OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

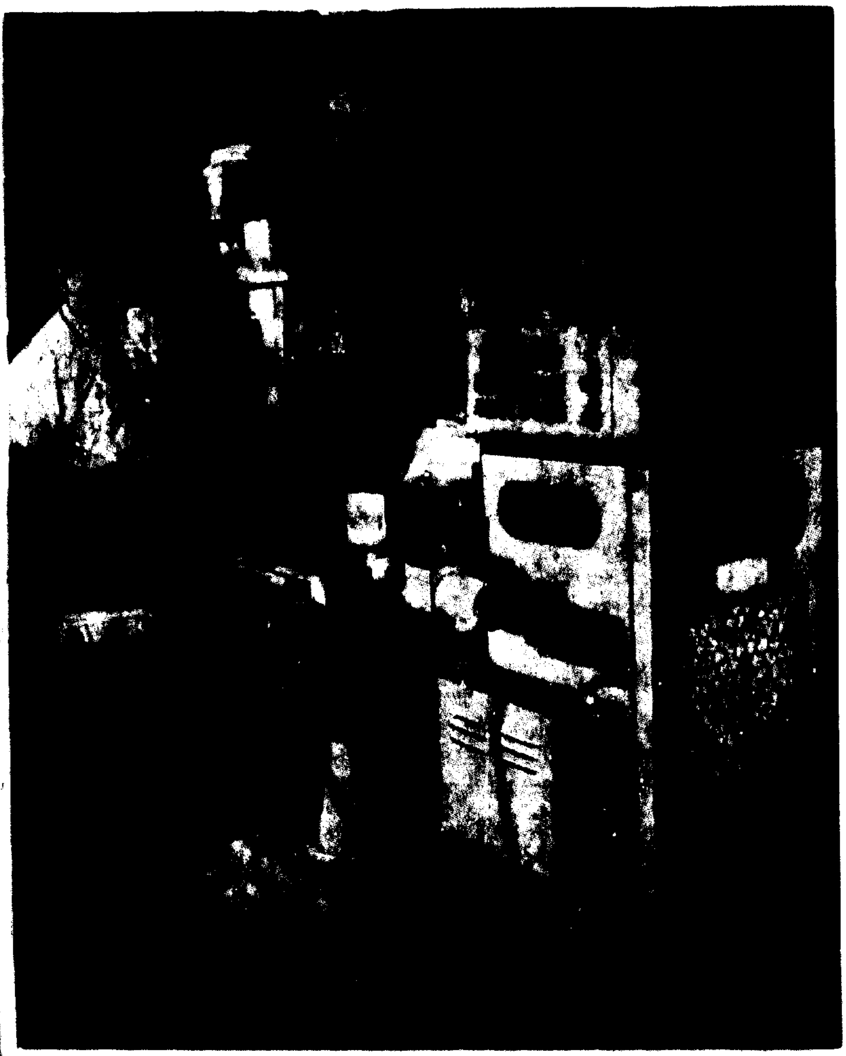
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D01622

The Role of Instrumentation and Automation in Industrial Development

The Author: *Before joining the International Atomic Energy Agency in 1968, Mr. H. C. Yuan served as the Director of Union Industrial Research Institute in Hsinchu, Taiwan (cf. IRDN Vol. III, No. 1). At IAEA he is in charge of industrial applications of radioisotopes and radiation technology, and has been active in the organization of study tours, training courses and scientific meetings related to the use of nuclear techniques in industry.*

By H. C. Yuan



THE EVER INCREASING technical gap between the industrialized countries is the cause of considerable concern to those engaged in maintaining the standards of industrial research. Technical innovation and productivity clearly indicate that the trend of manufacturing industries has shifted from manual operations to automatic control. The fully computerized plant is no longer a curiosity, but is, for example, vitally linked to the success of the petroleum, steel and fertilizer industries. Modern industry is in an era of instrumentation which has gained its momentum through process development, plant operations, and the exploration of natural resources. It is the age of automation. In industrial research and development it is essential that the role of instrumentation and the concept of automatic control be recognized and strengthened in order to meet future demand.

