving the problems created for modern society by the intensive application of technology calls for the application of more technology. Moreover, it is necessary to [illegible] technological capability [illegible] to [illegible] technology.

The three typical stages of technological evolution [illegible] (a) The [illegible] industrial production. (b) The availability of industrial production capability – the operation of conventional processes and the production of conventional industrial goods (mainly hardware), using technology predominantly imported; and (c) The capability of creating technology, of developing new processes and products. The technological imperative for developing countries, therefore, is to master and apply, as rapidly as possible, maximum relevant know-how.

Software becomes increasingly more important than hardware – and technology and know-how, as software, are important "products". However, in the acquisition or creation of technology and know-how, as in many other activities, the most important factor is neither hardware nor software, but what might be called "humanware": trained, competent, dedicated and imaginative workers.

The qualities of technology

Technology is intangible; hence the difficulty in identifying problems and finding solutions.

Technology is not exhaustible by use, but it is exhaustible with the passage of time. In other words, it is not "consumed" through use (on the contrary, it is improved) but it can become obsolete. It should be applied as soon as it is available, and as intensively as possible.

Technology is specific, yet diversified. Even in such a simple product as a ball-point pen, at least four distinct and independent technologies are involved.

Technology, know-how, engineering and research

Technology is the specific, detailed and exact knowledge of processes or products obtained through systematic study and experimentation, and through the application of scientific knowledge and methodology to production problems.

Know-how is a combination of technology and the experience of applying it under actual working conditions [illegible]

Engineering is the art of applying science to the production of goods or services.

Research is, strictly speaking, the experimental investigation of a problem by the application of scientific knowledge and scientific methods. It is important not to equate research and development (R + D) with technology. R + D is one type of innovative activity which, with other innovative activities, contributes to the renewal of the body of technological knowledge. It could be said that R + D is one of the faucets that fill the pool of technology.

Technological functions and instruments

In the analysis of know-how creation, transfer and trade it is important to define and analyse separately *(a)* the technological functions or types of know-how needed and *(b)* the ways and means of securing the necessary know-how. In other words, separate the WHAT from the HOW (figures I and II).

- ***Planning***
  - Long term, sectoral planning
  - Industrial project planning
  - Industrial operations planning
  - Technological project planning
- ***Feasibility studies***
  - Pre-feasibility
  - Feasibility
- ***Contracting***
  - Invitation of tenders
  - Evaluation of bids
  - Procuring and inspecting
- ***Project engineering***
  - Basic engineering
  - Detailed plant design and engineering
    - Production facilities
    - Utilities, buildings, site
- ***Design of equipment***
- ***Equipment construction and commissioning***
- ***Construction, commissioning of plant***
- ***Plant operations technology***
  - Production line
  - Auxiliary services (quality control, maintenance etc.)
  - Management functions
- ***Testing, analysis***
- ***Diagnosing and problem solving*** (trouble shooting)
- ***Research*** (on phenomena or materials)
- ***Development*** (of process or product)
  - In laboratory
  - Pilot plant or prototype
  - Under industrial conditions
- ***Management***
  - Industrial project
  - Industrial operations
  - Technological project
- ***Forecasting***
  - Industrial
  - Commercial
  - Technological

Figure I. Checklist of technical functions: WHAT

- ***Own staff***
  - Hiring
  - Training
    - School
    - In-plant
    - Special
- ***Information***
  - Freely available
  - Intelligence
- ***Industrial co-operatives***
  - Research associations
  - Pooling of engineering and design facilities
- ***Service contracts*** (payment for services rendered)
  - Specific, limited time, software (consultancy)
  - Specific, limited time, software and hardware services (e.g. turn-key contracts)
  - General, long-term, usually software only (e.g. technical assistance contracts)
- ***Technical assistance agreements*** (payment related to production volume or value but not directly involving proprietary know-how)
- ***Licensing*** (rent of proprietary know-how for definite period of time and frequently under other restrictive conditions) (e.g. use of patents)
- ***Purchase*** (outright purchase of patent or specific know-how)
- ***Equity participation*** (joint ventures)
- ***Government action***
  - [illegible]
  - [illegible]
- ***[illegible]***

Figure II. Checklist of ways to secure know-how: HOW

Technology as a product

Know-how and technology, as mentioned before, may be regarded as "products". They may also be considered as intermediate products. They can be produced (or manufactured) and marketed under techno-economic principles similar to those that apply in the case of other goods.

Technology production may be motivated by: *(a)* arbitrary decision: "send men to the moon"; *(b)* need: "develop automobile motors with low emission of pollutants"; or *(c)* profit: "develop new processes and products that will either decrease costs or increase the market". Since technology production is an industry, it requires, and deserves, governmental incentives and support similar to those usually provided to other basic industries, e.g. financial, legal etc.

Two kinds of technology may be produced: explicit technology (technical or special services that are negotiated or handled as such) or implicit technology (that are contained in, or built into, material goods or services).

Technological content (of a product or service), or implicit technology, is the direct, accumulated value of all specialized and specific knowledge essential to permit production of a given product or service. It should include the cost of all patents or licences, if any are used; the cost of all directly related specialized manpower needed in all phases of production; the cost of developing operations; and the cost of related research, on a pro-rata basis. Generally speaking, the higher the technological content, the more the specific cost per physical unit of a given material good.

For national planning purposes it is necessary to consider the national demand and supply of know-how and technology, as measured by the values of explicit technology required in a given year, whether of local or foreign origin. It is also useful to consider the technological balance of payments, which should include imports and exports of both explicit and implicit technology.

Transfer and trade of technology and know-how

In technological trade, technology can be negotiated in either an explicit or an implicit form. If it is absorbed and applied, there is no more valuable merchandise to be produced or imported than explicit technology. Imports of raw materials or food, on the other hand, are consumed or transformed and eventually exhausted.

In any analysis of the problems related to know-how production or transfer, it is necessary to examine carefully the various and diverse paths leading from origin (local or foreign) to final application.

In the commerce of know-how and technology, the following critical operations are involved: creation or production (abroad or locally); location; evaluation; selection; accession (through payment, if necessary); absorption; application.

No country should aspire to be technologically autarchic. (It is worth noting that the greatest importers—and exporters—of know-how and technology are the more highly industrialized countries.) All countries can rightly aspire, however, to an equilibrium in their technological balance of payments, by developing and exporting technology (explicit or implicit).

Methodology: the main guidelines

In planning technological development, the following sequence seems to be essential: begin with an overview of the realities of industry and market; identify problems and opportunities; define objectives; prepare action programmes; secure necessary resources; implement programmes [illegible] of industrial or [illegible]

Implementation of technological projects requires both [illegible]

technology production, it is particularly important to decentralize implementation and initiative as far as possible. For certain technological activities or services of national scope (information, standards and certification, industrial property), it is necessary to plan and implement in terms of national systems or networks.

The role of technological institutions

Technological institutions may be classified according to their main purposes: research and development, technical assistance to industrial operations, standards, testing and certification; industrial property; information; techno-economic planning. One of the main tasks facing government and industry in developing countries today is to create conditions that will encourage technological institutions to produce the technology demanded by either industry or the national economy.

The resources needed for the successful operation of technological institutions include: human (trained, competent, motivated personnel); material; technological (the body of knowledge and experience amassed by the institution as a whole); financial, and managerial.

Technological institutions should undertake as many types of technological functions as are needed by, and appropriate to, the community. Research is only one among many and includes a number of possibilities: pure or applied; scientific or technological; short-term or long-term; and "hard" or "soft" research.

Technological institutions vary, but their functions usually include: acting as efficient receiving stations for know-how developed abroad, selectively disseminating it throughout the community; developing new or improved technologies; providing effective technological assistance to industry; contributing to the formation of high-level specialists; and acting as a catalyst or stimulus in community action aimed at increasing technological capability (e.g. through holding meetings and organizing information exchanges).

Technological institutions could increase their relevance and effectiveness by becoming more concerned with understanding the nature of technology and its role in modern industry; the realities of industry and commerce (through closer work with industry); soft technology (analysis, planning, forecasting); and economic aspects of technical problems. Such understanding is particularly important to the technical development of small and medium sized enterprises.

Technological institutions should receive full support from both governmental and industrial bodies as they are essential to the industry and trade of a country.

Finally, the objectives, structure, methods, resources and work programmes of these institutions should be analysed with a view to maximising their actual contribution to the community. Priorities in the establishment of work programmes should be based on the potential impact of the programmes on existing problems or opportunities.

Industrial development in Brazil

Facts and prospects

A correct evaluation of the effort demanded of industry, government and technologists in Brazil requires consideration of at least some of the more significant aspects of the country's economy:

(a) The GNP has grown at a rate of about 10 per cent per year in the last five years.

