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on the Iron and Steel Industry

Moscow, USSR, 19 September - 9 October 1968

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RESEARCH FOR THE IRON AND STEEL INDUSTRY IN DEVELOPING COUNTRIES, POSSIBILITIES FOR REGIONAL COOPERATION 1/

by

Luiz C. Correa da Silva,
Brazil

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. The document is presented as submitted by the author, without re-editing.

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RESEARCH FOR THE IRON AND STEEL INDUSTRY IN DEVELOPING COUNTRIES POSSIBILITIES FOR REGIONAL CO-OPERATION[1/]

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SUMMARY

(1) Modern industrial activity in fully developed nations is characterized by the predominant role of creative technology (research, development, planning, design, construction, "mis-en-marche", "trouble-shooting", etc.).

(2) A number of developing nations (D.N.) have now essentially completed the second stage of development (first stage of industrialization), where a productive capability based on imported technology has been successfully created (industrialization "by copy"). The transition to the third and final stage of development (ninety-second stage of industrialization) in which the existence of local capability for "creative technology" (creation of new or better products and processes) is essential.

(3) Many mechanisms exist for "know how" creation and transfer. All of them are fully used by developed nations; and none should be disregarded by D.N., particularly those now approaching the last stage of industrial development.

* This is a summary of a paper issued under the same title as ID/WG.14/15.

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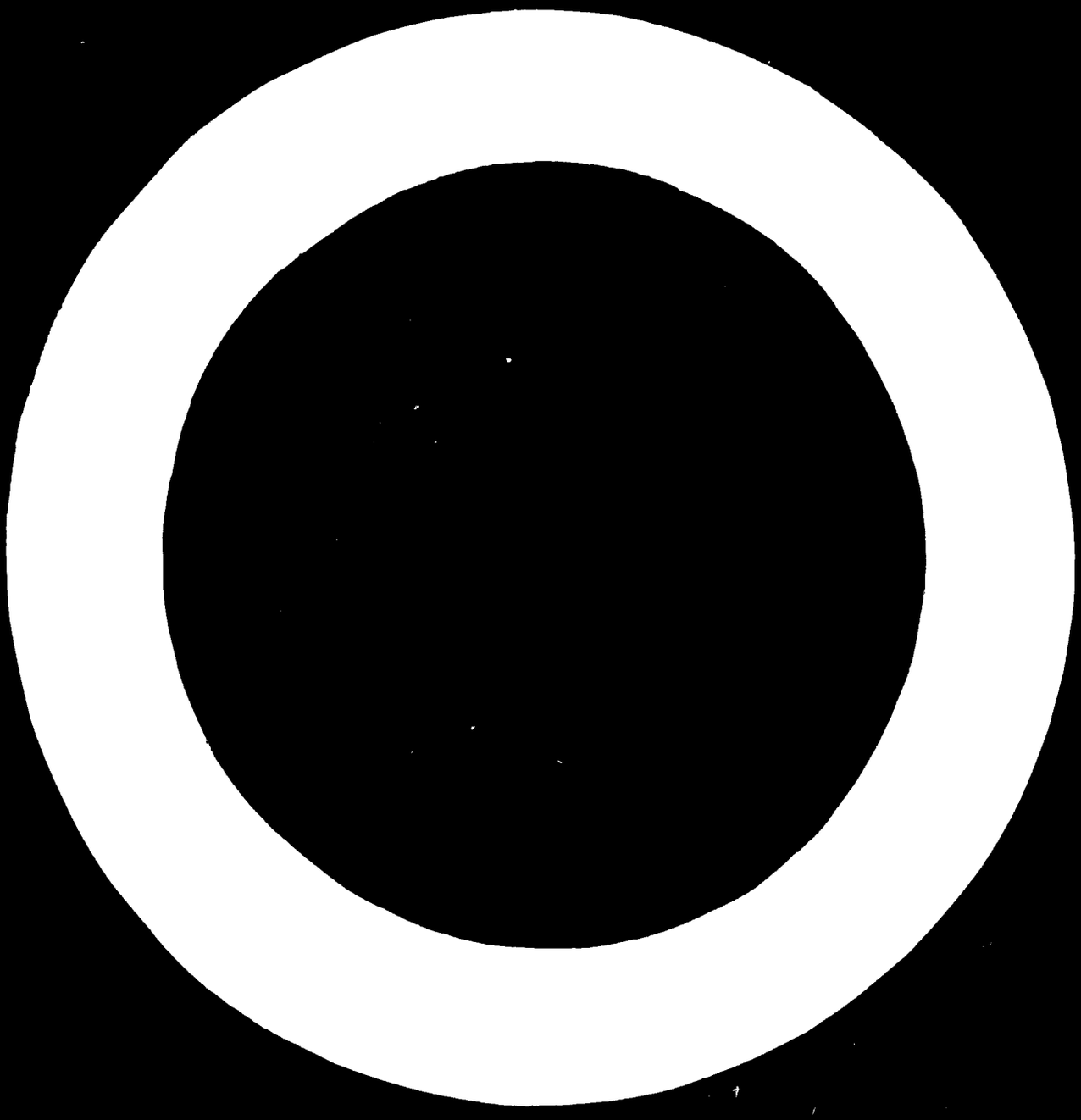


(4) Among the mechanisms for creation and transfer of technology (or "know how") one research stands out by reason of its importance not only because of its direct/or specific results, but also because it stimulates or activates other mechanisms.

(5) Industrial development is accompanied by an increase (not a decrease!) of problems encountered, in numbers and in difficulty. Many D.N. are increasingly aware of this fact. The solution is an increasing reliance on "creative technology", specially research.

(6) D.N. should try to direct their main efforts towards "short range" applied research, for a faster yield on their limited investment of human and material resources.

(7) The research activity is usually, and unavoidably, associated to "related activities": testing, examination and diagnosis, special studies, information, documentation, technical assistance, specialized training, technical exchange, experimental production, normalization, etc.

(8) The success of a research effort depends on the judicious reunion and administration of a minimum "critical mass" of human and material resources, under intellectually stimulating conditions, so as to maintain a "chain reaction" where ideas generate opportunities which lead to new ideas.

(9) Iron and steelmaking technology can be considered as the "Antarctica of technology", being full of opportunities for discovery and improvement, in the search of which the D.N. can successfully participate.

(10) The I. & S. industry of L.A. has made great progress but it is still unsatisfactory for a population and area roughly equivalent to that of the Union of Soviet Socialist Republics. The multiplication of its capacity in the next decades is an imperative.

(11) D.N. face today: (a) increasing competition among ore exporters (mainly D.N.); (b) increasing competition in the world market for steel products (with the threat to their own industry); (c) increasing difficulties in obtaining outside help commensurate with rapidly increasing needs for development. They will have to rely more and more on their own capability to solve problems of production volume, productivity and quality.

(12) A survey of the situation of I.& S. research in L.A. indicates: (a) a great variety and number of problems are encountered which would require a good research capability; (b) the research capability of the area is scattered through numerous small groups facing all sorts of difficulties. It is the general consensus that an almost total reliance on imported technology is not satisfactory.