Numerical control technique has become a versatile tool for automation in machine industry. The picture shows the research for drilling operation carried out at the Department of Mechanical Engineering, the University of Wisconsin, Madison, Wisc., USA

Function of instrumentation in manufacturing industries

There are many factors, particularly economic and technical, involved in the relationship of instrumentation to the advancement of technology.

Though labour saving is the immediate aim of automation, improvement in efficiency brings large bonuses in the form of speedy production, uniformity of product and less waste.

In Argentina, for instance, a vinyl sheet manufacturer installed a radioisotope thickness gauge in a calendaring machine. With the aid of this instrument which cost US$4,000, the manufacturer was able to save $13,000 annually because less time was taken in calendar adjustment and there was also a substantial reduction in sub-standard products. Similar benefits were obtained in a rolling mill which used a thickness gauge to keep the close tolerance of plate thickness.

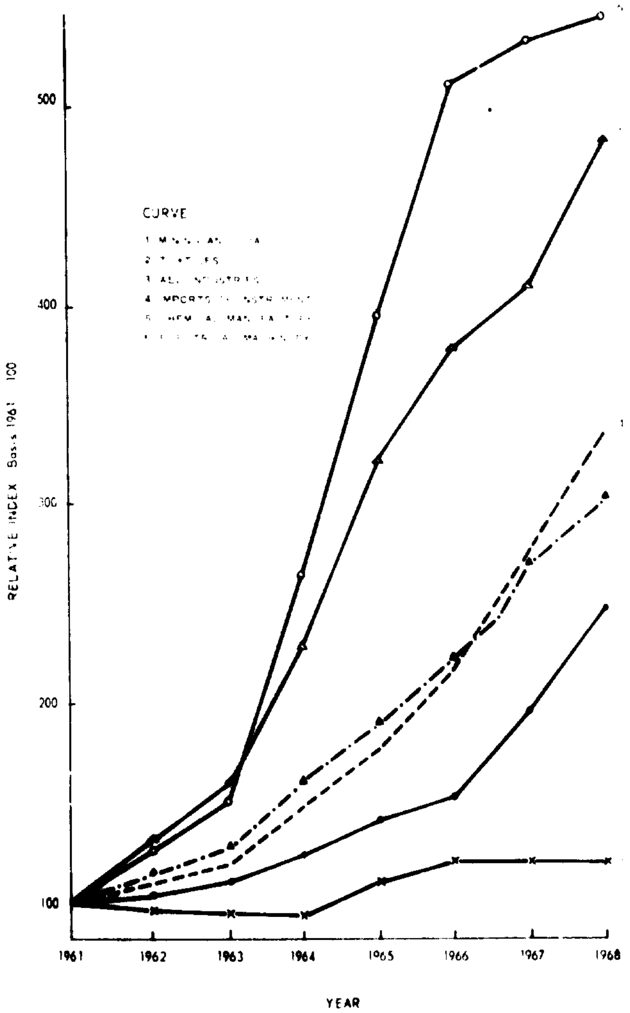
In a survey of the applications of radioisotope instruments in the United Kingdom, the economic savings achieved as a result of the improvement of plant efficiency and quality of products was estimated at $39,200,000 in 1969, while the cost of instruments installed was about $2,100,000. The substantial saving in relation to the cost of instruments was in the ratio of 19:1 and enabled the cost of the installation to be met. In a paper mill with a beta transmission thickness gauge coupled with an on-line computer control system, the installation cost of $140,000 was recovered in two years because of the profits gained by increased production and improved quality. The significance of automation cannot be evaluated by figures alone however, in a highly competitive market the increase in the volume of sales as a result of technical improvement is just as important.