(b) Industry today produces practically all conventional or traditional consumer goods and most of the conventional capital goods. In the former, Brazil is practically self-sufficient. In the latter, the country still depends on imports for a sizable share of its needs, but it could become practically self-sufficient with minor additional effort.

(c) Brazilian foreign trade has grown remarkably in the last five years (figure III), while specific value is tending to catch up with imports (figure IV);

(d) Assuming that the present favourable conditions for investment and production will continue, and taking into consideration the Government's targets, the Brazilian economy and industry by 1980 should reach a size and technical level comparable to that of some large countries in Western Europe. The indices shown in the following table are based on judicious projections, using extrapolative and normative techniques of forecasting.

BRAZIL 1980 – SOME PROJECTIONS

Steel (ingots)	
Installed capacity	30-32 million metric tons/year
Production	25 million metric tons/year
Electric power generation	30,000 MW
Cement (production)	26-28 million metric tons
Automobiles	
Production	1.8 million units/year
Total number	10-12 million
Capital goods (value)	
Production	\$2.0 billion[a]
Demand	\$2.7 billion[a]
Petroleum (consumption)	200,000 cubic metres/day
Computers	4,000-5,000 units installed
Housing	1 million units/year
Aluminium (demand, target)	600,000 metric tons/year
GNP	\$100-120 billion[a]
Population	125 million

[a] "Billion" in this article signifies a thousand million.

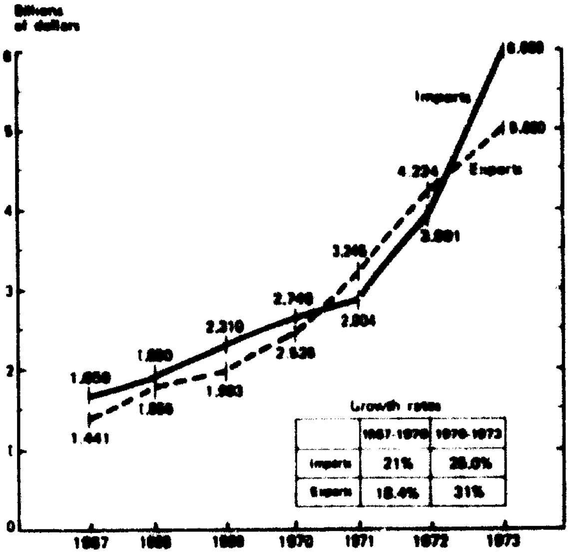


Figure III. Growth of foreign trade

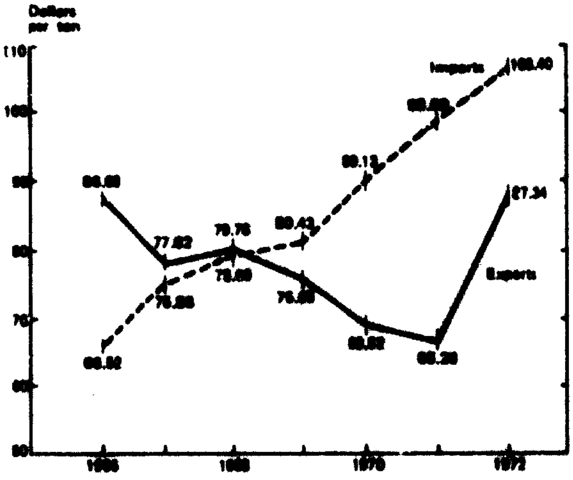


Figure IV. Specific value of imports and exports

National demand for technology

The Brasilian technological balance of payments for 1972 showed a deficit of about \$450 million for explicit and implicit technology. Projections indicate that if imports of know-how continue to increase at the present rate they might reach the \$1 billion mark in 1980 for explicit know-how alone. As such a heavy drain on the balance of payments will not be supportable, plans must be made now to develop local capability to the point where it will be possible to keep these imports down to a manageable amount possibly to about $500 million, ideally to much less. It will also be necessary to ensure local production and export of know-how, explicit and implicit, so as to improve the technological balance of payments.

Aside from foreign trade considerations, know-how and technology will be necessary for the growth of the economy and for the satisfaction of the national demand for increasingly sophisticated goods and services. Thus, it has been estimated that the implementation of the National Development Plan (1972-1974) corresponding to investment, by Government, of some $30 billion—will require the use of some $2.7 billion-worth of industrial know-how and technology in the three-year period. Of this amount, about $1 billion will have to be imported.

Brazilian industry, which, it is estimated, contributed about 35 per cent of the GNP in 1972, used some $3 billion of know-how in all forms in that year, including about $800 million of imported know-how, both implicit and explicit.

There are no reliable figures available on the total worth of technological innovation (including adaptive innovation) produced in Brazil yearly, or on yearly expenditures or investment for technology and know-how creation (all kinds of creative technological activities, not just research and development). There is no doubt, however, that by 1980 the total business of know-how and technology production or consumption must reach values of the order of $2 billion yearly (acquisition and production of new technology).

Technological development: the Brazilian position

The viability of the Brazilian economy in the coming years will depend on local capability to create processes and products that are competitive in the world market. Brazil must therefore participate in the exploration of the "technological space" that is open to the industrialized countries; the country now has an excellent opportunity for economic and social development based on the simultaneous occupation of physical and technological space.

The next stage of Brazilian industrial development will be based on the intensive application of technology and science to the production of goods and services, both through creation and transfer of technology. The time is past when the country was concerned mainly with problems; it is now entering a period when the opportunities are at least as important. In fact, it appears that Brazil today has more opportunities than problems. The main limiting factor to the country's industrial growth is the shortage of manpower with the training and experience required to occupy the critical executive or planning posts created by the booming economy. No action, by either Government or private sector, will contribute more to technological and industrial development than the massive training of the country's youth in technology and science. The encouragement of immigration of specialists from abroad (an inverse "brain drain") could also have an important positive effect in accelerating the development of local technological capability.

Government action

In July 1973, President Medici approved a National Plan for Development of Science and Technology which completely covered, for the first time, the efforts being made by the Federal Government in the fields of science and technology. The total expenditures and investments for the period 1973-1974 amount to about $700 million of which some $150 million has been earmarked for industrial technology programmes to be carried out under the supervision of the Ministry of Planning (Special Programme) and the Ministry of Industry and Commerce.

Another plan, prepared by the Ministry of Industry and Commerce for 1973—1974, involves expenditures of approximately $90 million for 32 programmes covering sectoral and intersectoral technology in addition to institutional infrastructure. Each programme includes subprogrammes, which, in turn, include a number of projects. The plan has been prepared according to the principles and methodology described earlier in this article, the emphasis being on the relevance of the projects to industry and to the national economy. Implementation of the plan is in its initial stages. A policy of decentralization in implementation is being adopted, and existing institutions and enterprises are being used. The role played by the Ministry of Industry and Commerce and the Secretariat of Industrial Technology is one of planning, selection of implementing agents, supervision and co-ordination.

Through the plan, it is expected that the following important new projects will be realized: a national system for industrial and technological information; a national system for standards and quality certification; a national network of industrial technology centres (activated by a reorganized National Institute of Technology); a techno-economic plan of action for the non-ferrous industry and one for the capital goods industry; and a plan for the development of industrial design and one for the development of engineering capability commensurate with the demand for such design services.

The success of the plan prepared by the Ministry of Industry and Commerce will depend on the continuity of the effort that is put into it and on the full understanding and support of industry. All indications are that these conditions are being met.

INTEGRATED AGRO-INDUSTRIES

This article is based on a paper prepared by the secretariat of UNIDO for the International Consultation on Agro-Industrial Development, held at Belgrade, Yugoslavia in May 1974. The original title of the paper was "Integrated agro-industries contribution and the present world food shortage" (UNIDO document ID/WG. 171/7).

Introduction

ONE of the most significant developments in world economics in recent years has been the escalation in the prices of raw materials. This escalation, which has been the catalyst in the formation of a new *modus vivendi* between the developing and the developed countries, has been particularly remarkable in the case of primary food products. For example:

- In 1970, world prices for sugar were far below production costs: even in countries with cheap labour resources a ton of sugar cost only $75. Yet, by the end of 1973, the price had soared to $500 a ton, and the current price is of the order of $670;
- In 1971, a ton of soya beans cost about $117; now it costs $300;
- Nigerian palm kernels, which cost $150 per ton in 1972, now cost about $520.

The price escalation is mainly due to an imbalance that has come about in the supply and demand of raw materials. The imbalance is caused primarily by the uncertainty of the international monetary situation, but there is a secondary reason: many of the developing countries are reassessing, and learning to exploit, their position as suppliers of certain essential raw materials to the developed world.

Up to the present time, trade in raw materials has been based on international agreements the terms of which have allowed the consumer countries to allocate to the supplier countries production quotas that were always a little higher than the planned consumption. In many instances this policy has led to an intolerable situation. Sugar producers in one developing country, for example, have been subsidizing consumers in a highly industrialized country, even though the average income in the developing country is only one-tenth of that of the industrialized country.