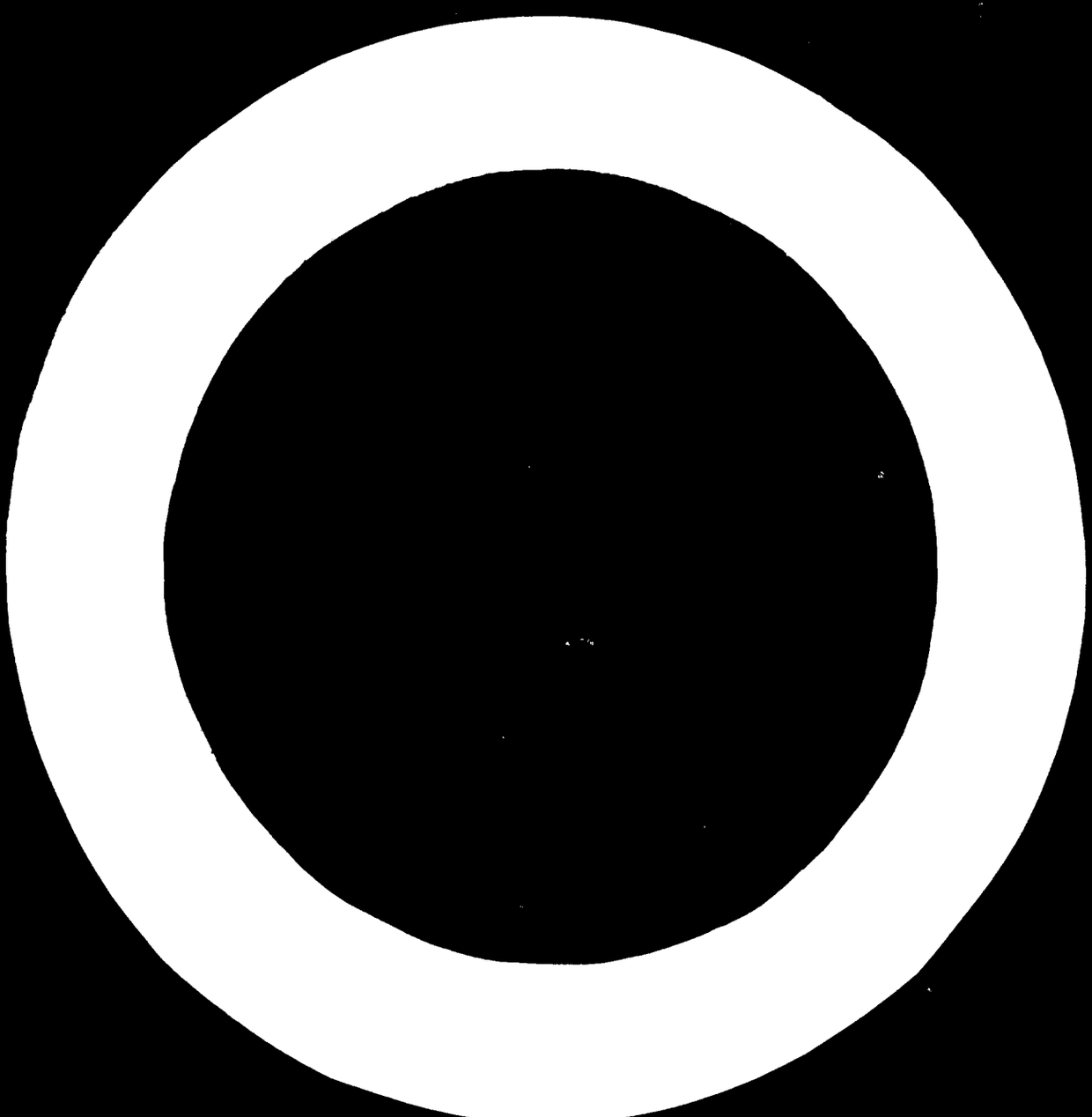
(13) Possible measures to promote creation and transfer of technology for the development of L.A.'s iron and steel industry would include: (a) Creation and maintenance of regular metallurgical engineering courses in all important centres; (b) Intensive post-graduate study and training, in the area and abroad, in universities and in plants; (c) Creation and maintenance of technical societies to stimulate technical exchange, on a national and regional basis; (d) Research groups in industry and in institutes of technology should be created and supported; (e) L.A. co-operation in research (and related activities) would seem desirable and should preferably be implemented by the creation of a regional centre for I.& S. technology, similar to IRSID or SIDERCA.

(14) L.A. nations (as other D.N.) should carefully establish their national (and regional) technological policies and systems for creation and transfer of technology (network of organs, institutions and services). A regional centre for I.& S. research and technology should be created as a part of a regional policy and a regional system.

(15) The IPT (Instituto de Pesquisas Tecnologicas) of S. Paulo (Brazil) is a good example and proof that specialized groups for metallurgical research and technology can successfully operate in L.A. nations and make sizeable contributions to technological development in their areas.

(16) A regional centre for I.& S. research (and technology) in L.A. could have as general objectives: (a) act as an "antenna" directed to the world's sources of "know how" and as a centre of creation and irradiation of technology in the L.A. area; (b) attack a number of important problems existing in L.A., the solution of which is of no particular interest for the developed nations; (c) do, by concentration of human and material resources, what small research groups now scattered through the area (in industry, universities and institutes) cannot do now and will not be able to do in the foreseeable future; (d) give "technological personality" and self-confidence to the I.& S. industry of the area.

(17) A regional centre for I.& S. technology would have a number of well defined specific objectives (see text). It should tackle problems in a variety of sectors of I.& S. technology (see text). It should maintain a "spectrum" of varied activities (from testing to cultural co-operation; see text). It would require a variety of working areas and auxiliary services (see text).



Contents

Abstract

Paper based on extensive observation and study of L. American conditions and problems. Mechanisms for "know how" creation and transfer. Characteristics of modern industrial activity: the role of "creative activities", specially research. Position of the developing nations vis-à-vis an increasing economical and technological competition. The L.A. iron and steel industry and its problems; research efforts. Case Study: the IPT of S. Paulo, Brazil. The need for a technological policy and a national or regional system for K.H. creation and transfer. Possibilities and advantages for regional cooperation in research and related activities.

1. INTRODUCTION

This paper is based on extensive observations and study of L. American conditions and problems, especially those pertaining to the Brazilian industrialization, which the author followed closely since 1942.

The main points the paper tries to make are: (1) research is an essential activity even in developing nations, to insure progress and competitiveness of their iron and steel industry; (2) regional cooperation seems advisable and even necessary.

Inevitably, some premises and broad perspectives have to be examined first, and this is done briefly, in the initial sections.