On the technical side, instrumentation can be regarded as the brain of the plant. The various processes can be checked for smooth working – or otherwise – and orders can be transmitted through the control mechanisms. Instruments can measure the variables in the process and test the properties of materials. The control instruments can register the feed rate of raw materials, the distribution of intermediates, the rate of production and even the quality of the finished products. Only through proper instrumentation is it possible to investigate the mass and energy balances of the plant operation and thereby discover the degree of efficiency of the plant. Technical modifications and optimization studies in a plant could not be carried out if adequate data on the process were not available. Another advantage of automatic control systems over manual operations is that they are faster to respond so that less errors occur.

In small and medium-sized industries the production systems are comparatively simple but involve extensive manual operations. Unfortunately most entrepreneurs do not realize the benefits of testing apparatus or that simple control devices can bring in improving production and quality of products. The lack of proper measuring devices has been responsible for many errors in the past that can be avoided when entrepreneurs accept the importance of quality control by investing in testing apparatus.

Figure 1

Industrial growth and import of instruments in the Republic of China

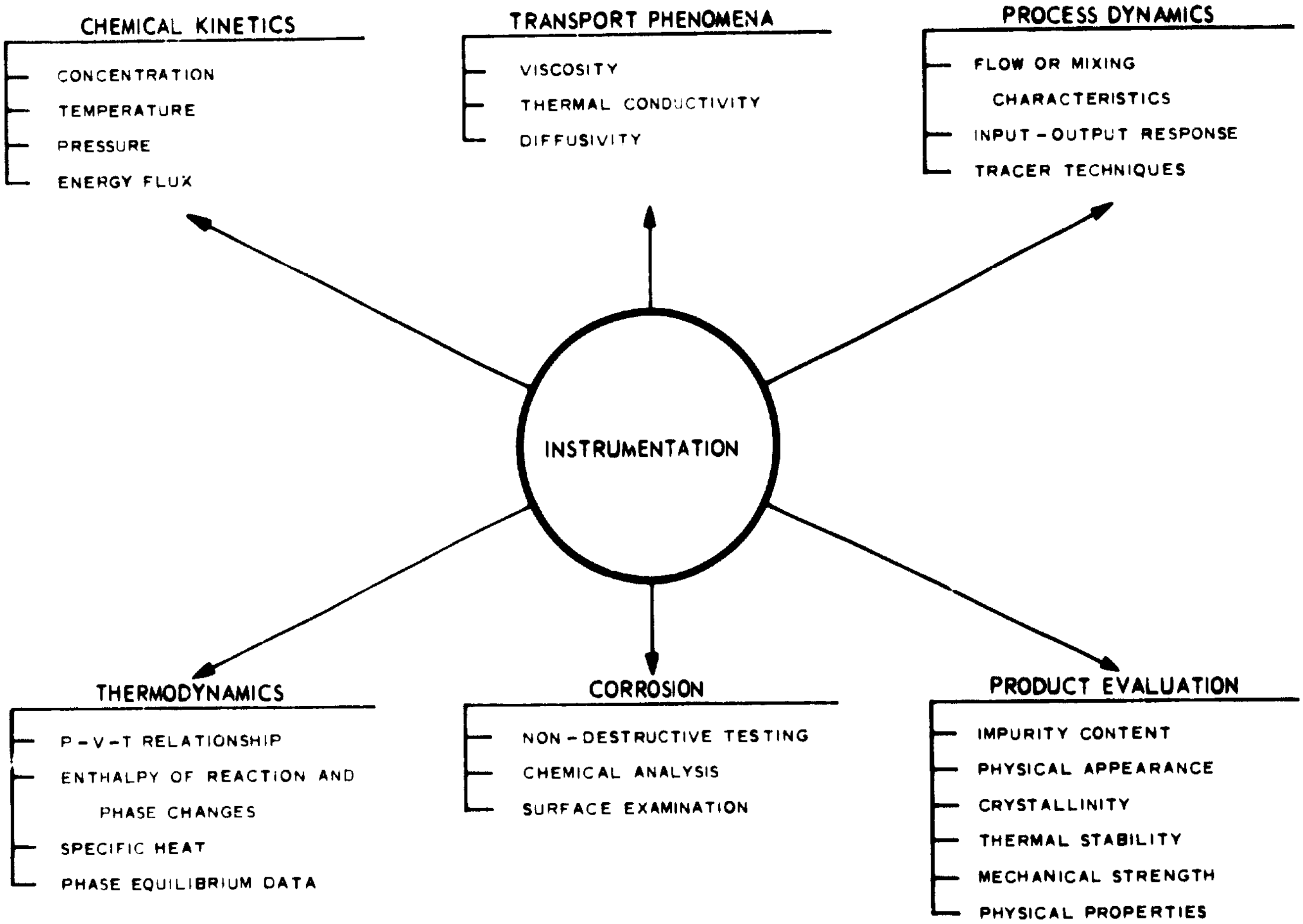


It is interesting to compare the industrial growth of a country with its demand for instrumentation. In the case of the Republic of China, for example, industrial production tripled between 1961 – 1968, and the import of instruments during the same period increased almost at the same rate. Figure 1 further indicates that the high industrial growth rate during this period was the result of the expansion of sophisticated industries such as petroleum, electronic and chemical industries, while the development of labour intensive industries, such as coal, mining and textiles was only moderate. This would throw some light on the supporting role of instrumentation in the build-up of technologically-oriented industries.

Role of instrumentation in industrial research

The importance of instrumentation in industrial research becomes more dominant as the calibre and sophistication of the work increases. Taking the chemical industry as an example, the translation of laboratory findings to engineering design can only be accomplished with the collection of specialized experimental data. The determinations of design parameters, the measurements of process variables,

Figure 2. The role of instrumentation in chemical process development