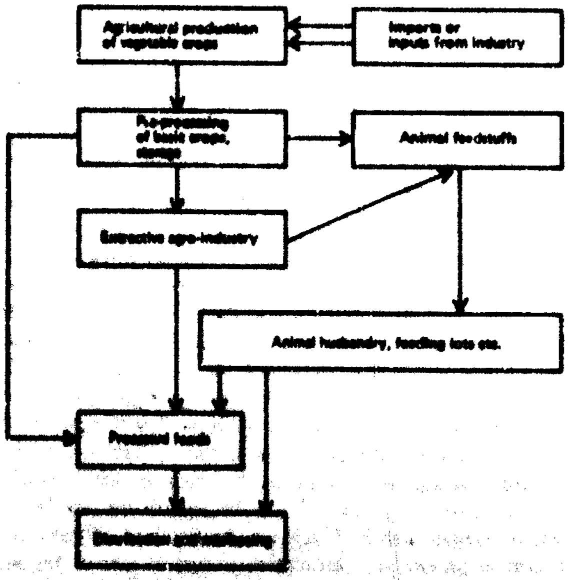
The unwillingness of entrepreneurs in the developed countries to enter into joint ventures with counterparts in developing countries, or even to invest capital and know-how in the production of raw or semi-processed materials, has also contributed to the perpetuation of this situation. Capital invested in the production of raw materials offers a return only after one or two years have elapsed whereas capital invested in the processing of raw materials to finished goods (e.g. palm oil to margarine or cocoa beans to chocolate) offers a tenfold return *per annum.*

Consequently, raw-material production has not kept pace with demand and the prices of raw materials are climbing to unprecedented heights. The solution to the supply/demand problem lies solely in close co-operation between developing and developed countries. Any such partnership, however, must be based on the equal sharing of opportunity, benefits and risks.

The agro-industries

The rapidly widening gap between supply and demand in the food and feed sectors of industry throughout the world provides a rare opportunity for a re-examination of the relationship between the poor and rich countries and a strong incentive for closer co-operation. It is quite apparent that now, as never before, the developed countries are in urgent need of certain processed foods which the developing countries can well supply—if they are provided with the appropriate technical and financial assistance. (One of the world's leading sugar equipment producers predicted recently that the world sugar deficiency would probably reach 22 million tons by 1980. He also said, however, that most of this sugar could be produced in the developing countries—provided that at least $1,700 million was invested in new sugar factories and $700 million in the reconstruction of existing plants.)

The key to agro-industrial success lies in the vertical integration of production (see figure), whether this involves ownership of the production facilities, joint management, or the contracting of common interests in marketing, processing and agricultural production. An agro-industry is not merely an industry based on agricultural raw materials, nor does the term refer to the suppliers of such auxiliary materials as pesticides, fertilizers, and agricultural machinery: it is a much wider concept involving the integration of marketing, processing and agricultural production under a comprehensive management responsible for the production, harvesting, processing and marketing of the products by the most direct means. Thus, an agro-industry should be a well planned, streamlined process for the production of maximum output of marketable goods from minimum inputs.



Production flow in the integrated agro-industry

This form of production may involve either a high degree of specialization or a wide range of products. A characteristic feature is the utilization of all by-products by other branches of the enterprise or association of enterprises. A further advantage of the agro-industrial system is the close relationship that can be established between it and the markets.

The first step in the establishment of an agro-industry is to make a thorough analysis of existing and potential markets at home and abroad. This is followed by an industrial survey to establish the profile of the factories needed to meet the demands of the markets analysed. Such a market-oriented approach inevitably means the rejection of certain items, but new products can be introduced on the basis of improved utilization of by-products, land, or human resources and capacities. A second market analysis will confirm the suitability of the programme selected and, by means of regular checks, an optimum agro-industrial development programme can be elaborated for both limited and broader areas of application.

If agro-industrial development is carefully planned, it will be possible to achieve rapid, yet economic results; rapid rural development; the large-scale utilization of virgin territories (including deserts); the optimum utilization of capital-intensive irrigation facilities; the solution of socio-economic and political problems; and best export results. Careful planning will also help to avoid competition with ongoing economic or political schemes; dissatisfaction within existing industrial and agricultural sectors; and economic failure. This planning can be limited to one region at a time and effected one step at a time.

Fully integrated agro-industries

Agro-industry is characterized by the very close relationships (in terms of time, distance, economic interests and management) between marketing and industrial processing on the one hand and between processing and agricultural production on the other. Such relationships constitute the most significant advantages of the integrated process, but if maximum benefit is to be derived, appropriate techniques and engineering must be applied. In a fully integrated sugar-cane enterprise, to take one example, agricultural production, harvesting activities and processing can be timed and co-ordinated in such a manner as to ensure minimum quantitative and qualitative losses. In an efficiently integrated pea industry, to take another example, the peas can be mechanically harvested, chilled and transferred to the processing line for canning or freezing within an hour and a half.

A fully integrated agro-industry must closely observe market behaviour at all stages of the operation so as to be able to derive the greatest benefit over the long or short term. Consequently, particular importance should be attached to the choice of techniques and engineering for the distribution, processing and production sectors.

When establishing export-oriented agro-industrial production, only integrated agro-industry should be considered. The benefits to be derived from such a system can be summarized as follows

- Integrated agro-industrial development can be accomplished in only a few years. (In traditional rural development schemes, schemes for the settlement of new territories, or plain agricultural development schemes, a schedule cannot be clearly established in advance, nor can results be forecast.)
- Integrated agro-industrial projects are bankable. Investments, production costs, revenue and net profits can be forecast. (In most other kinds of development, initial outlays can only be conceived as irretrievable losses.)
- Integrated agro-industrial projects can be implemented in countries with varying political and social structures and at very different stages of national development. An integrated agro-industrial enterprise can be owned by the State, private persons, shareholders or members of a co-operative.
- Integrated agro-industry generates long-term employment opportunities more rapidly and effectively than any other investment in agriculture and can serve as a working model for other industries, for co-operatives or even for the State itself.
- Integrated agro-industrial enterprises do not fall victim to social antagonism; they have unified management, obviating clashes of interests and safeguarding the optimum use of materials, capital production, transport facilities, and manpower.
- Integrated agro-industry need not be permanently subsidized as it is self-sufficient and tends to create its own markets, both domestic and foreign. Horizontal linkage with other integrated agro-industrial enterprises presents no problems and joint export endeavours, common technical and research work or even increased specialization can be effected simply.

Co-operation in agro-industrial development

Agro-industrial projects resulting from co-operation between developing and developed countries should be well planned and prepared, the partners being provided with all the information and data necessary to make clear-cut decisions. Broad-scale co-operation—in the research, manufacture and selection of food-processing equipment and in special agro-industrial consultancy services which would permit the joint elaboration of projects, training of staff, provision of management and repair and maintenance services, as well as the reconstruction of agro-industrial enterprises—would be, of course, essential to the success of the project. To enable them to agree on a viable project on equal terms, and to avoid mistakes, the partners should commission an objective consultant to prepare a good techno-economic study. On the basis of this study decisions could be taken jointly and mutual confidence would be established from the beginning.

The first stage of the study should be an export-oriented market analysis. (There are only a few developing countries that can afford to build up agro-industries exclusively for their home markets.) The second stage should be the selection and specification of the processing and storage facilities necessary for the production programme, as determined by the market.

It is important that part of the study be devoted to the streamlining of agricultural production and the flow of raw materials. Should the price, quality, quantity or assortment of goods fail to correspond to market expectations the necessary remedial changes and recalculations should be made immediately.

Joint venture contracts for the establishment of agro-industries should contain acceptable conditions for the developing countries with respect to the repayment of credits and loans. The question of know-how is often misunderstood by these countries: they readily pay twice the price for it if it is "invisible", i.e. included in the price of the equipment; but they usually feel at a disadvantage if the supplier of the know-how requests cash payments or royalties. There should be no objection whatsoever to half of the repayments for know-how being effected in kind, on the basis of world market prices.

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Making a Good Match

by John A. Gay

Mr. Gay is a patents licensing officer with the United Kingdom Atomic Energy Authority and president of the Licensing Executives Society International. This article is adapted, with permission of the publisher, from PLI Know How *magazine*

IN exploring the ways in which a good match can be made between licensor and licensee, I shall consider the necessary policy decisions which must be taken by both parties before any decision to license is made, the types of product which can most remuneratively be licensed by one company to another, and the personal relationships which are essential to the negotiation and implementation of a successful licence. While many of the observations I shall make will be directed towards licensors, they will more often than not apply equally to licensees.