In the text, abbreviations are used:

K.H. = "Know how"

I.&S. = iron and steel

D.N. - under-developed or developing nations

L.A. - Latin American

2. STAGES IN THE INDUSTRIALIZATION PROCESS

There are 3 characteristic stages in the scale of development: (a) inexistence of any industry; (b) existence of industry capable of production, but incapable of developing new processes and products; (c) existence of productive and creative industrial capability ("creative technology").

The second stage of development (which is the first stage of industrialization) is characterized by the existence of an industry based almost entirely on the transfer of K.H. from abroad. It corresponds to industrialization "by copy". The technology used is that existing elsewhere, plus local adaptation. Local technology is, undoubtedly, necessary, but to a limited extent. It seems reasonable to class Argentina, Brazil and Mexico as countries which have by now essentially completed their second stage of development (they have a problem of growth of their industry and internal market, but the "breakthrough" from an agricultural to an industrial economy has been successfuly achieved). These countries (as others) stand now on the threshold of their third stage of development, for which research leading to new products and processes (or to markedly better ones) will be essential. Great caution will be necessary, however, in the planning and execution of their research effort. Beside research, of course, the other "creative activities" must also be stimulated and supported (as well as all mechanisms for K.H. transfer; see Section 4).

It is only through full development and use of a local "creative technology" that it is possible to satisfy the "triple imperative of full industrialization": increased production, higher productivity and better quality.

3. CREATIVITY AS A DOMINANT CHARACTERISTIC OF MODERN INDUSTRIAL ACTIVITY

Industrial activity in the XIX Century and up to the 1st World War consisted essentially in the reunion of raw materials, machinery, power (steam or electric) and generally unskilled (or little skilled) manpower. Changes in processes and products were few and minor, generally speaking. There was great resistance to change on the part of both workers and management. Plants were essentially static, as organisms.

Industrial activity as it exists today is completely different and extremely more complex, not only in form but in essence. It can be described as a sequence or chain of activities; research + development + planning + design + construction + production + control. This sequence is constantly reiterated, causing constant change in process es and products. Industrial plants are dynamic, changing organizations.

The essential and drastic change to be noted is the predominant rôle that "creative activities" (research, invention, development, planning, design, construction, "mis-en-marche", trouble-shooting, etc.) play in the industrial process. Obsolescence of processes, equipment, installations and products is constant and rapid.

It is probably no exageration to say that in the near future those creative activities will be the essential part of the industrial activity. Production itself may become "secondary", in the sense that it will correspond merely to carrying out detailed plans and instructions emanating from the creative staff. It will be essentially "automatic" and "automated".

The tremendous acceleration of industrial progress is, of course, due to the intensive innovation consequent to the application of science to production, through technology.

Research and development, in particular, have become an essential part of the industrial process, particularly considering that the latter is accompanied by the existence of more (not less!) technical and scientific problems to be solved. Problems increase in number and in difficulty proportionately to industrial progress.

The research activity corresponds to the exploration of the richest of all "natural resources": human intelligence and has proven to be the most rewarding of investments. Besides the direct application of research results for economic gain, the K.H. itself can be sold and exported: the world "trade" in patents and K.H. is now of the order of billions of US dollars.

Research projects can, of course, lead to total failure. On the other hand, it is well known that quite unexpected and spectacularly successful results can derive from seemingly modest research efforts.

It is here taken for granted that research, dimensioned according to local resources and needs, is an open opportunity for D.N. to accelerate their own development and, in the near future, to allow the export of K.H., even if only in modest amounts.

4. "KNOW HOW" CREATION AND TRANSFER: THE ROLE OF RESEARCH AND DEVELOPMENT

Industrial and economic development of the D.N. require the intensive and judicious use of the mechanisms for K.H. creation and transfer. The relative emphasis on the various mechanisms depends on the particular stage and conditions of development, of a nation or region. As a rule, the more advanced the stage of development, the more mechanisms must be activated and intensively used. Developed countries make intensive use of all of them.

Mechanisms for K.H. creation - These include:

(a) Chance or fortuitous discovery

(b) Trial and error

(c) Invention (novel ideas originating mostly from "inspiration" or in the subconscious)

(d) Study, analysis and correlation of data and information (no "experimentation"). This is the case of: planning, design, "engineering", programming, scheduling, consulting, analysis of operations and systems, etc.

(e) Research.

(f) "Development" of products and processes.

Mechanisms for K.H. transfer - Two cases must be distinguished: the transfer of "diffuse" K.H. (K.H. freely available and the transfer of "specific" K.H., defined and regulated by special arrangements (generally involving or compensation).

Mechanisms for "diffuse" K.H. transfer:

(a) Technical literature (journals, books, catalogs).

(b) Courses and lectures (includes, besides special courses and lectures, the all important mechanism of technical education).

(c) Personal contact (specially in technical meetings).

(d) Visits (and direct observation) to plants, exhibits, etc.

(e) Training (in plants or other operations).

(f) Hiring of experts in the international labor market.

(g) Immigration of experts (frequently with aid of incentives).

Mechanisms for "specific" K.H. transfer:

(a) Purchase of patents or patent rights.

(b) Purchase of license to produce a certain product ("right to copy").

(c) Purchase of technical documents: drawings, specifications, mannuals, etc.

(d) Purchase of products with the purpose of using the contained technology revealed by analysis and examination (dimensions, materials, etc.)

(e) Technical assistance agreements (with compensation) with firms actually using a certain specific K.H.

(f) Purchase of K.H. related to specific products and processes from intermediaries (consultants).

(g) Transfer of K.H. through direct participation of "donnor" firm in "recipient" firm.

In the above "spectrum" of activities leading to K.H. creation or transfer research appears as only one item. This must be kept in mind since research and specially scientific research has sometimes received a disproportionate attention in D.N., with disregard of the many other essential mechanisms for

K.H. transfer.

On the other hand, research (applied or technological research in particular) does have an importance that goes beyond its typical sphere of action. As it is pointed out in Section 6, research activity carries with it or stimulates a number of "related activities" essential for an efficient implementation of many of the other mechanisms for K.H. transfer.

The existence of an active research group can assure, stimulate or lead to application of other mechanisms, and specially: all mechanisms for K.H. creation (specially "development); mechanisms (a) to (f) of "diffuse" K.H. transfer; mechanism (d), (e), and (f) of specific K.H. transfer.

Thus, the special importance of the existence of an active research group exceeds or may exceed by far the importance of their research activities proper.

5. THE NATURE OF RESEARCH

Since much confusion exists today as a consequence of the indiscriminate use of the word "research", it is necessary to indicate the meaning of the word as used here.

-Research: planned and systematic experimentation to gather data of significance for understanding a problem or question or for arriving at its solution (or answer).

Research is a creative activity "par excellence".

According to its nature, research can be: scientific or technological. According to its purpose it can be: pure or applied. These dilemas can be combined:

-Pure, scientific research: has as a goal the acquisition of knowledge pertaining to materials, organisms, systems, phenomena and processes through planned experimentation under well defined conditions, with the preoccupation of attaining maximum pertinence, exactness, permanence and reproducibility, but without preoccupation as to usefulness.