the analyses of compositions and the tests of corrosion of equipment depend extensively on instrumentation. Successful scale-up in general is closely related to the accuracy of such data. In product applications, quality control in addition to the evaluation of physical and mechanical properties, will determine commercial feasibility and these measurements need a variety of instruments. Figure 2 shows the over-all relationship of instrumentation to the chemical process development activities It is pertinent to stress that instrumentation forms part of a process development scheme. The instruments cannot be regarded as individual pieces, despite the fact that they have their own mechanical features and circuit designs. Once installed they are linked to the processes and have the additional assignment of control loops through the coupling of operations. Usually the dynamics of the process will govern the selection of instruments, but the specifications of the instruments cannot decide the process. A combination of instrumentation and process investigations seems to be the practical solution. This is a task for which national industrial research institutions generally are responsible.

Fruitful research, however, depends much on a systematic approach. It is not difficult to perform an experiment, but it is hard to collect the right data and to interpret the results correctly. It is necessary to understand not only the limitations of the instruments, but also the selection, maintenance, calibration and human errors during operation. The reliability of results is the main concern of industrial research institutions whether a research programme is of the in-house type or of contracted research. Malfunctioning of instruments, lack of standardization, or improper adjustment will make the results meaningless. While it is true that poorly equipped institutions will be unlikely to attract good research workers or potential contractual services, it is necessary for well-equipped laboratories to rely on skilled personnel to handle the instruments for high calibre research.

The technical gap

In the technological race the advanced countries have all the potentials for developing new tools or methodology for a better research effort. A big leap in experimental techniques is the result of the linking of the computer to analytical tools such as gas chromatography, neutron activation analysis and spectrophotometry. For instance, in mineral exploration or metal processing, the analysis of a vast number of samples by neutron activation analysis is required in a short time. With the concept of an integrated computer programme, automatic systems have been designed to run sample transfer for neutron activation, collection of gamma-ray spectra and data processing in sequence. Rapid and accurate results of analyses can thus be obtained at a reasonable cost.