The granting of a licence is by no means the prerogative of the larger companies: there is a good deal of evidence to suggest that successful development which can subsequently be licensed arises in companies of all sizes although there are some subjects, such as jet engines and nuclear power, where the cost of development is so high that only larger companies can be responsible for them. I shall therefore assume that small companies are just as concerned as large ones when it comes to considering and implementing a licensing policy. It is worth remembering that many of the important inventions in use today were originated by individuals and developed, at any rate initially, by small companies. Such inventions include air cushion vehicles, the electron microscope, the jet engine, penicillin, and the catalytic cracking of petroleum.

I would not like to give the impression that licences, once having been entered into, are automatically remunerative to the parties concerned. There is general agreement in both the United Kingdom of Great Britain and Northern Ireland and the United States of America that when one is dealing with the exploitation of new ideas, namely, those for which a market has not existed before, the success rate lies between 2 per cent and 4 per cent. It is also my experience that only one quarter or one fifth of this small proportion of new ideas that are duly licensed produce a worthwhile royalty income. Clearly, the certainty of success rises on licensing proven products, but the granting of a licence still does not lead necessarily to financial success. It is the object of this paper to [illegible] the [illegible] of licensing so that it can be remunerative for both licensor and licensee.

Strategy in the transfer of intellectual property rights

Before coming to a decision about whether or not to enter into licence arrangements it is necessary to consider very carefully the reasons why such action is thought desirable. There are, of course, other ways in which intellectual property can be transferred between parties. These principally include joint ventures, equity participation, the formation of subsidiaries, particularly abroad, and even the appointment of sales agencies.

In a joint venture, one company teams up with another, generally in a foreign country, to exploit jointly rights owned by one or sometimes both companies. . . . Very often, too, a joint venture results from previous less formal collaboration such as sales or assembly arrangements during which the parties have got to know one another—an important prerequisite for any successful venture.

With equity participation, one company, having exploitable rights, takes an equity share in another company which then proceeds to exploit the rights concerned. In this way the company owning the rights participates in the exploitation of the product concerned to a greater degree than is normally possible under a licence.

Exploitation abroad can also be carried out under the aegis of a wholly-owned subsidiary company, and new technology has been exploited successfully by UK industry in this way in Commonwealth countries and in the United States in recent years. Although exploitation through a subsidiary company may potentially promise the greatest financial return, the risk of setting up such a company, particularly abroad, may be appreciable and a decision of this kind should only be taken when a good deal of experience of the product in the particular country has been gained.

Due consideration must be given to licensing. It should however be remembered that licensing is only one of a spectrum of ways of transferring intellectual property and, in that it relies on the efforts of another party, it offers the least risk in exploitation, but generally the smallest financial return as well.

The strategy to be followed in transferring intellectual property rights therefore needs careful consideration and may require expert advice. In order to ensure a good match between licensor and licensee, it should first be established that licensing is unequivocally the preferred method of exploitation.

There are many circumstances which have to be taken into account in deciding whether to seek a licensee or obversely to look for a product to be manufactured under licence. Some of these may, of course, be relevant in considering other forms of associations but they will be discussed in this article in the context of licensing.

An inability to sell a product in a foreign country or a reduction in sales in that country are often good grounds for considering the grant of a licence to an indigenous company. Sales may be restricted by government regulation or by the desire of a developing country to manufacture the product for itself. In certain South American countries financial stringency may prevent products from being imported from a foreign country. In many of these circumstances, the granting of licences will be welcomed and encouraged by the country concerned.

A potential licensee should not be reticent about considering the taking of a licence. In a sense the royalty payment is a saving in the expense of development, and countries such as Australia and Japan have prospered in past years and made technolgical advances through a policy of taking licences. It is therefore both legitimate and acceptable for companies to acquire research and development knowledge through licence agreements, and arrangements of this kind have generally proved very successful for both licensor and licensee. After all, it is wasteful to re-invent products and processes.

A licence can permit a company to go forward and carry out developments, the exploitation of which may be otherwise prevented. Large companies particularly may obtain rights from other companies under cross licence arrangements.

A company may also decide that a product is due to be superseded by an improved one currently under development. Here licensing offers the possibility of obtaining a further return on the capital and resources expended on the original product. In my experience, however, it is necessary to be frank in informing any potential licensee that an improved product is being developed, as otherwise subsequent relationships between the parties may deteriorate when, unknown to the licensee, the licensor launches the improved product upon the market . . . . If a meaningful relationship is to be maintained between licensor and licensee the inclusion of improvements in a licence agreement is an important consideration. In some South American countries, in fact, it is obligatory if royalties are to continue for more than a few years.

There may be some tax advantages from entering into licence agreements particularly with, for example, affiliated companies which are not wholly-owned. This is a subject on which specialist advice will be required but a desire to minimize tax payments can be a good basis for a successful licensing match.

A decision about whether to license or take a licence and the terms for such a licence should be part of the corporate policy of the company and should not be considered as a casual matter unrelated to other company activities. The effect of licensing, particularly abroad where anti-trust considerations apply, should be taken into account especially if there is a possibility of the licensee competing with the licensor as could sometimes be the case in the United States. Making a good match depends on appreciating fully the reasons for licensing, giving licensing a proper place in the affairs of the company and understanding the ensuing benefits and pitfalls.

The product

There are advantages in deferring licensing until a product has been successful commercially. Proven success by the licensor reassures the licensee and the licensor when exploitation commences although extrapolation from one country to another is not easy on occasions. It is noteworthy that companies in the United States sometimes find that in spite of a successful marketing operation in their own country, a European licensee is not so successful. This may be due to practical difficulties such as changing drawings into metric measure and the different problems of a smaller and less sophisticated market, but also, for example, to differences in personal attitudes to consumer products. The consideration of a detailed market survey should be a prerequisite for any potential licensee. With technically complex products it is more necessary than ever for the potential licensee to understand fully the product or process being offered including the way in which it can be manufactured, altered, improved and used. The licensor would be well advised to supply sufficient information to enable a potential licensee to carry out this kind of assessment.

Unless the product or process has had considerable commercial success it is generally unwise for a licensor to attempt such an assessment for a potential licensee as he can seldom know all the points to be taken into account by the licensee. Sometimes, of course, the provision of information for assessment purposes must be passed under an option arrangement or a confidentiality cover.

I should now like to explore what sort of product should be sought by a potential licensee. In a number of cases the licensee accepts a licence to manufacture the product he is already manufacturing. The potential licensee is thus able to assess from existing knowledge products which are likely to be of value to him.

There is some evidence to suggest, however, that companies wishing to diversify their activities can successfully take licences on subjects which are markedly different from those with which they are already concerned. Some years ago I was fortunate enough to be able to discuss with a number of Scottish companies their experience in diversification and their requirements for new ideas. It was very interesting to find that a fair proportion of the companies which had successfully diversified their activities had done so with products that were quite dissimilar from those which they had traditionally manufactured. This policy seemed to be associated in many cases with a young and vigorous board of directors which had decided to strike off in a new and different direction.

This Scottish experience is interestingly matched by an instance concerning a major automobile manufacturing company in the United States. Here the company developed an additive to petrol and produced a fuel with anti-knock qualities. It went on to develop methods of making the anti-knock material in a practical form, activities which were radically different from the manufacture of motor cars. This vigorous diversity of development led, of course, to a most important product.

A good match may also be made between companies which have manufactured different products up to the time of their meeting and I suggest that a willingness to undertake the exploitation and perhaps development of a radically different product may augur well for the success of such a project.

A licence should seldom be a once-and-for-all-times deal. It concerns the relationship between two organizations and an agreement may eventually cover a range of activities and grow more complex as the relationship matures. Even before the licence agreement is granted, one company may decide to give another a sales agency for the product on which a licence may be subsequently granted. In this way the parties gain confidence in one another before a licence agreement is even negotiated so that licence discussions, when they take place, generally proceed smoothly. A licence agreement will almost certainly include grant-back provisions relating to improvements made by both licensor and licensee, and the arrangements can even extend to a package deal covering not only a licence but also the supply of equipment and associated information, nowadays called know-how, show-how, and how-to. Extensions of this kind of an original licence agreement underline the importance of making the right match between licensor and licensee in the first place.

[illegible]

[illegible]

principals before and during negotiations, and in many ways these relationships are more important than legal or patent matters. If there is unanimity between principals, ways will be found to complete the agreement and overcome, without recourse to the courts, any difficulties during the period of the agreement. It is noticeable that when both parties to a licence negotiation are suspicious of one another, the licence agreement takes a long time to negotiate, it finishes as a complex document, and success in exploitation is less certain than when negotiations are quickly and amicably concluded with a fairly straightforward document.