-Applied, scientific research: ditto, but with preoccupation as to usefulness for application in the production of goods and services.

-Technological research (always applied): has as a goal the acquisition of useful and relevant knowledge about materials, systems, phenomena and processes encountered in the production of goods and services, under conditions defined only insofar as necessary for efficient application of the results.

Another distinction frequently made is between "short range" and "long range" research, the terms referring loosely to the time foreseably necessary

for completion of the research and for the acquisition of significant data. This distinction is of special relevance for D.N., which should try to direct their main efforts towards "short range" applied research, for a faster yield of their investment of human and material resources.

Metallurgical research is planned and systematic experimentation to gather data of significance for the understanding of materials, phenomena and processes involving metals. It may vary from scientific to technological ir nature.

The analysis of research efforts or of research activities may be carried from different points of view - motivation; justification; objectives (direct and indirect); character or nature; conditions under which carried; resources available or necessary; methodology; organization and administration; types; sectors or branches of science or technology; consequences and "by products" of the research activity; application of results; related activities; auxiliary services; economic aspects (investments, operating costs, returns); psychological factors; etc.

Only great experience and judicious planning can adequately balance all of the factors involved in research and maximize results.

6. ACTIVITIES CLOSELY RELATED TO RESEARCH

Seldom can research be carried as an isolated activity. Generally, naturally, it is associated with other "related activities".

-Testing; examination and diagnosis ("trouble shooting"); special studies; information; documentation; dissemination of technical knowledge; technical sssistance to industry; inspection and quality control; specialized training; technical consulting; colaboration with technical societies; organization of special meetings; technical exchange with other institutions and countries; experimental production; development; normalization and standards; etc.

The organization of groups devoted to research, in D.N., will have a limited effect if not associated with at least some of the above "related activities"; preferably, with all of them.

7. RESOURCES AND CONDITIONS FOR A SUCCESSFUL RESEARCH EFFORT

The success of a research group depends on numerous factors, as suggested elsewhere in this paper, but a list of the most critical would include:

- -personel of the highest caliber, with different specializations pertinent to the problems to be tackled.
- -material resources (equipment, supplies, etc.) and auxiliary services.
- -a stimulating atmosphere of intelectual exchange and creativity.
- -close relationship or contact with a "market" for its results (this "market" might vary from a scientific community to an industrial complex or plant).

The reunion of a "critical mass" of human and material resources, in the proper intelectual setting and operating conditions to insure the maintenance of a "chain reaction" or "steady state" where results generate the stimulus conducive to new successes, and ideas multiply into new ideas. The mutual exchange of ideas, stimuli and criticism promotes the generation and use of new solutions and opportunities.

8. THE TECHNOLOGICAL EVOLUTION OF THE WORLD IRON AND STEEL INDUSTRY

The "scientific revolution" of the period following the last World War could not avoid having an impact on the I.&S. industry. It must be recognized, however, that the use of scientific knowledge in I.&S. making, besides coming rather late in the development of an industry centuries old, has not caused any spectacular change as yet. Techniques like pelletizing, oxygen conversion, continuous casting and vacuum degassing, however spectacular, have not derived from or depended on any new scientific discovery. They resulted, rather, from technological R.&D. The same applies to metal transforming (rolling, forging, extruding, welding, casting, etc.).

The effect of science has been marked, however, in the study and understanding of ferrous alloys: their properties, behavior and application. It is to be expected that spectacular progress will be made in the near future in steel product development based on scientific understanding.

With a bit of oversimplification it can be said that I.&S. making and transforming is the "Antarctica of technology". Much remains to be studied, understood and controlled in the transition from ore to finished steel, specially in the reduction of oxides and in the behavior of liquid metals and slags.

As in Antarctica, the D.N. can participate in the discovery effort and can make important contributions.

Conscious of the open opportunities and promises of I.&S. technology, the developed nations have been devoting increasing effort to conquer them. The IRSID (France), BISRA (England), CNRM (Belgium) and the laboratories

maintained by American and German firms are known examples of such efforts.

The increased competition for world markets will only raise the importance of the research efforts. It is to be expected that due to this factor alone, decisive improvements in productivity, quality and product mix will be made in the next few years.

9. THE IRON & STEEL INDUSTRY OF L. AMERICA: ITS ACHIEVEMENTS AND PROBLEMS

It is well known that L.A. has made, in the last 20 years, significant progress in the development of its own I.&S. industry. An all important first step was made. An economic and psychological victory has been obtained. However, although encouraging, the picture in L.A. is by no means satisfying, considering: (a) the conditions still prevailing in L.A.; and (b) the new conditions which are becoming apparent in the world I.&S. industry.

a. Latin America is a vast conglomerate of some 20 nations, with a population approaching 200 million people and an area of some 20 million square kilometers. It is, thus, roughly equivalent to the U.S.S.R. An annual production of about 10 million tons of steel ingots is far from satisfactory and far from corresponding to the needs of its population. By planning its development carefully, the region must multipy its production many times in the next 20 years. It is just not possible anymore to deny populations of hundreds of million people the benefits of modern industry.

b. The developing nations face today and will face in the near future a set of conditions which are markedly different from those that prevailed for the last two decades. The forces that will increasingly resist the development of their I.&S. industry are: increasing competition among exporters of iron ore; increasing competition among I.& S. producers (mostly developed nations); increasing difficulty in finding outside financing to develop their I.&S. industries to an extent corresponding to the needs of their populations.

The above three conditions are new and decisive. They increase a constellation of difficulties traditionally faced by the developing nations (D.N.).

Thus, the L.A. nations (as other D.N.) reach today a critical point in the development of their I.&S. industry.

The "heroic" period of industrialization is over, for many of those nations. The numerous mistakes in planning, financing, designing, constructing and operating their first large I.&S. plants, perhaps unavoidable in the past, cannot be repeated.

The next 10 or 20 years will be a period of "realism", when the D.N. will have to plan their development taking into full account the economic "rules" that dictate international trade and competition. There is no reason why they should not be successful.

However, a re-examination of all the factors involved (favorable and unfavorable) is essential. Decisive measures must be taken now to assure the continuation of their progress. Some of these factors, related to creation and transfer of known how are examined here, however, sketchily.

The D.N. on a national or regional basis, must establish their policy for development of their I.&S. industries and must create the necessary system of institutions, organs and enterprises to execute that policy. An organized and steady effort must be maintained so as to enable the D.N. to face the difficulties and problems of the next 20 years with a better chance of success.

10. RESEARCH PROBLEMS AND RESEARCH EFFORTS IN L.A., FOR DEVELOPMENT OF THE I.&S. INDUSTRY

A survey of possible research problems of the L.A. iron and steel industry was made in 1966 under sponsorship of ECLA. Consultation with L.A. engineers, businessmen, technologists and professors yielded a list containing some 150 suggested problems, covering all phases of I.&S. making, from raw materials preparation to product control and application.

The list indicated a remarkable variety of problems, the existence of a great need for research and a high degree of maturity and "sophistication" on the part of L.A. experts in Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela (countries surveyed).