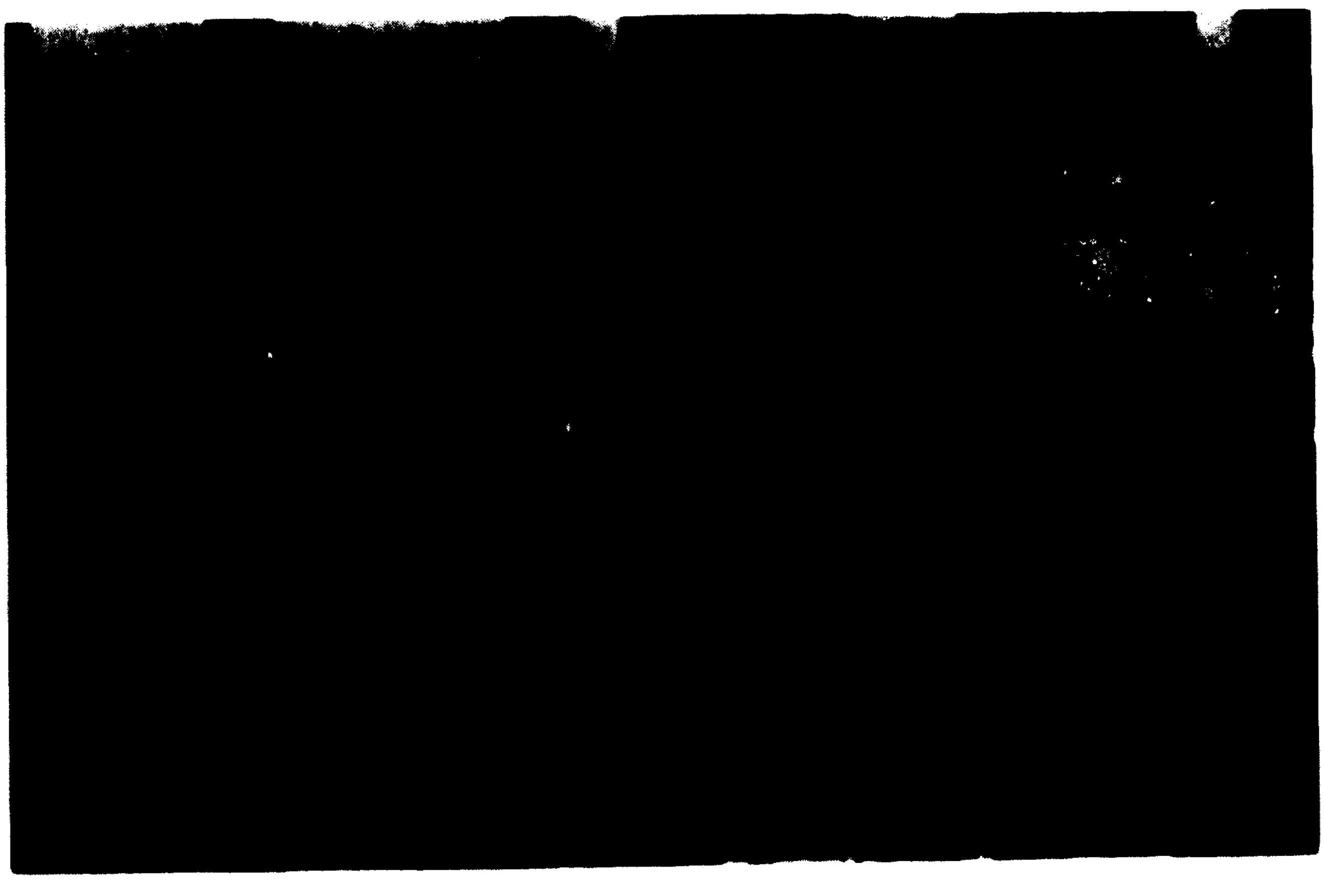
An automated computer programme applied to gas chromatographic analysis provides a better interpretation of overlapping peaks and eliminates the danger of inconsistent decisions. For instance, in chemical reaction mechanism studies, it has been estimated that the cost per gas chromatograph, including the collection and evaluation of data would cost $7.00 by manual operation, $5.00 with electronic calculator for a semi-automatic operation and $4.10 for complete computer programmed analysis. However, the principal advantages are to obtain fast results and to release the laborious and repetitive work for data reduction, the accuracy of which in a manual operation has always been a problem. This practice of automation in instrumentation also permits the efficient use of manpower with reference to both research personnel and supporting staff.