Negotiators should be generally knowledgeable about licensing matters and should know the technical, commercial and legal parameters for the arrangement they are discussing. They should, where necessary, be guided by appropriate experts although many negotiators acquire a good knowledge of the legal and patent aspects of licensing from the conduct of their work.

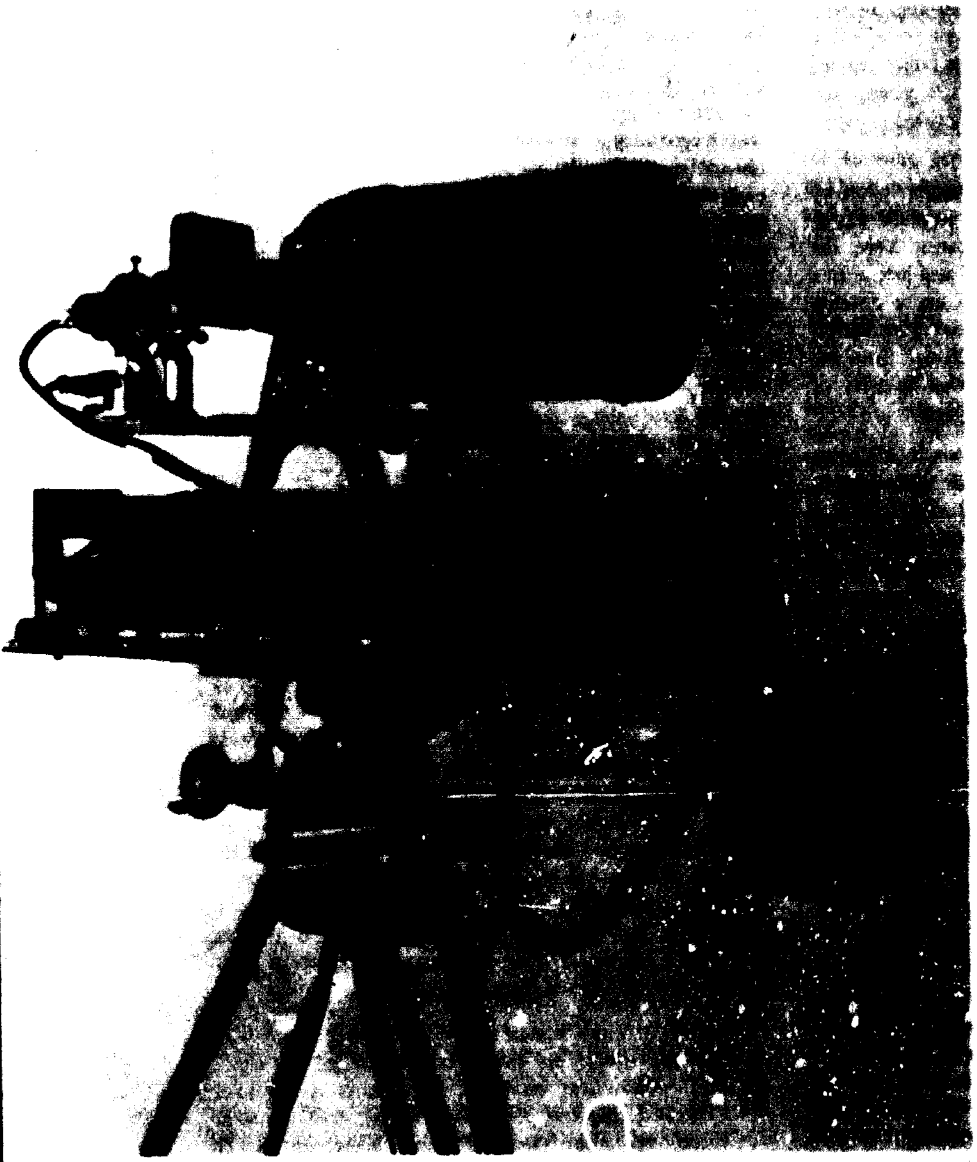
I would not wish to give the impression that one expert must always deal with licensing matters. In a smaller company a director will take this responsibility with appropriate guidance from professional advisers. Whatever the size of the company, however, personal relationships between individuals concerned in licence negotiations remain all important to the success of the negotiation. The best agreements are those which are kept locked away and never referred to!

In conclusion, may I therefore emphasise the importance of ensuring that licensing fits into the over-all policy of the company, that both parties to an agreement thoroughly assess the product to be licensed, and that the contribution made by good personal relationships to the negotiation and implementation of licence agreements is recognized.

Finally, may I quote some words which Sir William Petty is recorded as having written in the 17th century about the problems facing inventors and those who exploit the work of inventors. From these you will see that some of the criteria necessary to ensure a good match were recognized over 300 years ago:

> "Although the inventor, oftentimes drunk with the opinion of his own merit, thinks all the world will invade and encroach upon him, yet I have observed that the generality of men will scarce be hired to make use of new practices, which themselves have not thoroughly tried, and which length of time has not indicated from latent inconveniencies, so as when a new invention is first propounded, in the beginning every man objects, and the poor inventor runs the gauntlet of all [illegible], every man finding his several flaw, no [illegible] it, unless minded according to his [illegible]."

WHAT'S NEW . . .



Land-based "Fluorosensor" for monitoring water pollution

Night-time detection of water pollution

A unique system for the detection of water pollutants after dark has been built and successfully tested by scientists of the Inland Waters Directorate, "Environment Canada". Consisting of a laser, telescope and optical filters, it measures the fluorescence of [illegible] at ranges up to 75 metres and [illegible] distances of 500 metres. It can [illegible] dye and [illegible]

[illegible]

According to its designers, the system has two special advantages over other detection systems: it does not require a sample of the material to be identified and it is small and light enough to be readily airborne. It has detected fluorescence from oil-refinery wastes and pulp plants' settling ponds, as well as controlled spills of oil and dyes in tests conducted off the Bahamas and in Canada.

The system has been used to examine river water and, on board a ship, to monitor chlorophyll concentrations in Lake Erie.

A blue light from a low-powered laser excites fluorescence in the target area, and an eight-inch telescope focused on this area collects the light. Optical filters are used to block the reflected laser light and select pertinent wave-lengths from the fluorescent spectrum of the target. This light is converted to an electrical signal by a photomultiplier tube, processed and recorded on a strip chart.

The new system, which appears to be ready for market development, was designed by A. R. Davis of the Water Science Subdivision, and H. Gross, J. Kruus and R. A. O'Neil of the Remote Sensing Subdivision, Inland Waters Directorate.

Inland Waters Directorate, "Environment Canada", Ottawa, Ontario, Canada

New process for dehydrating foodstuffs

One of the disadvantages of conventional dehydration methods is that the quality of the products is impaired by the hot air and oxygen. In order to preserve the original quality, a process must therefore be applied in which oxygen and hot air are eliminated. One such process is freeze-drying, but the exceptionally high plant costs involved restrict its use mainly to the drying of costly substances for the pharmaceutical industry.

An Austrian company has now developed a new spray-drying process which turns fruit and other foods into a long-keeping instant powder. Somewhat more expensive than conventional dehydration methods, the process offers a high-grade final product of unimpaired taste and aroma and can be used for a wide range of dehydrating jobs.

Lysine production: 1

A [illegible] economical fermentation [illegible] of lysine has been developed [illegible]

[illegible]

Lysine production: 2

Extra-cellular production of L-lysine in a medium with cane sugar, blackstrap molasses or sugar-cane juice clarified by a previously obtained mutant of *U. maydis* has also been studied. The concentrate, obtained by direct evaporation and drying of the fermentation broth, could be used as a possible feed supplement because of its amino-acid and vitamin content.

A. Sanchez-Marroquin, Facultad de Ciencias, Universidad Central, Caracas, Venezuela

A wave-powered pump

A device that uses wave energy to pump water in a unique and uncomplicated way has been developed. The pump, which has only one moving part and an expected long and trouble-free service life, may be employed to pump liquid (most commonly sea water) in any direction by making use of the undulating motion of the waves. In relatively small waves (three to four feet) on a calm day it has pumped sea water at rates in excess of 20 gallons/minute from a depth of 60 feet to a height of about two feet above sea level. It can continue to work indefinitely and can pump to a considerably greater height (head of pressure) at a reduced flow rate. It would also be expected to pump a greater volume in larger waves. The pump is essentially a long tube or pipe held vertically with a simple inertia valve located somewhere along its length. The valve allows water to move in one direction only. When secured to a surface float that is forced to follow the vertical motion of the waves, the device pumps water in the direction permitted by the valve. The power that could be produced by a large pump of this type appears to be significant.

John D. Isaacs, Professor of Oceanography, Director, Institute of Marine Resources, University of California, San Diego, California

Antibacterial agent for vegetable tanning material

An antifungal and antibacterial agent which has the capacity to prevent mould and fungal growth in vegetable tanning liquors and on vegetable tanned leathers has been developed. Use of this product during tanning helps to achieve a higher yield of leathers by preventing sludge formation and the darkening of the [illegible] tanning infusions due to ageing.

