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

D00662

Distr.
LIMITED

ID/WG.44/[illegible]
30 September 1969

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Development Meeting on the Manufacture
of Telecommunications Equipment
(including low-cost receivers for sound
broadcasting and television)

Vienna, 13 - 24 October 1969

TRAINING FOR DESIGN AND PRODUCTION OF ELECTRONIC EQUIPMENT [1]

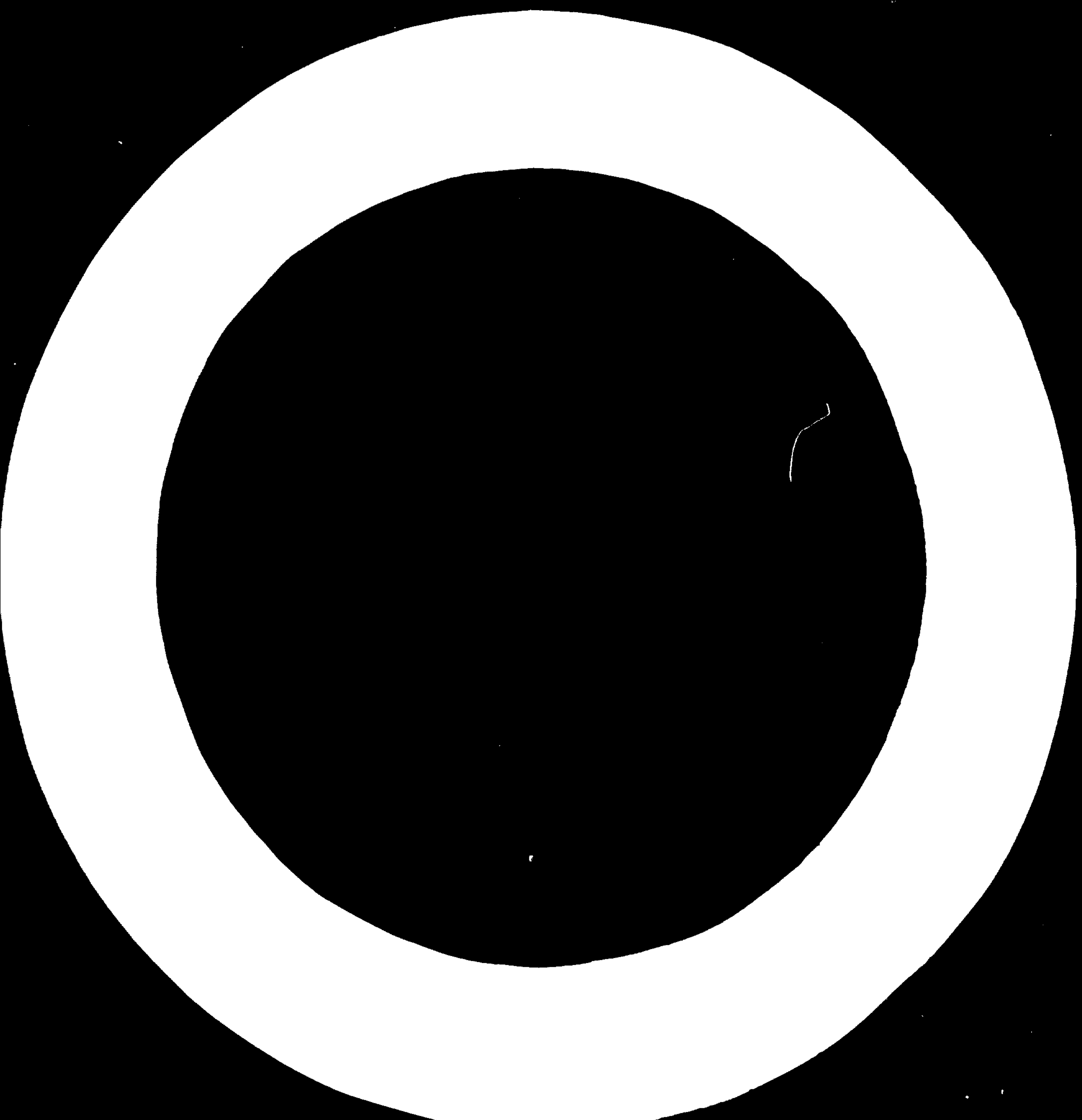
by

F.F. Papa-Blanco,

prepared on behalf of the International Labour Organisation,
International Centre for Advanced Technical and Vocational Training,
Turin, Italy

[1] This document has been reproduced without formal editing.

id. 69-493[illegible]



We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

1. SCOPE OF THE PAPER

Technicians and engineers can be involved in work with electronic devices in four basic ways : design, production, operation and servicing (or maintenance if preferred). The present paper is concerned with teaching of electronics when the main purpose is to stimulate the production of electronic devices in the less developed countries. Training for operation and servicing are therefore not dealt with.