The advance of sophisticated technology in the fields of nuclear energy, electronics and space exploration not only benefit the relevant sphere of work but many other disciplines. The use of radioisotopes in instrumentation has been related to the growth of the nuclear power programme (the subject of an article in Vol. IV, No. 2 of this journal). The evolution of computer design has featured the transition from vacuum tube to transistor and to integrated circuit. The exploration of outer space has stimulated the progress of instrumentation for reliability and miniaturization. In fact because of the exact precision of instruments required in space flight, it has created the concept of numerical control in machining the parts used in the instruments. The numerical control technique is also the result of automation and has been considered to have caused a revolution in mechanical engineering. It is almost certain that numerous principles and phenomena in optics, nucleonics, magnetics and sonics, have been applied to the design of novel instruments. Much practical work has been done to achieve high sensitivity, fast response and dependability. The shadow of such progress is the further widening of the gap in technical calibre existing between developed and developing countries. The gap is serious enough to warrant the attention of all industrial research workers in developing countries; it is not limited to the hardware alone but extends to the more critical concept of data processing and control principles.

Training programme

The training of staff and technicians has become a major theme of modern industry. Its significance cannot be underestimated with regard to professional competency, which constitutes the real support of the infrastructure of the organization, and well organized training programmes are indispensable for preventing technical obsolescence. The

Assembly of instruments designed and built by the Office of Atomic Energy for Peace, Bangkok, Thailand for Mineral Analysis