[illegible] Institute (Council of Scientific [illegible] Research), Adyar, Madras-20, India

BOOKS

RECENT PUBLICATIONS REVIEWED BY IRDN

The Third World and the Rich Countries; Prospects for the Year 2000

by Angelos Angelopoulos. Praeger Publishers,
New York, 1972. 248 pages.

The author discusses the major development problems of the developing countries and uses abundant and easily comprehensible statistics to support his reasoning. The measures taken at both the national and the international level to solve the problems are clearly described, particularly in chapters 5 and 6, which cover development financing.

Mr. Angelopoulos breaks the problems of the developing countries down into six headings in chapter 5: (1) the immense gap between rich and poor countries; (2) the tendency of this gap to widen; (3) the slow growth of *per capita* income; (4) the worsening of the terms of trade owing to intentional policies by the developed countries; (5) the growing indifference by the developed countries to the problems of the developing countries and, (6) the increasing burden of debt service. To prove point 5 he compares the relatively meagre amount being spent on development aid with the enormous sums being spent on armaments and space programmes by the highly industrialized countries. But while this situation is deplorable, Mr. Angelopoulos says, the economic and political competition and the domestic political problems that exist within the developed countries must also be given realistic recognition.

The author points out that the developing countries are urged to give highest priority to the adoption of long-term plans designed to utilize available resources to the fullest extent in order to equalize income distribution and to eradicate unemployment; to the adoption of plans that would make the most effective and productive use of foreign aid; and to close co-operation among developing countries. These, however, in the opinion of the author, are only the clichés of development economists. Among the problems that should be explained are: why development plans often fall short of target; and why co-operation among the developing countries does not work well.

Mr. Angelopoulos believes that the developing countries could attain 7 or 8 per cent growth easily enough if financial resources were directed to them. He proposes consolidated new loan arrangements; the contribution of 0.5 per cent of their gross national product (GNP) by the developed countries; and the revaluation of monetary gold accompanied by the distribution of the plus-value to the developing countries. His arguments on these points are well set out in chapters 5 and 6.

However, the author's proposals seem unrealistic in the absence of precise explanations as to how they could be implemented. For example, his suggestion that "the government of each developed country should include in its annual budget an amount equivalent to 0.5 per cent of the GNP . . . and transfer this to the credit of an account kept in the book of the World Bank" is interesting—but will the developed countries accept it? These countries have their own problems. Proposals such as Mr. Angelopoulos's must be formulated in a way that the developed countries can accept. On this point the author's arguments are not convincing.

In the macro sense, the developing countries need additional funds; this has been proved by many gap studies. In the micro sense, however, the scarcity of realistic, feasible projects is the main impediment to the flow of funds to the developing countries.

(S. H.)

The Role of Group Action in the Industrialization of Rural Areas

Edited by J. Klatzmann, B. Y. Ilan and Y. Levi.
Praeger Publishers, New York, 1970. 599 pages.

This book is based on papers submitted at a symposium on industrialization in rural areas held in 1969. It contains 51 articles, which are supplemented by the editors' comments and a very useful selected bibliography. As might be expected with so many articles, the contributions vary greatly in quality.

The book is divided into three sections. The first deals with the reasons for rural industrialization and concentrates upon the need for employment generation, plant size, and the choice of technology. This section is comprehensive in its coverage of the issues but the authors frequently wander away from the specific topic of rural industrialization, discussing the questions of technology and employment generation in the broader context of industrialization in developing countries.

Thus, much of this material constitutes a review of the considerable research that has been undertaken on these subjects without exploring the specific implications for rural industrialization. The location and types of rural industries are also considered and on these the proposals advocated are more specific. Part-time farming, with its advantages and disadvantages, is a subject which does not often receive the attention it deserves in this context, but a balanced approach is presented in this publication.

The second section deals with group action in the course of rural industrialization and approaches the question from both a social and an economic point of view. Most contributors consider that a co-operative system offers the most encouraging prospects for the dispersion of industry. The papers develop a good case for this argument. Several case studies, from both developing and developed countries, are included.

The final section of the book deals with methods for group action and rural industrialization. The discussion of government policy with respect to rural industrial plants contains some interesting ideas. However, the general conclusion seems to be that encouragement of these plants should be limited to the early stages. This position is reminiscent of the infant industry argument, an approach which has often proved to be disappointing in other contexts. With regard to discrimination in favour of rural industries, the authors tend to neglect the impact of such discrimination upon existing urban industry, which must suffer accordingly. This consideration may be very important to many developing countries. The majority of the contributors advocate agro-industries for rural industrialization, differing only with regard to questions of technology, plant size etc. A few authors do argue that rural industrialization need not be based upon agro-industries; they contend that similar efforts in the past failed because the products were oriented towards the urban rather than the rural market.

Despite the fact that the book is not as well balanced as one might wish, it offers a variety of discussion from economic, social and institutional viewpoints and could be of benefit to students of the subject.

(R.B.)

Human Resources as the Wealth of Nations

by Frederick H. Harbison. Oxford University Press, 1973, 173 pages.

The author of this book attempts, within 160 pages, to demonstrate a rather optimistic theory on developing the skills and knowledge of man, whose "capacity for learning is [illegible]".

[illegible] Mr. Harbison [illegible] a rather good [illegible] of the [illegible] [illegible] [illegible] in [illegible] [illegible]

[illegible]

United Nations Development Programme by the International Labour Organisation and therefore offers some valuable lessons in drawing up a technical assistance programme for developing human resources.

On the one hand, Mr. Harbison points out the limitations of formal and non-formal education and training. On the other, he points out the need for further training and development of human resources. Almost every aspect of human resources development is touched upon.

The reader will find this book useful for the questions it raises rather than for the solutions it offers. It is something of a compendium of the problems to be encountered in developing countries. The author laments the high cost of training programmes both for industrial and for rural populations, but his own examples, as illustrated in various chapters—such as providing model schools, mobile teaching units, visual aids and mass media—seem to be fully as costly as the existing programmes.

There appears to be no way of avoiding the fact that the development of human resources is a long-term, costly endeavour fraught with the possibilities of poor government organization, national apathy, underskilled teachers and poorly formulated programmes (even well financed programmes are often implemented at a high cost not commensurate with expected results). Mr. Harbison takes an optimistic view of the great potential of the underutilized portion of the manpower resources of the developing world but offers no choice other than that of continuing along the road which development programmes are currently taking.

The outlook for the world is rather bleak, owing to the fact that the populations of the developing countries are increasing at a rate of 2.5 or 3 per cent per year. His solution is to develop the skills and knowledge of man and to strive to build effective, nation-wide learning systems so that all countries may prosper even though they are poorly endowed with material wealth or natural resources.

In summary, *Human Resources as the Wealth of Nations* is a useful guide for those interested in human resources development.

(M.Y.)

Group Technology

by G. M. Ranson, McGraw-Hill Book Company (United Kingdom) Limited, 1972, 150 pages.

Much has been written about the lack of capital investment and how it is responsible for the slow rate of economic growth in the developing countries. However, according to this author, more attention should be drawn to the need for the better use of existing resources. This book is an attempt to describe the benefits that may be derived through the application of group technology to the problem.

The theme of the book is group technology, which is applicable to approximately 80 per cent of the world's engineering industry concerned with manufacturing a wide range of products in various quantities. Mr. Ranson defines group technology as "the logical arrangement and sequence of all facets of company operation in order to bring the benefits of mass production to high variety, mixed quantitative production".

It should be noted that although this book has been written essentially for the engineering industry, its content is applicable to other industries that have problems of batch processing.

The author uses a case study carried out in his own enterprise over a period of 11 years to illustrate his arguments. The initial problems that faced management were "high levels of stocks and work-in-progress, long and unreliable deliveries, poor measurement capability, poor control procedures, fragmented and unco-ordinated interdepartmental relations, a multifarious payment system, and last, but not least, a poor over-all company performance". Especially troublesome was the fact that 75 per cent of sales were from a standardized product line which had an abundance of products that were not wanted and a shortage of products that were. At the same time, the value of all stocks was 52 per cent of annual sales value. Finally, an improvement scheme was initiated by the management. The key recommendation, following an appraisal and analysis phase, was for the introduction of group technology which would mean that the totality of the enterprise's activities would be co-ordinated according to department and function. One of the major benefits of this improved co-ordination was the spirit of co-operation that was created between the production and the sales departments. To a large extent, group technology enabled the management to better cope with market changes and other uncertainties associated with the nature of the business. The following procedures and steps were involved in the introduction of group technology to the company:

(a) A team of work-study engineers was employed to analyse and review the general operation of the firm;

(b) Production planning was centralized through the use of a code system and the establishment of a system of "one drawing and one number per part";

(c) High-speed production was supported by disciplined stores control and reduced inventories;

(d) Through-put time was reduced from an average of twelve weeks to under four weeks, with broken delivery promises representing less than 2 per cent of total sales;

(e) Job evaluation and greater labour mobility were introduced along with a scheme for sharing the benefits of increased productivity;

(f) An extensive introduction to all the new techniques was made in order to effect the application of the new technology with a minimum of conflict;

(g) A reduction was made of special orders through a realistic pricing schedule;

(h) A new look was given to the sales force, based upon confidence and co-operation;

(i) A total company outlook was achieved, based upon the totality of integrated operations.