The list was necessarily heterogeneous regarding types and level of difficulty of the problems. Many of the problems were not at all peculiar to L.A., which is to be expected: the L.A. industry is encountering the same problems that face the industry of other regions.

The research groups and efforts found in L.A. in the same survey are briefly listed below:

-Argentina: (a) INTI (Inst. Nac. de Tecnologia Industrial) with its separate Centers for ores, welding, stamping, and metallurgical research. (b) LEMIT (La Plata). (c) Quality control group at SOMISA (San Nicolas). (d) Metallurgy Dept. of the CNEA (Comision Nacional de Energia Atomica). The latter is a remarkable group of metallurgists and scientists of a strength comparable to that of famous groups in Europe and the USA. Although primarily and initially devoted to nuclear metallurgy, they are now cooperating with the

local ferrous and non-ferrous industry through a special service (SATI).

-Brazil: (a) Plant research groups at CSN (Volta Redonda), USIMINAS (Ipatinga), CSBM (Monlevade). (b) Research groups connected to engineering schools maintaing metallurgical engine ering courses, at Ouro Preto, Rio de Janeiro, S.Paulo etc. (c) Research groups at institutes of technology: Rio, S.J. Campos, S.Paulo. The last group, that of IPT (Inst. Pesquisas Technologicas) at S.Paulo, is also a remarkable group, active for over 30 years in the S.Paulo area and instrumental in the development of metallurgy in Brazil (See elsewhere in this paper).

-Chile: (a) Research group at CAP (Huachipato) which has shown exceptional "élan" and success. (b) Research groups connected to Universities in Santiago, Concepcion and Santamaria.

-Colombia: (a) Research group at Acerias Paz de Rio. (b) Ditto, at I.I.I. (Inst. Investigaciones Industriales).

-Mexico: (a) Research effort at HyL (Monterrey), well know for its successful development of the Hy L process on a full industrial scale. (b) Groups at Fundidora (Monterrey) and at AHMSA (Monclova). (c) Group at IMIT (Mexico City).

-Peru: (a) Group at SOGESA (Chimbote).

-Venezuela: (a) Research effort at SIDOR (Matanzas). (b) Ditto at INVESTI (Caracas).

A summary of the observations pertaining to the panorama found in the survey is presented below.

(1) It is clear that the development of the I.&S. industry of L.A. is an irreversible process and that such process will increasingly depend on the application of modern technology and innovation.

(2) A diversified "demand" for research exists, not only for the solution of trivial plant problems but also for the solution of problems of national and regional importance.

(3) There is obvious demand for more efficient services and activities related to research (technical information and assistance, specialized training, study of standards and specifications, etc.).

(4) The methodology of the present research efforts varies from group to group but, in general, the lack of well defined research projects (goals, resources, plan of work, etc.) is to be noted. Lack of objectivity (relation of research projects to actual needs) is frequent.

(5) Insufficiency of resources (human and material) is coupled with their dispersion in groups frequently too small to maintain a "chain reaction" of ideas, experiments and application.

(6) The lack of trained personnel is apparent (in numbers and in level of preparation).

(7) Lack of information is felt everwhere. Contacts with foreign centers are tenuous and infrequent. Libraries and documentation centers (and systems) are defficient in number or in efficiency. There are few journals regularly published, which could act as "vehicles" for exchange of technical

information.

(8) There is lack of planning, administration and financing of research for the I.&S. industry, at the corporate, national and regional levels.

(9) The I.& S. companies of the area encounter obvious difficulties to create and maintain a significant research effort independently. The necessary financial and human resources are difficult to spare and the risks of failure are a deterrent to action.

(10) It is the general consensus that simple transplantation of foreign technology is not satisfactory. It is necessary to adapt, change and create technology.

(11) It is quite obvious that the present research efforts, of very small groups scattered over an area of some 20 million km^2, will only yield very limited results at the same time that a degree of duplication will exist.

11. POSSIBLE MEASURES CONDUCIVE TO DEVELOPMENT OF I.&S. TECHNOLOGY IN L.A.

On the basis of observation and analysis of the panorama found in L.A., certain measures seem advisable in order to intensify the creation and transfer of K.H. The measures suggested will have a specially important effect on the creation of K.H., but it will also stimulate efficient K.H. transfer (directly or indirectly).

(1) Engineering education - In the most important centers for nucleation and irradiation of L.A. industry, Metallurgical Engineering courses should be created and/or maintained. Amazingly enough this is far from the situation existing today, where countries with sizeable I.&S. industries do not yet have schools granting degrees in metallurgical engineering. Such courses should include, at least, the following subjects: physics of metals; metallurgical physical-chemistry (both physical metallurgy and high temperature physical chemistry); non-ferrous extractive metallurgy; iron and steel metallurgy (ore to ingot); mechanical transformation of metals; ferrous and non-ferrous metallography. Teaching should be objective, with a good proportion of laboratory and plant work.

(2) Post graduate courses should have as a main goal the training of a maximum number of engineers according to the interests of local industry and development. Degrees and diplomas (Doctor's, Master's) should be secondary. Post graduate courses in L.A. should have a predominantly "utilitarian" character; they should allow a wide spectrum of study, of varying intensity: from high level and long courses (leading to Doctor's or Master's degree)

to intensive, short courses given in plants.

(3) Training of metallurgists abroad, in developed countries, should be intensified and made into a regular policy of companies, institutions and nations. Training should cover scientific as well as technological and industrial aspects. It should vary from post-graduate work, to in-plant training.

(4) The creation or activation of institutions capable of stimulating technical interchange, at the national and at the regional level, would be desirable. A fine example of success is provided by ABM (Brazilian Society for Metals) which will have this year its 24th Annual Meeting; with 2,500 members it has published something like 1,000 papers and 10 books since 1944; it publishes a monthly "Metalurgia" with the same level of quality (material and technical) characteristic of much older journals of developed countries. The journal of ILAFA, "Siderurgia", not strictly a technical journal, has some effect, but not sufficient. A parallel journal (or separate section of "Siderurgia") entirely devoted to technical papers and technical matters might be of great value. A L.A. metallurgical society (technical) or confederation of technical societies might help exchanges in the area. The organization of regular technical meetings, in the national or regional level, is essential.

(5) The maintenance of significant research effort in the L.A. area is also necessary. This effort should include (besides local groups attached to universities and schools) independent institutions for technology (information, testing, diagnosis, research, technical assistance, etc.). Through these a good level of research activity can be maintained, with great help to

industry (as proved by the IPT - S.Paulo - Brazil). In schools, research is a subordinate activity to teaching (it has more the character of a "teaching tool" or "aid").

(6) I.& S. companies in L.A. should try to create and maintain at least small groups devoted to research (or more generally: to technology creation and transfer). These groups would be of great help in keeping the company aware of technological innovation and potentialities, besides solving non-routine problems.