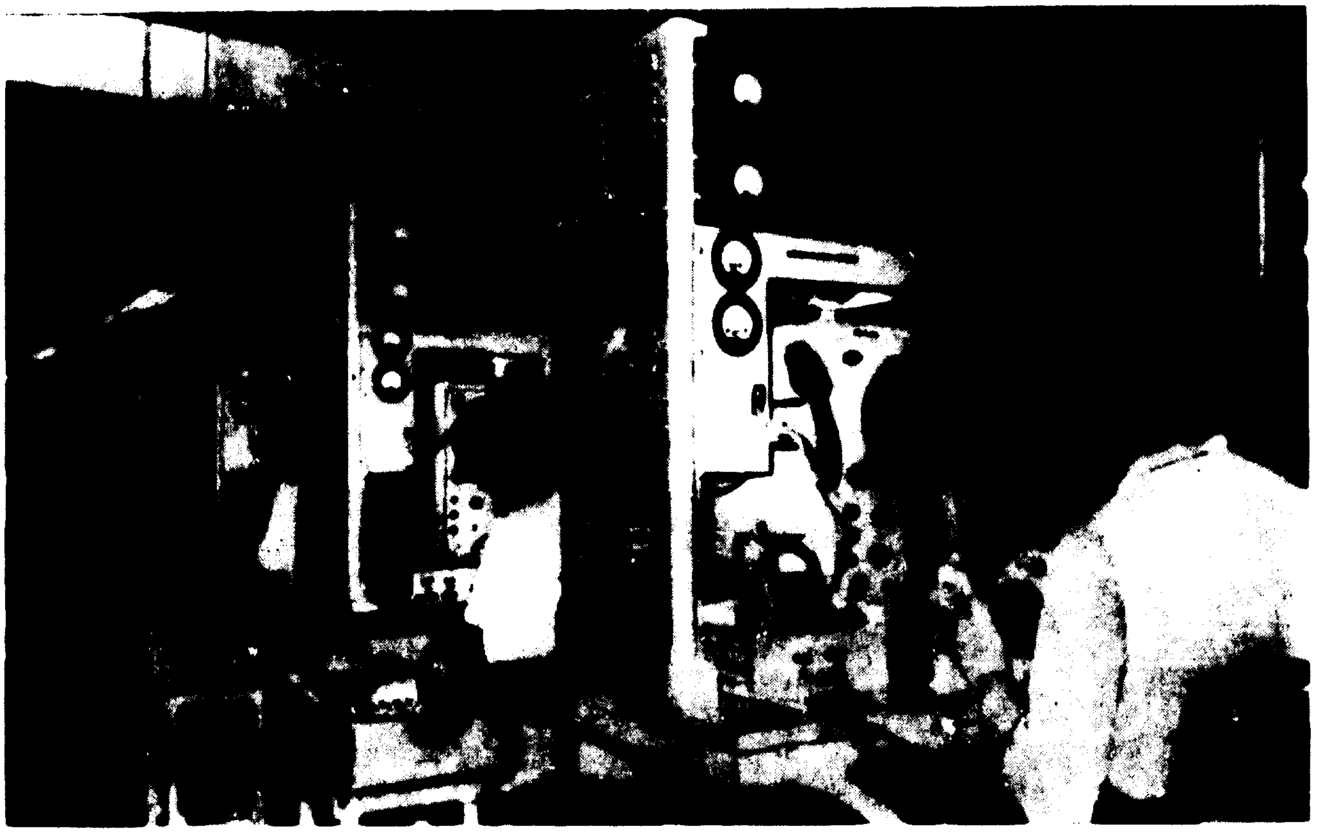


versatilities underlying instrumentation and automation are not in doubt in industrial research and production, but the complexities involved will certainly retard the proper uses of instruments in many countries where competent scientists and engineers are scarce.

To alleviate the gap in technology, realistic steps must be undertaken through the exchange of experience, training programmes and study tours. For developing countries, emphasis should be on the application rather than the development of high precision equipment. By building a nucleus of skilled staff the purpose of systems engineering training is to stress the importance of the interactions of the components upon each other. Topics such as servo-mechanisms, digital control systems, process dynamics and tracer techniques could be included. An example of this approach is the experience of the Monsanto Chemical Company. In view of the advance of the automatic control theory in electrical, mechanical and aeronautical engineering, the Monsanto Chemical Company decided to co-operate with Washington University, St. Louis, Missouri, in the development of training programmes for chemical engineering staff with little background in electronics and vice versa for electrical engineers. After the completion of the programmes, the electrical engineers and chemical engineers worked together to analyse problems by the application of mathematical and physical principles. The electrical engineers supplied the necessary servo-mechanism theory for control problems, while the knowledge of chemical processing was contributed by the chemical engineers.

The organization of study tours under the United Nations Technical Assistance Programme is another way of encouraging scientists and engineers from developing countries to gain experience. For example in 1966 the International Atomic Energy Agency (IAEA) arranged a study tour on the industrial applications of radioisotopes in the Czechoslovak Socialist Republic, France, the Union of Soviet Socialist Republics and the United Kingdom. Because of the success of this tour, the Agency is now planning another study tour in Canada and the United States in 1970.

Many developing countries have asked UN organizations such as the IAEA, UNESCO and UNIDO to provide expertise and fellowship training in instrumentation, and a few countries have established instrumentation centres with UN assistance. The expansion and consolidation of these programmes will certainly bring fruitful results (and the time will soon come when instrumentation and automation can be linked) to manufacturing processes in developing countries.



Precision instruments are indispensable for the quality control of industrial products. The picture shows woman workers in the electronic industry in Taiwan fabricating component parts with the aid of oscilloscopes

74. 10.10