The distinction between electronic gear for communications or other (such as automatic control, signal generation, etc.) is of secondary importance from the point of view of the objectives of this paper. In fact, all electronic devices are in reality data processing equipment. Their function in all cases consist in transforming an incoming signal and delivering an output signal of the same or of different nature. The input signal can be a physical magnitude of practically any kind, such as an electromagnetic wave, an electric voltage [illegible], a force, photons impinging upon a surface, etc. For the purposes of their processing, it is convenient to convert the various physical magnitudes in electrical ones which are easier to modify at will. From then on, processing is effected on an electronic signal, thus the whole processor is termed an electronic device.

At any rate for all purposes, be it production, operation, teaching, design, [illegible], it is convenient to think of a front end, - a transducer which serves to transform a given type of physical value [illegible] electronic [illegible] "core" consisting of electronic [illegible] which modifies in the desired way the input signal [illegible] and an output end [illegible] converts the signal already processed into the form [illegible] suits the purpose of the whole [illegible]. [illegible] receiver, the antenna [illegible] electromagnetic wave into an electronic signal, which, [illegible], is converted into mechanical energy by the [illegible].

When one speaks about [illegible], one could refer to simply assembling apparatus following [illegible] produced elsewhere and using materials also produced elsewhere [illegible] however attractive and commercially or technically justified this could be, this case is of little or no interest for the purposes of this paper, since the techniques involved consist mainly in following instructions, applying certain more or less elementary skills or utilising equipment in a pre-determined [illegible].

Technical judgement, and scientifically based knowledge only come into play when the technical problem tackled does not have a ready-made solution. This is the case of production when the parts or components utilised do not correspond, - as to characteristics, physical configuration, or other -, with the design being followed, and, of course, of production on the basis of new design.

2. USUAL PATTERN IN TEACHING OF ELECTRONICS

Teaching of electronics is in the great majority of cases centered on the understanding of the role played by the elementary components of a circuit. So, in most cases the graduate will be more or less deeply acquainted with the way the electronic signals are modified in the circuit, with the feedback signals necessary to ensure certain features such as stability, or to produce self-sustained oscillations. He will be more or less familiar with the limits to respect to avoid undue distortion of the signals, or overloading, as well as how to limit or eliminate spurious signals, how to match the impedances of quadripoles in a sequence, etc., but most probably, he will depend only on his ingenuity if he has to design a device with a view to its economic or competitive production.

It is interesting to note that in other branches of technology, production is given a lot more attention. For instance in civil engineering the concern is exactly how to build; within mechanical engineering, production is frequently offered as an option, and occupies a part of all study programmes, and so on.

In electronics, perhaps due to indispensable analytical approach to functions and to circuitry, the attitude has always been more intellectual, more academic. So, a polarisation has resulted, on the one side the scientific minded electronic engineer, on the other, the serviceman, whose approach usually should also be predominantly analytical and, up to a point, scientific (but that, for common devices at least, is often empirical or intuitive).

In developed countries, existing industry is a breeder for the technician and engineer who will eventually handle design and production problems : research serves to test design, solve problems and bottlenecks, etc., and thus also feeds the know-how on the design and production ends.

But, of course, this is not the case of most of the less developed countries. Therefore, teaching should make up for this lack in a systematic way, if the technicians or engineers are wished to foster local production.

3. TECHNICAL AND ECONOMIC ASPECTS IN DESIGN AND PRODUCTION

In design and production, a number of interrelated elements come into the picture, for instance the choice among the degree of integration of the components utilised the matching of the characteristics of the various parts so as to avoid an overall loss in performance, consideration of the cost originated by incremental improvements, average life of the parts chosen, the influence of tolerances in the characteristics of the components in the overall performance, the geometrical arrangement of components, the equipment necessary for production of parts and assembly, the sequence to be followed and even elements such as heat dissipation, fastening of parts, housing, atmospheric conditions, physical endurance of movable parts, etc.