On balance, Mr. Ranson's work, *Group Technology*, may be recommended. However, and as the author rightly points out, the book must necessarily be supplemented with additional reading inasmuch as it constitutes, in essence, "one man's story in one company". Particularly appropriate for follow-up study is G. A. B. Edwards's book *Readings in Group Technology* (The Machinery Publishing Company Ltd, 1971). In addition, G. Burbridge of the International Centre for Advanced Technical and Vocational Training, Turin, Italy has published *Conference Proceedings* (International Labour Organisation, Turin, 1969), which includes the contributions of various authorities which have recognized group technology as a major break-through in the field of production management. The proceedings of the Turin conference might be especially interesting to managers and technicians in the developing world in view of the collection of reports of practical experiences in group technology they contain.

Mr. Ranson, in addition to being Chairman of his own company, has accumulated considerable experience in management and production engineering. He is a fellow of the Institutions of Mechanical Engineers and Production Engineers and is widely recognized as an international authority on group technology.

(R. D. C.)

Society and the Assessment of Technology: Premises, Concepts, Methodology, Experiments, Areas of Application

by François Hetman. Organisation for Economic Co-operation and Development, Paris, 1973. 420 pages.

This hefty paperback, which includes copious charts, tables and other visual data, offers a broad analysis of the subject. The chapter headings are: "Technology on trial"; "Concepts of technology assessment"; "Experiments and development of methodologies"; "Areas for the application of technology assessment"; and "Promises and problems of technology assessment". While the contents are of concern primarily to the member countries of the OECD, the book could well serve as a bench-mark for a similar analysis for developing countries. The book can still usefully serve, however, in a quasi *caveat emptor* capacity, readers in developing countries involved in the transfer of technologies

The following quotation from the foreword of the book was written by the Director General for Scientific Affairs of the OECD, Alexander King.

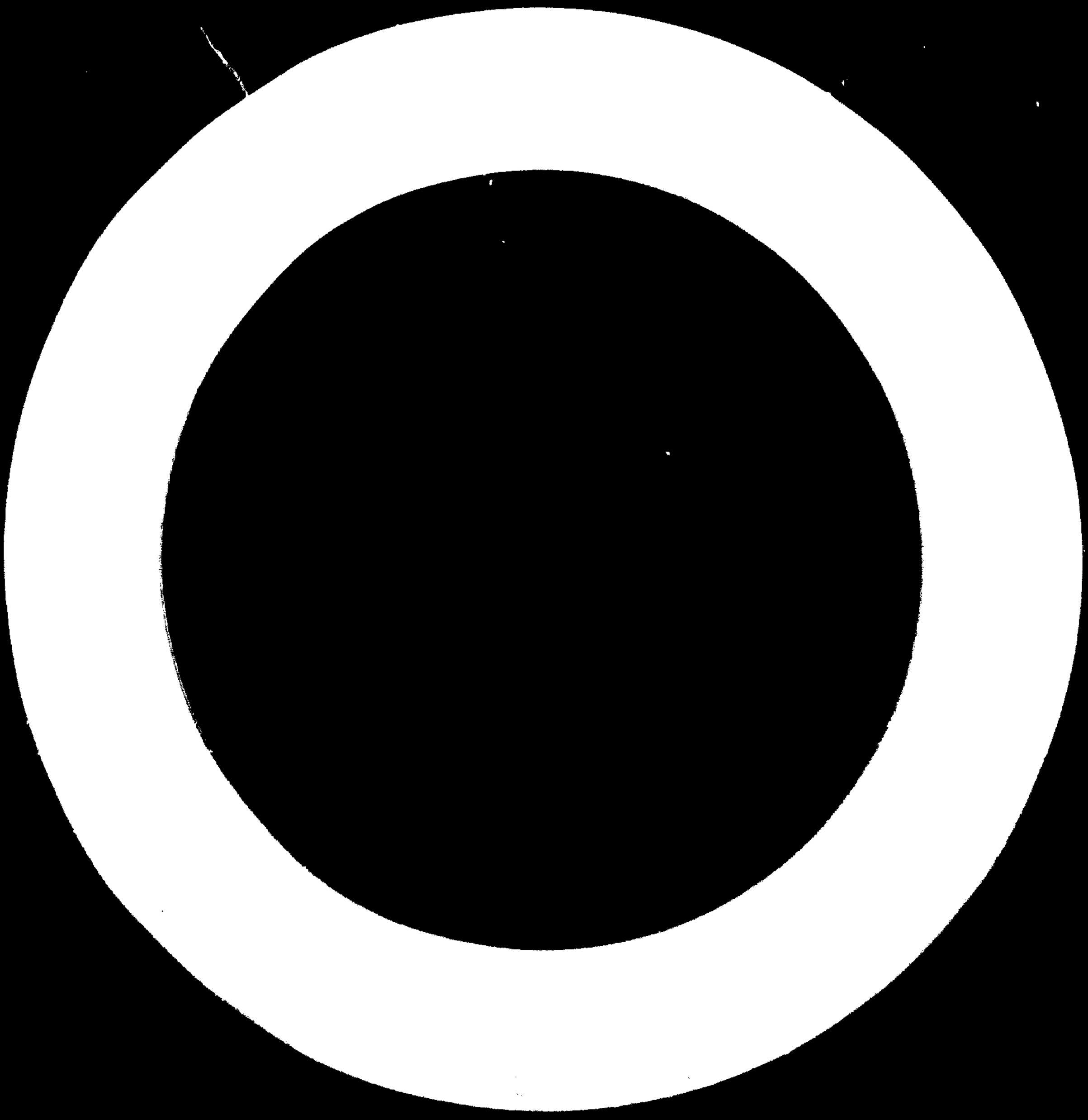
> Science and technology have contributed greatly to the shaping of the kind of world in which we now live—for better and for worse. The last few decades have seen a tremendous expansion in research and development activity in all industrialized countries and, despite the fact that the main justifications in providing the necessary resources have been the objectives of defence, national prestige and economic growth, the expansion period has been one of somewhat unquestioning euphoria for science. This has now come to an end and both legislators and the public at large are questioning not only the costs and benefits of research but the very objectives which have induced its expansion.
>
> The unwanted and often unforeseen side effects of technology are clearly manifest; some of these are direct, such as the obvious pollutions and general environmental deterioration, as well as a loss of work satisfaction in repetitive industrial manufacture. Others are more subtle and indirect, including the increasing frustrations and difficulties of urban life, increase in crime and violence and a growing sense of irrelevance in contemporary education. All of them are too easily attributed to technology or to the type of world which technology has built.
>
> Yet technology has been man's main weapon in his agelong struggle upwards from subsistence. Inventions of flint tools, of the wheel, the lever, the use of fire and many other technical discoveries, at first simple but becoming ever more sophisticated, have been the main indicators of human ingenuity. They were all questioned, no doubt, at the time of their emergence, by the conservative majority of the community, but each triumphed in the end by the power it conferred on the possessor. The arising of modern technology raises many of the same questions. Few of those who are most critical of its influence would advocate return to a primitive period, with a technological level unable to sustain our present population. The question can never be one of getting rid of technology entirely, but of determining at what technological level to make a stop, or else deciding what types of technology to encourage and which to prohibit. Attitudes towards economic growth are parallel; the problem here is not growth or no growth as is sometimes posed, but rather the quality and rhythm of growth desired.
>
> It is all too easy to make technology a scapegoat for the ills of society. It is not the origin of these difficulties but a tool which gives the frail human body an access to power which has enabled mankind to subdue nature and acquire wealth. The difficulty lies not in the technology, the power or the wealth, but in man's wisdom to make proper use of them. He has to learn to select, develop, manage and exploit technology for the ultimate benefit of society; with insufficient wisdom, power can, in the end, only be destructive.
>
> If we agree that the essential problem is not technology, but the management of technology, new difficulties arise concerning the nature of the society we would desire and which technology would help to construct and enrich. This is of course a matter of the system of values and brings with it all kinds of political and consensus difficulties. In fact, technology has until now served well, both in market and marxist societies, the agreed objectives of security, and economic growth. Again, why should we blame technology for its success? However, if it is to be equally well used in the future, we must agree what sort of society we wish to shape. There is little agreement about this, only vague dissatisfaction with the present situation and equally vague desiderata as to the future: improved quality of life—which means different things to different people—the provision of social justice, equality of opportunity and the removal of various types of discrimination.
>
> In the absence, then, of any real concensus and precision regarding the characteristics of a society both desirable and possible, it is difficult to redirect technology or the research and development behind it. Technology has been successful in the past because its objectives were clearly defined. Its future development will be much more difficult because its goals are insufficiently clearly formulated. Vague aspirations are insufficient to attract satisfactory technical solutions.
>
> The very concept of unwanted side effects of technology raises difficulties of a continuing nature. We are gradually realizing the interdependence and interaction of the various problems of society and hence the fact that attempts to improve the situation within a single sector will influence that in other sectors, both positively and negatively. In fact, there is not only an interrelationship between the various national goals of security, economic achievement, employment, social improvement, improved health and the like, but also a considerable degree of conflict. Isolated success in one field may be at the expense of others. Agricultural improvement, for example, may produce more food but, at the same time, cause unemployment, drift from the land and increased urban pressures. High levels of economic growth, while contributing to the material prosperity of the individual, can lead to a lowering of the quality of life in other directions. Equally, technological achievements towards the attainment of a particular goal may have either positive or negative influence on others. This success with a particular technological innovation in industry may have a negative influence through pollution or worker dissatisfaction. Military research, on the other hand, may have a positive spin-off in the civil economy and even in medicine
>
> The management of technology in the broad social interest is thus a very complicated process which must take into account social as well as economic costs and benefits and foresee the long-term effects of its achievements over the broad spectrum of human activity. For its optimum use, goals must be much more clearly formulated than at present and, until this has been done, technology management can only hope to avoid major disutility, while attempting to achieve its direct objectives.
>
> These were amongst the considerations in the discussions of the Fourth Meeting of Ministers of Science of the OECD Countries, held towards the end of 1971. The general conclusions of this meeting were that science and technology had until now an overwhelmingly positive influence on national development, but that in the future would have to be considerably reoriented to contribute to social as well as economic objectives. The ministers, while agreeing that continued stimulation of technological innovation was required to achieve both qualitative and quantitative growth, stressed that the new technology would have to be socially desirable and acceptable. This, they considered, demanded a more effective management and control of technology in the public interest. They recognized that it was a major task for science policy to assess both the beneficial and adverse consequences of technological development and to foresee scientific and technological trends. They agreed to share the effort of making such studies and to exchange the results, in order to develop more effective methods and to evaluate national case studies.
>
> Technology assessment is thus conceived as a tool of technology management, as a necessary link between