(7) L. American cooperation in research (and related activites) would be advisable. A regional organization similar to IRSID or BISRA would be of enormous value for the region's industry. It could create, in a single place, a "critical mass" of numan and material resources, avoiding dispersion and duplication of effort. The operation of such a center would enable L.A. to better follow and compete with the developed nations. Similar institutions or regional centers might be interesting also in Africa and in Asia. In the present paper the desirability of such a center for L.A. is taken for granted, on the basis of the considerations presented in the previous sections. For convenience, such a center will be referred to, in this paper, as "Center" or "Regional Center"(R.C.).

(8) L.A. nations should carefully but firmly establish and keep up to date:

-National and/or regional <u>technological policies</u>.

-National and/or regional <u>systems for creation and transfer</u> of technology (or K.H).

A regional center for I.&S. research could, and in our opinion should, be created as a part of a regional policy and of a regional system for creation and transfer of technology.

12. CASE STUDY: THE IPT (INSTITUTO DE PESQUISAS TECNOLOGICAS) OF SAO PAULO, BRAZIL

As an example of a successful effort for technological support of industrial development and, particularly, of development of a metallurgical industry, the case of the I.P.T. of S. Paulo (Brazil) deserves attention. Its characteristics and activities are summarized below.

-Institution maintained by the State of S.Paulo. Independent institution since 1934. Started with testing and analysis, and progressed to demonstration, developmen. and research. Main goal: application of science to industry, through technology. Extremely active since the early thirties, in metallurgy. Has always kept a body of 10-20 engineers and some 4 times that many employees in its Metallurgy Department, which includes laboratories and pilot plant equipment.

-Close to 400 papers published in metallurgy, by its engineers. Thousands of reports prepared for industry. Introduced (in Brazil) various branches of modern metallurgical technology among which: metallography as a tool for diagnosis and control of processes and properties of steels and cast irons; modern foundry technology of cast irons and steels, including high alloy steels; heat treatment of steels on the basis of scientific principles; iron ore sintering and pelletizing; modern techniques for alloy steel production (during 2nd. world war); scientific metallurgy principles (physics of metals; thermodynamics and kinetics of metallurgical reactions); etc.

-The IPT was instrumental in the creation and support of the Brazilian Society for Metals (ABM), mentioned elsewhere in this paper.

-Recent experimental research (published in some 20 papers per

year, plus unpublished reports for industry) covers: sintering; pelletizing; self-reducing pellets; reduction experiments and tests; oxygen-refining of pig iron and of nickel alloys; alloy cast irons; nitriding; "maraging" steels; etc.

This "case-study" proves that successful groups for research (technology creation and transfer, in general) can be maintained in D.N., being of valuable help for the process of industrial development of those nations.

13. OBJECTIVES OF A REGIONAL CENTER FOR I.&S. RESEARCH, IN L.A.

The general justification and long range objectives of a regional center for I.&S. research, in L.A., derives from considerations already discussed in previous sections of this paper. Such general objectives of the R.C. are summarized below.

(1) Act as an "antenna" to acquire information and as a center of irradiation of knowledge, solutions, improvements, assistance, new processes, new materials, patents, stimulus, example, inspiration, guidance and co-operation within and among L.A. nations, industries and institutions.

(2) Attack a number of important L.A. problems which are of no interest to the developed countries and which cannot be attacked effectively by the present scattered and small groups.

(3) Demonstrate that a successful blending of scientific, technical, industrial and economic knowledge is possible and profitable for solving problems of the L.A. iron and steel industry.

(4) Do by concentration of resources what small research groups now existing in universities, industries and independent institutes of the area cannot do now and will not be able to do for a number of years.

(5) Aim at the rapid creation of a L.A. "Know How" and "technological personality" for its iron and steel industry, the motivation being not the desire to be "different" but the need to be "efficient" and "independent" (making its own contribution to the progress of iron and steel technology not only in L.A. but also in other nations).

More specific objectives of a R.C. are listed below.

(1) Study and make available specialized and detailed information regarding iron and steel raw materials, products, processes and equipment, taking into account the particular needs and conditions existing in the area.

(2) Initiate, maintain and develop systematic research aiming at the solution of the multiplicity of technical problems facing the L.A. iron and steel industry.

(3) Keep watch and actively investigate new technological

developments and possibilities which may be put to use in the L.A. iron and steel industry, point to and leading the way for a sound growth of this industry in the future.

(4) Perform testing, examination, analysis and other specialized services not only as needed for research being carried but also to serve the industry of the area.

(5) Act as consultant to industry and to Governments in the study of specific projects or problems.

(6) Collect, select and distribute (through adequate publication or other means) technical and scientific information relative to materials, processes and equipment for the iron and steel industry.

(7) Provide specialized training for the preparation of high level specialists for work in L.A.industry, Universities and research groups. This training should be provided through work in its laboratories or through special courses given by its staff.

(8) Help and assist in the study of specifications and norms, whenever specialized knowledge is required.

(9) Prepare, design and build certain specialized materials or instruments for experimental use in L.A. plants, whenever this procedure seems advisable and pertinent.

(10) Provide technical and scientific support for exploration and eventual patenting of processes or materials initiated in L.A. steel plants.

(11) Study problems of application, behavior and fabrication of steel products in L.A.

(12) Study problems of efficienty, data processing and automation whenever such problems are strongly dependent on technical and scientific knowledge of iron and steel processes or materials.

(13) Cooperate with initiatives of common interest to the L.A. area, whenever such initiatives are related to technical and scientific knowledge and provided such cooperation is pertinent (cooperation with universities, technical societies, metallurgical meetings, special courses, advisory work, etc.).

14. FIELDS OR SECTORS OF ACTIVITY OF A REGIONAL CENTER FOR I.&S. RESEARCH

To cover adequately the variety of problems encountered by the L.A. I.&S. industry, activities will have to be maintained in different fields or sectors of metallurgical technology. The following are the fields or sectors requiring the activity of specialized research groups or teams. Such research groups would be the essential units of the institution. Each one of those groups should have a leader of the highest technical or scientific caliber: either an expert brought from developed countries or a local expert of proven competence.

a) "Technical" sectors or sections

-Coal: properties, concentration, beneficiation, preparation, agglomeration, coking, byproducts, etc.

-Iron ores: characteristics, concentration, preparation, agglomeration, etc.

-Reduction of iron ores: basic principles and technology of reduction of iron ores and agglomerates in the blast furnace or in special processes ("sponge iron" or "direct reduction" processes).

-Steelmaking: technology of melting and refining molten iron alloys; conventional and continuous casting; vacuum treatment and other new techniques.

-Plastic forming of steel: rolling, forging, drawing, stamping, extruding, etc.

-Heat treatment of steels and steel products: quenching, tempering, annealing, normalizing, etc., of steels and of steel products.

-Surface properties and treatment of steels and steel products: treatment at high temperatures; electrodeposition; painting; corrosion and protection; etc.

-Characteristics and application of carbon and alloy steels: properties, choice, specification, testing, quality control, problems, failures, behavior in service.

-Iron and steel casting: technology of casting applied to iron and steel.