What precedes is indeed mentioned in most electronics courses in technical or engineering schools; but besides of a general awareness, the graduate gets little else as to design or production; moreover, there are differences between the highly industrialized contries and the others, that should be accounted for.

The design adopted for a product influences not only its technical characteristics, but quite naturally its cost, its durability, the cost and ease of its servicing, etc. From the strictly technical point of view anything that is produced in one country can be reproduced anywhere else in the world. So, nowadays, steel mills or petrochemical complexes spring up in countries where the degree of industrialisation, or general development, does not match the technological level of those industrial plants. This happens quite frequently when the objective is to mass-produce goods for which certain universal standards apply.

However, this is not the case of most industrial production. For instance, in a developed country one talks of hundreds of of thousands of washing machines, or bicycles, or radio receivers for a factory to produce, while in the less developed countries one might even refer to a few thousands or a few hundreds at a time. Even then, one could conceivably aim at producing in the latter countries identical goods, utilising the same materials, following the same design, aiming at the same quality and finishing.

Nevertheless, when one considers the equipment needed to produce, the organization of the sequence, the stock of raw materials, the mechanisation and the order of the steps required for mass production, it is obvious that many changes can be introduced to have the goods produced with much less capital investment, less planning, less stock of materials, less diversity in the specialisations required from the workers, etc. In short, the design of the product itself and the procedure for its production can be adjusted to the local conditions. This notion is readily understood by everybody around the world and much has been written on it, international meetings, surveys of all types are devoted to the problem, names have even been coined to refer to things akin to the idea expounded above ("intermediate technology"). But no set of courses is normally available in most countries to cover technical design and economic production of goods in short-runs under the conditions usually encountered in the less developed countries. In fact, the production methods and the principles of design are developed through research or experience precisely in the countries where engineering and production are more advanced, and quite naturally those are the countries where mass production and other favourable conditions prevail.

It should be noted that design for short-runs is not necessarily (in fact is very seldom) design as was prevalent decades ago prior to the development of some of the techniques utilised nowadays. The materials or the techniques called for in the case of short-runs may be very advanced, but the geometrical shapes, the choice of components or constituting parts, the sequence in production, the devices or mechanisms utilised, the methods of assembly, welding, fastening, etc. may be chosen so as to optimize the operation in a way which may differ substantially from the optimal equivalent in mass production.

For instance, production of a given model of certain instruments or devices, such as a capacitor tester or a bar generator, even in the most developed countries seldom goes beyond a few thousands; but one can not say that the design, circuit, or materials, are necessarily years behind. Nothing precludes utilizing similar design characteristics or components in the manufacture of more commonly utilised electronic devices, whenever the economy of the whole operations so dictates.

4. CONTENTS OF THE COURSES

What precedes permits to emphasise certain points as to training. We shall not attempt to give a detail of the subject matter that could be introduced in the courses aiming at training technicians and engineers at various levels, for design and production of electronic gear. The following considerations deal with aspects to cover, as well as with the orientation to give to some traditional and indispensable subject matter, in particular basic sciences.

Basic science should aim at giving an understanding of the physical world at large. In effect the phenomena involved in electronic devices is of the widest diversity and by no means is restricted to electron behaviour. It is sufficient to consider that the transducing elements at both ends of the electronic gear proper make use at present of practically every physical phenomenon known. Needless to say, the fact that electronic devices are really signal processors, makes it necessary to include information theory among the basic subjects, at least for the "design" options.

Understanding of the physical world does not necessarily mean theoretical treatment of every subject in physics; it means that the students should have basic and sound comprehension on the cause-effects relationships in physics, at least at the particle level.

This basic knowledge should be complemented by a knowledge of the physical properties of materials. By this we mean not acquiring and remembering an inventory of data on materials but, again, understanding of the characteristics underlining the behaviour of materials. The wider and wider utilisation of peculiarities of the materials originating in their intimate structure, or in the presence of impurities, etc., serve to substantiate the point.

But even less subtle considerations would force a technician or engineer involved in design and construction of electronic gear to be aware of the characteristics of the common materials he is likely to resort to. This is not perhaps the case of an engineer working exclusively in circuit analysis, in basic design of components to obtain certain characteristic or response curves; but it is certainly that of the man who defines the specifications which will bear upon the operation, reliability, life, assembly, etc. of the equipment. Moreover, what we have called the "electronic core" of the devices may in some cases be of less importance than the input and output ends as well as of the switching or signal carrying components.