research and development and the needs of society. It was realized, of course, that difficult decisions might have to be taken as a consequence. For example, Governments operating policies for the general stimulation of technological innovation for economic growth might well have to discourage or prohibit particular innovations on social criteria.

The science and technology programmes of the Organisation have been modified considerably as a consequence of the ministerial meeting and now stress social aspects and constraints of science policy, for example in making more clear the role and potentialities of research in the social sciences with regard to science policy and decision-making in general, by study of the innovation process in the service sector and in relation to technological assessment.

The present book . . . attempts to place the topic of technological assessment in its social and economic perspective, to define its scope and to outline the various methodological approaches it has evoked until now. The subject is still at an early stage of definition and method at which such a "state of the art" compilation should be useful. It is a field for which there is great and generally recognized need, but in which there is as yet little concrete achievement. While Governments are seriously concerned with the need for technology assessment, institutions for its accomplishment exist in only a few cases. An interesting development, however, has been the recent decision by the Congress of the United States to set up a technology assessment agency under its direct control. The precedent of establishing such a body under the legislative rather than the executive is very significant.

If, as seems probable, we are entering a phase in which decision-making will have to balance, much more carefully than in the past, social as well as cultural criteria, a whole range of new tools are required in addition to suitable social indicators. Technology assessment represents not so much a technique as an area of enquiry in which a whole series of new analytical tools will have to be shaped including those to measure cross-impacts. The area of enquiry is itself diverse. It may be relatively easy to foresee the more important of the social impacts of two alternative technological options and to have a better idea of the spread of both economic and social costs and benefits. Quite different approaches will be required when assessing the probable cultural as well as social consequences of a new field of research or application taken as a whole and over an extended time scale, for example the influence which the widespread use of the computer in education would have. Again, a once-and-for-all assessment may be misleading. For instance, had we at the beginning of the century attempted to assess the social and other consequences of the introduction of the automobile, attention might well have concentrated on its danger to rural life, danger to dogs and chickens and the like. It would have been difficult to foresee the situation a few decades ahead when motorized transportation had revolutionised the distribution system and contributed so strikingly to individual freedom and mobility. Were we looking at the same problem from today's situation of cluttered and polluted cities, the result might well be different again. Technological assessment, if it is to mean anything, must be a continuing process. These and many other issues are explored in Mr. Hetman's book.



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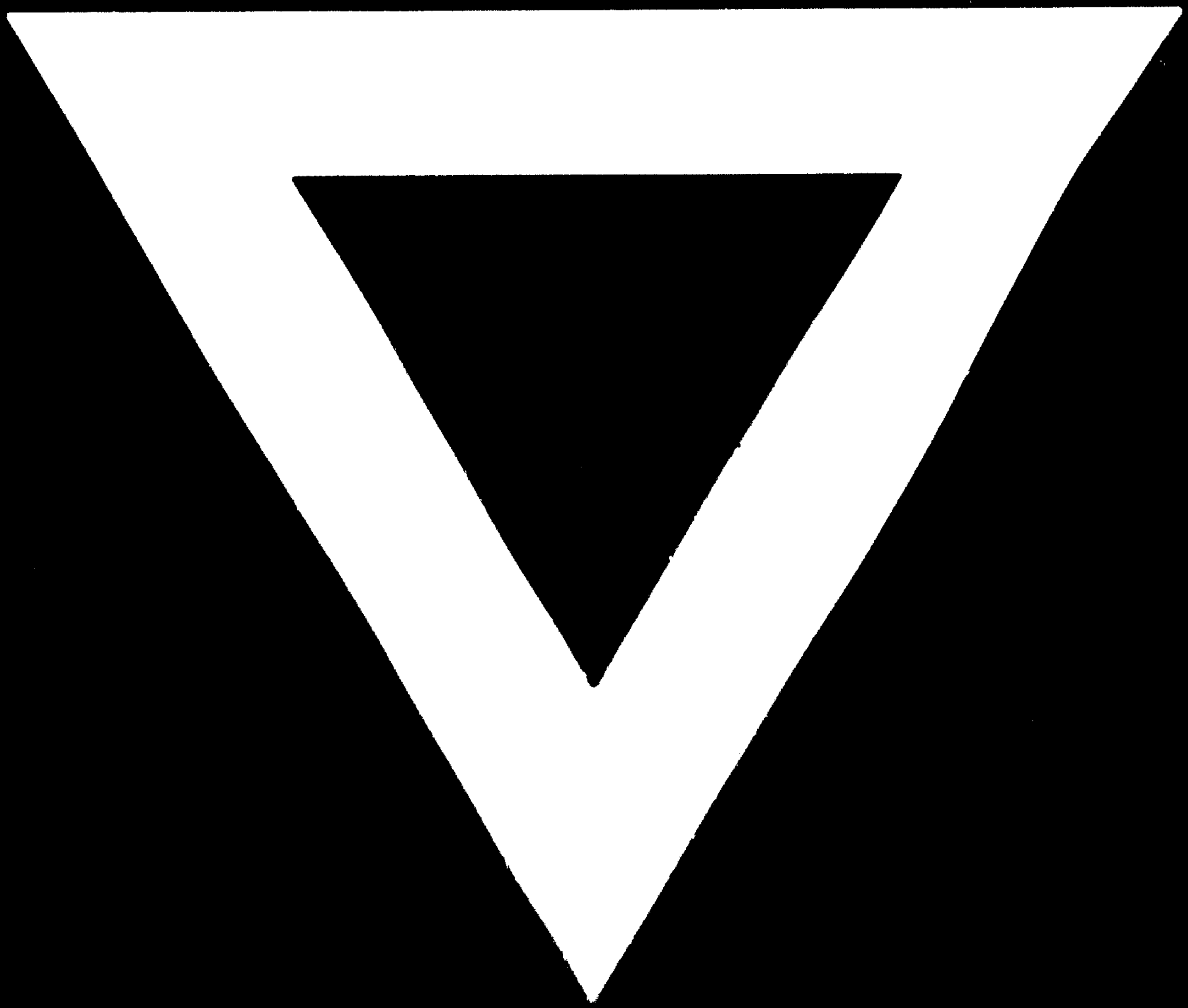

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