-Welding and joining: technology, processes.

-Refractories for the iron and steel industry: properties, behavior, specifications, etc.

b) "Basic" sectors or sections

-Metallurgical physical chemistry: fundamental study of reactions of interest to iron and steel technology, with special attention to L.A. problems.

-Physics of metals: fundamental study of physical properties and behavior of steels (particularly mechanical and magnetic).

-Ferrous metallography: systematic study of the nature, properties and behavior of ferrous alloys.

c) "Industrial" sectors or sections

-Equipment, instrumentation, automation: study and testing of equipment and instruments (particularly control instruments) of interest to the industry; automation of equipment and operations; pyrometry; etc.

-Operational research: analysis and study of operations, to minimize costs and maximize quantity and quality; scheduling, programming, standard procedures, etc.

-Data processing and computation: applied to the iron and steel industry (analysis of data, numerical control of operations, programming, etc.).

-Economical aspects of iron and steel processes and materials of interest to the L.A. industry: analysis, costs, productivity of specific processes or materials, etc.

15. TYPES OF ACTIVITY OF A R.C. FOR I.&S. TECHNOLOGY

The action of a Regional Center (R.C.) of I.&S. technology should not, and could not be restricted to research only. It is essential to maintain activities related to or arising from the research activity. Such related or subordinate activities could be considered as "by-products" of research.

A complete list of the types of activities would be as follows:

-Testing: mechanical, physical and special testing.

-Chemical analysis: analysis of metals, slags, raw materials, etc.; with use of diversified techniques now available, in micro or macro-samples.

-Metallographic examination: use of optical and electronic microscopy, as well as of the electron beam analyzer, to determine distribution and nature of constituents present in metallic (and certain non-metallic samples).

-Non-destructive testing: use of X-rays, ultra-sound and electromagnetic methods to the study of defects or inhomogeneities of steel ingots, blooms, parts, structures, etc.

-Special studies: study and analysis of processes, materials and projects (based mainly on the processing of existing data, but specifically directed to L.A. problems and conditions).

-Research: systematic experimentation to obtain data or information necessary to solve a given problem or to explore a new possibility (research in the laboratory or, through adequate agreements, in industrial installations).

-Information: providing a constant flow of technical and scientific knowledge related to iron and steel technology (from the developed areas, to the L.A. industry and technical institutions); including direct information in answer to questions and the printing and distribution of special monographs or papers.

-Training of specialists: offering opportunities for advanced training in its laboratories and aborad, to engineers and technical personnel of the L.A. iron and steel industry (including institutions for research and Universities).

-Experimental production: of special products or special equipment, with a view to solve specific problems.

-Cultural cooperation: with schools, institutes of research, technical societies, etc.

-Technical assistance: special assistance to companies and Governments whenever high level technical and scientific knowledge may be required for solutions or decisions related to the steel industry.

16. WORK AREAS AND GENERAL SERVICES NEEDED

To the various fields or sectors of iron and steel technology should correspond research groups ("teams") of research personnel. These groups would use laboratories and services which are listed below. It is important not to confuse the groups (or teams) with the work units listed here. Administratively, most or all of the latter might be placed under the supervision of the research group leaders, but this would be incidental or fortuitous; for instance: all research groups would depend on chemical analysis which, as a work unit, might be administrated independently from the research groups (or placed under the supervision of one of the research group leaders, if convenient).

The following would be the main working areas (laboratories or halls) needed by the research groups:

-Materials preparation hall (grinding, screening, etc.)

-Coal research laboratory

-Iron ore research laboratory (examination, identification, etc.)

-Iron ore research hall (ore dressing units, furnaces, sintering units, etc.)

-Ore reduction laboratory

-Ore reduction hall

-Steel making hall (including casting)

-Foundry

-Plastic forming hall: rolling, etc.

-Heat treatment lab

-Surface properties, corrosion and surface treatment lab

-Corrosion stations (at appropriate locations)

-Welding and joining lab

-Refractories lab

-Metallography and petrography lab

-Mechanical and physical testing lab

-Non destructive testing lab

-Physics of metals lab

-X-ray analysis lab (diffraction, electron beam, etc.)

-Metallurgical physical-chemistry lab

-Pyrometry lab

-Chemical analysis lab (conventional, spectrography, etc.)

-Data processing and automation lab

-Offices for operations research

-Offices for economic studies

The operation of the center will require certain general and specialized services, which might be grouped as follows:

-Administrative services: for administration, contacts, correspondence, accounting, purchasing, follow-up, public relations, recruiting of staff, personnel, supervision of details of construction and installation, secretary pool, etc.

-Library and documentation: books, catalogs, journals; review, classification, synopsis, literature research, translation, preparation of publications, etc.

-Graphic and photographic services: drawing, mimeo, off-set, Xerox, heliograph, photography, photostats, microfilms, printing, etc.

-Specialized shops and services: mechanical, electrical, electronic, glass blowing, etc., for construction and maintenance of research equipment.

-General stock room: for maintenance of good stocks of materials, supplies, spare parts, accessories, etc.

-Miscellaneous services: transportation, maintenance of buildings and grounds, guard, cleaning, coffee or tea service, etc.

-Common areas and installations: lecture room, wash rooms, halls and corridors, etc.

CONCLUSIONS

(1) Modern industrial activity in fully developed nations is characterized by the predominant role of creative technology (research, development, planning, design, construction, "mis-en-marche", "trouble-shooting", etc.).

(2) A number of developing nations (D.N.) have now essentially completed the second stage of development (1st stage of industrialization), where a productive capability based on imported technology has been successfully created (industrialization "by copy"). The transition to the third and final stage of development (92nd stage of industrialization) in which the existence of local capability for "creative technology" (creation of new or better products and processes) is essential.

(3) Many mechanisms exist for "know how" creation and transfer. All of them are fully used by developed nations, and none should be disregarded by D.N., particularly those now approaching the last stage of industrial development.

(4) Among the mechanisms for creation and transfer of technology (or "know how") one, research, stands out by reason of its importance not only because of its direct/or specific results, but also because it stimulates or activates other mechanisms.

(5) Industrial development is accompanied by an increase (not a decrease!) of problems encountered, in numbers and in difficulty. Many D.N. are increasingly aware of this fact. The solution is an increasing reliance on "creative technology", specially research.

(6) D.N. should try to direct their main efforts towards "short range" applied research, for a faster yield on their limited investment of human and material resources.

(7) The research activity is usually, and unavoidably, associated to "related activities": testing, examination and diagnosis, special studies, information, documentation, technical assistance, specialized training, technical exchange, experimental production, normalization, etc.

(8) The success of a research effort depends on the judicious reunion and

administration of a minimum "critical mass" of human and material resources, under intelectually stimulating conditions, so as to maintain a "chain reaction" where ideas generate opportunities which lead to new ideas.

(9) Iron and steelmaking technology can be considered as the "Antarctica of technology", being full of opportunities for discovery and improvement, in the search of which the D.N. can successfully participate.