Such is for instance the case of communications using straight-forward telephonic equipment. The mechanical or electromechanical parts may in these cases become quite important. However, their design or construction cannot be treated as problems of mechanical design, since there may be rather special problems as to the electric properties of the metals and other materials utilised, as to the alteration of the surfaces produced by heat, sparks, dust, impact, etc.

In this respect, two major areas should be recognised : that of the electronic processing proper, and that of the mechanical elements; and this constitutes one more reason to include materials science in the courses.

A third category could be added, that of the transducing devices; they, however, do not lend themselves to a generalised treatment in view of the diversity of phenomena that can be involved. We have referred to this when talking about basic scien

The quantitative treatment of the phenomena commonly encountered in electronic devices, circuity, and measuring instruments, is in general adequately covered in the course studies of most institutions. It usually accompanies a description of the physica characteristics of the devices, components or circuity.

What is important for our purpose, is to deal in detail with matters such as limitations of components, circuits or devices; their causes; the relative effect of tolerances of components in overall performance, quality or performance standards and their true meaning from the point of view of the user; reliability of components and the effect of climatic conditions, salinity, dust; ruggedness under mechanical solicitations, etc.

This brings us to the last type subject matter of importance that of techno-economic elements. It can be handled by giving first of all, the basic concepts as to optimization of operations and as to production in short-runs, and then referring particularly to correlations involving technical elements and cost. For instance, for a given type of device, the cost is a function of the performance called for, other elements kept constant. The relative influence of the various individual specifications constituting the overall performance, depicted in graphic or other form, quantified if possible, give valuable guidelines as to design or adaptation of devices, or as to compromise solutions, or as to ways to keep cost within bounds.

Another example is that of degree of integration of a given circuit. One could design for assembly on the basis of very elementary components (resistances, capacitors, etc.), using traditional wiring and soldering; On the other end, the use of silicon slivers, incorporating many elementary functions integrated into a complex circuit. The economics of the use and the feasibility of both extreme solutions and all the intermediate ones, is a key element in design for production anywhere in the world. In a way, the problem is simpler in a country where all the technological solutions known can easily be resorted to, and where the market is sizeable; then, the cost considerations are the most important parameter.

In a country where the conditions are not ideal in more than one respect, cost considerations alone does not suffice. For instance replacement of parts, servicing, standardization of parts, potential utilisation of the equipment needed for production or assembly, etc., can become important if not critical factors. This further detracts from the validity of the pure technical choices and even conditions the economic ones.

Case studies and project work can help cover these subjects. Cooperation with local industry, however incipient it might be, can be invaluable not only in case studies or project work but also in lecturing and associated laboratory work. It can also guide in formulating study plans, and in developing the attitude of mind of the students, to entice them towards production.

This cooperative effort could extend to the government agencies that formulate policies as to industrialisation, import of finished or semifinished products, and the like; thus, studies do not take place in isolation, as it should always be the case for courses related to production or to direct utilisation, where knowledge alone does not suffice, and the attitude of mind is paramount.

One last remark concerns conceptual vs informative courses In all that precedes, emphasis has been put on the conceptual side. In fact, once the concepts are grasped, one is not bound by the sum of know-how acquired; and use of the existing technology is a matter of access to information. However, very often the link between basic knowledge and application falters, due to the difficulty of acquiring an attitude of mind centered on production, on application, on practical approach to problems, in countries where environment and traditional patterns contribute little towards it.

In these cases, often the lecturers themselves are at a loss when discussing applications. As a palliative, and

During a transition period, descriptive courses, of the type "how to", could be offered, until such time a better established electronic industry becomes a breeder of technicians and engineers especially competent in design and production problems. Then the schools could forsake purely informative courses, while keeping the conceptual basis that facilitates the proper retrieval and use of information both existing and new.

The Turin Centre orients its technology courses to serve the interests of the developing countries: at present the Electronic courses aim at training engineering instructors in the basic technical and pedagogical concepts of teaching electronics. In a current effort to define courses and orientations for the future, the Centre is delving into considerations of the type advanced above, which are applicable to design and production in general, when the circumstances, technical, economic, human, are not ideal, as is the case of the developing countries.

Once the ideas materialise in a course, either as they stand now or modified, the result of the experience will indeed contribute to better training in the countries themselves.

In fact, by its own nature the Centre has to offer courses apt to add to a prior knowledge of the fundamentals, to make that knowledge useful in the developing countries; precisely the type approach followed in this paper.

10. 7. 72