(10) The I.&S. industry of L.A. has made great progress but it is still unsatisfactory for a population and area roughly equivalent to that of the U.S.S.R. The multiplication of its capacity in the next decades is an imperative.

(11) D.N. face today: (a) increasing competititon among ore exporters (mainly D.N.); (b) increasing competition in the world market for steel products (with the threat to their own industry); (c) increasing difficulties in obtaining outside help commensurate with rapidly increasing needs for development. They will have to rely more and more on their own capability to solve problems of production volume, productivity and quality.

(12) A survey of the situation of I.&S. research in L.A. indicates: (a) a great variety and number of problems are encountered which would require a good research capability; (b) the research capability of the area is scattered through numerous small groups facing all sorts of difficulties. It is the general consensus that an almost total reliance on imported technology is not satisfactory.

(13) Possible measures to promote creation and transfer of technology for the development of L.A.'s iron and steel industry would include: (a) Creation and maintenance of regular metallurgical engineering courses in all important centers; (b) Intensive post-graduate study and training, in the area and abroad, in universities and in plants; (c) Creation and maintenance of technical societies to stimulate technical exchange, in a national and regional basis; (d) Research groups in industry and in institutes of technology, should be created and supported; (e) L.A. cooperation in research (and related activities) would seem desirable and should preferably be implemented by the creation of a regional center

for I.&S. technology, similar to IRSID or BISRA.

(14) L.A. nations (as other D.N.) should carefully establish their national (and regional) technological policies and systems for creation and transfer of technology (network of organs, institutions and services). A regional center for I.&S. research and technology could should be created as a part of a regional policy and a regional system.

(15) The IPT (Instituto de Pesquisas Tecnologicas) of S. Paulo (Brazil) is a good example and proof that specialized groups for metallurgical research and technology can successfully operate in L.A. nations and make sizeable contributions to technological development in their areas.

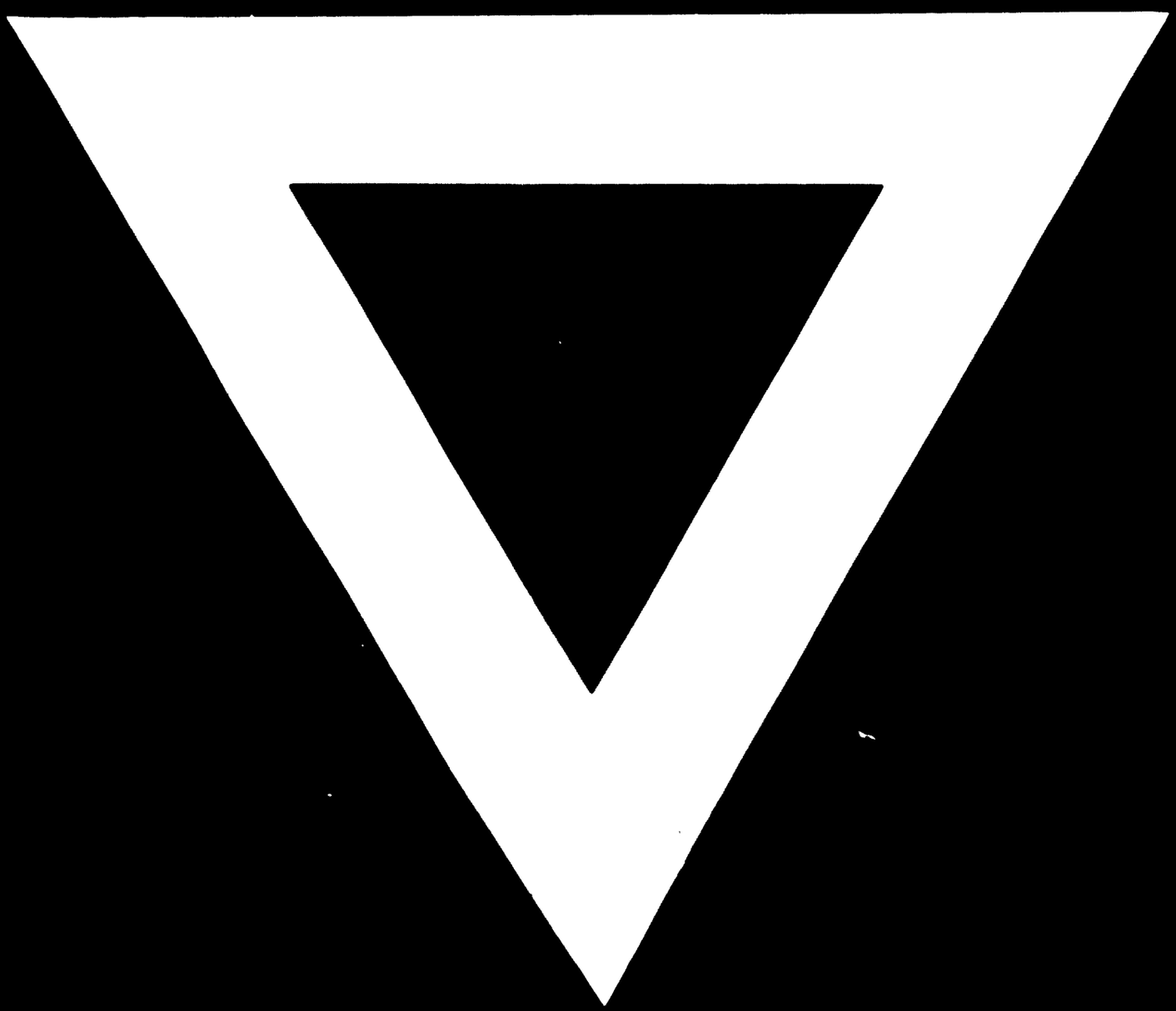
(16) A regional center for I.&S. research (and technology) in L.A. could have as general objectives: (a) act as an "antenna" directed to the world s sources of "know how" and as a center of creation and irradiation of technology in the L.A. area; (b) attack a number of important problems existing in L.A., the solution of which is of no particular interest for the developed nations; (c) do, by concentration of human and material resources, what small research groups now scattered through the area (in industry, universities and institutes) cannot do now and will not be able to do in the foreseeable future; (d) give "technological personality" and self-confidence to the I.&S. industry of the area.

(17) A regional center for I.& S. technology would have a number of well defined specific objectives (see text). It should tackle problems in a variety of sectors of I.&S. technology (see text). It should maintain a "spectrum" of varied activities (from testing to cultural cooperation; see text). It would require a variety of working areas and auxiliary services (see text).

(Observation: the present paper draws heavily on a number of documents and reports prepared by ECLA or sponsored by ECLA, and on other papers and documents prepared by the author in various previous opportunities; two of which are mentioned below).

(1) "Pesquisas siderurgicas na A.Latina" - L.C. Correa da Silva - prepared for ECLA and presented at the L.A. Symposium on Industrialization (Santiago, March, 1966).

(2) "A Latin American Center for Iron and Steel Research" - a study prepared for ECLA (1966), by the author.



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